Protection of the Canary Current Large Marine Ecosystem (CCLME) Project – GCP/INT/023/GFF

Economic and Social Valuation of the CCLME Ecosystem Services

- Final Version -

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Content

Executive Summary

The present report is a first estimation of value of the Ecosystem Services - for human wellbeing, social welfare and economic growth - provided by the Canary Current Large Marine Ecosystem´s marine and coastal ecosystems. These ecosystems comprise of rich and diverse marine habitats, with an abundance of marine flora and fauna, especially fish, and ecologically important coastal habitats like mangroves, estuaries, seagrass beds and meadows, and extensive sandy beaches and dunes. All these ecosystems both represent important habitats for animals and plants, as well as crucial sources of income for local populations and national budgets.

The estimation of the "monetary value" of these ecosystems was based on a formerly developed methodology applied in the Guinea Current LME region, and is a first and rough attempt to depict the importance of the ecosystems in monetary terms, which is always a difficult endeavor, especially with regard to the fragmentary data situation in the region. Accordingly, distributional effects of the values generated are not being analyzed in the current study.

Although conservative estimations were used throughout the report (i.e. in case two or more figures or assumptions were available, the lower or more conservative one was always chosen), the resulting figures are nevertheless clearly demonstrating the importance of the marine and coastal ecosystems of the CCLME for West African societies: the CCLME ecosystems generate a yearly economic value of around 11,7 billion U$. One hectare of mangroves alone provides ES valued 2.235 U$/a, the most part of it credited to coastal protection (versus storms and erosion), the provision of fish nurseries, and climate regulation; put differently, the destruction of one hectare of mangroves costs over 2.000 U$ per year (which does not include the damages resulting from the emission of "blue carbon").

Due to significant gaps in data availability, a number of assumptions had to be taken to close or "bridge" these. Several key recommendations for improving the "next generation" evaluation exercise in the CCLME region were issued based on the assumptions taken:

- Generation of local or regional information (i.e. from the CCLME), regarding the following topics:
    - Size/spatial scale of coral reefs in Cape Verde.
    - Categorizing the ecosystems present in estuaries, to allow including these important ecosystems in future assessments.
    - Data on waste treatment, water purification and coastal protection infrastructure (to avoid benefit transfers and enable more accurate estimations through the Replacement Cost method).
    - Non-use values, especially of marine habitats. For the future work on the conservation of the CCLME, it will be advisable to consider exercising tailor-fitted evaluation studies in the region that provide for much more detail and that will be also mobilize local population for participative decision making processes.
    - Exact data on IUU fishing activities and maximum sustainable yield.
- Generation of more general information, regarding:
    - Climate regulation/"blue carbon" of marine ecosystems (especially deep sea ecosystems).

- Ecosystem Services provided by seagrass beds and meadows.

The report is structured as follows: in the next chapter 1, an introduction into the project and the rationale for this report are provided. In chapter 2, the potential role of economic valuations of ES in LME conservation is briefly outlined, and the paradigm shift from a sectoral to an ecosystem-oriented management approach is described; as stated above, this is one of the chapters that draws on the Guinea Current LME report, and provides literature hints and recommendations for further reading. Chapter 3 is short, as it briefly summarizes the methodology developed for the GCLME project, referring to the freely available project report. The following chapter 4 describes the main ecosystems and ES present in the CCLME region, and forms the background to the evaluation exercise itself (i.e. it describes the "quantity structure", meaning the "amount" of ES existing in the region). In chapter 5, the ecosystems and ES selected for the evaluation are presented on the basis of available data, and the practical considerations - such as necessary assumptions due to data limitations, etc. - regarding the subsequent evaluation of ES (chapter 6) are explained. Chapter 6 then also reflects on the importance of valuation exercises for policy/decision making, focusing on uncertainties, reliability of data, and data gaps. An outlook and some recommendations (chapter 7) close the report.

1. Introduction - Background and Rationale of this Report

The international "Protection of the Canary Current Large Marine Ecosystem (CCLME) Project", under the auspices of the UN Food and Agriculture Organization (FAO) and the UN Environmental Programme (UNEP), aims at stopping and reversing "*the degradation of the Canary Current LME caused by over-fishing, habitat modification and changes in water quality by adopting an ecosystem-based management approach*" (FAO/GEF 2007). The project enables the seven CCLME countries - Cape Verde, Guinea, Guinea Bissau, Mauritania, Morocco, Senegal and Gambia[1] - to address "*priority transboundary concerns on declining fisheries, associated biodiversity and water quality, through governance reforms, investments and management programs*" (FAO/GEF 2007).

Marine ecosystems, such as the CCLME, offer a wide range of goods and services being used and/or consumed by humans. These services - called "Ecosystem Services" (ES) [2], are usually provided "for free", and include food provisioning (fish and other marine products) and coastal protection (through mangrove forests and coastal swamps), but also more indirect services, like a beautiful landscape that attracts visitors. It is important to better understand and estimate the value of the benefits of these services for society, as such a valuation - which can be in monetary terms - can help to demonstrate and quantify the "real" economic value of ecosystems, as well as the costs associated with the loss of these beneficial values through ecosystem degradation.

Ecosystems are systems consisting of biotic and abiotic factors. Ecosystems are not a static composition of elements, but consist of the interaction of animals, plants, micro-organisms, mineral resources, climatic and other factors. An ecosystem is more comparable with a living organism than with dead material. Thus, the provision of services by an ecosystem is the result of specific interactions. The task of ES valuation is to assess the economic value of this output. If one looks at the extraction of crude oil, sand, gravel or other mineral resources, it can be stated that the extraction also produces a value. But this value does not derive from the living, functioning ecosystem but just happens to share the same spatial area. Mineral resources and fossil fuels are inert substances, and rarely have any influence on the functioning of ecosystems. As a result, the revenue from the extraction of non-renewable resources such as crude oil can in this context not be regarded as a service provided by the ecosystem. Economic valuation of ES is furthermore not about summing up every economic activity in the area of investigation but to valuate those goods and services that directly derive from the existence of an ecosystem and its functioning (this latter also applies to fisheries, where the annual sustainable output/yield is being evaluated, instead of the total value of all available fish stock).

In this context it needs to be noted that the economic valuation of ecosystem services is only one aspect that policy makers need to take into consideration when taking decisions. The value of oil extraction and other mining activities should not be ignored by decision making. But the assessment of this value is not part of an ES valuation.

Under the supervision of the Marine and Inland Fisheries Service (FIRF), and with assistance and guidance provided by the Regional Coordinator of the CCLME project and in close cooperation with diverse experts requested by the CCLME project, the present report was prepared. It describes the socio-economic value of the ES provided by the CCLME, and thus contributes to gaining insight on the actual losses suffered through declining ecosystem quality (or, gaining insight on the gains of

[1] Geographically, the Canary Island (Spanish territory) and Madeira (Portuguese territory) are also situated inside the boundaries of the CCLME; neither country, however, is a partner to the CCLME Project, and are therefore excluded from this analysis.
[2] Depending on source and author, ES are sometimes also referred to as "Ecosystem Goods and Services" (EGS).

improved ecosystem quality). Due to the exploring nature of the report, distributional effects of the values generated are not being analyzed.

The report will herein utilize a methodology developed by Eduard Interwies for a similar exercise performed in the Guinea Current LME (GCLME) project, under the auspices of UNIDO[3]. The methodology was adapted, however, if deemed necessary. Other parts of the report - such as chapters 2 and 5 - are also based on the GCLME report, adapted to the CCLME circumstances.

The CCLME evaluation exercise roughly followed these steps:

- Gathering of information: in collaboration with CCLME national experts, information on the existence and importance (quantity) of ES in the CCLME countries was gathered. This included, for example, figures for yearly fish landings, costs of coastal protection infrastructure, and the area covered by mangrove forests and seagrass beds.
- Gathering information on reference evaluations: in certain cases, a direct evaluation of the values of some ES was not possible, as no national/regional figures existed. In these cases, a "benefit transfer" (see chapter 3) was performed, transferring data from other world regions onto the CCLME.
- Preparation of an approximation of the value of ES in the CCLME region, including a short chapter on the current versus potential values and the use of these values in support of decision-making.

[3] To be found at: http://gclme.iwlearn.org/publications/our-publications/the-economic-and-the-social-value-of-gclme/view.

2 The Role of Economic Valuation of Ecosystem Services in LME Conservation

If the right policies are not adopted quickly, the current global decline in biodiversity and the related loss of Ecosystem Services will continue and in some cases even accelerate – some ecosystems are likely to be damaged or degraded beyond repair.

From an economic perspective, marine and coastal ecosystems should be treated, counted and invested in as elements of development infrastructure — as a stock of facilities, services and equipment which are needed for the economy to grow and society to develop and 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 those of intensifying demands and pressures in the future — just like any other component of infrastructure.

In contrast, a failure to value ecosystems when choices are made about allocating land and marine resources can result - beside the general loss of diversity and quality of life - in significant economic costs. In the past, values and benefits provided by ecosystems have been almost completely ignored in decision-making. One of the reasons for that ignorance is the failure of market mechanisms that most of the time do not assign an economic value to the public benefits of ecosystem services (as there is no direct price to pay), but attribute values to the private goods and services, whose production and consumption may lead to ecosystem damage (Sukhdev 2009). Economic valuation can help to provide evidence for the "real value" of public benefits that are not reflected in private goods and services (that do not have a price tag attached to them).

Ecosystem Services are benefit specific. On the one hand, this means that the use of one ES (e.g. wastewater cleaning/sewage treatment) could prevent/damage another (e.g. fish nursery) (EFTEC 2006). On the other hand, it is important to distinguish between the function of the ecosystem and the service that is resulting from the function. The function of water purification of a wetland, for example, produces the service "clean water", that in the end represents the benefit for the society (Boyd/Banzhaf 2006). Public priorities and willingness to make trade-offs to protect and restore key natural resources are cornerstones in the set-up of effective natural resource protection.

Areas producing ES and areas of high biodiversity are not necessarily in concordance. Thus, economic valuation can help to identify the highly productive areas with a good economic revenue that are not necessarily located in biodiversity hotspots. The result of an economic valuation can thus be a powerful argument for the protection of these less productive areas of high biodiversity and help in zoning conservation efforts (Sherman 2009; UNEP-WCMC 2011).

Economic valuation can help to address, mitigate and calibrate the following issues (Emerton 2006 and 2004; Naber/Lange/Hatziolos 2008):

- Human well-being and ES.
- Quantify trade-offs between ES, conservation and other priorities.
- Address non-linear and abrupt changes.
- Expand the scope of probabilistic analyses: Environmental decision making is often based on estimates, scenarios and incomplete knowledge due to the complexity of natural processes. In this context, economic valuation is an additional factor in the attempt to gain the most complete picture for possible future developments.
- Evaluate interactions of ES with other determinants of human well-being.

- Gaps in understanding regarding human well-being.

The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) elaborated an ecosystem-bases approach to the conservation of marine environments. It fosters the paradigm shift from sectoral management to a marine governance that tackles the current challenges of our oceans at the global scale. To this end, the GPA identified 64 Large Marine Ecosystems (LME) that provide for a congruence of ecologically defined space, that is, the geographic areas encompassed by the extent of natural ecosystems and politically defined space, the geographical area coming under the legal jurisdiction of particular political authorities (Tallis 2009).

The Handbook on Governance and Socio-economics of Large Marine Ecosystems (Olsen et al. 2006) stresses that the management of ecosystems and their services is intrinsically linked with the management of human behavior and the initiation of practices that take into account the operation of the natural world.

Therefore, the socio-economic importance of LME-related activities and economic and socio-cultural value of key uses of LME resources needs to be identified. In this regard the following issues are important:

- What are the drivers of change in marine and coastal ecosystems?
- Why should we care about the loss or degradation of marine and coastal ecosystems and their services?
- How can the loss of marine and coastal ecosystems and their services be slowed down? Or how could it be even reversed?
- Can valuation of marine ecosystems help in identifying appropriate measures to solve or mitigate the problems?

The Millennium Ecosystem Assessment (MA) report on marine and coastal ecosystems (Pauly/Alder 2005; Tundi/Alder 2005) was the first report that has systematically explored these questions at the global scale. The report states that the provision of the services provided by marine and coastal ecosystems is threatened by the worldwide degradation of marine and coastal ecosystems, including a severe decline of global fisheries. There are still major gaps in the knowledge of marine and coastal ecosystems and in methodologies to assess and manage them, including inadequate understanding of the marine nitrogen cycle - and other marine nutrient cycles - and of the El Nino/Southern Oscillation (ENSO) phenomenon. The MA report highlighted that anthropogenic activities are the major drivers of change, degradation, or loss of marine and coastal ecosystems and services.

The direct drivers of change in marine and coastal ecosystems are:

- land use change;
- development of aquaculture;
- overfishing and destructive fishing methods;
- invasive species;
- pollution and nutrient loading (eutrophication); and
- climate change.

And the major indirect drivers of change in marine and coastal ecosystems are:

- shifting food preferences and markets;

- subsidies;
- illegal fishing;
- population growth;
- technology change; and
- globalization.

Terrestrial drivers also impact upon marine and coastal ecosystems (Brown et al. 2006).

First options for responding to these challenges have also been identified by the MA report. It distinguishes between operational responses related to policy options and specific responses related to sectors.

The operational response options include the following (Brown et al. 2006):

- stakeholder participation in decision-making from global to local levels;
- development of stakeholder capacity;
- communication, education, and public awareness, and the empowerment of communities;
- generating alternative incomes;
- monitoring of biophysical and socioeconomic effects of responses, addressing of uncertainties, such as basic knowledge of biodiversity and ecosystem processes; and
- addressing trade-offs among uses of ES.

The specific response options include the following:

- international and regional mechanism that may focus on biodiversity, fisheries, habitat loss, or wider aspects of sustainable development;
- successful implementation of international agreements;
- integrated coastal management requiring a holistic view including land-based and freshwater influences;
- marine protected areas;
- coastal protection against storms and floods through provision of natural barriers;
- management of nutrient pollution and waste at source point;
- geo-engineering for CO sequestration;
- economic interventions such as financial incentives, taxes, and subsidies;
- fisheries management; and
- aquaculture management.

Economic valuation can play an important role in the identification of concrete measures and development strategies. In the past much enthusiasm has been spread out about win-win situations of conservation and development planning. In reality the today's resources are very much under pressure and trade-offs between different uses are more likely to occur. In this context economic valuation can be very important, because it often reveals hidden trade-offs for the first time. Making these tradeoffs explicit is a core function of ecosystem assessments (Carpentera et al. 2009).

3 The Methodology for evaluating the ES in the CCLME

The objective of the valuation exercise in the framework of this study report is to get a first insight about the costs and benefits deriving from LME conservation at the large scale of the CCLME. In the timeframe of the project, neither the analysis of distributional effects of the values generated, nor new surveys and data generation were possible, as such endeavors are usually very labor-intensive. Nevertheless, the report aims at assessing also the values of ES that are difficult to quantify, e.g. the maintenance of biodiversity. As a solution to these contradictory aims, the report will mainly use readily available market data (in cases of marketable products and services, such as fisheries and tourism), replacement costs, and "benefit transfer", i.e. the adaptation and transfer of data generated in other evaluation studies and surveys into the CCLME[4].

Such benefit transfers are naturally more uncertain and less exact than studies conducted directly in the respective region. The benefits of utilizing data of existing evaluation studies and their “transfer”, however, overweigh the inaccuracy of this approach. As already stated, the goal is a first rough estimate. In a later stage of the project, it might be advisable to put efforts on more detailed economic valuations and data generation.

As already stated in the introduction, the assessment excludes values created that do not depend on the well-functioning of the ecosystems, or that represent the use of a non-renewable resource (e.g. oil extraction). This also applies to fisheries, where the annual sustainable output/yield is being evaluated, instead of the total value of all available fish stock.

The methodology used in this report is based on the similar exercise conducted in the GCLME region. Similarly, national CCLME experts provided information that is relevant for the valuation, via a questionnaire[5]. The categorization of ES benefits follows the "Total Economic Value" (TEV) framework, i.e. the values of ES are classified into "use values" and "non-use values" (see Interwies 2011).

As this report closely follows the GCLME evaluation, it was agreed to not repeat the sections on general methodological approaches in the current document. Therefore, for a detailed explanation of the methodologies used in general for valuating ES, a description of the existing methodologies, including the TEV framework and the benefit transfer, as well as a discussion of the boundaries of economic evaluations, see the report prepared by Eduard Interwies in the context of evaluating the GCLME Ecosystem Services (Interwies 2011; see footnote 3).

Nevertheless, there are some methodological issues that need to be treated with a specific focus on the CCLME, and which, accordingly, cannot be transferred from the GCLME report. These topics are of course described in the present document: For a description and classification of ecosystems present and evaluated in this report, see chapter 4.3; for the ES evaluated, see chapter 4.4; and finally, for a description of the specific assumptions used in this report, and the handling of data gaps, see chapter 5.

[4] For a general analysis and discussion of valuation techniques, see DEFRA 2007; evaluation of Ecosystem Services in the context of marine and coastal ecosystems, see UNEP-WCMC 2011 and Ten Brink et al. 2011.
[5] The information obtained through the national experts via the questionnaire is marked throughout the document as "QUEST".

4 The main Ecosystems, ES and relevant Uses in the CCLME

The following chapter describes the "quantity structure" of the Ecosystem Services evaluation, i.e. it outlines the principal socio-economic and demographic background information, and introduces the principal coastal and marine ecosystems present in the CCLME, and the most relevant Ecosystem Services.

4.1 Short overview on studies assessing Ecosystem Services, LME in general and the CCLME

The present idea and concept of Ecosystem Services was developed and described in several important reports and publications, starting in the late 1990ies with publications by, for example, Costanza et al. (1997) and Daily (1997, 2000). The concept got covered in considerable detail globally by the UN´s "Millennium Ecosystem Assessment" (MA 2005), and, from that point onwards, in an increasing number of publications (see, for example, Silvestri/Kershaw 2010; Turner/Daily 2008; Boyd/Banzhaf 2007). More recently, the TEEB Report ("The Economics of Ecosystems and Biodiversity"; De Groot et al. 2009), especially the "TEEB for Water and Wetlands" (Russi et al. 2013), and several international initiatives (such as the UN´s Intergovernmental Platform on Biodiversity and Ecosystem Services/IPBES, or the EU´s Common International Classification of Ecosystem Services/CICES) are underlining the potential of the concept for sustainable policy and decision making.

Marine and coastal ES are covered in less detail than their terrestrial counterparts, due to generally more difficult circumstances regarding access to information and data. In the MA, chapter 18 ("Marine Systems") provides for an overview on the current status, major threats and development opportunities of the world’s marine fisheries systems (MA 2005). Furthermore, in the context of establishing Large Marine Ecosystems (LME), the Regional Seas Programme of the United Nations Environment Programme (Hoagland 2006; Sherman/Hempel 2009), IUCN (Sherman 2009), the GEF and NOAA (Olson et al. 2006; Sutinen 2000; Sherman et al. 2007), and others (Schuhmann 2012) commissioned studies and reports analyzing the possibilities for evaluating and protecting marine and coastal resources, addressing LME in general and in specific economic terms.

In addition, there are several in-depth studies executed in specific LMEs, of which the reports covering the Guinea Current LME ("Combating coastal area degradation and living resources depletion in the through regional actions"; Interwies 2011) and the Benguela Current LME Project are of the greatest importance for the CCLME. Other projects/assessments in the West African region include UNEP/IUCN´s "Identification, Establishment and Management of Specially Protected Areas in the WACAF Region", and UNEP´s "Addressing Transboundary Concerns in the Volta River Basin and its Downstream Coastal Area".

In the Canary Current LME, most notable existing assessments include the Global International Waters Assessment - Regional Assessment No. 41 (UNEP 2005), and the preliminary and preparatory work done by the CCLME Transboundary Diagnosis Analysis Working Group (preliminary TDA and working documents; for example Sambe et al. 2012). Furthermore, IUCN and PARTAGE (Projet d’Appui à la Gestion de la Pêche Artisanale Transfrontalière) commission annual reports on fisheries in the CCLME (Kinadjian 2012, 2013).

4.2 Socio-Economics of the CCLME Countries

The majority of the seven CCLME countries - Cape Verde, Guinea, Guinea Bissau, Mauritania, Morocco, Senegal and Gambia - rank among the poorest countries in Africa, and are characterized by low literacy levels and high population growth rates. Industry is generally weakly developed, and contributes in a minor way to national GDPs. Overall population in the coastal zone (as defined by the GIWA Assessment; UNEP 2005) amounts to 41,4 million people[6], of which a large proportion of the population is living below the poverty line, and is engaged in marine fisheries, agricultural production and tourism activities. Population densities are depicted in figure 1.

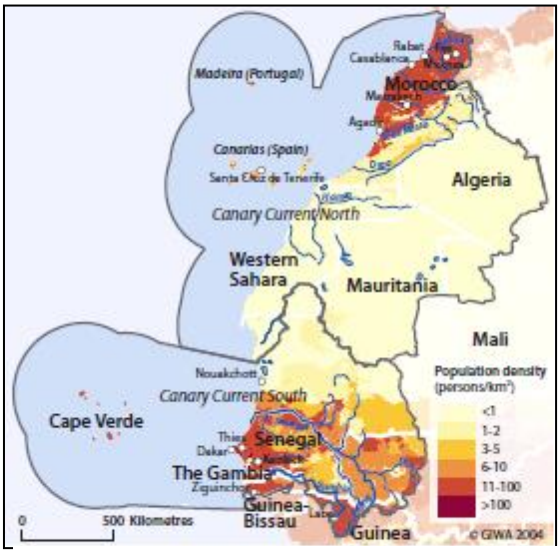

Figure 1: Population densities in the CCLME (Source: UNEP 2005).

The majority of the inhabitants are dependent on the direct use of ecosystems for the provision of food, fuel wood, water, building materials etc.; an estimated 70% of the population is directly dependent on international waters for their livelihoods. Subsistence farming is if importance mostly in the rainforest regions of Guinea und Guinea-Bissau (UNEP 2005).

The preliminary Transboundary Diagnostic Analysis identified three most crucial transboundary issues for the CCLME - issues that are directly linked with ecosystem quality and, therefore, the livelihoods of the majority of the CCLME inhabitants (TDA Working Group 2006):

- Declining fisheries and changes in ecosystems (declining or vulnerable small pelagic resources, declining demersal finfish fisheries, decline and vulnerability of sharks and rays, decline of marine turtles, decline of cetaceans and uncertain status of tuna resources);
- Habitat modification (disappearance and destruction of mangroves, degradation and modification of seabed habitat and seamounts, degradation and modification of coastal wetlands, coral reefs, estuaries);
- Declining water quality (changing salinity upstream of river mouths, hydrocarbon pollution, eutrophication of coastal waters, alien invasive species, sediment mobilization in water column and toxicity from pesticides.

Several socio-economic parameters are crucial for the evaluation exercise. These parameters are depicted in the following table 1.

Statistics	Cape Verde	Gambia	Guinea	Guinea-Bissau	Mauritania	Morocco	Senegal	Total
Population (million)	0,5	1,6	9,6	1,5	3,1	31,2	11,9	57,4
Population density (per km²)	122	173	44	42	3	74	69	32
Population in the region (million)	0,4	1,4	1,4	0	2,6	25,6	10	41,4
GDP (nominal; million USD)	1.899	918	5.632	870	4.199	97.530	13.864	-
GDP per capita (Int. Dollars)	2.705	377	487	211	847	2.434	900	-

[6] The GIWA Assessment (UNEP 2005) states 45,2 million inhabitants; from this number, the 3,8 million inhabitants of the Canary Islands, Madeira, Mali and Algeria have been subtracted (as these countries are not in the focus of this evaluation exercise). For overall population in the countries, see table 1.

HDI ranking (1 to 182)	121	168	170	173	154	130	166	-
Fisheries contribution to GDP (%)	1,25%	2,2%	3,6%	3,7%	6%	2,5%	1,9%	-
Tourism* contribution to GDP	15,3%	8,2%	2,0%	x	5,0%	8,7%	5%	-
Average fish consumption (kg/person/yr)	16-22	25-28	12	2,1	17,5	8,7	26,8	-

Table 1: Socio-economic parameters of the CCLME countries (Source: Sambe/Lymer 2011, adapted through QUEST; IMF; Princeton University).

*mostly coastal tourism.

4.3 Marine and Coastal Ecosystems in the CCLME

The Canary Current LME extends northwards from the coasts of Guinea and Guinea Bissau (Bijagos archipelago), up to the Atlantic coast of Morocco/Western Sahara, including - it its marine area - the Canary Islands and Madeira. The CCLME represents an important upwelling areas (cold, nutrient-rich waters ascending from the deep ocean), and is one of the world's most productive LME (ranked third in terms of primary productivity after the Humboldt and Benguela LMEs[7], and having the highest fisheries production of any African LME) (FAO/GEF 2007; Sambe et al. 2011).

The following coastal and marine ecosystems are present in the CCLME, and the most important ones in terms of size and, due to their relative occurrence, ES provision. The typology follows the MA, and as described in Naber/Lange/Hatziolos (2008):

Coastal Ecosystems (the area between 50 meters below mean sea level and 50 meters above the high tide level or extending landward to a distance 100 kilometers from shore).

- Estuaries, marshes, salt ponds, and lagoons (present in the CCLME).
- Mangroves (present in the CCLME).
- Intertidal habitats, deltas, beaches, dunes (present in the CCLME).
- Seagrass beds or meadows (present in the CCLME).
- Coral Reefs and Atolls (marginally present in the CCLME).

Marine Ecosystems (deeper than 50 m below sea level).

- No sub-classification.

According to Heileman/Tandstad (2008), the marine area of the CCLME has an overall size of 1,1 million km², equaling roughly the Exclusive Economic Zones (EEZs) of the coastal states (i.e. excluding Cape Verde; FAO/GEF 2007). The overall length of the coastline sums up to 3.900 km (see table 2 for details; UNEP 2005).

Coastal ecosystems in the CCLME consist mainly of mangrove forests and saltwater swamps, as well as sandy/natural beaches and estuaries/lagoons (UNEP 2005; Spalding et al. 1997). Mauritania also has extensive seagrass beds and meadows (Mayif 2012), and in all three northern states, as well as

[7] The CCLME is ranked a "Class I", highly productive (> 300 g C/m2/a) ecosystem (UNEP 2005).

Gambia, there are stretches of beaches important for the tourism industry. Data on the size of ecosystems, however, is fragmentary (see table 2 below).

Mangroves stretch from Mauretania southwards, the northern limit of their occurrence being the He Tidra (19°50'N) in Mauritania, and the southern well beyond the CCLME´s boundaries, in the Angolan estuary of the Rio Longa (10° 18'S) (see figure 2; Spalding et al. 1997).

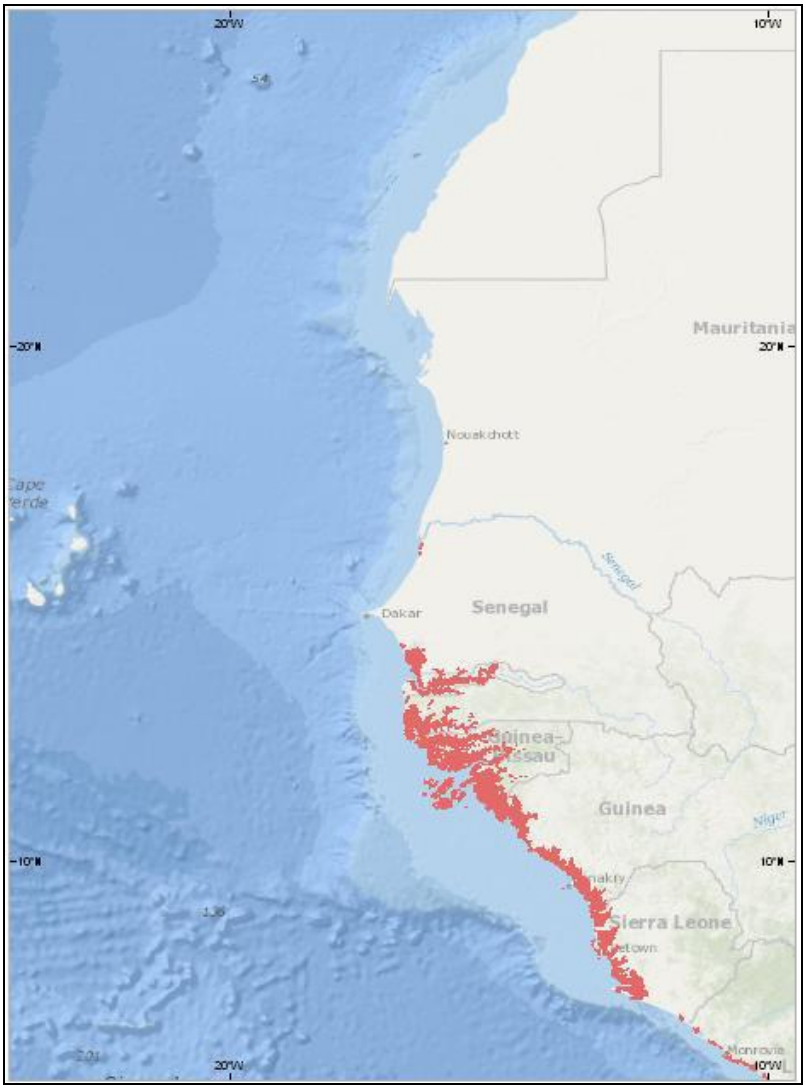

Figure 2: Mangrove forests/swamps in the CCLME (Source: Carocci 2013)

In some parts, mangrove forests and salt swamps stretch significantly inlands, for example at the mouth of the Gambia river (see figure 2; UNEP 2005).

Regarding coral reefs, the literature does not provide consistent information: one source (Heinemann/Tandstad 2008) states that 0,01% of the world´s coral reefs are situated in the CCLME; expert information from the region points to a large population of deep-sea corals off the coast of Mauritania (Brahmin 2013)[8]; other, more relevant sources, state that there are no coral reefs in the CCLME, except for a very small occurrence it Cape Verde (Spalding et al. 2001; Seaaroundus)[9].

[8] These, however, were excluded from this analysis, due to several reasons: first, the deepwater corals are part of the marine environment, in which it is - with regard to economic evaluation - impossible to distinguish between various ecosystems (i.e. deepwater corals, sea mounds, trenches etc.); second, the deepwater corals are not a

Huge estuary systems are also present in the region (dwarfing any other ecosystems). These consist mostly of mangrove forests and swamps, tidal marches, and open water[10].

The following table 2 provides an overview of the ecosystem present in the CCLME region, including the spatial information available in terms of distribution and sizes.

CCLME Countries/ Ecosystem	Marine Ecosystems (km²)*	Share of marine area**	Coast-line (km)	Mangroves (ha)	Sandy beaches /dunes (km)	Seaweeds/ Meadows (ha)	Estuaries (km²)	Corals
Cape Verde	796.840	-	(239)	0	No data	No data	No data	No data on size.
Gambia	22.630	2%	80	58.000	5	-	77.000	-
Guinea	109.456	9,7%	320	276.000	(4 beaches)	No data	5.100	-
Guinea-Bissau	106.117	9,4%	125	210.000	350	525	271	-
Mauritania	155.422	13,9%	754	100	No data	100.000	No data	Deep-Water Corals
Morocco	572.712	51%	2.410	0	(141 beaches)	-	53.000	-
Senegal	157.550	14%	531	115.000	No data	-	Ca. 330.000	-
Total	1.123.887	100%	4.220	659.100	-	100.525	-	No data.

Table 2: Ecosystems and share of ecosystems of CCLME countries (Sources: Seaaroundus; UNEP 2005; CIA; QUEST; Sambe 2013; Robalo/Cordeiro 2013; Mayif 2012; Chafik 2012).
*equals EEZ; **excluding Cape Verde.

4.4 Identifying the main ES and relevant Uses in the CCLME

The present report understands "Ecosystem Services" as goods and services provided by a living system", thus the extraction of non-renewable resources (oil and gas mining, sand and mineral extraction) is not considered as ES in the context of this analysis. This also applies to fisheries, where the annual sustainable output/yield is being evaluated, instead of the total value of all available fish stock.

Since the Millennium Ecosystem Assessment, Ecosystem Services are usually grouped into four categories - in the MA, these were provisioning, regulating, cultural and supporting services (MA 2005). The slightly newer TEEB Report replaced the difficult-to-grasp category of "supporting services" with a category called "habitat services", describing the functions of an ecosystem that do

touristic attraction, i.e. studies valuing coral reefs in general cannot be transferred to deepwater corals; and third, no evaluation study valuing deepwater corals individually exists.

[9] As no further information about the size of this colony could be obtained, it is excluded from the analysis.

[10] However, there is no information available regarding the share these ecosystems have in the overall area of estuaries (i.e. how much of the estuary ecosystems consist of open water, of mangroves etc.). Due to this fact, estuaries are excluded from this analysis. At the same time, and as estuaries are a significant habitat for mangroves in the region (and are, consequently, partly covered by mangrove forests), it can be concluded that significant parts of the estuaries are already included in the analysis.

not directly provide goods or services to humans, but instead are crucial for the functioning of the whole system[11].

For the present Ecosystem Services evaluation, the TEEB Report´s understanding[12] and typology of ES will be used (see figure 3 below).

	Main service-types
	PROVISIONING SERVICES
1	**Food** (e.g. fish, game, fruit)
2	**Water** (e.g. for drinking, irrigation, cooling)
3	**Raw materials** (e.g. fiber, timber, fuel wood, fodder, fertilizer)
4	**Genetic resources** (e.g. for crop improvement and medicinal purposes)
5	**Medicinal resources** (e.g. biochemical products, models & test organisms)
6	**Ornamental resources** (e.g. artisan work, decorative plants, pet animals, fashion)
	REGULATING SERVICES
7	**Air quality regulation** (e.g. capturing (fine)dust, chemicals, etc.)
8	**Climate regulation** (incl. C-sequestration, influence of vegetation on rainfall, etc.)
9	**Moderation of extreme events** (e.g. storm protection and flood prevention)
10	**Regulation of water flows** (e.g. natural drainage, irrigation and drought prevention)
11	**Waste treatment** (especially water purification)
12	**Erosion prevention**
13	**Maintenance of soil fertility** (incl. soil formation)
14	**Pollination**
15	**Biological control** (e.g. seed dispersal, pest and disease control)
	HABITAT SERVICES
16	**Maintenance of life cycles of migratory species** (incl. nursery service)
17	**Maintenance of genetic diversity** (especially gene pool protection)
	CULTURAL SERVICES
18	**Aesthetic information**
19	**Opportunities for recreation & tourism**
20	**Inspiration for culture, art and design**
21	**Spiritual experience**
22	**Information for cognitive development**

Figure 3: The typology for ES according to the TEEB Report (Source: De Groot et al. 2009).

The Ecosystem Services provided by the CCLME ecosystems include the provision of habitat for fish and other coastal species, supply of fresh water from coastal rivers and estuaries, wood from mangroves etc. (see figure 4 below). Even more importantly, the CCLME ecosystems are a vital food and economic resource not only for coastal populations bordering the LME, but also for much of West Africa and beyond, as it supports extensive fish stocks (annual production ranges from 2 to 3 million tons) and also millions of migrating birds. Sardines, pilchards, Horse mackerel, Chub mackerel and Hake are some of the commercial species found and caught in the region (Russi et al. 2013; FAO/GEF 2007; UNEP 2005).

The following figure 4 depicts the Ecosystem Services provided general by marine and coastal ecosystems in general.

[11] More information on classification of ES, and different categories: MA 2005; De Groot et al. 2009; Haines-Young/Potschin 2009.

[12] In the TEEB Report, Ecosystem Services are defined as "*the direct and indirect contributions of ecosystems to human well-being*" (De Groot et al. 2009).

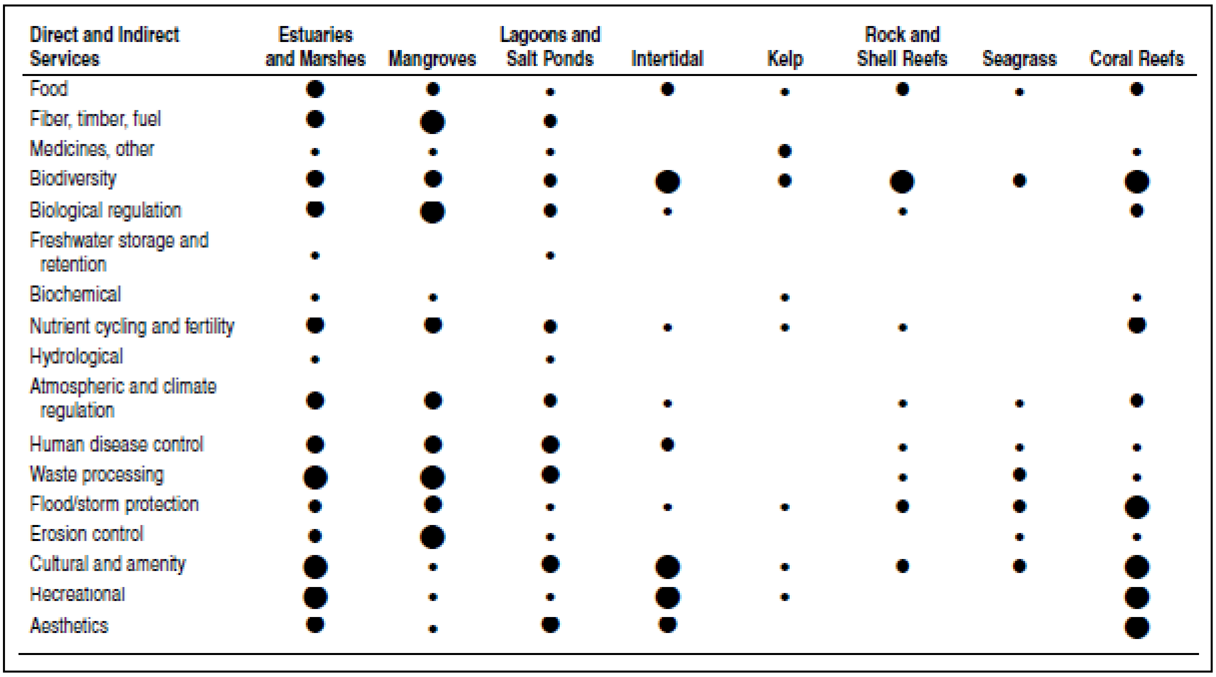

Figure 4: Summary of Ecosystem Services and their relative magnitude provided by different coastal ecosystem sub-types (Source: Tundi/Alder 2005).

Considering the geographic scale of the CCLME, it is difficult to list and analyze every single ES provided by every single ecosystem. The authors therefore propose to select those goods and services that are directly linked to the major problems identified by the preliminary TDA (TDA Working Group 2006), or whose use aggravates these problems:

- Declining fisheries and changes in ecosystems (declining or vulnerable small pelagic resources, declining demersal finfish fisheries, decline and vulnerability of sharks and rays, decline of marine turtles, decline of cetaceans and uncertain status of tuna resources);
- Habitat modification (disappearance and destruction of mangroves, degradation and modification of seabed habitat and seamounts, degradation and modification of coastal wetlands, coral reefs, estuaries);
- Declining water quality (changing salinity upstream of river mouths, hydrocarbon pollution, eutrophication of coastal waters, alien invasive species, sediment mobilization in water column and toxicity from pesticides.

The ES selected for evaluation in this report are listed in chapter 5. Of course, a deeper, more thorough investigation in the future could/should go more into the details and values of specific, singular ecosystems.

5 The Valuation Approach for the CCLME - Practical Considerations

In this chapter, the ecosystems and Ecosystem Services selected for the evaluation are presented on the basis of available data and some practical considerations. Also, an overview of methodological details and simplifications undertaken by the authors in order to cope with the varying quality of available data as well as to provide a comprehensive report is given. Herein, the various use values are described, structured according to their belonging to either marine or coastal ecosystems, followed by the non-use values (which are described for coastal and marine ecosystems combined).

5.1 Available Data and Information

The situation in the CCLME countries regarding availability of data necessary for a comprehensive economic assessment is fragmentary. Several significant data gaps persist even after intense consultation with national experts, for example with regard to the size or distribution of certain important ecosystem types in some countries (see table 3 below), and some socio-economic data (for example, the population density in coastal areas).

CCLME Countries/ Ecosystem	Marine Ecosystems (km²)*	Share of marine area**	Coast-line (km)	Mangroves (ha)	Sandy beaches /dunes (km)	Seaweeds/ Meadows (ha)	Estuaries (ha)	Corals
Cape Verde	796.840	-	(239)	0	No data	No data	No data	No data on size.
Gambia	22.630	2%	80	58.000	5	-	77.000	-
Guinea	109.456	9,7%	320	276.000	(4 beaches)	No data	5.100	-
Guinea-Bissau	106.117	9,4%	125	210.000	350	525	271	-
Mauritania	155.422	13,9%	754	100	No data	100.000	No data	Deep-Water Corals
Morocco	572.712	51%	2.410	0	(141 beaches)	-	53.000	-
Senegal	157.550	14%	531	115.000	No data	-	Ca. 330.000	-
Total	1.123.887	100%	4.220	659.100	-	100.525	-	No data.

Table 3: Ecosystems and share of ecosystems of CCLME countries (Sources: Seaaroundus; UNEP 2005; CIA; QUEST; Sambe 2013; Robalo/Cordeiro 2013; Mayif 2012; Chafik 2012).
*equals EEZ; **excluding Cape Verde.

Other data gaps exist in terms of information on "values" of certain ES. These data gaps consist of:

- Data from the region regarding most Ecosystem Services and their benefits/values, especially regarding regulating, habitat and cultural (non-use) services.
- Non-use values of marine ecosystems, both regarding tourism and recreation as well as other cultural/non-use values (for more information on the difficulties involved in evaluating marine ecosystems, see UNEP-WCMC 2011).

- Exact data on IUU fishing activities (which is an important factor regarding overfishing and overall value of fisheries resources).
- Data on Sustainable Maximum Yield (i.e. necessary percental reductions etc.).
- Data about climate regulation function of marine ecosystems, especially the deep sea (see Naber/Lange/Hatziolos 2008)
- Data on ES provision of seagrass beds and meadows (most ES).
- Data on the ecosystems present in the estuaries[13], and the share of land and water in the huge estuary systems.

5.2 Ecosystems to be considered

Considering the data situation and associated restrictions (see above), the following marine and coastal ecosystems will be included in the present analysis:

- mangrove forests and swamps;
- beaches/dunes;
- seagrass beds and meadows;
- marine habitats (no differentiation).

Due to data limitations, estuaries/lagoons - and the associated Ecosystem Services - cannot be evaluated (see footnote 10 above). Coral reefs - both warm and cold water corals - are excluded due to the very limited occurrence (of warm water corals) in the CCLME/Cape Verde (and the lack of information regarding the size of the colony), and because it is not possible to distinguish various different marine ecosystem types (see footnote 8).

5.3 Ecosystem Services to be considered

According to literature, the ecosystems selected for the analysis principally provide the following Ecosystem Services, following the TEEB categorization (Pendleton et al. 2012; Feka et al. 2009; Russi et al. 2013; MA 2005; Tundi/Alder 2005; Vo et al. 2012; Sala et al. 2008, in: Briand (ed.) 2008; MA, Naber/Lange/Hatziolos 2008; Nagelkerken 2009):

- Mangrove forests and swamps: The main ES provided by mangrove ecosystems include the provisioning services food (fisheries resources) and raw materials (fiber, timber, fuel); the regulating services climate regulation (carbon sink), moderation of extreme events (flood and storm protection), waste treatment (nutrient cycling, water purification, adsorption of heavy metals), and erosion prevention (land stabilization); the habitat services maintenance of life cycles of migratory species (nursery function) and maintenance of genetic diversity; and a whole range of cultural services (tourism/recreation, as well as aesthetic information, inspiration, spiritual experience and education).

  Mangrove ecosystems of a specific area often have very unique features that can't be found in other regions of the world. Therefore, the regionally varying characteristics of mangroves

[13] See footnote 10 above.

need to be kept in mind. The result of benefit transfer, therefore, cannot be the only basis for local decision making, but for a global trade-off analysis for the whole CCLME region.

- Beaches and dunes: The main ES provided by beaches and dune ecosystems include habitat services maintenance of life cycles of migratory species (breeding grounds for birds) and maintenance of genetic diversity; and a whole range of cultural services (mainly tourism/recreation, as well as aesthetic information, inspiration, spiritual experience and education). Extraction of sand is also regionally important, but not covered in this report (see above).

- Seagrass beds and meadows: The main ES provided by seagrass ecosystems include the provisioning services food, raw materials (fodder, agar) and medicinal resources; the regulating services moderation of extreme events (flood and storm protection), waste treatment (nutrient cycling, water purification, filtering sediment from coastal waters), climate regulation and erosion prevention (stabilizing coastal sediments and shorelines); the habitat services maintenance of life cycles of migratory species (nursery function) and maintenance of genetic diversity; and a whole range of cultural services (tourism/recreation, as well as aesthetic information, inspiration, spiritual experience and education).

- Marine ecosystems: The principal ES provided by marine ecosystems is the provisioning service food (fisheries resources). Beside, marine ecosystems represent a significant sink for carbon, and fulfill an important climate regulation function.

Due to the most severe data limitations, the following of the ES listed above are not considered in the analysis:

- Climate regulation of marine ecosystems.

- Food, raw materials (fodder, agar), medicinal resources, moderation of extreme events, waste treatment, erosion prevention and maintenance of life cycles of migratory species of seagrass beds and meadows.

- Maintenance of life cycles of migratory species and maintenance of genetic diversity of beaches and dune ecosystems.

- Other non-use values than tourism and recreation of marine ecosystems.

Based on the above (also the data limitations, see section 5.2), the following table 4 summarizes the selection of ecosystems and Ecosystem Services - following the TEEB and TEV frameworks - to be analyzed (or excluded).

Ecosystems	Total Economic Value (TEV)			
	Use Value			Non-use Value
	Direct Use Values Provisioning services	Indirect Use Values Regulating services	Indirect Use Values Habitat Services	Bequest and Existence Values
Marine ecosystems	Food (fisheries: artisanal/semi-industrial/industrial)	Climate regulation		Opportunities for recreation and tourism Aesthetic information Inspiration for culture, art and design Spiritual experience Information for cognitive development
Coastal ecosystems: Mangroves (swamps/forests)	Food Raw materials (non-food forestry products: fiber, timber, fuel etc.)	Moderation of extreme events and Erosion prevention Waste treatment Climate regulation	Maintenance of life cycles of migratory species Maintenance of genetic diversity	
Coastal ecosystems: Seagrass meadows/seagrass beds	Food Raw materials (fodder, agar) Medicinal resources	Moderation of extreme events Waste treatment Erosion prevention Climate regulation	Maintenance of life cycles of migratory species Maintenance of genetic diversity	
Coastal ecosystems: Beaches/dunes			Maintenance of life cycles of migratory species Maintenance of genetic diversity	
Coral Reefs				
Estuaries/lagoons				

Table 4: Ecosystems and Ecosystem Services selected or excluded for the current analysis.

Red: Excluded due to data limitations. Green: Included. Yellow: partly included (for some ecosystems only).

5.4 Approaches for assessing the different Ecosystem Services

All values will be estimated on the basis of US Dollar (current 2013 value) per hectare (U$/ha) of mangroves/seagrass beds/meadows/marine area, or per km of coastline/beach.

The approaches will be explained in detail for direct and indirect use values, separately for the different ecosystems (coastal and marine). Then, the approach to non-use values will be detailed for coastal and marine ecosystems combined.

5.4.1 Coastal Ecosystems - Mangroves

Direct Use Values

Mangrove forests have been shown to sustain more than 70 direct human activities, ranging – beside fisheries - from fuel collection to the gathering of medicinal herbs and raw materials for constructing housings or manufacturing traded goods (Dixon 1989). For the purpose of this report (and to adapt to the fragmentary data situation), the provisioning ES provided by mangrove forests/swamps are re-classified into "timber" and "non-timber forestry products" (NTFP), following a classification used by Ukwe (BDCP 2007), to describe the value of NTFP in the Guinea Current LME. To depict the economic gains generated by using the forestry products of mangroves, a twofold approach was chosen. First, a benefit transfer was conducted, using studies from south Asian mangrove regions as study sites. Second, the value for NTFP generated for the GCLME by Ukwe (BDCP 2007), using shadow prices, was adapted to the CCLME, and broken down to a "per hectare" figure.

Indirect Use Values

Mangroves furthermore provide the following indirect use values:

- Moderation of extreme events.
- Erosion prevention.
- Waste treatment.
- Maintenance of life cycles of migratory species and of genetic diversity (in this case: nursery grounds for fish).
- Climate regulation.

Moderation of extreme events and erosion prevention

The value of ecosystems for storm protection and preventing land erosion is generally difficult to estimate, and impossible to distinguish from another (considering the available data and studies). Hence, these two services are assessed together.

A possibility to close this gap is the usage of the Replacement Cost method, although in itself not undisputed (Barbier 2007). In this case, two projects were identified of planned or existing coastal protection works in damaged coastal areas in the CCLME (a protective dyke against coastal erosion of 730 meters length in Rufisque (Dakar), and a dyke construction in Saly, Senegal, of 4km length), and were used as a basis for the calculation, in which the cost of the erosion control measure can be regarded as the Replacement Cost of coastal ecosystems that are not yet damaged. The respective width of mangroves necessary to offer the same degree of coastal protection is assumed to be 100 m, according to relevant literature (Barbier 2007, 2008).

In addition to this, a benefit transfer was performed, using several South Asian studies on the economic value of mangroves as study sites.

Waste treatment

Mangroves and also have a very important ecological function in filtering water and degrading and decomposing organic materials, thus serving as a biological purification plant. Thus, the indirect use values waste treatment could be calculated in a similar way as above, by using costs of treatment plants and cleaning processes. As it was impossible to obtain data from the region regarding such projects, the values needed to be displayed by carrying out a benefit transfer, again using several South Asian mangrove studies.

Maintenance of life cycles of migratory species and of genetic diversity (nursery)

Mangroves (and other coastal ecosystems) provide a further extremely crucial service to the surrounding ecosystems and societies, namely the restocking of fish stocks by constituting fish nurseries and breeding grounds[14] (Rönnbäck 1999). To exactly calculate the reproduction rate of fish species in mangrove areas, or the losses in catch inflicted by the destruction of mangrove ecosystems, it would be important to get reliable information in the linkages between mangrove forests and fishery production (Rönnbäck 1999; Barbier 1994). However, data on those linkages is unavailable for the CCLME region. Fortunately, some international studies are available, providing some insight into this topic. In a 1996 World Bank study, it was estimated that one hectare of mangrove forest provides rearing habitat for 0.7 tonnes of fisheries yield. This figure could be interpreted in a simplified manner: that a loss of 100 ha of mangroves would cause fish landings to fall by 70 tonnes in the region (World Bank 1996).

Rönnbäck (1999) recommends a quota of 30% – 80% of the total annual value of near-shore fisheries to be credited to mangrove services, Samonte-Tan (2007) 25% (stating that this figure is a "conservative estimation"), while Emerton/Kekulandala (2003) assume a 10% relation between fishery value and nursery/breeding ground service provided by mangroves.

In this report, at first a calculation according to the World Bank assumption was undertaken, i.e. a concrete number has been assigned to each ha of mangrove ecosystems, by using per tonnes values derived from data on fisheries provided by the national experts. Secondly, the conservative, careful 10% figure of Emerton/Kekulandala (2003) was used, to obtain a comparison and some insight on the scope of the contribution of coastal ecosystems to total fishery output. As seagrass beds/meadows are assumed to fulfil a similar function, they are equally treated (see below); the per hectare-figure (see chapter 6) will be calculated on the basis of the cumulated areas of both ecosystems.

In case the two figures vary (i.e. the figure based on the World Bank assumption, and the one based on Emerton/Kekulandala), the lower figure will be used to calculate the overall TEV. As detailed below, these results are to be subtracted from the total fishery output, to avoid double counting.

Climate regulation

Tropical forests, including mangroves, also have an important role in regulating carbon dioxide in the atmosphere through the processes of respiration and photosynthesis, whereby plants absorb CO_2 and store it in their biomass. Therefore, another major ecological function of mangroves is to serve as

[14] For simplicity, and in relation to the data situation, "fish nursery" describes the nursery function for all fisheries products. For example, the significant share of shrimps in fishery output is included here (as it is in the estimation of the value of "fish" landings).

carbon sink. The general approach in estimating the potential of a forest in sequestrating carbon involves calculating the total biomass per hectare (biomass density), and then applying appropriate conversion factors to get the carbon equivalents. In estimating a monetary value of the carbon sequestered by the forest, an international price per unit of carbon reduced is usually applied (UNEP-WCMC 2011). As these prices are subject to market forces, rising and falling according to demand and supply, they are rarely accurate. As an alternative, the official UK guidance on carbon values - factored into UK public sector appraisals - from DECC (2009) was used, setting out in some detail the official rates for valuation of carbon (80 U$/t$CO_2$e presently, with an increase to 307 U$/t$CO_2$e by 2050) (UNEP-WCMC 2011).

Note: The described use values of coastal ecosystems are independent of each other. Therefore, no risk of double counting of values exists. Thus, the overall value of ES can be calculated through a simple addition.

5.4.2 Coastal Ecosystems - Seagrass beds and meadows

Seagrass beds and meadows are - like mangroves - credited with providing a range of Ecosystem Services (see above for details). However, monetary evaluations or other studies assessing the "quantity" of these ES, are lacking for - almost literally - all ES provided by seagrass beds (Barbier et al. 2011; Naber/Lange/Hatziolos 2008). Therefore, a monetary evaluation is hardly possible in this case.

Nevertheless, in the present study the ES "Maintenance of life cycles of migratory species and of genetic diversity (nursery)" will be estimated, based on the evaluation performed for mangroves, i.e. it is assumed in this study that the nursery function of seagrass beds and meadows equals the nursery function on mangroves. The per hectare value of the "nursery service" of mangroves and seagrass beds/meadows will therefore be calculated together (i.e. the areas of both ecosystem types will be added to calculate the final per hectare value).

In case the two figures vary (i.e. the figure based on the World Bank assumption, and the one based on Emerton/Kekulandala), the lower figure will be used to calculate the overall TEV the lower of the two resulting figures will be used (in line with the general approach of the report to prefer conservative figures over higher ones). As detailed below, these results are to be subtracted from the total fishery output, to avoid double counting.

Additionally, one source estimates the average potential CO_2 emissions "stored" ("blue carbon") in seagrass beds/meadows (Pendleton et al. 2012), equaling 3,26 t per hectare (mean value). This figure is applied to the 100.525 ha of seagrass bed/meadows in the CCLME, but not calculated into the Total Economic Value (which, in this report, considers only the ES provided regularly on a yearly basis[15]).

5.4.3 Coastal Ecosystems - Beaches and Dunes

Beside representing an important opportunity for tourism and recreation (see non-use values below), the beach and dune ecosystems represent an important habitat for breeding birds, sea turtles and other migrating animals (ES "Maintenance of life cycles of migratory species and of genetic diversity"). However, there is no information available either regarding the species breeding or being dependent on these ecosystems in the CCLME, or regarding any information on the economic value associated with these services.

[15] If this figure - i.e. the damage that would occur if seagrass beds/meadows were being destroyed - would be included, this would consequently have to be done for all other ecosystems as well. This, however, is not what this ES evaluation exercise is about (i.e. evaluating the services that are provided sustainably and regularly over a longer period of time).

Hence, the direct or indirect use values if beaches and dune ecosystems are excluded from this analysis (only the important tourism and recreation opportunities are being evaluated; see below).

5.4.4 Marine Ecosystems

Fisheries

The direct use values of marine ecosystems consist mainly of the income generated by fishing[16], including artisanal, semi-industrial and industrial activities. As fish is traded on markets, the value of fisheries will be estimated using available market data. Initially, it was foreseen to use the data provided by BDCP (2007) for the GCLME region (a per ton estimate of 11.832 U$). This figure, however, leads to a significant overestimation of the total value of fish landings, compared to data provided by several regional sources (see chapter 6 below). Additionally, it was not possible in the scope of this report to assess prices per fish species, or get consistent data on the individual fish species (and other marine species) landed.

Therefore, the value of fisheries in the CCLME region was calculated using data provided by Sambe/Lymer (2011), regarding the contribution of fisheries to the GDP of the CCLME countries. This figure was then double-checked with the overall estimations for the CCLME region.

As mentioned several times above, the values of resources extracted from (marine) ecosystems are not regarded as ES. This also applies to fisheries, where the annual sustainable output/yield is being evaluated, instead of the total value of all available fish stock.

A major limitation, however, is the missing quantitative, specific information on illegal, unreported and unregulated fishing activities (IUU)[17], whose assessment is extremely difficult, and which relies mostly on estimations. One thing, however, is clear: IUU fishing activities are a very important factor in West African waters, being estimated to have the highest share of IUU fishing in the world (up to 35% of total catches in the region; locally higher, e.g. more than 50% of total catches in Guinea, and 50-60% in Guinea-Bissau) (MRAG 2005; Brown 2013). It is extremely difficult to apply these figures to the whole region, as in the northern states - Senegal, Mauritania, Gambia, Cape Verde - fewer IUU events are generally reported (MRAG 2005).

As a simplified method, in this report it is assumed that 25% of total reported catch value is caught in addition illegally or unreported. This figure must be regarded as a low estimate, being well below the estimation by Brown and MRAG (the latter for Guinea and Guinea-Bissau). The resulting value is added to the overall figure, before applying a 20% reduction for MSY (see below).

It is recognized by the authors of this report that a portion of the fishing output accredited to marine ecosystems is actually originating from coastal ecosystems (e.g. fishing activities in mangrove swamps). As it was impossible to distinguish between those two areas with regard to fishing output, the direct use value “fishing” is accredited exclusively to marine ecosystems. The important share of the coastal ecosystems of the total fishery output was accounted for, however, by accrediting the indirect use value “maintenance of life cycles of migratory species” (i.e. fish nursery) to coastal ecosystems, a value that was calculated on the basis of the total fishery output. This value was then subtracted from the overall value of fisheries to calculate the final figure, in order to avoid double counting.

[16] "Fishing" and "fish landings" are to be understood as the total of the fishery output, i.e. including shrimp fishing, for example.
[17] For a definition and more information on IUU fishing activities at a global and regional level, see MRAG (2005).

This value of fisheries, however, needs to be assessed in the light of the question whether the current fishing practices exceed Maximum Sustainable Yield (MSY), i.e. whether current fishing leads to a depletion of fish stock, or not (World Bank/FAO 2009). Although concrete and consistent data on MSY for different marine species is lacking for the whole CCLME (some concrete numbers can be found for Mauritania, for example, in UNEP 2005), several authors agree that fish stocks in the LME are fully or over exploited (Sambe 2011; FAO/CECAF 2010; Caramelo 2010). In the author´s opinion, the value of fishing in marine ecosystems must not exceed MSY, i.e. the total value of fishing needs to be calculated with respect to the reproduction rate.

Some problems had to be considered here. First, the reproduction rate of fish is dependent on various factors (condition of nursery grounds, water pollution etc.). Secondly, precise assessments of fish landings are impossible, as many fish trawlers are coming not from CCLME countries, but also from other regions, and because of the share of IUU activities in the region (see above). Not surprisingly, a concrete figure for MSY is not available for the CCLME region. To cope with that, in this report, an estimation from Sumaila et al. (2007) was adopted, speaking of a global reduction of 20% in fishing area (and, as it can be assumed, fisheries output) to foster sustained fish stocks. A similar figure was proclaimed for Nigerian waters as well (Tobor 1990). Thus, the figures provided by the national experts and literature regarding the amount and value of fish landings in the region were used as a basis (plus 25% to accommodate IUU fishing activities), and adapted to MSY by applying a 20%-reduction to reflect a sustainable level of fishery output.

Summarizing, to get the final result, the total market value of fish landings in the CCLME (based on the share of fisheries in the respective GDPs) was taken as a basis, 25% of this sum added to accommodate IUU fishing activities, and then reduced by 20% to integrate MSY levels. Then, the resulting figure was reduced by the value determined for the indirect use value "fish nursery" of coastal ecosystems, to avoid double counting.

Climate Regulation

Marine ecosystems store significant amounts of carbon, both "*in terms of CO_2 uptake from the atmosphere (plankton production and food webs), and deep carbon storage by macro vertebrate fauna (whales and other marine mammals, sharks, tuna, turtles, big schools of fish)*" (Naber/Lange/Hatziolos 2008), and therefore fulfill an important regulation function with regard to (global) climate regulation.

Due to very limited knowledge of marine, especially deep sea ecosystems, and about the amount of carbon stored over a given period of time, there are almost no studies available that try to evaluate the value of these services. For the present study, no information could be obtained that would have allowed for a first, even rough, estimate of this service. Hence, the climate regulation service of marine ecosystems is not included in the further analysis.

5.4.5 Coastal and Marine Ecosystems - Non-use values

Non-use values of ecosystems - i.e. the bequest (possible use through future generations) and existence values (the right of existence) - consist of the TEEB cultural services:

- Opportunities for recreation and tourism
- Aesthetic information
- Inspiration for culture, art and design

- Spiritual experience
- Information for cognitive development

The valuation of such non-use values is a difficult topic, and still subject to a great extent of uncertainty. Although many studies have been performed covering non-use values (DEFRA 2007), the methods employed suffer from empirical as well as statistical problems (Hutchinson et al. 2008). Without going into details, challenges include the measurement of non-use values (Mullan/Kontoleon 2008; Baumgärtner 2006) and statistical problems in interpreting the results of valuation studies ("embedding effect": see Bateman/Turner 1993; Kahnemann/Knetsch 2002). Considering these difficulties, applying study results through a benefit transfer seems to be a difficult exercise (see Woodward/Wui 2001; Thiele/Wronka 2002). However, some insights can be drawn from a comparison with global estimates on non-use values as well as single case studies in this respect.

To be able to approximate the value of cultural services, however, a simplification was necessary. For the purpose of this report, cultural services will be sub-classified into "possibilities for tourism and recreation" (representing the more tangible values, i.e. income opportunities through tourism), and the other cultural services (aesthetic information, inspiration for culture, art and design, spiritual experience and information for cognitive development, representing the existence and bequest values). These two categories will be evaluated using different approaches.

To include "possibilities for tourism and recreation" as a non-use value is due to the categories established by TEEB and the TEV framework - in the TEV framework, cultural ES are categorized as non-use values. In the TEEB, possibilities for tourism and recreation are categorized as cultural services. Hence, possibilities for tourism and recreation are left as cultural services, and as non-use value.

Tourism and Recreation

The coastal ecosystems of the CCLME (often protected through extensive marine and terrestrial protected areas, which are especially important for tourism), including mangroves, seagrass beds/meadows and beaches/dunes, are very important resources for the regional tourism industry. Unfortunately, in the CCLME countries (except for Morocco), there is few detailed data available on tourism (e.g. figures like shares between coastal and inland tourism, or visitors per ecosystem), even after consulting the national experts. Furthermore, it is not possible to transfer tourism data from other world regions to the CCLME, because tourism is highly dependent on access and standards of infrastructure. Therefore, a benefit transfer exercise was not possible in this case.

Thus, an alternative way of generating monetary values depicting the importance coastal and marine ecosystems for the tourism industries of the CCLME countries was chosen. First, information available via the national experts, national tourism statistics and the World Tourism Organization (WTO) was collected, with a focus on the relative importance of tourism for the economy of a country (% share of GDP).

This share of GDP was then used as the basis for calculating the value of tourism and recreation in the CCLME countries (see chapter 6 for details regarding the calculation). The data inaccuracy that derives from the inclusion of tourism revenue that is not related to visits to ecosystems (conferences, scientific and educational tourism, for example), was purposefully ignored.

For Morocco, more detailed figures were available, based on data from the finance ministry and estimations regarding the share of guest-nights between the Atlantic and Mediterranean regions of the country (Kamili 2013). This customized approach for Morocco was chosen due to the great relevance of the Moroccan tourism revenues for the overall estimation of the value of tourism and recreation in the CCLME. However, the inaccuracies resulting from the unknown share of visits that are not related to visits to ecosystems (see above) could not be corrected in the case of Morocco either.

Other Non-Use Values

The CCLME is one of the world's most productive marine areas and a globally important region of marine biological diversity. The coastal ecosystems like mangroves and shallow lagoons, as well as the terrestrial ecosystems not covered by this report, like the tropical West African rainforest, are recognized as hotspots of biodiversity.

Biodiversity has specific use value components (e.g. fishery, timber and non-timber products etc.) to which it is easier to attribute concrete values (and which are already described in the above sections). Indeed, most studies on valuing biodiversity focus on the use-value, although a significant share of the value of biodiversity is related to non-use values. The loss of biodiversity is one of the most important global challenges. It is still not possible to estimate what consequences the accelerated loss of biodiversity will have for the survival of human mankind in the future.

Biodiversity of animal and plant species, as well as of ecosystems, is used in the present report as "substitute" for other non-use cultural values (aesthetic information, inspiration for culture, art and design, spiritual experience and information for cognitive development, representing the existence and bequest values). In the following, therefore, "biodiversity" should be understood as the sum of these cultural values; reflecting on the general uncertainty attached to evaluations of non-use values, this approach was chosen as a pragmatic solution to the otherwise insurmountable gaps in data and study availability.

Under the auspices of the Convention of Biodiversity (CBD), all CCLME countries have prepared National Biodiversity Strategies and Action Plans. These documents provide for estimates on species diversity (numbers of species) and their threats. For the CCLME region, for example, the following information was provided:

Table 5: Information regarding biodiversity in the CCLME region

CCLME country	Plants	Animals
Morocco	8.000	25.602
Mauritania	1.400	
Senegal	2.500	3.000
Gambia		3.900
Guinee-Bissau		
Guinee	1.200	6.926
Cape Verde	1.515	2.772

Source: QUEST.

Unfortunately, such data is rarely comparable between countries, due to difficulties in data provision. Furthermore, it is quite impossible to use such data directly because of a lack of instruments to *measure* biodiversity for the purpose of evaluating it (Mullan/Kontoleon 2008).

First attempts for quantifying the losses of terrestrial biodiversity have been made on the global scale. One example is the report on the "Cost of Policy Inaction" (COPI) (Braat/ten Brink 2008). The COPI Report estimated an approximate loss of 10 - 30% of biodiversity for the CCLME region for the period between 2000 and 2050, if no measures for biodiversity conservation will be taken. The African biodiversity losses will result in welfare losses of 17% of projected African GDP in 2050. Welfare losses do not only include the economic value in monetary terms but include anything related to human welfare. As the COPI Report includes the use-values of biodiversity, but at the same time excludes marine ecosystems, the COPI figures cannot be used as a measure for the non-use value of biodiversity in the whole CCLME region.

The figures for biodiversity losses, however, contain the direct and indirect use values already listed in the respective sections. Ergo, the COPI figure *includes* the non-use values of biodiversity, but all other values as well – to use some of the COPI results as a measure for the non-use values, the task would be to extract the non-use value, which cannot be done on the current data basis.

Due to the impossibility of extracting exact ratios out of this mixture of use and non-use values, in this report the figure from the COPI Report was double-checked with available valuation studies which list extractable numbers (meaning that the studies available have to provide a very clear distinction between "tourism and recreation" and the other cultural services, or at least between use and non-use values). Most of these studies usually evaluate the non-use values (of biodiversity) by using the Contingent Valuation Method (CVM). They are, unfortunately, not suitable for conducting a benefit transfer, as they first of all differ very much in methodology and initial situation, thus rendering them not transferable to the CCLME region. Second, the results of these studies directly depend on the socio-economic situation of the persons requested to express their willingness to pay (WTP) or willingness to accept (WTA), and thus vary widely, the results often encompassing several orders of magnitude.

As a consequence, it would be prudent not to try to monetize the biodiversity benefits in the CCLME region.

There are, however, several meta-analyses on economic valuation specifically of wetlands, namely Brouwer (1999), Woodward/Wui (2002), Schuyt/Brander (2004) and Brander (2006). These studies include values for the non-use value of biodiversity, and cover a broad range of studies and study sites. Therefore, the results are certainly not tailor-fitted to the CCLME. Nevertheless, they give a good overview on minimum and maximum values for terrestrial biodiversity, and were used in this evaluation exercise to provide a comparative figure, given the nature of the report as an initial screening.

Summing up the approach for the evaluation the non-use values (excluding tourism and recreation), i.e. the cultural values aesthetic information, inspiration for culture, art and design, spiritual experience and information for cognitive development, represented through "biodiversity" in this report, a two-step approach was used, consisting first of the results listed in the COPI Report, providing numbers that describe the overall importance of biodiversity conservation. Second, the figure was double-checked with the results of the most important and comprehensive meta-analyses.

Valuing marine cultural services suffers the added complication that the marine environment is extremely diverse. In addition, the marine environment is difficult to sample and monitor. This complexity results in significant limitations in current scientific knowledge of the effects of marine biodiversity on ecosystem functioning. As a result, valuation studies have tended to focus on the terrestrial environment, as the above mentioned COPI Report. The figures generated below will also be applied to the marine environment, but the uncertainties are significant in this case.

6 Valuation of the ES in the CCLME

In this section, the ES of the selected ecosystems will be evaluated, starting with marine ecosystems. Then, the coastal ecosystems will be evaluated, followed by the non-use values of both marine and costal ecosystems. The concrete approaches to the evaluation, reflecting the data situation and availability of evaluation studies, are described above in chapter 5.

6.1 Marine Ecosystems

Use Value: Fisheries

The Canary Current LME is rich in fisheries resources, of which approximately 60% are constituted of small pelagic fish such as sardine (Sardina pilchardus), sardinella (Sardinella aurita, S. maderensis), anchovy (Engraulis encrasicolus), chub mackerel (Scomber japonicus) and horse mackerel (Trachurus spp.). Other species caught in the LME include tuna (e.g., Katsuwonus pelamis), coastal migratory pelagic finfish, hakes (Merluccius merluccius, M. senegalensis and M. poli), a wide range of demersal finfish including Pagellus bellotti, Pseudotolithus sp., Dentex canariensis, Galeoides decadactylus and Brachydeuterus auritus, cephalpods (Octopus vulgaris, Sepia spp., and Loligo vulgaris) and shrimps (Parapenaeus longirostris and Penaeus notialis). Many of these fish species are transboundary of migratory, their distribution extending the bordering countries' EEZs into international waters. In addition to small national fleets, the EEZs of Mauritania, Senegal, Gambia and Guinea-Bissau all accommodate large fishing fleets from the EU and Asia (UNEP 2005).

These stocks constitute vital natural resources that provide food and income for local populations, revenues for the national governments, foreign exchange earnings as well as employment opportunities. The yearly catches, however, show - after increasing steadily to around 2,4 million tons in 1976 - large fluctuations, ranging between 1,5 and 3 million tons (see figure 6). The fluctuating catches are, naturally, also reflected in the market value, which varies between U$1.5 billion and just under U$3 billion (in 2000 US dollars) (Sherman/Hempel 2008).

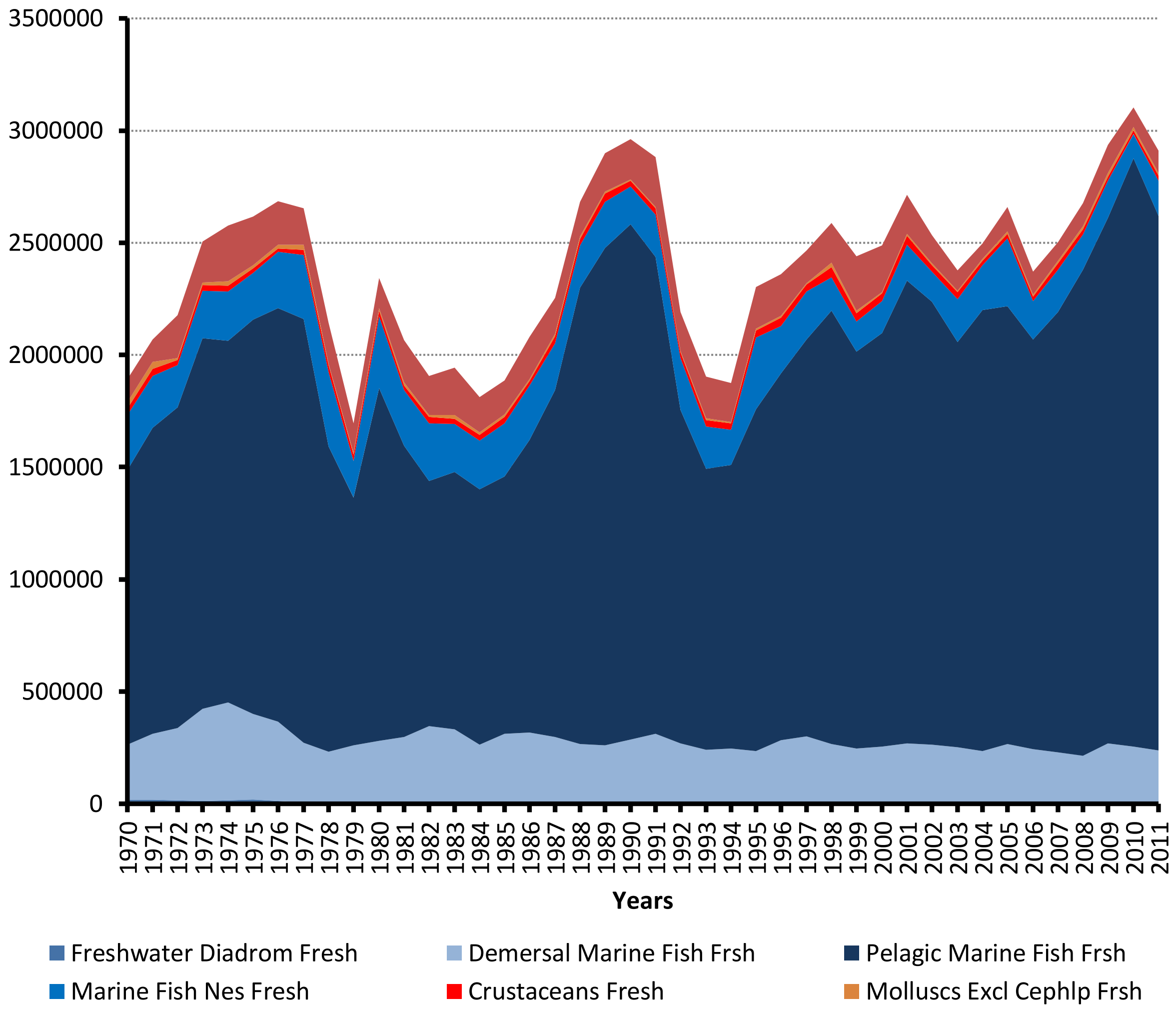

Figure 6: Fish landings in the CCLME from 1970 to 2008 (in tons) (Source: FAOSTAT 2013).

Fisheries furthermore support at least 1 million jobs[18], including more than 150.000 artisanal fishermen (FAO/GEF 2007; Sambe/Lymer 2011).

The data provided by the national experts is consistent with these amounts. The following table 6 depicts these for the year 2009 (the last year for which the data is complete), subdivided for artisanal and industrial fisheries.

Country	Artisanal Fisheries	Industrial Fisheries	TOTAL
Cape Verde	4.559	4.336	8.895
Morocco	1.067.277	142.935	1.210.212
Mauritania	110.131	834.113	944.244
Senegal	479.749	40.768	520.517
Gambia	46.388	3.357	49.745
Guinea	96.846	59.060	155.906
Guinea-Bissau	20.118	72.145	92.263
TOTAL	1.825.068	1.156.714	2.981.782
TOTAL including IUU	-	-	3.727.227,5
TOTAL MSY (-20%)	1.460.054	925.371	2.526.782

[18] Other sources, such as the UNEP (2005) report of 300.000 direct and indirect jobs supported by fisheries, although this number is inconsistent with other figures in the same report, which state that in the Senegal alone, 600.000 are supported by fisheries.

Table 6: Fish landing in the CCLME in 2009 (tons of fish landings) (Source: QUEST).

As explained above, the annual value of fish landings is calculated on the basis of the respective countries´ GDP, and the share of fisheries in this number. It is recognized that these numbers neither reflect the IUU activities in the region (which are estimated on the basis of percental shares of reported landings, and then added), nor the value generated by the CCLME fish products in other countries of the world (such as the EU and Asia). The following table 7 depicts the values of fish landings per country.

Country	**GDP (nominal; million USD)**	**Share of fisheries in GDP (%; average 2007-2011)**	**Annual value of fish landings (million U$)**
Cape Verde	1.899	1,25	23,7
Morocco	97.530	2,5	2.438,3
Mauritania	4.199	6	252
Senegal	13.864	1,9	263,4
Gambia	918	2,2	20,2
Guinea	5.632	3,6	202,8
Guinea-Bissau	870	3,7	32,2
TOTAL	-	-	3.232,6
Estimated value of IUU catches*	-	-	808,2
TOTAL including IUU			4040,8
TOTAL MSY	-	-	3232,6

Table 7: Annual value of fish landings in the CCLME countries (Source: own depiction).

*IUU value based on a conservative estimation of 25% of total reported catches (MRAG 2005).

The resulting figure (non-MSY and without IUU activities) - 3,2 billion U$/a - is very close to the figures provided by regional sources, which vary between 1,5 and 3 billion U$/a. Including IUU fishing, the figure rises to 4 billion U$/a.

As detailed above (chapter 5), this figure needs to be reduced by a 20%-amount reflecting the assumed sustainable levels of fishing, as well as by the value of coastal ecosystems as fish nursery, to avoid double counting. Thus, the figure for sustainable fisheries output is:

Annual value of fish landings = 4040,8 million U$ x 0,8 (MSY factor) = 3232,6 million U$ in sustainable fish landings.

The final figure, i.e. subtracting the value of nursery functions of mangroves and seagrass beds/meadows (a conservative estimation of 10%), is:

MSY fisheries output: 3.232.600.000 U$/a - (323,3 U$/a[19]) = 2.909.300.000 U$/a.

Broken down per hectare - 112.388.700 ha - results in a value of 25,9 U$/a. Interestingly, this figure is quite close to the value of fisheries in the European waters (10,05 €/ha, or 13,4 U$/ha), calculated by ten Brink et al. (2011).

It has to be remarked, however, that in addition to the market value of marine products, fisheries are the base for a significant amount of (local) employment, possibly exceeding the market value in local significance.

<u>Non-use value: Tourism and Recreation, Biodiversity and other Non-use Values</u>

[19] See below regarding the calculation of this number.

Not included in the evaluation (see chapter 5).

6.2 Coastal ecosystems

6.2.1 Mangrove forests and swamps

Overall TEV of mangroves

Mangroves have been in the focus of many evaluation studies in the last decades (for a comprehensive overview of studies, see Vo et al. 2012). Of these, some studies evaluated the global value of mangroves, for example Alongi (2002), estimating it to reach 181 billion U$, or 10.000 U$/ha. Russi et al. (2013) present figures ranging from 1.995 int. $/ha/a to 215.349 int. $/ha/a. Most other studies´ results range from 475 U$/ha to 1.675 U$/ha, but several easily exceed these values (Vo et al. 2012; Ronnback 1999; Corps 2007).

Direct Use Value: Timber and non-timber forestry products

According to the methodology outlined above, a twofold approach was chosen to depict the economic gains generated by using the forestry products of mangroves. First, a benefit transfer was conducted, using studies from south Asian mangrove regions as study sites. Second, the value for NTFP in eight GCLME countries generated by BDCP (2007), using shadow prices, was adapted to the 7 CCLME countries, and broken down to a per ha figure, to allow for better comparison.

The studies identified as study sites for the benefit transfer are the following:

- Nam Do/Bennett (2005): *"An economic valuation of wetlands in Vietnam's Mekong Delta: a case study of direct use values in Camau Province"*, estimating the value of timber products at 20 US $/ha/a (adapted 2012 value), using market prices.

- Emerton/Kekulandala (2003): *"Assessment of the economic value of Muthurajawela wetland"*, Sri Lanka. The authors estimate the value of non-timber products at 187,1 US $/ha (adapted 2012 value), using market prices.

As both studies assess ecosystems that are very much comparable to the ones evaluated in this report – mangroves in the first study, and a coastal wetland with a large share of mangroves in the second – there is no need to adapt the study results, except for adjusting the values to the general economic price level in West Africa (see Interwies 2011), reflected by the GDP (PPP) per capita (see table 8 below).

State/Region	**GDP (PPP) per capita (2009[20])**	**Ratio West Africa to Country**
West Africa	1.710	1
Vietnam	2.850	0,6
Sri Lanka	4.720	0,36

Table 8: GPD (PPP) ratios between study and policy sites (Sources: OECD Stats; IMF).

Adapted to national price levels, the results of the benefit transfer are as follows:

- Timber forestry products: 12 US $ (2012)/ha/a.

[20] Values from 2009 are used as no later estimates for an aggregated West African GDP/capita were available.

- Non-timber forestry products: 67,5 US $ (2012)/ha/a.

In comparison, Ukwe (BDCP 2007) calculated the annual value of one of the major non-timber forestry products, the *periwinkle* snail, in eight countries of the GCLME (Benin, Cameroon, Cote d´Ivoire, Equatorial Guinea, Gabun, Ghana, Nigeria, Sao Tome) to be at 1,941 billion U$. As those countries represent a mangrove area of 1.151.040 ha, the value per hectare of periwinkle amounts to 1.686 U$/a (2007 value). Another study - by Barbier (2007), assessing mangroves in Thailand - estimated the (net present) values arising from collected forestry and other products, and shellfish, to reach 720 to 869 U$/ha (2013 value).

The huge span in the results reflects the difficulties in assessing the correct price for products that are not traded on a real market, but exchanged or consumed locally. In order to use more conservative values, in the present report the results gained through the benefit transfer are utilized, the great spans and accompanying uncertainties are, however, mentioned whenever necessary.

<u>Indirect Use Values: Moderation of extreme events (storm protection) and Erosion prevention</u>

The value of mangroves for the moderation of extreme events (storm protection) was estimated utilizing on the one hand the Replacement Cost method with two coastal protection projects in the CCLME as basis, and on the other hand deriving values through a benefit transfer (see chapter 5).

The two projects for which data from the CCLME region was available are:

- The construction of a protective dyke against coastal erosion of 730 meters length in Rufisque (Dakar), a walk and an outlet of waters for a value of 4.000.000.000 CFA (approximately 8 million U$) (QUEST).

- Dyke construction in Saly, Senegal, of 4km length, at an approximate cost of 21,7 million U$ (QUEST; Sambe 2013).

Because in the present study, the respective width of mangroves necessary to offer the same degree of coastal protection is assumed to be 100 m, according to relevant literature (Barbier 2007, 2008), first the cost of the dykes for a 100 m stretch is calculated:

- Dakar: approx. 1 million U$/100 m.

- Saly: approx. 550.000 U$/100 m.

A 100 m long stretch of coastal protection therefore costs between 550.000 and 1 million U$, not considering maintenance and other related costs (transaction costs). Expecting a life expectancy of 50 years, the costs broken down per year and 100 m stretch range from 11.000 to 20.000 U$ (no discount rate applied). This figure can directly be transferred to one hectare of mangroves (representing a "block" of mangroves both 100 m in length and width, i.e. one hectare).

For comparison, a benefit transfer has been performed, using the following studies as study sites:

- Barbier (2007): "*Valuing ecosystem services as productive inputs*", evaluating the storm protection service of mangroves in Thailand at 13.343‐16.104 U$/ha/a (2013 value).

- Emerton/Kekulandala (2003): “*Assessment of the economic value of Muthurajawela wetland*”, Sri Lanka. The authors estimate the value of “coastal protection” at 2.420 U$/ha/a (2013 value), also using the Replacement Cost method.

- Emerton (2005): "*Values and Rewards – Counting and Capturing Ecosystem Water Services for sustainable Development*", including a case study on the Ream National Park, Cambodia. The author estimates the value of "storm protection" at 38 U$/ha/a, and of "coastline protection" at 146 U$/ha/a (both 2013 values), in both cases utilizing a benefit transfer (aggregated value 184 U$/ha/a).

- Sathirathai (1998): "*Economic Valuation of Mangroves and the Roles of local Communities in the Conservation of natural Resources: Case Study of Surat Thani, south of Thailand*". The author assesses the value of mangroves for "coastline protection" using the Replacement Cost method be at 109 U$/ha/a (2013 value).

- Batagoda (2003), cited in Kathiresan (2007), evaluating mangroves in Sri Lanka, and estimating their value for "storm protection" at 10.150 U$/ha/a (2013 value).

- Tallis et al. (2008): assuming the value of mangroves in Vietnam for "coastal protection" in terms of real annual savings to be at 659 U$/ha/a (2013 value).

As all studies assess ecosystems that are very much comparable to the ones evaluated in this report – mangroves and coastal wetlands with large shares of mangrove – there is no need to adapt the study results, except for adjusting the values to the general economic price level in West Africa (see Interwies 2011), reflected by the GDP (PPP) per capita (see table 9 below).

State/Region	GDP (PPP) per capita (2009) (International Dollars)	Ratio West Africa to respective country
West Africa	1.710	1
Vietnam	2.850	0,6
Sri Lanka	4.720	0,36
Cambodia	2.015	0,85
Lao	2.210	0,77
Thailand	8.060	0,2

Table 9: GPD (PPP) ratios between study and policy sites (Sources: OECD Stats; IMF).

Adjusted to national price levels, the results of the benefit transfer are as follows:

- Emerton/Kekulandala (2003): 871,2 U$/ha/a.

- Emerton (2005): aggregated value 156,4 U$/ha/a.

- Sathirathai (1998): 21,8 U$/ha/a.

- Batagoda (2003): 3.654 U$/ha/a.

- Tallis et al. (2008): 395,4 U$/ha/a.

- Barbier (2007): 2.668,6 - 3.220,8 U$/ha/a.

Quite obviously, the range of resulting values is significant (several orders of magnitude), leading to significant uncertainties.

The average value across these six studies is 1340,6 U$/ha/a, which will be used as an indication of the order of magnitude of the value of storm protection and erosion prevention provided by mangroves in the CCLME region.

<u>Indirect Use Value: Waste treatment</u>

As no information regarding costs of waste/sewage treatment could be obtained from the CCLME countries, the ES "waste treatment" was calculated using a benefit transfer. The international studies chosen for this exercise are:

- Emerton, L., Iyango, L., Luwum, P., and Malinga, A., (1999): "*The Economic Value of Nakivubo Urban Wetland, Uganda*". The authors estimate the value of the swamp for “sewage treatment” to be at 253 U$/ha/a (2013 value), utilizing the Replacement Cost method.

- Gerrard, P. (2004): “*Integrating Wetland Ecosystem Values into Urban Planning: The Case of That Luang Marsh, Vientiane, Lao PDR*”. The author estimates the value of the swamp for “water purification” to be at 44 U$/ha/a (2013 value), as well utilizing the Replacement Cost method.

Regarding the first value, it has to be kept in mind that the Nakivubo Swamp is situated very close to the Ugandan capital Kampala, with a very high population density of around 4.600 people/km² in the greater metropolitan area (Nyakaana et al. 2007). It is suggested, therefore, to adjust the value to a lower level reflecting the estimated mean population density of populated coastal strips in the CCLME of around 500 people/km²[21], resulting in a value of 27,6 U$/a per hectare. The second study likewise describes a wetland that borders an urbanized area, but there is no data available on population density in that region. Therefore, the only adaptation that can be done is the adjustment of the values to the general economic price level in West Africa (see Interwies 2011), reflected by the GDP (PPP) per capita (see table 9 above), resulting in an adjusted value of 33,9 U$/ha/a. Calculating the mean value of the two almost congruent results, the value for the ES “waste treatment” in the CCLME is assumed to be at 30,8 U$/ha/a.

<u>Indirect Use Value: Climate regulation</u>

Several studies exist that evaluate the value of ecosystems in regulating the global climate (i.e. the climate sequestration service, reducing carbon emissions and anthropogenic climate change). As described above, these studies are mostly based on the price of carbon (certificates) on various national or international markets. As these prices are heavily dependent on market forces, such studies are always a “snap-shot” of the value. In chapter 5 was explained that rather than using certificate prices, in this study the official UK guidance on carbon values - factored into UK public sector appraisals - from DECC (2009) was used, setting out in some detail the official rates for valuation of carbon (80 U$/t$CO_2$e presently, with an increase to 307 U$/t$CO_2$e by 2050).

Siikamäki et al. (2012) estimate the average carbon stored in one hectare of mangroves at 466,5 t (or 1.710,5 t CO_2e). The annual carbon accumulation, estimated by Bouillon et al. (cited in Siikamäki et al. 2012), equals 1,15 t/ha (or 4,2 t CO_2e/ha).

Hence, the value of total carbon stored in one hectare of mangroves (or: the value of the CO_2e not emitted into the atmosphere) is about 136.604 U$; the value of the amount of carbon sequestered by mangroves annually equals 335,5 U$/ha.

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[21] No concrete data available. The figure above represents an estimation based on the GCLME report, and information from UNEP (2005).

Indirect Use Value: Maintenance of life cycles of migratory species and of genetic diversity (nursery)

As detailed in chapter 5, a two-fold approach was chosen to assess the value of mangroves as nursing ground for fish stocks. First, a calculation according to the World Bank assumption that each hectare of mangrove supports around 0,7 tons of fish was undertaken, i.e. a concrete number was assigned to each ha of mangroves, by using per ton values derived from data on fisheries provided by the national experts. Secondly, the conservative 10% figure of Emerton/Kekulandala (2003) was used, to obtain a comparison and some insight on the scope of the contribution of coastal ecosystems to total fishery output.

According to the evaluation of fishery output, one ton of fishery products is worth approximately 1.279 U$, on average (2.526.782 tons caught in 2009 at a value of 3.232,3 million U$; figures adapted to accommodate MSY). Hence, according to the World Bank estimation, one hectare of mangroves would generate an economic output in the fishing sector of 895,5 U$.

Using the conservative, careful estimation of Emerton/Kekulandala (2003), around 10% of the fisheries output should be attributed to mangrove ecosystems (323,3 million U$/a). With a total area of mangroves in the CCLME reaching 659.100 ha (plus 100.525 hectares of seagrass beds, which are figured into this amount), the annual per hectare value for the fish nursery service provided by mangroves would be 425,6 U$. As detailed above, the lower of the two resulting figures will be used (in line with the general approach of the report to prefer conservative figures over higher ones); the result is then subtracted from the total fishery output, to avoid double counting.

Comparing these figures to other evaluations - e.g. the one by Barbier (2007; cited in Barbier 2011), stating 1.053 - 1.469 U$/ha/a ("breeding and nursery habitat in support of offshore fisheries"), or De Young et al. (2008), varying between 35,7 and 119,3 U$/ha/a - it is obvious that a) the ranges are considerable here as well, and that b) the calculated values of 425,6 and 895,5 U$/ha/a, respectively, are situated more or less in the medium range of existing estimations.

6.2.2 Seagrass beds and meadows

As described above, the availability of data does not allow for an evaluation of most ES of seagrass beds and meadows. With regard to the nursery function of these ecosystems, an estimation seems possible, under the assumption, however, that the nursery function of seagrass beds and meadows equals the one provided by mangroves. Hence, the same methodology is applied here (see above).

Additionally, it was possible to estimate the overall amount (and value) of carbon stored in seagrass beds/meadows in the CCLME.

Indirect Use Value: Maintenance of life cycles of migratory species and of genetic diversity (nursery)

As stated above, the same approach as used for mangroves is used for seagrass beds/meadows. Using the conservative estimation of Emerton/Kekulandala (2003), around 10% of the fisheries output should be attributed to mangrove and seagrass beds/meadows ecosystems, under the assumption that the provision of the service is similar between the two ecosystems, i.e. 425,6 U$/ha/a.

As detailed above, this result is subtracted from the total fishery output, to avoid double counting (see chapter 6.1).

Climate Regulation

Several studies exist that evaluate the value of ecosystems in regulating the global climate (i.e. the climate sequestration service, reducing carbon emissions and anthropogenic climate change). As described above, these studies are mostly based on the price of carbon (certificates) on various national or international markets. As these prices are heavily dependent on market forces, such studies are always a “snap-shot” of the value. In chapter 5 was explained that rather than using certificate prices, in this study the official UK guidance on carbon values - factored into UK public sector appraisals - from DECC (2009) was used, setting out in some detail the official rates for valuation of carbon (80 U$/t$CO_2$e presently, with an increase to 307 U$/t$CO_2$e by 2050).

Pendleton et al. (2012) estimate the average potential CO2 emissions "stored" in one hectare of seagrass beds/meadows at 3.26 t . Hence, the value of total carbon stored in one hectare of seagrass beds/meadows (or: the value of the CO_2e not emitted into the atmosphere) is about 260,8 U$. As explained above, this figure is not calculated into the TEV of coastal and marine ecosystems in the CCLME.

6.3 Non-Use Values of Marine and Coastal Ecosystems

Non-use value: Possibilities for tourism and recreation

The tourism and recreation industries are a significant factor in the economies of the CCLME countries, both in terms of national income, as well as employment. For example, in some countries, like Cape Verde and the Gambia, tourism is one of the main sources of foreign exchange, and contributes strongly to the economic performance (Sambe/Lymer 2011). According to the World Travel and Tourism Council (2010), around 900.000 people are employed by the tourism sector in the CCLME countries, with almost 300.000 people employed in Morocco only (more than 50% of the total employment of the coastal region) (UNEP 2005). In the Senegal, pollution close to major tourism and recreation hot spots, such as Dakar, cause losses of up to 40% in the tourism industry in this country, underlining the great importance of the coastal areas for the tourism industries in the CCLME region (UNEP 2005).

As stated above (see chapter 5), the value of the ES "possibilities for tourism and recreation" is calculated on the basis of the relative share that tourism/recreation have in the GDP of the respective country, and displayed per coastal kilometer, with the exception of Morocco, where a customized approach was chosen due to the great relevance of the Moroccan tourism industry.

Table 10 below depicts the GDP of the CCLME countries, the share of tourism and recreation, and presents the monetary value calculated.

Statistics	Cape Verde	Gambia	Guinea	Guinea-Bissau	Mauritania	Morocco	Senegal	Total
GDP (nominal; million USD)	1.899	918	5.632	870	4.199	97.530	13.864	-
Tourism contribution to GDP	15,3%	8,2%	2,0%	x	5,0%	8,7%	5%	-
Monetary value (million USD)	290,5	75,3	112,6	x	210	3,302*	693,2	4.684
Length of coast (km)	239	80	320	125	754	2.410	531	4.220
Monetary value (million USD) of tourism per coastal km	1,2	0,94	0,4	x	0,3	1,4	1,3	1,1

Table10: Importance and value of tourism in the CCLME countries (Sources: Sambe/Lymer 2011, adapted through QUEST; IMF; Princeton University; Kamili 2013).

*based on overall tourism revenues in Morocco and the distribution of guest nights between Atlantic and Mediterranean regions.

According to Sambe (2013), the major share of the tourism and recreation activities are taking place in the coastal region; the activity in the hinterland seems negligible. Thus, it is assumed that 100% of the income displayed in table 10 above is generated in the coastal area (this is not valid for Morocco)[22].

Table 10 demonstrates that one kilometer of coastline - not differentiating between ecosystems or anthropogenic usage - generates around 1,1 million U$ in tourism/recreation income per year on average.

A note has to be taken, however, with regard to this figure:

First, it is obvious that a focus on the coastal areas/ecosystems ignores the fact that the marine areas, i.e. the sea, play an important role for visitors choosing a beach or other coastal area as a destination for tourism or recreational activities. Hence, the figure should actually not be depicted per kilometer of coastline, but for the whole coastal and marine ecosystems. At the same time, depicting the value per hectare of marine and coastal area would, of course, make little sense, as on the one hand large parts of the marine environment are not visited by tourists, and on the other hand such an approach would result in extremely low per hectare values.

As a solution, in the present report the value of the ES "possibilities for tourism and recreation" is depicted as absolute number, as an overall value provided by all coastal and marine ecosystems in the CCLME region.

Thus, the final figures for the value of the ES "possibilities for tourism and recreation" in the CCLME region is almost 5 billion U$/a (4,684 billion, to be accurate.

<u>Other non-use values: biodiversity</u>

As explained in chapter 5 above, the evaluation of the other non-use values, represented by "biodiversity" in this report, is not a simple task. Here, the projected results of the COPI Report were used as a first approximation to underline the overall importance of biodiversity conservation. Furthermore, the assumed share of cultural services excluding tourism/recreation of the TEV (1%) - extracted from the COPI Report - was used, to provide figures for the CCLME, and double-checked with the most recent and most comprehensive meta-analyses.

The COPI Report lists the welfare losses incurring in different world regions by 2050, assuming a further degradation of (terrestrial) biodiversity. For understanding the COPI assessment, it is important "*to appreciate that the COPI costs are actually a mixture of cost types – some are actual costs, some are income foregone (e.g. lost food production), some are stated welfare costs (e.g. building on willingness to pay (WTP) estimation approaches). Some directly translate into money terms that would filter directly into GDP (gross domestic product); some would have an effect indirectly, and others would not be picked up by GDP statistics (which themselves are only economic statistics and not fully representative of welfare or wellbeing). The combined COPI costs should be seen as welfare costs, and for the sake of ease of comparison are given as % of GDP*" (Braat/ten Brink 2008).

[22] It is recognized by the authors of the study that this is - naturally - not accurate. In case more accurate data regarding the share between coastal and inland tourism in the CCLME countries is available, it should be fairly straightforward to adapt the figures stated in table 10.

For Africa, this translates into a 17% loss of projected 2050 GDP, or, in numbers, a loss of 3.150 billion Euro. Assuming an equal coverage or density of biodiversity on the whole African continent, the losses in the CCLME states would be equivalent to the CCLME share in African GDP of approximately 8,5% in 2009 (IMF), or 267,75 billion Euro (356,2 billion U$). Depicted on a yearly basis, the losses amount to 7,124 billion U$/a. As explained above, this figure is provided to underline the overall importance of biodiversity conservation, and actually applies only to terrestrial ecosystems (as the COPI Report covers only terrestrial ecosystems).

To double-check this figure with international findings, several meta-analyses of valuation studies that include a value for biodiversity were analyzed, namely Brouwer (1999), Woodward/Wui (2002), Schuyt/Brander (2004) and Brander (2006). The latter - the most recent and most comprehensive one - includes the following figures:

- In the 191 studies examined in the meta-analysis, five wetland types were considered (21% covering mangroves).
- The ecosystem service “biodiversity” was examined 19 times, with an average value of 26.500 U$/ha/a (2013 value), surpassing all other values considered. The median of 23 U$/ha/a (2013 value), however, indicates how huge the statistical spread of the data is.

Obviously, extracting reliable numbers out of such a high number of studies differing enormously from each other is extremely vague at best. Nevertheless, the median value of the above mentioned study by Brander (2006) was used, giving some hint at the monetary value of the non-use values of biodiversity in international studies.

As said before, the COPI Report and most other valuation studies - as well as the above mentioned meta-analyses - cover only the value of terrestrial biodiversity, mainly because of the difficulties of evaluating marine ecosystems, especially regarding biodiversity (see above, or Beaumont et al. 2008; Delaney/Wilson 2009). Some studies specifically treating marine ecosystems, however, exist. A brief review of marine valuation studies is provided by Ledoux and Turner (2002), but the authors list only two studies evaluating marine biodiversity, assessing the willingness-to-pay (WTP) for the conversation of seals in Greece and the net present value of a Marine Park in the Caribbean, respectively. Patterson/Cole (1999) attempted to attribute a value to New Zealand’s biodiversity, but omitted a value for the open ocean from their final valuation, as marine biodiversity was considered too difficult to value in monetary terms. Pimentel et al. (1997) undertook a study of the economic benefits of biodiversity in the United States, and included no marine-related values except for fisheries. Beaumont et al. (2008) directly aimed at valuing marine biodiversity, defined as richness and composition at species level. The study specifies an existence value of 0,5 – 1 bn. British pounds for the British seas, derived from a CV study identifying the WTP for the conservation of marine mammals around the British coast. All these results (or non-results), however, are extremely difficult to transfer to the CCLME, due to huge differences in terms of socio-economic (income distribution, knowledge base etc.) and geographical (size and type of concerned area, richness in biodiversity etc.) factors. Therefore, it was not possible to provide other comparative figures for the non-use values of marine biodiversity and to double-check the above number.

Hence, the figure above (i.e. the median value of Brander (2006), 23 U$/ha/a) could be applied to marine ecosystems as well, assuming an equal value of terrestrial and marine biodiversity (or an equal "density"). The resulting figure - approx. 2,6 billion U$ - reflects the size of the marine ecosystems, and should be applied with great care, as several significant uncertainties surround it (for example, the assumption that marine and terrestrial biodiversity can be equally treated, beside the general uncertainties of applying a figure generated by meta-analyses).

6.3 Economic Valuation: Summary of Results

The following table 11 provides an overview of the calculated use values and non-use values of ecosystems in the CCLME.

Ecosystems	Ecosystem Service	Total Value (U$/a)	Area of ecosystem in CCLME	Value per hectare (U$/a)
Marine Ecosystems	Fisheries (IUU activities and MSY considered)	2.909.300.000	1.123.887 km²	25,9
	Biodiversity/cultural ES	2.584.940.100	1.123.887 km²	23
TOTAL Marine Ecosystems	Fisheries and Biodiversity/cultural ES	5.494.240.100	1.123.887 km²	48,9
Mangroves	Timber forestry products	7.909.200	659.100 ha	12
	Non-timber forestry products	44.489.250	659.100 ha	67,5
	Extreme events and erosion control	883.589.460	659.100 ha	1.340,6
	Waste treatment	20.300.280	659.100 ha	30,8
	Climate regulation**	221.128.050	659.100 ha	335,5
	Fish nursery	280.516.084	659.100 ha	425,6
	Biodiversity/cultural ES	15.159.300	659.100 ha	23
Mangroves	*Overall TEV**	*313.072.500 to 1.103.992.500*	*659.100 ha*	*475 to 1.675*
Seagrass-beds and meadows	Fish nursery	42.783.916	100.525	425,6
	Biodiversity/cultural ES	2.312.075	100.525 ha	23
Beaches/dunes	Biodiversity/cultural ES	no information	no information	23
All marine and costal ecosystems	Opportunities for tourism and Recreation	4.684.000.000	n. a.	Per kilometer of coastline: 1,1 million
TOTAL Marine and Coastal Ecosystems	**ALL**	**11.696.427.720**	**n. a.**	**n. a.**

Table 11. Summary of results.

*according to several mangrove evaluation studies (this number is included in the table only for comparison; it is not calculated into the TOTAL VALUE).

**The underlying figure is valid for the present; according to DECC (2009), the value attached to carbon/the damage associated with CO_2 emissions, will increase sharply in the future.

Table 11 demonstrates that the total annual value of the Ecosystem Services provided by the CCLME marine and coastal ecosystems is around 11,7 billion U$. One hectare of mangroves alone provides ES valued 2.235 U$/a, the most part of it credited to coastal protection (versus storms and erosion), the provision of fish nurseries, and climate regulation; put differently, the destruction of one hectare of mangroves costs over 2.000 U$ per year (which does not include the damages resulting from the emission of "blue carbon").

These estimations are more on the conservative side, as lower values and assumptions that led to smaller results were always applied, if a choice was to be made (see chapter 5 above).

6.4 Reflection on current versus potential Values of ES in the CCLME

This section aims at discussing for the potential value of ES in the CCLME region. One possible approach would be to generate a figure depicting the overall value of ES without human intervention - although such an endeavor seems difficult, as "setting the clock to zero" (i.e. describing a situation without human intervention) would on the one hand not offer helpful advice, and on the other be misleading (as the concept of ES is intrinsically anthropocentric, i.e. without humans to "benefit" from the ES provided by ecosystems, the value would be zero).

Another approach would be to develop different scenarios for the future as regards to the overall economic development, and of specific sectors, the influence of climate change, future exploitation of marine resources etc., and compare the resulting potential values in the future with the currently existing ones.

The importance of such scenarios in ES evaluation is emphasized in the TEEB Report (De Groot at al. 2009), where scenarios are applied as an important analytical component. Other sources - such as UNEP-WCMC (2011) also emphasize the usefulness of scenarios, especially regarding the assessment of (future) cumulative impacts and drivers of change (UNEP-WCMC 2011; De Groot et al. 2009).

At the same time, developing such scenarios is an ambitious endeavor that would have to be linked to both globally and regionally available (sub-)scenarios, and ideally also to local stakeholder expertise and experience.

Alternatively, it might also be useful to conduct specific assessments of how specific ES values would change if a specific policy decision is taken, and comparing these to the direct economic benefits/costs of the decision (e.g. increased oil/mineral extraction, better protection of the fishery stocks etc.). This would not produce overall ES values, but might be more useful for supporting practical decision-making (see also below).

6.5 ES Valuations and Decision Making

Since the first evaluation studies were published - especially after the first globally significant studies done by Costanza and Daily, beginning in the 1990ies - the number of reports and evaluations is increasing from year to year. Several of these were globally recognized and had a serious impact on decision making. Especially the release of the Millennium Ecosystem Assessment (MA 2005a) helped foster the use of the concept of ES by policy makers and the business community. The MA was followed by the EU´s TEEB Report, gained global attention, and is momentarily followed-up by several national TEEB studies, for example in Germany, the Netherlands, Sweden and several East European countries.

Nevertheless, progress in the practical application of the results of such studies in natural resource use planning and decision making has been slow. This lack of progress stems on the one hand from the systematic failure of markets and the underlying systems of accounting for "success and progress" - e.g. the general focus on GDP - to capture values of ES (De Groot et al. 2009). In addition, the practical integration of such valuation studies is a complex process, which - combined with a general lack of understanding and knowledge regarding the importance of ES - hinders the further establishment of evaluation studies in decision making. De Groot et al. (2009) list several of the most important open questions:

- How different ES are interlinked with each other and to the various components of ecosystem functioning and the role of biodiversity.
- How different human actions that impact upon ecosystems change the provision of ES.
- The potential trade-offs among services.
- The influence of differences in temporal and spatial scales on demand and supply of services.
- What kind of governance and institutions are best able to ensure biodiversity conservation and the sustainable flow of ecosystem services in the long term.

Other factors hindering the uptake and direct utilization of evaluation studies are various methodological issues inherent in the evaluation of (mostly) non-market benefits. Some of these - in addition to the ones that are linked to the questions listed by De Groot et al. (2009) - directly jeopardize the credibility of evaluation exercises. Notably among these are the multitude of studies employing the Contingent Valuation Method (CVM), which assess the stated preference of people, and assume the stated preference to be similar to the revealed preference (i.e. such studies assume that questioned people would in reality pay the same amount of money for the assessed ES that they stated in the study, confronted by interviewer and/or questionnaire). To policy makers who do not share this belief, such studies are not credible. Similar problems lie in the calculation of the number of benefitting people, the proper discount rate, etc.

Summarizing, many practical issues of integration, but also open questions and methodological difficulties have so far hindered the widespread uptake of studies evaluating the benefits provided by ecosystems by policy an decision makers.

Considering these general difficulties that are also inherent in globally recognized reports, the question arises whether less global, less prominently developed evaluation studies, for example with a local or regional focus, have a chance of "making a difference" in decision making and influencing policy makers.

It may be useful to reflect on the general state of decision making with regard to resource management in general, by a citation of Berkes et al. (2007): "*Resource management is at a crossroads. Problems are complex, values are in dispute, facts are uncertain, and predictions are possible only in a limited sense. The scientific system that underlies resource management is facing a crisis in legitimacy and power. Top-down resource management does not work for a multitude of reasons, and the era of expert-knows-best decision making is all but over*". This, at the same time, leads to the conclusion that participatory approaches are - although expensive and time-consuming - a very important decision making tool of modern and future-oriented policy making, necessary for broad support of policies by stakeholders (Briand 2008).

Participation by stakeholders in resource management is, however, not always easy to mobilize - a common interest in the topics at hand needs to be raised and channeled into enduring participation. This can be achieved by assessments - and later discussion - of the value of ES for the local population - as many decision making processes take place on the local level. This is true both for developing and developed societies - in developing societies, the provision of food and materials necessary for survival or income will naturally be in the focus of such assessments, whereas in developed societies, the services important for the general well-being might be of more importance. In using assessments of ES as a tool to mobilize the population to participate in policy making, the focus of the assessments should be more on the qualitative than on the quantitative side - i.e. the participating people be encouraged to express their perspective on the importance of the respective ES, instead of aiming at a "full monetization". This, also, would circumvent several of the above mentioned general and methodological problems surrounding any attempt to quantify all ES.

Thus, considering the significant hindrances faced even by globally recognized evaluation studies in terms of uptake in policy and decision making, it can be stated that smaller, local studies aiming at the integration of local people into a decision making process are maybe more important and relevant than the bigger global ones.

Fact is, however, that evaluation studies, although facing severe methodological problems and limited data availability, definitively have an important role to play in present decision making that can further be improved.

7 Summary and Outlook

In this report, the authors evaluated and described the value of the CCLMEs marine and coastal ecosystems for human wellbeing, social welfare and economic growth. This value was expressed in monetary units, which was a difficult endeavor. Although conservative and careful estimations were used throughout the report, the resulting figures are demonstrating the importance of the ecosystems of the CCLME for West African societies: the CCLME ecosystems generate a yearly TEV of around 11,7 billion U$. One hectare of mangroves alone provides ES valued 2.235 U$/a, the most part of it credited to coastal protection (versus storms and erosion), the provision of fish nursery habitats, and climate regulation; otherwise put, the destruction of one hectare of mangroves costs over 2.000 U$ per year (which does not include the damages resulting from the emission of "blue carbon").

The result of this first valuation exercise for the CCLME region, however, provides only for a rough estimate of the value of the most important ES provided by ecosystems in the region. Policy makers and stakeholders involved in the process of decision making need to be aware of the fact that the results of this valuation have their weaknesses.

In the present report, the major sources for uncertainties are the following points:

- Use of benefits transfers: The values derived via benefit transfer need some additional consideration: Mangrove (and other) ecosystems often have very unique features that can’t be found in other regions of the world. The regional ecological specifics of the mangroves need to be kept in mind, and the results of benefit transfers should not be the sole basis for local decision making. In addition, the specific role that parts of the CCLME ecosystems have for the spiritual and cultural traditions of specific countries/areas need to be considered, even if not put in monetary values.

- Data availability and quality: The availability and quality of data was mostly only partly adequate to perform the evaluation exercises envisaged beforehand. Due to this, many data gaps needed to be bridged by assumptions or by accepting data and estimations from the literature, although consensus on the exact dimension is lacking, Examples in the present report include fisheries (maximum sustainable yield and IUU fishing activities), fish nurseries (contribution of coastal ecosystems to fishery output) and climate regulation (i.e. the value for carbon storage and sequestration taken from DECC 2009 is only one out of many).

- Other assumptions: For simplicity, it was assumed that every hectare of a certain ecosystem equals all other hectares of the same ecosystem, neglecting social and ecologic region-specific factors that would certainly influence the values of ES; as such, the study has to be understood as a first and general approach of valuating ecosystem services in the CCLME region.

- Also, the cultural ES were sub-classified into "possibilities for tourism and recreation" (representing the more tangible values, i.e. income opportunities through tourism), and the "other cultural services" (aesthetic information, inspiration for culture, art and design, spiritual experience and information for cognitive development, representing the existence and bequest values). These "other cultural services" were then evaluated using meta-data for the non-use values of biodiversity (which might, to a significant degree, overlap, but which certainly is not the best solution).

- General limitations and methodological issues: the general limitations and statistical errors occurring in economic evaluations in general, and by using a benefit transfer specifically, have to be kept in mind. These are described in chapter 6.5 in more detail.

- Regarding the tourism sector, it was assumed that actually all of it is generated in the coastal areas (except in the case of Morocco). While the coastal areas are certainly harboring the major share of all tourism activities (which was confirmed by the regional partners), there certainly are also some inland activities of relevance.

- The ES “Waste treatment” and “Moderation of extreme events/Erosion prevention” were evaluated based on a benefit transfer using South Asian mangrove studies, not precosely reflecting African circumstances.

To sum up, the present report provides a first estimation of the value of ES in the CCLME. It is recognized, however, that due to a lack of both qualitative and quantitative information regarding several crucial topics, the estimations presented here can be improved through either specific studies covering ES in the CCLME region itself, or the advance of scientific methodologies to evaluate them, especially non-use values. Hence, the following recommendations for improving the "next generation" evaluation exercise in the CCLME region are issued:

- Generation of local or regional information (i.e. from the CCLME), regarding the following topics:

    - Size/spatial scale of coral reefs in Cape Verde.

    - Categorizing the ecosystems present in estuaries, to allow including these important ecosystems in future assessments.

    - Data on waste treatment, water purification and coastal protection infrastructure (to avoid benefit transfers and enable more accurate estimations through the Replacement Cost method).

    - Non-use values, especially of marine habitats. For the future work on the conservation of the CCLME, it will be advisable to consider exercising tailor-fitted evaluation studies in the region that provide for much more detail and that will be also mobilize local population for participative decision making processes.

    - Exact data on IUU fishing activities and maximum sustainable yield.

- Generation of more general information, regarding:

    - Climate regulation/"blue carbon" of marine ecosystems (especially deep sea ecosystems).

    - Ecosystem Services provided by seagrass beds and meadows.

Hence, is recommended to improve on data quantity and quality regarding ES in the CCLME. This is especially true for data on marine ecosystems (and of course does not only apply to the CCLME region), where a lot of information, knowledge and understanding is still missing. Hence, a TEEB Report for marine ecosystems is direly needed - and being developed, fortunately. A TEEB "…*for Oceans and Coasts will respond to the growing demand from decision makers to better manage human activities and their impact on ecosystems and their services and to better understand and acknowledge the dependence of human well being on healthy ecosystem function independent of human needs*" (Solgaard et al. 2012).

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