VULNERABILITY AND ADAPTATION ASSESSMENT TOOLKIT: FISHERIES

User Manual

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Ministry of Social Security, National Solidarity, and Environment and Sustainable Development
(Environment and Sustainable Development Division)
Republic of Mauritius

Vulnerability and Adaptation Assessment (VAA) Toolkit (Mauritius): User Manual for Fisheries

About this manual

This VAA-Fisheries User Reference Toolkit manual forms part of a family of toolkits to assess vulnerability of climate change for the Fisheries Sector. The user reference has been written from an application developer's perspective. A fundamental conceptual and operational knowledge of Excel is assumed.

Disclaimer

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VAA-Fisheries Toolkit

1. Introduction

This document refers to a user-friendly toolkit developed to assess vulnerability and adaptation in the fisheries sector – also known as VAA-Fisheries Toolkit for the Republic of Mauritius. The VAA for the fisheries was assessed in the Third National Communications (TNC) Report (2016) for the various climate change-related impacts observed in the fisheries sector in Mauritius.

The VAA-Fisheries Toolkit performs basic calculations taking the indicators of the Environmental Vulnerability Index (EVI) under different fisheries related issues. Applicable fisheries and related indicators were shortlisted, besides some common indicators about climate. Users of the VAA-Fisheries Toolkit can adjust the indicators by choosing appropriate parameters/assumptions to suit their needs of the vulnerability assessment.

With the significant warming trend of about 1.2°C, a decreasing trend in rainfall amount of about 8% and a projected rise of sea-level ranging between 52 cm and 98 cm by the end of the century if no mitigating action is taken (IPCC, 2013), the risk from natural disasters arising from extreme events such as cyclones, flood and droughts are expected to increase. Already, according to the World Risk Report 2016, Mauritius is ranked as the 13th country with the highest disaster risk and 7th on the list of countries most exposed to natural hazards (UNU-EHS, 2015). The vulnerability of RoM is projected to increase with these phenomena impacting adversely on its socio-economic and environmental sectors. The assessment of the vulnerability made on the basis of climate trend projections of the regional climate model COSMO-CLM, developed under the Disaster Risk Reduction Strategic Framework and Action Plan 2013 (DRR, 2013), predicts temperature to increase, with a range (depending on the seasons and scenarios) between 1°C and 2˚C for the period 2061-2070, with respect to the period 1996-2005 (TNC, 2016).

The threatening impacts of climate change are increasingly being felt with an accelerated sea level rise, accentuated beach erosion, increase in frequency and intensity of extreme weather events, decreasing rainfall patterns as well as recurrent flash floods. The climate challenges ahead for Mauritius should not be underlooked, especially when considering the facts that water supply by 2030 may not be sufficient to satisfy projected demand, agricultural production may decline by as much as 30% and that several beaches, that are so important for our tourism industry may slowly disappear, thus severely undermining one of our major economic pillars and depriving the economic value of this sector, worth over USD 50 million by 2050.

2. Overview of the Fisheries sector

The fishery sector constitutes four main types, namely, coastal/artisanal, aquaculture, offshore demersal, and tuna and is restricted to the marine state of Mauritius (Figure 2.1).

So far, the fishing industry has not reported dwindling offshore marine resources owing to climate change-related factors but rather to overfishing of some species. Government acknowledges the urgency of conducting a fish stock assessment to investigate the possible effect climate change and its auxiliary factors on fish stock.

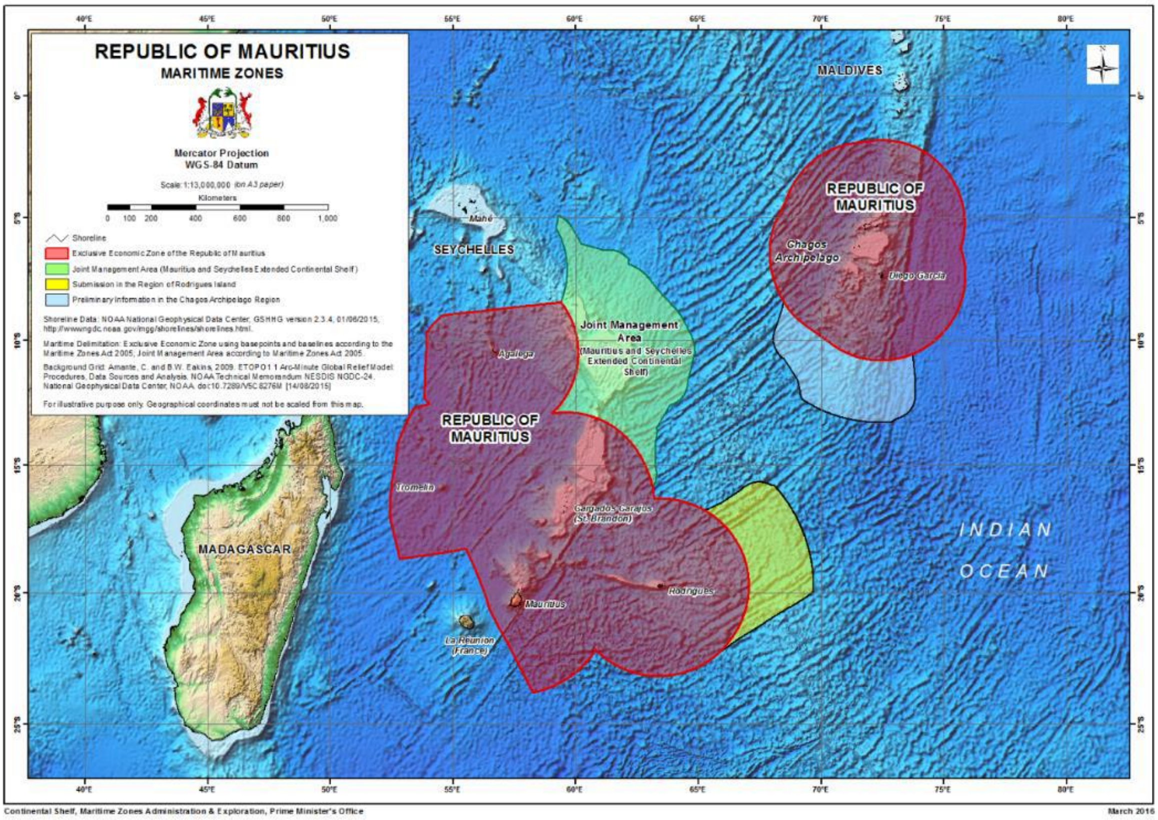


Figure 2.1: Geographical location of Mauritius and Outer Islands with the EEZ
EEZ (light red), Joint Management Area - Mauritius and Seychelles Extended Continental Shelf (light green), Extended Continental Shelf Submission to the UN Commission on the Limit of the continental shelf (CLCS) in the region of Rodrigues (yellow) and Preliminary Information in the Chagos Archipelago Region (light blue).

Mauritius

There are four main types of fisheries in Mauritius, namely: coastal/artisanal, aquaculture, offshore demersal, and tuna. The fisheries sector in Mauritius employs an estimated 5 000 people with around 2 038 registered fishers in 2014 and the total domestic production in the sector is valued at MUR 1000 million (ASCLME 2012). In order to sustainably increase fish production, an Aquaculture Master Plan has been developed with over 20 potential sites identified for aquaculture purposes.

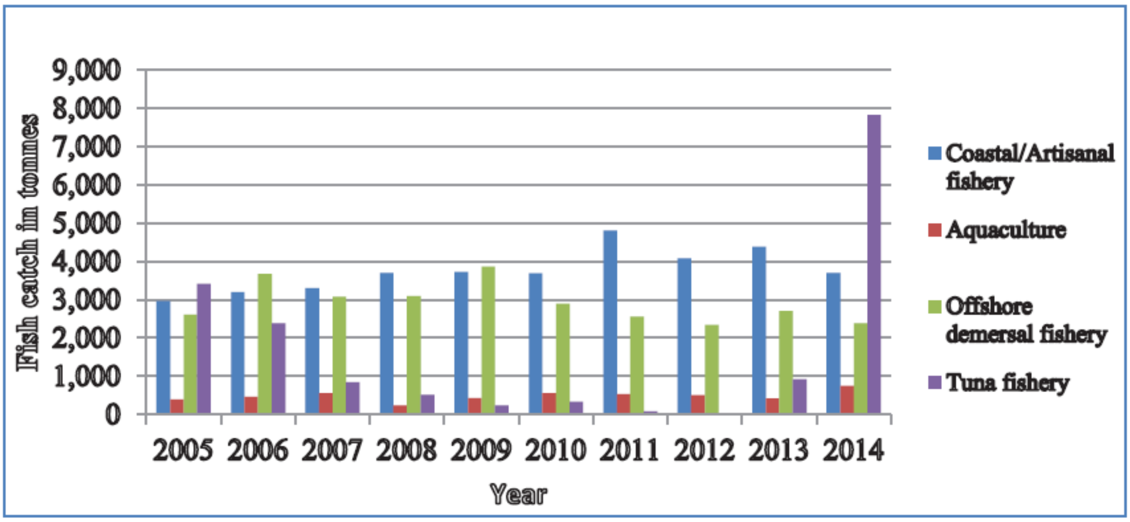


Figure 2.2: Total fish production in net weight equivalent (tonnes))(Source: MoFED, 2014)

In 2014, total fish production was 12,329 t (Figure 2.2) representing a decrease of around 13% over the previous year (14,222 t); the spike in production is due to one Mauritius-flagged purse seiner which started operation in 2013 and seven in 2014. As shown in Figure 2.2, coastal/artisanal catch was 1,649 t in 2014 compared to 1,749 t in 2013, representing a decrease of 6%. Other catch (aquaculture, offshore demersal, and tuna) decreased by 13% from 9,838 t in 2013 to 8,625 t in 2014 (MoOEFSOI, 2016). The octopus closed season initiative, started in 2011 in Rodrigues, was first introduced in 2015 in Mauritius. The Rodrigues and Mauritian initiatives yielded positive results in terms of size of octopus caught, and such an activity is now being considered in the forthcoming Fisheries Bill.

The main critical ecosystems include mangroves, seagrass beds and coral reefs. In Mauritius there are 159 species of scleractinian corals, two species of mangroves covering 145 ha (MoESD, 2009), 1 656 species and 290 families of marine species, some 340 species of fish out of which 42 are of economic importance, over 400 species of seaweeds (Bolton et al. 2012), and nine species of seagrass. Existing stresses on fisheries include fishing pressure, decreasing habitats and pollution including those arising from ballast water. These stresses are likely to be exacerbated by climate change which may cause local shifts in production, altered growth rates, and stock migration.

Rodrigues

The main type of fisheries practiced in Rodrigues is artisanal fishery with line, basket trap and large net, octopus and off lagoon fisheries. There are 1,221 registered fishers out of which 190 are fisherwomen and 31 are large net fishers, and a fleet of 1973 registered fishing boats.

In 2014, about 502 t of octopus along with 1,158 t of fish were caught within the lagoon, and 363t outside the lagoon (Figure 2.3). It is recognised that the lagoon around Rodrigues has degraded to the point of suffering from overfishing and this is largely due to the large number of casual fishers who use unsustainable fishing practices for their daily living. As regards octopus, since 2011, the practice of marine co-management of resources in Rodrigues by periodic octopus fishery closure has been successful in restoring gradually the stock.

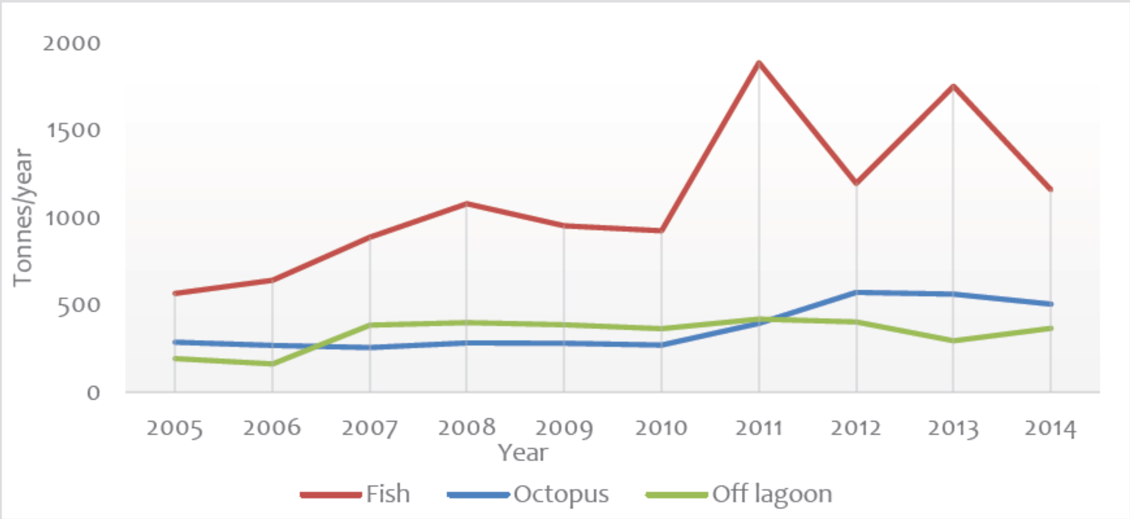


Figure 2.3: Fish catch by type of activity in Rodrigues (Source: MoFED, 2015)

The main critical ecosystems include mangroves, seagrass beds and coral reefs. In Rodrigues there are 493 fish species, 138 coral species, 175 gastropod species, 104 species of algae, 109 bivalve species, 74 species of echinoderms and 41 bryozoan species (Oliver and Holmes, 2004). Planted mangroves (Figure 3.15), cover an area of 24 ha (MoESD, 2009). The stresses on fisheries in Rodrigues are intense fishing and decreasing habitat and habitat quality, which are likely to be exacerbated by climate change. These developments may in turn cause local shifts in catch, altered growth rates of fish population and stock migration.

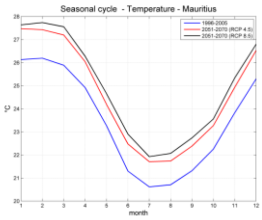
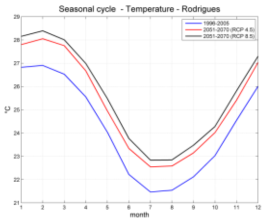
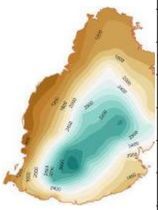
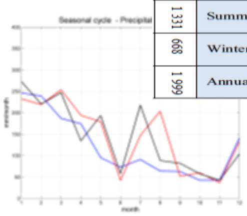
3. Climate, Climate variability and IPCC Forecasts

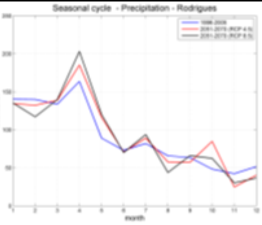
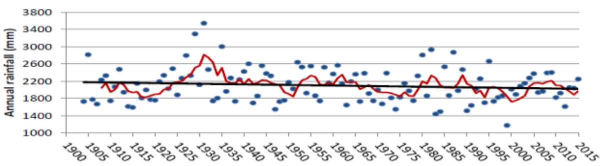
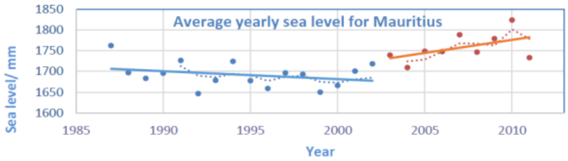
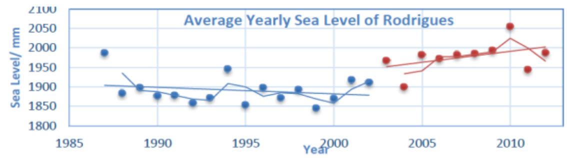
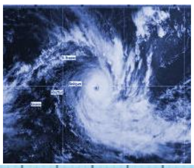
The various islands constituting the Republic of Mauritius (RoM) all enjoy a mild tropical maritime climate throughout the year. With the months of May and October described as transitional months, RoM observes two seasons:

- a warm humid summer extending from November to April and
- a relatively cool dry winter from June to September.

RoM, is located in the tropical cyclone belt of the South Western Indian Ocean (SWIO) where rapid formations of high intensity tropical cyclones and super cyclones have been observed. Table 3.1 shows the trend and projections (including future climate scenario for the region forecasted using IPCC regional models) of key weather parameters (for details see TNC, 2016). Table A1 (Appendix A) contains a list of climate change impact indicators for RoM.

Table 3.1: Trend and Projections of key weather indicators (TNC, 2016)

Indicator (TNC)	***Past and Present Trend (MMS)***	***Projections***
Temperature  	The mean temperature over Mauritius is 24.7°C during summer and 21.0°C during winter. The temperature difference between the two seasons is relatively small and it varies from place to place and is usually larger over coastal areas when compared to the Central Plateau. Records over the period 1951-2014 show a significant warming trend of about 1.2 °C in both Mauritius and Rodrigues. Analysis of temperature records indicate that the observed rate of temperature change is on average 0.020°C/yr and 0.023°C/yr for Mauritius for the period 1951-2014 and for Rodrigues for the period 1961-2014, respectively.	IPCC reckons an increase in mean annual temperature of up to 3.8°C by 2100; Projections made on the basis of RCP 4.5 and RCP 8.5 (the business as usual scenario and the worst case scenario, resp.) indicate an increase in temperature of up to 2 °C over Mauritius and Rodrigues for the period 2051-2070.
Rainfall   	From the mean monthly rainfall data for the period 1981-2010, February is the wettest month and October is the driest. Records over the period 1951-2014 show a decreasing trend in rainfall amount of about 8% for Mauritius and a change in precipitation pattern. For Rodrigues, which is a water scarce island, a downward trend has also been observed in the rainfall compared to the data of the 1960's. The trend and the 5-year moving average for the long-term variations in annual rainfall over Mauritius indicate a steady decreasing trend over the period 1904 to 2015.	A declining trend in total annual rainfall, but an increase in the frequency of intense rainfall episodes (Gastineau and Soden, 2009); Projections for RCP 4.5 and RCP 8.5 scenarios, does not show significant variation with respect to the present rainfall pattern. There will be a shift in rainfall distribution, over Mauritius (e.g., from March to October season). Further reduction in amount of water by 13% by 2050.

	The Central Plateau, the main recharge zone of  the island, has endured a decrease from a maximum of ~4000 m m/year (1951-1980) to ~3800 mm/year with more pronounced drying to the North and the West.	For Rodrigues, the interpretation of the model projections is quite complex as no clear long-term-trend could be identified. However, wide variations emerge across seasons, with a projected decrease in rainfall over the summer months and a likely increase over the transition months.
Sea level	Analysis of sea level data indicates an accelerated rise of 5.6 mm/yr and 5.1 mm/yr for, strikingly, for both Mauritius and Rodrigues, respectively since 2003, much higher than the global average of 3.2 mm/yr. The local mean sea level rose by 2.1 mm/year since mid-90's. The average yearly sea level for the period (1987 to 2011) along with the trend line and the 2-year moving average for Mauritius and those for Rodrigues clearly demarcates into a period when sea level was decreasing (blue) and a period when it is increasing (red).  	Sea level rise (SLR) of 18 – 59 cm by 2100; SLR of about 35 cm if the rate remains constant over the next 90 years;
Cyclones  	Cyclone season is normally from November to mid-May. For the cyclone seasons from 1975-76 to 2014-15, data show that: a) mean number of named tropical storms/cyclones in the SWIO has not changed; b) frequency of storms reaching at least tropical cyclone strength has increased; c) rate of intensification of tropical storms has increased, and a higher number of explosive intensification has been observed over the last 15 years; d) no change in latitudinal cyclogenesis has been observed. For cyclones which reach Category 5 intensity wind gusts can attain over 345 km/h. An increase in the intensity and the rate of intensification is also evident since 1975.	An increase in the intensity and rate of intensification of tropical (Lal et al, 2002);

4. Climate Change: Vulnerabilities, Impacts, and Projections on the Fisheries sector

Table A1 (Appendix A) contains a list of climate change impact indicators for RoM.

The fisheries sector is indirectly influenced by climate change.

Mauritius

Frequent fish mortality is suspected to be linked to climate change observed in the nearshore around Mauritius. Observed dynamics include variations in meteorological parameters (e.g. water temperature and ocean acidification) affect ecosystem, and eventually disturb fisheries dynamics. This is relevant because Mauritius has a lagoon area of around 243 km^2 with two Marine Parks and six Fishing Reserves, known to be highly diverse and very productive. These areas remain relatively shallow, making ecosystem health vulnerable to climate change.

The increased sea surface temperature (SST) are mostly responsible for coral bleaching that reduce coral biodiversity and fish species, with only resilient species surviving. Mass coral bleaching were observed in 1998, 2003, 2004, 2009 and 2015 and are projected to occur more frequently. Algal blooms due to high SST and nutrient rich seepage into lagoons are known to be the cause of mass mortality of corals and fish. More frequent and intense rainfall is expected to cause increased sedimentation of the lagoons thus smothering the corals. Mangroves will be impacted by climatic change as well, leading to a reduction in fish reproduction and fish stocks. MoESDDRM, in collaboration with NGOs, is actively involved in the propagation of mangrove around Mauritius and Rodrigues.

Overall, the assessment of climate change impacts on fisheries remains complex due to the simultaneous presence of anthropogenic and other non-climate-related stresses. Both of these factors affect habitat and the exploitation of the resource. As fisheries contribute to GDP, the socio-economic implications of climate change on fisheries are expected to be significant in Mauritius.

Rodrigues

Rodrigues has a lagoon area of 240 km^2 with the South East Marine Protected Area (SEMPA) covering some 43 km^2 and four Marine Reserves. These areas are known to be very diverse and highly productive, but they remain relatively shallow which make the ecosystem vulnerable to climate change, especially when considering the rising trends of temperature and ocean acidification. As for Mauritius, projected increase occurrence of coral bleaching, would reduce coral biodiversity and fish species for Rodrigues while algal blooms due to high sea surface temperature would result in mass mortality of marine biodiversity and resources.

5. Adaptation Strategies proposed under the TNC

Mauritius

In order to address the challenges within the fisheries sector and progress towards reaching national development goals, GoM, in collaboration with other relevant entities is committed to adopt policies aimed at reducing the vulnerability of the sector (Table 5.1).

Table 5.1: Adaptation policies related to the reduction of vulnerabilities of fisheries sector

Action proposed	Means of implementation and expected results
Improve the health of marine ecosystem	The improvement could be achieved by (a) strengthening governance and the enforcing existing legislation regarding marine protected areas, and (b) expanding the protected areas to places which are sensitive and vulnerable to climate change. The rehabilitation and expansion of sensitive coastal habitats such as corals, seagrass and mangroves could be also undertaken
Adopt and promote sustainable fishing practices	This could be carried out through the provision of incentives to promote entrepreneurship for sustainable aquaculture and by encouraging and enabling fishers to fish outside lagoons
Improve the capacity of institutions and fishers in understanding and managing the marine ecosystem	This could be achieved through the sensitisation of fishers over the effects and impacts of climate change over the resources and through an improved and harmonised monitoring of the marine environment

The implementation of the VAA strategies (Table 5.2) is expected to reduce the loss of marine habitat and thus improve landings and the competitiveness of the fisheries sector and, in so doing, improve livelihoods in the coastal areas.

Table 5.2: VAA strategies for addressing current problems and transforming development challenges into new opportunities for achieving the development goals in the fisheries and marine biodiversity sectors (TNC, 2016).

Sector	Development challenges	Goals	VAA strategies	
			To address current problems	To create new opportunities
Fisheries and marine biodiversity	i) Loss of marine habitat ii) Reduced landings and competitiveness of the sector iii) Disruption of livelihoods in coastal areas	Improve the health of marine ecosystem	**F1.** Expand protected areas and improve governance and enforcement	**FN1.** Rehabilitation and expansion of coastal and marine habitats
		Adopt sustainable fishing practices	**F2.** Incentivise aquaculture	**FN2.** Incentivize fishing outside of the lagoons
		Improve capacity of institutions and fishers	**F3.** Sensitisation of fishers	**FN3.** Improve the monitoring of coastal areas and harmonise monitoring methodology

Note[1]: F1 etc. refer to proposed strategies to address current problems

Note[2]:FN1 etc. refer to strategies for creating new opportunities while addressing the current problems

An integrated approach that identifies the intervention options, which turn challenges into opportunities, the corresponding required investments, and the resulting policy-induced avoided costs and added benefits in the fisheries sector are given in Table 6.3.

Fisheries - ***Transforming challenges into opportunities*** **(Mauritius)**
Strategies (F1etc.) and corresponding actions (F1.1 etc.) and investments from Households (*H*), Government (*G*) and Private sector (*P*) with resulting policy-induced avoided costs and added benefits

	Strategies	Action List	Investment	Avoided costs	Added benefits
F1	Expand protected areas and improve governance and enforcement	**F1.1.** Implement management plan (MPAs) **F1.2.** Identify sensitive areas in light of future climate change impacts	*H:* N/A *G:* survey (biodiversity), consultancy, labour, enforcement *P:* survey (biodiversity)	*H:* fish cost *G:* public spending (rehabilitation) *P:* catch and revenue	*H:* employment and income, nutrition, leisure (biodiversity) *G:* health costs, tax revenue *P:* labour productivity, tourism (biodiversity)
F2	Rehabilitation and expansion of coastal and marine habitat	**F2.1.** Science-based and site specific coral nursery **F2.2.** Seagrass restoration **F2.3.** Mangrove propagation **F2.4.** release of fingerlings	*H:* N/A *G:* survey (site identification), consultancy, nursery, monitoring, propagation, software, labour *P:* training, survey	*H:* property value, injuries *G:* coastal erosion, public spending (coastal infrastructure, health) *P:* property value, catch and revenue, insurance	*H:* employment, well-being, leisure (biodiversity) *G:* tax revenue, carbon sequestration, mitigation of ocean acidification *P:* tourism arrivals and revenue
F3	Incentivise sustainable aquaculture	**F3.1.** Identify and review suitable sites **F3.2.** Incentives and capacity building for aquaculture entrepreneurship **F3.3.** Implement M&E	*H:* N/A *G:* survey (site identification), labour, incentives *P:* equipment and infrastructure co-financing	*H:* N/A *G:* fish import *P:* loss of productivity and income	*H:* employment and income, nutrition *G:* tax revenue *P:* revenues and profit
F4	Incentivise fishing outside of the lagoon	**F4.1.** Incentives to mitigate costs **F4.2.** Permitting	*H:* N/A *G:* incentive, certification (consultancy, labour) *P:* co-financing	*H:* N/A *G:* coastal and marine habitat loss, public spending (compensation) *P:* loss of productivity and income	*H:* employment and income *G:* tax revenue, climate resilience *P:* revenues and profit
F5	Sensitization of fishers	**F5.1.** Capacity building on the use of climate-related impacts (e.g. stock migration) **F5.2.** Awareness raising on the importance of coastal and marine ecosystem health **F5.3.** Capacity building on sustainable fishing techniques (lagoon and open sea)	*H:* N/A *G:* consultancy, training package, labour, campaigns *P:* fees (commercial), campaigns	*H:* N/A *G:* malpractice (overfishing, habitat loss), public spending (rehabilitation) *P:* productivity loss	*H:* well-being, employment and income (inclusiveness) *G:* human capital, tax revenue *P:* catch and revenue
F6	Improve the monitoring of coastal areas and harmonize monitoring methodology	**F6.1.** Ongoing capacity building **F6.2.** Facilitation of technology transfer **F6.3.** Create an open access and centralized knowledge repository **F6.4.** identification and monitoring of coral disease	*H:* N/A *G:* consultancy, labour, training materials, equipment *P:* labour, equipment	*H:* N/A *G:* public spending (duplication of efforts) *P:* labour cost	*H:* N/A *G:* human capital, information sharing *P:* human capital

Rodrigues

In order to address the challenges within the fisheries sector and progress towards reaching national development goals, RoM through the Rodrigues Regional Assembly, in collaboration with other relevant entities could undertake to implement suitable strategies (Table 5.4).

Table 5.4: Adaptation policies aimed at reducing the vulnerabilities of the fisheries sector (TNC, 2016)

Strategy	Means of implementation and expected results
Improve the health of marine ecosystems	The actions include improving governance, enforcing existing regulations over the existing marine protected areas, and expanding the protected areas to places that are sensitive and vulnerable to climate change. The rehabilitation and expansion of sensitive coastal habitats such as corals, seagrass and mangroves could also be undertaken
Adopt and promote sustainable fishing practices	This approach could be carried out through the identification and implementation of suitable sustainable small-scale aquaculture opportunities, provision of incentives to promote entrepreneurship for sustainable aquaculture and by encouraging and enabling fishers to fish outside lagoons
Improve capacity of institutions and fishers in understanding and managing the marine ecosystem	This strategy may be achieved through the sensitisation of fishers over the effects and impacts of climate change on the resources, and through an improved and harmonised monitoring of the marine environment

For the fisheries sector in Rodrigues, the development challenges, goals and the VAA strategies to address current problems and create new opportunities are very similar to those of Mauritius. In particular, the implementation of the VAA strategies in Rodrigues is expected to reduce the loss of marine habitat and thus improve landings and the competitiveness of the fisheries sector and in doing so improve the livelihoods of the inhabitants in the coastal areas.

An integrated approach that identifies the intervention options, which turn challenges into opportunities, the corresponding required investments, and the resulting policy-induced avoided costs and added benefits in the fisheries sector are given in Table 5.5 below.

Fisheries - *Transforming challenges into opportunities* (Rodrigues)
Strategies (A1etc.) and corresponding actions (A1.1 etc.) and investments from Households (*H*), Government (*G*) and Private sector (*P*) with resulting policy-induced avoided costs and added benefits

	Strategies	Action List	Investment	Avoided costs	Added benefits
F1	Expand protected areas and improve governance and enforcement	**F1.1.** Implement management plan (MPAs) **F1.2.** Identify sensitive areas in light of future climate change impacts	*H:* N/A *G:* survey (biodiversity), consultancy, labour, enforcement *P:* survey (biodiversity)	*H:* fish cost *G:* public spending (rehabilitation) *P:* catch and revenue	*H:* employment and income, nutrition, leisure (biodiversity) *G:* health costs, tax revenue *P:* labour productivity, tourism (biodiversity)
F2	Rehabilitation and expansion of coastal and marine habitat	**F2.1.** Science-based and site specific coral nursery **F2.2.** Seagrass restoration **F2.3.** Mangrove propagation **F2.4.** release of fingerlings	*H:* N/A *G:* survey (site identification), consultancy, nursery, monitoring, propagation, software, labour *P:* training, survey	*H:* property value, injuries *G:* coastal erosion, public spending (coastal infrastructure, health) *P:* property value, catch and revenue, insurance	*H:* employment, well-being, leisure (biodiversity) *G:* tax revenue, carbon sequestration, mitigation of ocean acidification *P:* tourism arrivals and revenue
F3	Identify and implement sustainable small scale aquaculture	**F3.1.** Identify and implement small scale aquaculture **F3.2.** Incentives and capacity building for aquaculture entrepreneurship **F3.3.** Implement M&E	*H:* N/A *G:* Study and survey (site identification), labour, incentives *P:* equipment and infrastructure co-financing	*H:* N/A *G:* fish import *P:* loss of productivity and income	*H:* employment and income, nutrition *G:* tax revenue *P:* revenues and profit
F4	Incentivise fishing outside of the lagoon	**F4.1.** Incentives to mitigate costs **F4.2.** Permitting	*H:* N/A *G:* incentive, certification (consultancy, labour) *P:* co-financing	*H:* N/A *G:* coastal and marine habitat loss, public spending (compensation) *P:* loss of productivity and income	*H:* employment and income *G:* tax revenue, climate resilience *P:* revenues and profit
F5	Sensitization of fishers	**F5.1.** Capacity building on the use of climate-related impacts (e.g. stock migration) **F5.2.** Awareness raising on the importance of coastal and marine ecosystem health **F5.3.** Capacity building on sustainable fishing techniques (lagoon and open sea)	*H:* N/A *G:* consultancy, training package, labour, campaigns *P:* fees (commercial), campaigns	*H:* N/A *G:* malpractice (overfishing, habitat loss), public spending (rehabilitation) *P:* productivity loss	*H:* well-being, employment and income (inclusiveness) *G:* human capital, tax revenue *P:* catch and revenue
F6	Improve the monitoring of coastal areas and harmonize monitoring methodology	**F6.1.** Ongoing capacity building **F6.2.** Facilitation of technology transfer **F6.3.** Create an open access and centralized knowledge repository **F6.4.** identification and monitoring of coral disease	*H:* N/A *G:* consultancy, labour, training materials, equipment *P:* labour, equipment	*H:* N/A *G:* public spending (duplication of efforts) *P:* labour cost	*H:* N/A *G:* human capital, information sharing *P:* human capital

Cross-sectoral considerations

Cross-sectoral considerations (Table 5.6) are now taken into account to identify and highlight entry points for interventions that will lead to increase efficiency of budget allocation and policy implementation. The strategies that more markedly contribute to the overall development include capacity building and awareness-raising, along with improved data collection and analysis. In addition, ecosystem restoration (terrestrial and marine) was identified as an ideal intervention in six of the seven sectors analysed. The main benefits identified when considering cross-sectoral dynamics include a reduction in public spending (with several instances in which avoided costs emerge) along with an increase of public revenues (e.g. tax revenues, through increased economic activity); employment creation (across all sectors and interventions); improved well-being (with better health and a reduction of injuries and diseases); and an amelioration of leisure opportunities (both for the local population and for tourists).

Table 5.6: Policy interventions and their inclusion in sectoral strategies (TNC, 2016)

	Sustainable land use planning	Ecosystem restoration	Resource efficiency	Integrated water management	Climate resilient infrastructure	Eco-tourism	Institutional capacity and support	Awareness raising	R&D and data analysis
Agriculture	√	√		√			√	√	√
Coastal areas and tourism	√	√	√	√	√	√		√	√
Water		√	√	√				√	√
Biodiversity	√	√				√		√	√
Fisheries	√	√					√	√	√
Health					√		√	√	√
Infrastructure		√		√	√	√	√	√	√

Table 5.7 highlights some of the more outstanding opportunities emerging from cross-sectoral linkages for the Fisheries sector.

The rehabilitation and expansion of coastal and marine habitats support biodiversity conservation, and hence improved leisure activities and tourism. The improvement of governance for protected areas incentivises eco-tourism, and the improvement in the monitoring of coastal areas can reduce climate-related impacts on infrastructure. Policies that have cross-sectoral advantages include the integrated management of coastal ecosystems that benefit fish stocks, tourism and other leisure activities. Another area of intervention that benefits the fishery sector is the management of terrestrial biodiversity, as well as the utilisation of sustainable agriculture practices, averting the increasing challenges being faced for coastal livelihoods.

Table 5.7: Strategies and opportunities emerging from cross sectoral linkage for the Fisheries sector

Mauritius	Rodrigues
Strategies 1 • Rehabilitate and expand coastal and marine habitats ***Direct Cross cutting issues/ benefits*** - Enhancement of biodiversity conservation; - Improvement of leisure activities and tourism; - Improvement of governance for protected areas, and incentivizes eco-tourism ***Strategies 2*** • Improve monitoring of coastal areas ***Direct Cross cutting issues/ benefits*** - Reduction in climate related impacts on infrastructure ***Other benefits and remarks*** Policies that have cross-sectoral benefits include the integrated management of coastal ecosystems that benefit fish stocks, as well as tourism and other leisure activities. Another area of intervention that benefits the fishery sector is the management of terrestrial biodiversity, as well as the utilization of sustainable agriculture practices, averting the increasing challenges being faced for coastal livelihoods.	***Strategies*** Improve governance and enforcement over the existing marine protected areas; expand protected areas; adopt and promote sustainable fishing practices; improve capacity of institutions and fishers in understanding and managing the marine ecosystem.

6. VAA-Fisheries Toolkit

The structure, methodology, and components/modules of the VAA-Fisheries Toolkit has been described in the main User Manual.

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8. Appendices

Appendix A

Key Climate Change Impact indicators for RoM

Table A1: Key CC Impact indicators for RoM (source: DRR Report, 2016)

Indicator	*Trend (DRR Report)*	*Cases*
Beach Erosion	17% of the beaches are suffering from long term erosion and that 23% are being accreted, the remaining 59% are considered as being stable. A loss of **10 meters** of beaches over the last 8 years has been observed.	At Pointe aux Cannoniers, in the north of the island the shoreline has retreated by 10m and up to 18m within 45 years from 1967, with the volume of sediment loss amounting to 10,000 m^3. Mon Choisy, the shoreline has retreated by 12m on average and 18m at the maximum within the same period of time with a sediment loss of 20,000m^3 loss. Coral condition at Mon Choisy has been noticed to be relatively worse comparing to other coral reefs in Mauritius.
Flash Floods	Some 19-30 km2 of agricultural land, 5-70 km2 of built up land, 2.4-3 km of motorway, 18-29 km of main roads and 68-109 km of secondary roads are at risk of flooding. The damages to building and infrastructures have been estimated to be around USD 2 Billion in 50 years (2070 horizon).	Increase in the frequency of extreme weather events more frequent torrential rains resulting in flash floods, causing 11 deaths in March 2013. During recent heavy rainfall in January 2015, over 250 sites were flooded in Mauritius. During the first five days of May 2017, Mauritius recorded a mean rainfall of 275mm which represents 186% of the long term mean rainfall for the month; the Eastern part recording almost 300% of its normal rainfall. The flash flood of May 2017 affected around 74 households in the Flacq region namely, Central Flacq and Poste de Flacq (Cite Hibiscus, Camp Poorun and Cite Débarcadére).
Landslides	As heavy precipitation events increase, so does the risk of landslide. In Mauritius, 3 mountainous/hilly zones (enclosing 38 localities) are highly prone to landslide. The estimated values of built up areas and roads exposed to landslide are in the order of 7233 Million USD and 196 Million USD respectively.	These are 3 zones are notably regions around Vallee des Pretres-Chitrakoot, Quatre Soeurs-Louis de Rochecouste and Grande Riviere Noire-Chamouny. Regions such as Chitrakoot and Quatre Soeurs have recurrently been affected by landslide events such that in situ infrastructures are prone to damages. More recently the Terre Rouge-Verdun road was damaged due to landslide after a heavy downpour.
Coastal Inundation and Storm Surges	According to the DRR report, 12.2 km2 of built-up land, 11.8 km2 of expansion areas and 60 km of primary and 80 km of secondary roads are identified at risk to inundation as a result of sea surges. The damages to building and infrastructures has been estimated to be around 1.4 Billion USD for inundation in 50 years (2070 horizon).	According to scenarios established in the DRR, the north area of Mauritius is highly exposed to coastal risk, especially the zone between Pointe aux Cannoniers and Cap Malheureux. Analogously, the entire shoreline between Mon Choisy and Baie de l'Arsenal seem to be subject to significant inundation. Besides, high coastal risk appears in correspondence of Port Louis area from Baie du Tombeau to Baie de la Grande Riviere. The same type of problem is found in the south of Flic en Flac, through Baie de Tamarin up to Baie de la Grande and Petite Riviere Noire. Along the southern border, localized issued are in Pointe aux Roches, Pomponette, Riambel and in Mahebourg. Along the eastern coast, high local

		risk has been identified at Trou d'Eau Douce, Poste de Flacq and Roche Noires.
Sea water intrusion	Problem of salinity due to sea water intrusion in the water ponds on farms in the south eastern and south coastal belts.	Areas such as Belle Mare, Palmar, Quatre Soeurs and Deux Frères, Bambous Virieux and Pomponette has been observed.
Forest/Bush Fire	Climate change is projected to increase the extent, intensity and frequency of forest fires in certain regions of Mauritius. Warmer summer temperatures, coupled with decreases in water availability, dry out woody/dry grasses materials in forests/grassland increases the risk of wildfire.	Regions that are regularly plagued by wildfires in Mauritius include: Signal Mountain, La Ferme, Ile D'Ambre, Petit Sable and Ile aux Benitiers.
Coral Bleaching	El Niño Southern Oscillation (ENSO) generated massive bleaching and coral mortality during 1982-1983, 1997-1998, 2002-2003, 2005, and 2010, and contributed to the likely extinction of a coral species. In 1998, the NOAA reported an episode of extremely high ocean temperatures migrated from south to north throughout the Indian Ocean during the first six months of 1998 causing considerable coral reef bleaching in its wake. It was estimated that 16% of the world's coral was lost.	Bleaching has been reported in the Indian Ocean reefs of Mauritius as well as in Seychelles, Reunion, Madagascar and Maldives, amongst others. The coral reefs of Rodrigues which escaped the mass coral-bleaching event of 1997-1998, was affected by the 2016 El-Nino event. Surveys showed occurrences of severe bleaching leading to the mortality of up to 75% of corals at some sites, particularly in the North and West of Rodrigues.
Acidification	Since the beginning of the industrial era, oceanic uptake of CO_2 has resulted in acidification of the ocean; the pH of ocean surface water has decreased by 0.1 pH units (high confidence), corresponding to a 26% increase in acidity. The ocean has absorbed about 30% of the emitted anthropogenic CO_2, causing ocean acidification. According to the Fifth Assessment Report of the IPCC, Earth System Models project a global increase in ocean acidification for all RCP scenarios by the end of the 21st century. The decrease in surface ocean pH is in the range of 0.06 to 0.07 (15 to 17% increase in acidity) for RCP 2.6.	