



BCG ECONOMIC VALUATION: METHODOLOGY AND SOURCES



REVIVING THE WESTERN INDIAN OCEAN ECONOMY: Actions for a Sustainable Future

Front cover

A traditional fisherwoman gleans for octopus on a vast reef flat during low tide. Octopus fishing is a source of food and livelihood for many communities across the Western Indian Ocean.

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WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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Ocean annual income and asset-valuation methodology & sources

This methodology document produced by the Boston Consulting Group (BCG) provides supplemental information to the discussions on economic value in part 1 of the report *Reviving the Western Indian Ocean Economy: Actions for a Sustainable Future* and illustrated by Figure 1 of the same report (pp 16-17).

The assumptions, analysis and data sources that inform the Western Indian Ocean's annual contribution ("gross marine product") and asset-valuation ("shared wealth fund") are outlined in this methodology document. BCG's intent was to triangulate across and refine existing primary research at the regional scale, adapted from the methodology used in the global report, *Reviving the Ocean Economy: The case for action – 2015*, published by WWF International. The full report can be found at ocean.panda.org.

The analyses are partly based on information that has not been generated by BCG and has not, therefore, been fully verified. The information, opinions and analyses contained here are based on sources believed to be reliable and comprehensive but no representation, expressed or implied, is made as to the accuracy, completeness or correctness of the original methods used to gather the primary data.

Furthermore, the analyses and conclusions contained in this document are based on various assumptions that BCG has developed regarding economic growth, and the current and future state of the ocean (based upon factors and events that are subject to uncertainty). Of course, future results or net present values (NPV) derived from forecasted results could thus be materially different.

We welcome constructive comments and contributions (published regional economic valuation papers regional valuation references) to help improve the economic analysis further. We can also share the spreadsheet which contains our calculations, upon request.

Terminology

What is the “gross marine product” and how does it relate to gross domestic product?

Following the same approach as the global report, this regional report introduces the measurement “gross marine product” (GMP) to allow comparison to the national economies in the Western Indian Ocean region. As gross domestic product (GDP) measures the total dollar value of goods and services produced by a country in a year, GMP is the value of the annual economic output of the Western Indian Ocean. BCG’s economic analysis offers a conservative estimate of US\$20.8 billion for the Western Indian Ocean’s GMP

The GDP of a country comprises the sum of *value-added* by each industry, whereby *output* is adjusted for intermediate inputs from other industries. GMP directly calculates the *output* of marine-related industries.

What is an ocean “shared wealth fund”?

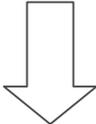
The ocean “shared wealth fund” leverages the analogy made in the *Reviving the Ocean Economy: The case for action – 2015* report. The “shared wealth fund” is an attempt to calculate the total asset base of the ocean in the Western Indian Ocean region, from which annual economic production (i.e. the GMP) is drawn. For the marine assets of the Western Indian Ocean, this has been conservatively estimated at US\$333.8 billion.

What is the difference between the ocean “shared wealth fund” and the “gross marine product”?

The ocean “shared wealth fund” is the overall asset value of the ocean in the Western Indian Ocean region, based on market value of assets (for marine fisheries) or on net present value (NPV) of assets’ cash flows (for all other elements of ocean “shared wealth fund”), whereas the GMP is the output of economic activities generated by these assets every year.

**Total Western Indian Ocean “shared wealth fund” by asset categories
valued at US\$333.8 billion**

Six primary 'value-generating' asset categories

	Asset	(US\$ billion)
<i>Primary Assets of the Western Indian Ocean</i>	<i>Marine Fisheries</i>	<i>135.06</i>
	<i>Mangroves</i>	<i>42.71</i>
	<i>Coral Reefs</i>	<i>18.09</i>
	<i>Seagrass</i>	<i>20.78</i>
<i>Adjacent Assets</i>	<i>Productive Coastline</i>	<i>93.24</i>
	<i>Carbon Absorption</i>	<i>23.96</i>
		
	“Shared Wealth Fund” asset base	~333.84

The total asset value of US\$333.8 billion is an aggregate of the most readily measured ocean assets within the Western Indian Ocean. Four of the six assets are marine ecosystems that generate services that can be consumed directly from the ocean and are valued at US\$216.6. The remaining two are adjacent assets, which provide functional benefits that are utilized indirectly. They are valued at US\$117.2 and include productive coastlines (focussed on tourism) and carbon absorption. All of these assets are dependent on the sound ecological function and wellbeing of the ocean environment to generate value. The calculations for arriving at these sums are available upon request.

These categories are not a collectively exhaustive list but aim to tackle main components where primary analysis exists.

Methodology: In order to value each asset class two different methods were utilized:

1. **Market Based:** Derived asset value looking at quantity of a resource priced at its current market value
2. **Value Based:** Implied asset value ascertained by identifying annual value generation of the asset, and conducting an NPV of future years

For several of the asset categories, a hybrid or modified version of the two above methods was employed to better estimate and triangulate total asset value.

- **Net Present Value Calculations**

For all calculations utilizing the NPV method, certain assumptions were established to ensure consistency and accuracy.

In order to appropriately calculate the NPV of our asset classes, we needed to determine an appropriate regional risk-free rate and regional risk premium. We leveraged World Bank data: risk-free treasury bill rate (lending rate minus risk premium on lending) and risk premium on lending. Based on these data, we calculated the arithmetic mean across the Western Indian Ocean countries for which 2014 data were available (Kenya, Mauritius, Mozambique, Seychelles, South Africa and Tanzania; Madagascar was excluded due to an extremely high value which could not be explained), to determine the regional risk-free rate (6.4 per cent) and regional risk premium rate (6.5 per cent) for our NPV calculations. (Source: <http://data.worldbank.org/indicator/>)

Definitions:

A **net present value** requires specification of the number of future years being considered (e.g. 10 years, 50 years, infinity) and a discount rate, which is the sum of the risk free rate and risk premium to represent the fact that society places a greater value on current benefits than future benefits.

A **risk-free interest rate** is the theoretical rate of return of an investment with no risk of financial loss. One interpretation is that the risk-free rate represents the interest that an investor would expect from an absolutely risk-free investment over a given period of time.

A **risk premium** is the return in excess of the risk-free rate of return an investment is expected to yield; an asset's risk premium is a form of compensation for investors who tolerate the extra risk, compared to that of a risk-free asset, in a given investment.

For each asset category, methodology and sources are provided:

- **Marine Fisheries**

Type of Valuation: Market Based

Calculation: Total productive fish biomass (in tons) multiplied by an implied market port side price for 1 ton of fish multiplied by the Western Indian Ocean's exclusive economic zone (EEZ) share of total global ocean area

Considerations: This valuation builds on the methodology applied in the Global Report. It does not take into account supply and demand elasticity, recognizing that the larger the supply becomes, lower prices are expected. Additionally, this figure does not distinguish between readily catchable and common fish varieties, and those fish categories that may not be in high market demand, or that are too difficult to feasibly catch (e.g. deep-sea varieties). Due to lack of definitive references and quantitative data, we were unable to make adjustments to account for region specific information (e.g. impact of climate change on fish distribution). Should more granular data or region-specific data become available, a more precise valuation could be performed.

Primary Sources:

- **Total Fish:**
Wilson RW, Millero FJ, Taylor JR, Walsh PJ, Christensen V, Jennings S and Grosell M (2009) "Contribution of Fish to the Marine Inorganic Carbon Cycle" Science, 323 (5912) 359-362.
- **Market Value of fish:**
OECD-FAO Agricultural Outlook (Fisheries) 2014-2023
<http://stats.oecd.org/>
- **EEZ area:**
UBC Sea Around Us database (Industrial, Artisanal)
<http://www.seaaroundus.org/data#/eez>
- **Total ocean coverage:**
NOAA (National Centers for Environmental Information) database
http://www.ngdc.noaa.gov/mgg/global/etopo1_ocean_volumes.html
- **Inflation rate:**
World Bank (consumer price annual inflation rate)

- **Mangroves**

Type of Valuation: Value Based (using some market assumptions – i.e. quantity of resource)

Calculation: NPV of all future mangrove values based on the following assumptions:

- A. Total Mangroves: 769,760 hectares
- B. Degradation of mangroves: rate varies by country, ranging from -1 per cent to +4 per cent yearly. The average regional degradation rate is -1 per cent annually.
- C. Value derived from mangroves = US\$4,185 per hectare (applied for each year, not adjusted for forecasted inflation as we want NPV in current dollars).
- D. Discount rate: Average regional risk-free rate
- E. No risk premium – decision made not to apply risk premium to natural assets (following the methodology applied in global report: risk premium applied only on assets directly connected to industrial / market output)

Primary Sources:

- **Total Mangroves:**
Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme.
- **Value generation:**
Brander, Luke M., et al.. "Ecosystem Service Values for Mangroves in Southeast Asia: A Meta-analysis and Value Transfer Application." *Ecosystem Services* 1.1 (2012): 62-69.
- **Asset degradation:**
Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme.

- **Coral Reefs**

Type of Valuation: Value Based (using some market assumptions – i.e. quantity of resource)

Calculation: NPV of all future coral reef values related to coastal protection, tourism/recreation and biodiversity values based on the following assumptions:

- A. Total Coral: 1,205,000 hectares

- B. Degradation of coral at -1 per cent yearly
- C. Value derived from coral = US\$849 per hectare (applied for each year, not adjusted for forecasted inflation as we want NPV in current dollars)

Note: Value derived taking into account only relevant benefits (coastal, tourism / recreation, and biodiversity) to avoid double counting with other “shared wealth fund” assets:

- Total value of benefits from coral reefs in the world: US\$29,081 million per year on a global coral area of 284,000 km², thus a total benefit value of US\$1,050 per hectare.
- Relevant benefits value: 81 per cent of total benefit value, hence a value of coral reef benefits of US\$849 per hectare.

- D. Discount rate: Average regional risk-free rate
- E. No risk premium – decision made not to apply risk premium to natural assets (following the methodology applied in global report: risk premium applied only on assets directly connected to industrial / market output)

Primary Sources:

- **Total Coral Reefs:**
Transboundary Diagnostic Analysis of Land-based Sources and Activities in the Western Indian Ocean. Rep. United Nations Environment Programme, 2009. Web.
<[http://www.unep.org/NairobiConvention/docs/UNEP\(DEPI\)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf](http://www.unep.org/NairobiConvention/docs/UNEP(DEPI)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf)>.

- **Value generation:**
Cesar, Herman; Burke, Laretta; Pet-Soede, Lida (2003). "The Economics of Worldwide Coral Reef Degradation" Published by: Cesar Environmental Economics Consulting (CEEC) WWF - Netherlands

NOTE: Identifying the correct value estimate for 1 hectare of coral reef proved challenging as many widely varying values are reported. We selected Cesar et al as the most applicable source for this calculation as it provided a breakdown of direct benefits. We only included values for coastal protection, tourism / recreation, and biodiversity value to avoid double counting with other “shared wealth fund” assets (e.g. fisheries).

- **Asset degradation:** Bruno JF, Selig ER (2007) Regional Decline in the Indo-Pacific: Timing, Extent, and Subregional Comparisons. PloS ONE 2(8): e711. doi: 10.1371/journal.pone.0000711

- **Seagrass**

Type of Valuation: Value based (using some market assumptions – i.e. quantity of resource)

Calculation: NPV of all future seagrass values based on the following assumptions:

- A. Total seagrass: 58,704 hectares
- B. Degradation of seagrass: -1.5 per cent yearly
- C. Value derived from seagrass = US\$26,479 per hectare (applied for each year, not adjusted for forecasted inflation as we want NPV in current dollars)
- D. Discount rate: Average regional risk-free rate
- E. No risk premium – decision made not to apply risk premium to natural assets (following the methodology applied in global report: risk premium applied only on assets directly connected to industrial / market output)

Consideration: Benefits from provisioning services from seagrass have been excluded in order to avoid double counting (e.g. with marine fisheries).

Primary Sources:

- **Total Seagrass:**
Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme.
- **Value generation:**
De Groot, Rudolf et al. "Global estimates of the value of ecosystems and their services in monetary units" (2012) 55
Costanza, Robert et al. "Changes in the global value of ecosystem services". *Global Environmental Change* 26 (2014) 152-158
- **Asset degradation:**
Telesca, Luca, et al. "Seagrass Meadows (*Posidonia Oceanica*) Distribution and Trajectories of Change." *Sci. Rep. Scientific Reports* 5 (2015): 12505. Web.
<<http://www.nature.com/articles/srep12505>>.

- **Productive / Destination Coastlines**

Note: productive coastline asset value is calculated as the NPV of coastal tourism activity. Coastal tourism includes consumptive and non-consumptive activities in coastal zones. Consumptive activities include fishing, shell fishing, etc., whereas non-consumptive activities include swimming, diving, boating, surfing, wind-surfing, jet skiing, bird watching and snorkelling.

Type of Valuation: Value Based

Calculation: NPV of all coastal production (tourism-based) values based on the following assumptions:

- A. Total value produced annually: US\$10.4 billion (taken from yearly calculation)
- B. Perpetual growth rate: 1 per cent (based on global report methodology)

Note: BCG's analysis concludes that only 27 per cent of potential coastlines are utilized by human development. It is likely this will continue to rise in the coming decades, however this also may diminish value of this and other connected assets – thus a conservative perpetual growth of 1 per cent was used.

- C. Discount rate: Average regional risk-free rate + average regional risk premium
- D. Risk premium – decision made to apply risk premium to all assets deriving value from industrial / market based sources, based on the methodology applied in the global report.

Consideration: There is potential for double counting between productive coastline asset value and mangroves / coral reefs asset values. This cannot be avoided based on available data.

Primary Sources:

- **Coastal tourism value**
Coastal Value annual assessment – see below sections for methodology.

Secondary Sources:

- World Wildlife Fund. Marine Problems: Tourism and Coastal development
http://wwf.panda.org/about_our_earth/blue_planet/problems/tourism/
- UNWTO. Tourism Highlights. 2014 Edition
- World Wildlife Fund – Blue Plan: Coasts
http://wwf.panda.org/about_our_earth/blue_planet/coasts/
- Sustainable Development of Tourism – UN World Tourism Organization. Coast Project.
<http://sdt.unwto.org/en/content/coast-project>
- World Ocean Review. Coasts
<http://worldoceanreview.com/en/wor-1/coasts/living-in-coastal-areas/2/>
- Intergovernmental panel on Climate Change. "Increasing human utilization of the coastal zone"
http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch6s6-2-2.html
- NOAA – State of the Coast
<http://stateofthecoast.noaa.gov/population/welcome.html>
- UN Atlas of the Oceans
<http://www.oceansatlas.org/servlet/CDSServlet?status=ND0xODc3JjY9ZW4mMzM9KiYzNz1rb3M~>
- Estimates of Coastal Populations
<http://www.rockefeller.edu/labheads/cohenje/PDFs/256Cohensmall.htm>
<http://www.prb.org/Publications/Reports/2003/RippleEffectsPopulationandCoastalRegions.aspx>

- **Carbon Absorption**

Carbon sequestration rates were applied to area of natural assets that sequester carbon (mangroves, seagrass) and the total weight of carbon multiplied by the cost of carbon

Type of Valuation: Value and market based

Primary Calculation: NPV of future expected carbon sequestration from seagrass, mangroves and salt marshes multiplied by market price of carbon

- A. Estimated annual value of carbon sequestration from biological processes over the Western Indian Ocean: US\$2.9 billion per year.
 - Two references used for sizing; maximum value between the two selected, where applicable
 - Estimated yearly monetary value of blue carbon storage in Northern Mozambique Channel countries (2015) from Nunes and Ghermandi (2015)
 - Regional State of the Coast, Western Indian Ocean (2015) report
- B. Discount rate: average regional risk-free rate + average regional risk premium
- C. Risk premium – decision made to apply risk premium to all assets deriving value from industrial / market based sources, based on the methodology applied in the global report

Primary Sources:

- **Annual value of carbon sequestration:**

Nunes, Paolo A.L.D., and Andrea Ghermandi (2015). *Understanding and Valuing the Marine Ecosystem Services of the Northern Mozambique Channel*. WWF International

Transboundary Diagnostic Analysis of Land-based Sources and Activities in the Western Indian Ocean. Rep. United Nations Environment Programme, 2009.

<[http://www.unep.org/NairobiConvention/docs/UNEP\(DEPI\)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf](http://www.unep.org/NairobiConvention/docs/UNEP(DEPI)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf)>.

- **Asset degradation: *degradation rates of underlying resources***

Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme.

Bruno JF, Selig ER (2007) Regional Decline of Coral Cover in the Indo-Pacific: Timing, Extent, and Subregional Comparisons. *PLoS ONE* 2(8): e711. doi: 10.1371/journal.pone.0000711

Telesca, Luca, et al. "Seagrass Meadows (*Posidonia Oceanica*) Distribution and Trajectories of Change." *Sci. Rep. Scientific Reports* 5 (2015): 12505. Web. <<http://www.nature.com/articles/srep12505>>.

Annual Value Generated from the Western Indian Ocean's economy (Gross Marine Product)

The analysis in Figure 1 of the report demonstrates the annual economic value of ocean-related activities in the Western Indian Ocean. If the ocean economy were its own economy, it would be fourth largest in the region after South Africa, Kenya and Tanzania.

We determined the annual economic value range using both a top-down and bottom-up analysis. Our top-down analysis (~US\$25 billion) was conducted by surveying available public information for the Western Indian Ocean nations regarding the annual economic value of the ocean to local economies. Our bottom-up analysis (~US\$20.8 billion) was conducted by categorizing and evaluating the annual economic value for ocean-related goods and services in the Western Indian Ocean.

Top-down estimate

Methodology: We conducted research on the 10 Western Indian Ocean countries and territories to source for literature on economic value of the ocean. All data points used from the United Nations Environment Programme (UNEP) report were in US dollars. The UNEP report calculates the value of the blue economy is US\$25 billion for Comoros, Kenya, Madagascar, Mauritius, Mozambique, La Reunion (France), the Seychelles, Somalia, South Africa and Tanzania.

Primary Sources:

- **Ocean economic valuation**
Transboundary Diagnostic Analysis of Land-based Sources and Activities in the Western Indian Ocean. Rep. United Nations Environment Programme, 2009.
<[http://www.unep.org/NairobiConvention/docs/UNEP\(DEPI\)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf](http://www.unep.org/NairobiConvention/docs/UNEP(DEPI)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf)>.
- **GDP of countries**
World Bank database (2014)
- **Currency exchange rate**
Oxford Economics Exchange Rate Database

Ocean related activities grouped into 4 primary categories
All directly dependent on the ocean's ecological functions and well-being

4 categories of annual ocean activities

Category	Total value (US\$ billion)
A) Direct output of the ocean <ul style="list-style-type: none"> • Activities related to the contents of the ocean 	1.9
B) Services enabled by the ocean <ul style="list-style-type: none"> • Activities occurring in/on the ocean 	4.3
D) Adjacent benefits of the ocean <ul style="list-style-type: none"> • Quantifiable benefits enabled by the ocean 	14.6
E) Other intangible benefits of the ocean <ul style="list-style-type: none"> • All undefinable activities attributed to the presence of the ocean 	n/a

Total value: ~US\$20.8 billion

This demonstrates a classification of all ecosystem services that rely on the ocean. As one moves down the table, the correlation to the ocean becomes less direct, moving from direct services, to services enabled by the ocean, adjacent benefits of the ocean, and other intangible benefits of the ocean.

Categories include the following services: A) fishing related activities, marine renewable energy, B) education & training, research & development, ocean survey, cruise industry, marine tourism, security & control, C) direct impact of coastal tourism, carbon sequestration, coastal protection, and marine biotechnology, D) spiritual & cultural benefits, climate change benefits, and overall utility. The latter category – intangible benefits – is likely to include highly valuable benefits, but we found it difficult to ascribe a dollar value.

Bottom up estimate

We conducted a complementary "bottom-up" analysis to estimate the annual economic value generated by marine related industries. Marine industries were broken down into 4 primary categories, each with respective services allocated within. The list below is not exhaustive and only takes into account the primary activities related to the ocean. This analysis is decidedly conservative in its approach, and only values what we are capable of assessing and quantifying. Thus, the true yearly economic value of the ocean in tangible and intangible terms may be much higher.

Once all primary industries were identified, and placed into the categorization framework, we calculated the annual value generated for each sub-category. Publicly available data for the regional / country value for each of the industries is not fully available for some activities, with some data estimated from the past, or extrapolated from a global figure used in the global report. Multiple publicly available sources were leveraged and triangulated to arrive at a fair and estimated amount for each respective industry. For certain industries where past information was available, but not most recent data, historical compound annual growth rate (CAGR) was calculated and used to estimate current economic value.

Additionally, oil & gas production revenue and expenditures are not included in this overall analysis. The contribution of yearly offshore production, in conjunction with potential offshore reserves and annual oil & gas expenditures such as oil rigs, liquid natural gas containers, etc., would inflate the true value of an industry that would remain operational with or without the ocean. In addition, shipping and maritime transport and infrastructure, although dependent on the surface of the ocean like passage of ships, is not dependent on the ecological function and well-being of the ocean. Hence these sectors have been excluded from the analysis as well.

The exercise aims at sizing the value of the output generated by the ocean in the Western Indian Ocean region, but does not tackle the share of value captured locally versus externally.

Below is the methodology leveraged to arrive at economic estimates. For source information please see primary source citation.

- **Direct output of the ocean**

- **Marine fisheries (Commercial)**

- Comprises marine fisheries (offshore), marine fisheries (coastal), and access fees

- Methodology*

- Weight of fish multiplied by price of fish for total value of marine fisheries, access fees added (where data were available).
 - Weight of fish obtained by extrapolating total regional fish catch in 2010 by applying historical 2006-2010 UBC catch CAGR for the region, 2006-2013 FAO catch CAGR used for Tanzania due to one-off spike in fish capture
 - 2015 price of fish obtained from OECD FAO Outlook database, World Fish price used
 - Data on 2015 Access fees and licensing data available from the European Commission used directly

Primary Sources:

- **Marine fisheries (offshore) and marine fisheries (coastal) fish weight**
UBC Sea Around Us database (Industrial, Artisanal) <http://www.seaaroundus.org/data/#/eez>
- **Price of fish:**
OECD-FAO Agricultural Outlook (Fisheries) 2015-2024: <http://stats.oecd.org/>
- **Access fees:**
http://ec.europa.eu/fisheries/cfp/international/agreements/index_en.htm

Marine fisheries (subsistence & recreational)

Comprises marine fisheries (subsistence) and marine fisheries (recreational)

Methodology

- Weight of fish multiplied by price of fish for total value of marine fisheries
- Weight of fish obtained by extrapolating total region fish catch in 2010 by applying historical 2006-2010 University of British Columbia (UBC) catch CAGR for the region, 2006-2013 FAO catch CAGR used for Tanzania due to one-off spike in fish capture
- 2015 price of fish obtained from OECD FAO Outlook database, World Fish price used

Primary Sources:

- **Marine fisheries (subsistence) and marine fisheries (recreational) fish weight**
UBC Sea Around Us database (Industrial, Artisanal) <http://www.searoundus.org/data/#/eez>
- **Price of fish:**
OECD-FAO Agricultural Outlook (Fisheries) 2015-2024
<http://stats.oecd.org/>

Aquaculture

Methodology

- Weight of fish multiplied by price of fish for total value of aquaculture
- Weight of fish obtained by extrapolating total region fish catch in 2013 by applying historical CAGR. Used different historical CAGRs – 2009-2013 for French Territories, Madagascar, Mauritius, Reunion, Somalia, and South Africa; 2011-2013 for Kenya, Mayotte, and Mozambique; and 2012-2013 for Comoros, the Seychelles and Tanzania. Growth rates were selected to choose more conservative estimates due to high variability in catch data which could potentially skew growth rates.
- 2015 price of fish aquaculture obtained from OECD FAO Outlook database
- 2015 price of plant aquaculture was obtained from Bryceson and Beymar-Farris paper

Primary Sources:

- **Aquaculture fish weight:**
FAO aquaculture data
<http://www.fao.org/fishery/statistics/global-aquaculture-production/en>
- **Price of fish aquaculture:**
OECD-FAO Agricultural Outlook (Fisheries) 2015-2024
<http://stats.oecd.org/>
- **Price of plant aquaculture:**
Bryceson, I. and Beymar-Farris, B. (2011). Main challenges for coastal aquaculture development in the WIO region – who are the winners and losers? In Mariculture in the WIO Region “Challenges and Prospects” (eds. Troell, M., Hecht, T., Beveridge, M., Stead, S., Bryceson, I., Kautsky, N., Ollevier, F. and Mmochi, A.) No 11, pp. 6-8. WIOMSA Book Series

Marine renewable energy

Methodology

- Referenced Regional State of the Coast Report section on marine renewable energy – no current value in this sector.

Primary Sources:

- Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme.
- Hammar, L., Ehnberg, J., Gullstrom, M. and Molander, S. (2009). *Ocean energy in combination with land-based renewable energy sources: appropriate technology for smaller electricity grids in Africa?* Proceedings of the 8th European Wave and Tidal Energy Conference. Uppsala, Sweden

- **Direct services enabled by of the ocean**

Marine tourism

Methodology

- Total marine and coastal tourism calculated by applying the percentage of tourism attributable to marine ecosystems to total tourism receipts
- Total tourism receipts comprise international tourism receipts and domestic tourism spending
 - International tourism receipts unavailable for French Territories, Mayotte, and Somalia.
 - Domestic tourism receipts unavailable for French Territories, Mayotte, Reunion, and Somalia.
- Where latest tourism receipt numbers were not available, historical CAGR for each country was applied to the latest available data point
- Percentage of tourism attributable to marine ecosystems based on two UNEP reports.
- Marine and coastal tourism split is based on marine & coastal tourism proportion from the global report (marine tourism – 27 per cent, coastal tourism – 73 per cent)

Note: For South Africa it was not possible to separate tourism receipts on the Indian Ocean coast from revenues on the Atlantic coast. For the purposes of this analysis it has been assumed that the majority of marine and coastal tourism activities are occurring on the Indian Ocean coast.

Primary Sources:

- **International tourism receipts**

World Bank

<http://data.worldbank.org/indicator/ST.INT.RCPT.CD>

- **Domestic tourism spending**

WTTC

<http://www.wttc.org/datagateway/>

- **% tourism attributable to marine ecosystems**

Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme.

Transboundary Diagnostic Analysis of Land-based Sources and Activities in the Western Indian Ocean. Rep. United Nations Environment Programme, 2009.
<[http://www.unep.org/NairobiConvention/docs/UNEP\(DEPI\)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf](http://www.unep.org/NairobiConvention/docs/UNEP(DEPI)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf)>.

Cruise industry

Methodology

- Cruise industry value calculated by aggregating direct and indirect revenues for total cruise market (data only available for Mauritius).

Primary Sources:

- **Direct and indirect cruise industry revenues**

Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme.

Education & training

Methodology

- Scaled down global education & training number to the Western Indian Ocean based on the top-down regional GMP estimate as a percentage of global GMP (1.0 per cent)
- Global education & training value based on annual expenditures derived from "Marine industries global market analysis" report and grown at historic 5 year CAGR rate of 3 per cent. Data found in Euros and converted to US\$ at 2014 exchange rate.

Primary Sources:

Marine Industries Global Market Analysis. Vol. 1. Douglas-Westwood Limited, Mar. 2005.
<<http://oar.marine.ie/bitstream/10793/559/1/Foresight%20Series%201%20Marine%20Industries%20Global%20Market%20Analysis.pdf>>.

Research & development

Methodology

- Scaled down global research & development number to Western Indian Ocean based on top-down regional GMP estimate as a percentage of global GMP (1.0 per cent)
- Global research & development value based on annual expenditures derived from "Marine industries global market analysis" report and grown at historic 5 year CAGR rate of 2 per cent. Data found in Euros and converted to US\$ at 2014 exchange rate.

Primary Sources:

- *Marine Industries Global Market Analysis*. Vol. 1. Douglas-Westwood Limited, Mar. 2005.
<<http://oar.marine.ie/bitstream/10793/559/1/Foresight%20Series%201%20Marine%20Industries%20Global%20Market%20Analysis.pdf>>.

Ocean survey

Methodology

- Scaled down global research & development number to Western Indian Ocean based on top-down regional GMP estimate as a percentage of global GMP (1.0 per cent)
- Global ocean survey value based on annual expenditures derived from "Marine industries global market analysis" report and grown at historic 5 year CAGR rate of 3 per cent. Data found in Euros and converted to US\$ at 2014 exchange rate.

Primary Sources:

- *Marine Industries Global Market Analysis*. Vol. 1. Douglas-Westwood Limited, Mar. 2005.
<<http://oar.marine.ie/bitstream/10793/559/1/Foresight%20Series%201%20Marine%20Industries%20Global%20Market%20Analysis.pdf>>.

Security & control

Methodology

- Scaled down global security & control number to Western Indian Ocean based on top-down regional GMP estimate as a percentage of global GMP (1.0 per cent)
- Global security & control value based on annual expenditures derived from total expenditures on maritime related security for 2014.

Primary Sources:

- *Marine Industries Global Market Analysis*. Vol. 1. Douglas-Westwood Limited, Mar. 2005.
<<http://oar.marine.ie/bitstream/10793/559/1/Foresight%20Series%201%20Marine%20Industries%20Global%20Market%20Analysis.pdf>>.

- **Adjacent benefits of the ocean**

Coastal tourism

Methodology

- Total marine and coastal tourism calculated by applying percentage of tourism attributable to marine ecosystems to total tourism receipts
- Total tourism receipts comprise international tourism receipts and domestic tourism spending
 - International tourism receipts unavailable for French Territories, Mayotte, and Somalia
 - Domestic tourism receipts unavailable for French Territories, Mayotte, and Somalia
- Where latest tourism receipt numbers were not available, historical CAGR for each country was applied to the latest available data point
- Percentage of tourism attributable to marine ecosystems based on two UNEP reports.
- Marine and coastal tourism split is based on marine & coastal tourism proportion from the global report (marine tourism – 27%, coastal tourism – 73%)

Note: For South Africa it was not possible to separate tourism receipts on the Indian Ocean coast from revenues on the Atlantic coast. For the purposes of this analysis it has been assumed that the majority of marine and coastal tourism activities are occurring on the Indian Ocean coast.

Primary Sources:

- **International tourism receipts**
World Bank
<http://data.worldbank.org/indicator/ST.INT.RCPT.CD>
- **Domestic tourism spending**
WTTC
<http://www.wttc.org/datagateway/>
- **% tourism attributable to marine ecosystems**
Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme.

Transboundary Diagnostic Analysis of Land-based Sources and Activities in the Western Indian Ocean. Rep. United Nations Environment Programme, 2009.
<[http://www.unep.org/NairobiConvention/docs/UNEP\(DEPI\)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf](http://www.unep.org/NairobiConvention/docs/UNEP(DEPI)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf)>.

Carbon sequestration

Comprises carbon sequestration from seagrass, mangroves, and salt marshes.

Methodology

- Sum of carbon sequestration values for salt marshes, mangroves and seagrasses in each Western Indian Ocean country.
 - 2 different sources were used, with maximum value selected where the 2 were available
 - For the *Regional State of the Coast* values: whenever a range was provided, median value was used.

Primary Sources:

- **Annual value of carbon sequestration**
Nunes, Paolo A.L.D., and Andrea Ghermandi (2015). *Understanding and Valuing the Marine Ecosystem Services of the Northern Mozambique Channel*. WWF International

Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme.

Coastal protection

Methodology

- Coastal protection values taken from valuations of the annual coastal protection values of mangroves, salt marshes and coral reefs (no estimate available for seagrass), multiplied by the surface area of mangroves, salt marshes and coral reefs in Western Indian Ocean countries.

Mangroves:

A- Estimated average value of coastal protection: US\$1,088 / ha / year

B- Total Mangroves area: 769,760 hectares

Salt marshes:

A- Estimated average value of coastal protection: US\$8,236 / ha / year

B- Total Salt marshes area: 2 517 hectares

Coral reefs:

A- Estimated average value of coastal protection: US\$317 / ha / year

- Value derived from world coastal protection from coral reefs value divided by world coral surface

B- Total coral reef area: 1,205,000 hectares

NOTE: Identifying the correct value estimation per hectare of coastal resources proved challenging as many widely varying values are reported. We only included values for coastal protection for this portion of the economic analysis.

Primary Sources:

- **Total areas:**
 - **Mangroves & Salt marshes** :Bosire, Jared, Louis Celliers, Johan Groeneveld, José Paula, and Michael H. Schleyer (2015). *Regional State of the Coast Report: Western Indian Ocean*. Rep. Ed. José Paula. N.p.: United Nations Environment Programme
 - **Coral reefs:**
Transboundary Diagnostic Analysis of Land-based Sources and Activities in the Western Indian Ocean. Rep. United Nations Environment Programme, 2009. Web.
<[http://www.unep.org/NairobiConvention/docs/UNEP\(DEPI\)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf](http://www.unep.org/NairobiConvention/docs/UNEP(DEPI)_EAF_CP_6_INF_6_Transboundary%20Diagnostic%20Analysis%20of%20Land-based%20Sources%20and%20Activities.pdf)>.
- **Value generation:**
 - **Mangroves:** Cesar, Herman et al (2008), Economic Value of Coral Reefs, Mangroves, and Seagrasses: A global compilation.
Note: A 2005 assessment of the Rekawa mangrove-lagoon ecosystem, Sri Lanka, found that the Total Economic Value was about \$1,088/ha/year
 - **Salt Marshes:** Barbier, Edward et al (2011), The Value of estuarine and coastal ecosystem services, *Ecological Monographs*, 81(2), 2011, pp. 169–193
Note: Coastal protection attenuates and/or dissipates waves. Important controlling components are tidal height, wave height and length, water depth in or above canopy, marsh area and width, wind climate, marsh species and density, local geomorphology
 - **Coral Reefs:** Cesar, Herman; Burke, Laretta; Pet-Soede, Lida (2003). "The Economics of Worldwide Coral Reef Degradation" Published by: Cesar Environmental Economics Consulting (CEEC) WWF – Netherlands
- **Asset degradation:**
Bruno JF, Selig ER (2007) Regional Decline of Coral Cover in the Indo-Pacific: Timing, Extent, and Subregional Comparisons. *PLoS ONE* 2(8):e711.
doi:10.1371/journal.pone.0000711

Marine biotechnology

Methodology

- Marine biotechnology market estimated by scaling down global market for marine biotechnology to the Western Indian Ocean based on the top-down GMP estimate as a percentage of global GMP (1.0 per cent)
- Global market for marine biotechnology was provided for 2018, and adjusted to get to 2015 based on growth rate provided (4 per cent)

Primary Sources:

- **Global marine biotechnology market**
Global Industry Analysts Inc. (2013). *Marine Biotechnology: A Global Strategic Business Report.*, http://www.strategy.com/marine_biotechnology_market_report.asp (Referenced in *Regional State of the Coast Report: Western Indian Ocean*, page 407)

The Western Indian Ocean in numbers



60 MILLION

About 60 million people live within 100km of the coast across the Western Indian Ocean

US\$333.8BN

The overall value of ocean assets in the Western Indian Ocean is more than US\$333.8 billion



4TH

The economic output of the Western Indian Ocean makes it the fourth largest economy in the region

2.4%

Only 2.4 per cent of marine areas are under some form of protection in the Western Indian Ocean



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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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