

Dependency on mangroves ecosystem services is modulated by socioeconomic drivers and socio-ecological changes – insights from an insular biodiversity hotspot

Raphael Merven (✉ mervenraphael73@gmail.com)

University of Montpellier

Chandani Appadoo

University of Mauritius

Vincent Florens

University of Mauritius

Pricila Iranah

University of Nebraska at Kearney

Research Article

Keywords: Coastal Management, Ecosystem Services, Households survey, Mangroves, Oil spill, SIDS

Posted Date: May 25th, 2023

DOI: <https://doi.org/10.21203/rs.3.rs-2970503/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Small island developing states (SIDS) display high biodiversity due to their insular situation but suffer from a disproportionate vulnerability to climate change, economic and environmental shocks. In Mauritius, a SIDS located the Indian Ocean, mangroves ensure essential ecological functions and support coastal communities' livelihoods, they are however threatened by continuous degradations. In 2020, communities on the southeast of the island experienced compounded overlapping effects of a global pandemic and an ecological crisis, with impacts on livelihoods and well-being. This same area is known for its extent of mangroves. While regulating and provisioning services of mangroves are well documented, this study elucidates some of the lesser-known cultural values attached to mangroves and the ways in which communities depend on them for their well-being. Based on a multi-dimensional ecosystem services framework, an in-person survey was implemented between August and October 2021 in coastal villages on the east-southeast of Mauritius, totalling 281 surveyed households of Mauritians in middle- to low-income categories with livelihoods associated to fishing and/or tourism. The collected data was analysed through distribution analysis, multiple correspondence analysis and logarithmic regression. Our results show that two thirds of respondents depend on mangrove ecosystem services with low (37.2%) to medium and high (26.3%) dependencies. Dependency on mangroves is materialized through cultural services, and as a support for food security and income generation. Socio-economic drivers and multiple crises play a direct and indirect role in mangrove dependency. Study results suggest that precarious households have higher levels of dependency, and are subsequently more vulnerable to mangroves degradation and socio-ecological changes. The impact of changes and socio-economic parameters are therefore essential dimensions to take into account for coastal management and biodiversity conservation policy design in an insular context.

1. INTRODUCTION

Mangrove ecosystems develop in tropical and subtropical intertidal areas, comprising roughly 70 woody plant species occupying an estimated 14.8 million ha globally (FAO, 2020). They are nursery areas for juvenile fish and other aquatic animals and provide habitats for both terrestrial and aquatic fauna (Hogarth, 2015). They play a direct role in shaping coastal landscapes by modulating complex sedimentary, hydrologic, and climatic cycles (Godoy & Lacerda, 2015) and carbon sequestration (Donato et al., 2011, Alongi, 2012). Mangroves also mitigate stochastic events like cyclones and tsunamis (Sandilyan & Kathiresan, 2015). By providing an array of goods and services, mangrove ecosystems support the livelihoods of many coastal tropical communities worldwide (Bandaranayake, 1998; Walters et al., 2008), totalling around 100 million people living within 10 kilometres of large mangrove forests (UNEP, 2014). Moreover, mangroves carry socio-cultural values, although these are typically underrepresented in most ecosystem valuation assessments (James et al., 2013; de Souza Queiroz et al., 2017; Himes-Cornell et al., 2018; IPBES, 2022).

Despite their essential functions for tropical coastlines, mangrove ecosystems showcase one of the major impact of anthropogenic change, with a global loss of 1.04 million ha between 1990 and 2020 (FAO, 2020) and this even though 42% are under a protected area designation (Spalding & Leal, 2021). Their clearing for aquaculture, urbanization and coastal landfill, and their deterioration by pollution, upstream land uses, sea level rise and climate change, have brought scientists to consider the prospect of the disappearance of mangroves worldwide within a century (Alongi, 2002 ; Duke et al., 2007). Mangroves are not an isolated case, the last Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) global assessment report on degradation and restoration shows that three-quarters of the planet's land surface is considered as 'degraded', around 87% of wetlands have disappeared since 1700 (Davidson, 2014) while areas covered by living coral reefs have roughly halved since 1870 (Brondizio et al., 2019). Adding up to these environmental issues, anthropogenic climate change continues to exert worldwide impacts on human societies, living organisms and the geosphere at different scales (IPCC, 2022; Wheeler and Von Braun, 2013; Doney et al., 2012; Zundzewicz *et al.*, 2018).

Small island developing states (SIDS) comprise 58 countries that, despite being disproportionately vulnerable to climate change impacts, as well as environmental and economic shocks (Terauds and Zhuawu, 2021), are underrepresented in studies addressing related issues (Robinson, 2020; Kelman et al., 2021). The recent COVID-19 pandemic has further weakened the socio-economic situation of SIDS, and recent studies suggest a slow and long recovery from this global event (Gu et al., 2022; Kim, 2020). In Mauritius, a SIDS located in the Western Indian Ocean, rapid and sustained anthropogenic activities continue to impact biodiversity and ecosystems (Florens et al., 2017; Gosling et al., 2017), with native habitat cover today remaining at about 4.4% of the total island extent (Hammond et al., 2015) as compared to 82.5% in 1773 (Florens, 2013).

The island is considered as a biodiversity hotspot and exhibit fragile ecosystems such as mangroves, seagrasses, coral reefs and wetlands, but coastal areas of the island are in the middle of socio-ecological tensioning. The tourism sector, in particular luxurious and high-class tourism, is a major economic pillar of the island (Anisimov et al., 2020). The island boasted nearly 1.3 million international tourist arrivals in 2019 though the number declined in 2020 (308,980) and 2021 (179,780) (Statistics Mauritius, 2022), mostly because of the pandemic-associated travel restrictions. Coastal development has brought employment and economic growth, but has also exerted increasing pressure

on marine and intertidal ecosystems, especially wetlands and mangroves. Out of 209 coastal wetlands surveyed in 2011, most were exhibiting edge-related disturbances and more than half were fragmented (Laurance et al., 2012). Hammond et al. (2015) reported that twelve out of the fourteen environmentally sensitive areas (ESAs) in Mauritius are at risk of degradation, with six coastal and marine ESAs types, including mangroves, being exposed to urban expansion and resource over-use.

Compounding development impacts, an ecological disaster struck the southeast coast and communities of the island in August 2020. A Japanese owned carrier bulk vessel, the Panama-flagged MV Wakashio, ran aground on coral reefs in late July that year, and released some 1,000 tons of oil into the region's lagoon on the 6th of August, with a portion of that oil depositing on rocky shorelines and in mangrove forests (Gurumoorthi et al., 2021; Scarlett et al., 2021; Seveso et al., 2021). Registered fishers have received pandemic and oil spill related compensation, but registration is male dominated and women who rely mostly on artisanal fishing, crustacean collection, and fishing bait collection in mangroves, have not been able to receive compensation (Nagea et al., 2021). While the impacts of the global COVID-19 pandemic were already affecting the coastal areas relying on tourism and fisheries, this oil spill is considered by many as the worst ecological disaster Mauritius has ever experienced since its independence in 1968, and has exacerbated socio-economic difficulties of many households of the region (De Rosnay et al., 2021).

Mangroves socio-economic importance is poorly referenced in Mauritius, as well as their associated provisioning and cultural services. In the island, mangroves have a historical use in traditional medicine as poultice on wounds, teas against haemorrhages, and for their antihypertensive and anti-diabetic properties (Gurib-Fakim & Brendler, 2004), but these practices have declined due to lifestyle and income changes. Moreover, with loss of mangroves, coastal households have come to rely more on small-scale fisheries outside mangrove areas, for their food and income security (Soondron, 2010) but here too, artisanal fisheries have been declining (Ollivier, 1993; Soondron, 2010; United Nations Development Program, 2015). Restrictions on collecting and using mangrove parts have also declined because of the Fisheries and Marine Resources Act (2007) which provides legal protection to remaining mangrove patches.

More recently, a study on the perceptions of local communities on mangroves and their associated ecosystem services in the South-West of Mauritius, revealed little to no direct dependence on mangrove products (Abib & Appadoo, 2021). However, the study identified strong importance associated to recreational activities and cultural services, suggesting that coastal communities have high cultural values for mangroves. Various studies from Bangladesh, Brazil and Mexico report mangroves' cultural services including recreational and tourism activities, aesthetics values, maintenance of traditional ecological knowledge, environmental education and cultural heritage among others (Uddin et al., 2013 ; de Souza Queiroz et al., 2017 ; Reyes-Arroyo et al., 2021). By encompassing complex social and ecological couplings, mangroves are global socio-ecological systems (SES) (Cormier-Salem, 1994; Walters et al., 2008; Nagendra, 2009; Blanco-Libreros & Estrada-Urrea, 2015).

This study aims at bridging the gaps on mangroves socio-economic and cultural importance for coastal communities in Mauritius, with a focus on the eastern coastal areas and a multiple crisis context, using an ecosystem services (ES) framework. Implemented worldwide to assess the contributions made by the structure and function of ecosystems to human well-being (Millennium Ecosystem Assessment, 2005), the ecosystem services framework however faced strong criticism for its anthropocentric and utilitarian view of nature (Ridder, 2008; Redford & Adams, 2009; Fairhead et al., 2012; Raymond et al., 2013), and for the shortcomings of the evaluation methods, which have been mostly monetary (McCauley, 2006; Sagoff, 2008; Turnhout et al., 2013). Recognising these controversies, this study's approach encompasses socio-economic determinants of mangroves dependency for ecosystem services (Mallick et al., 2021), the linkage between ecosystem services, human well-being and mangroves dependency (Kadaverugu et al., 2021; Dawson & Martin, 2015), as well as the impact of internal and external events on mangrove dependency.

More specifically, during this study, the following research questions were investigated:

1. What are the current provisioning and socio-cultural services provided by mangroves in the east coast of Mauritius?
2. How are internal socio-economic determinants affecting community members' dependency on mangroves ecosystem services?
3. How is mangrove dependency for ecosystem services affected by external environmental and socio-
4. economic pressures?

2. MATERIAL AND METHODS

2.1. Study Sites

Mauritius is a volcanic tropical island located about 900 km east of Madagascar with a population of 1.3 million spread over 1,860 km² (Statistics Mauritius, 2022). The island's coastline stretches over 322 km², with a 233 km long reef fringing all but the southern coast of the island and constituting the island's prime touristic asset. The lagoon contains various patches of coral reef (163 coral species) (Fenner et al.,

2004), seagrass beds (nine species) and, closer to the shore, coastlines of sandy beaches, rocky zones, mud flats or mangroves (Hammond et al., 2015). The island's mangrove forests have been exploited in the past for firewood, construction and development purposes and for providing boat access (Anon, 1991 ; Cheke & Hume, 2010), with about 1.45 km² remaining (Bosire et al., 2015). They occur mainly on the Northeast, East and Southeast coast of Mauritius, some patches occur on the South–Southwest coasts (Appadoo, 2003) and Northwest coast (Cheke et al., 2020).

The chosen study sites are four villages (Fig. 1) located on the east-southeast coast of the island: Bambous Virieux (20°20'45"S-57°45'50"E), Bois des Amourettes (20°21'40"S-57°44'30"E), Trou d'Eau Douce (20°14'15"S-57°47'40"E) and Poste de Flacq (20°10'00"S-57°44'50"E). The study site selection has been made based on (i) the presence of numerous mangrove patches ii) the presence of fishing areas; (iii) the location of all the villages on the same coastline to produce local and regional analytic comparison; (iv) the proximity of household's numbers; (v) two of the villages impacted by the oil spills (Bambous Virieux and Bois des Amourettes), one low impacted village (Trou d'Eau Douce and one village which was not directly impacted by the oil spill (Poste de Flacq). The village of Trou d'Eau Douce which was traditionally a fishing village, is now a very popular touristic destination and retains small patches of mangroves on the coastline. In Poste de Flacq, fishing activities and oyster collection are still a main source of livelihood, as well as tourism, with a large mangrove cover near the eastern part of the village. In comparison, the villages of Bambous Virieux and Bois des Amourettes (referred afterwards as south-east villages) have not experienced similar growth of touristic resorts, staying more rural with households earning in the lower end of income-ranges. Mangroves are less abundant, and the inhabitants rely mostly on local fisheries and gleaning of marine products at low tide.

2.2. Data collection

The data used in this study was collected between August and November 2021. A mixed framework was implemented to gather both quantitative and qualitative data using household surveys. A survey-based non-monetary valuation approach was implemented to assess mangroves provisioning and socio-cultural services following similar studies in Brazil and in Bangladesh (e.g. de Souza Queiroz et al., 2017; Santos et al., 2017; Mallick et al., 2021). The study received Institutional Review Board approval (IRB #072121-1). All respondents consented to anonymously participate in this study with measures put in place to maintain confidentiality of the data.

The household survey followed a structured questionnaire approach. Under the supervision of the research team, a group of nine senior undergraduate and graduate students from the University of Mauritius helped with deploying the survey. They were trained through visioconference and in the field to implement the questionnaires and follow guidelines on ethical research using human subjects. The household survey is structured to collect (a) respondents' demographics; (b) perceptions of the impacts of the recent crises (i.e., the COVID-19 pandemic and the MV Wakashio oil spill) on their socio-economic situation; (c) their activities related to mangroves and fisheries; and (d) their perception on status and changes within mangroves. The survey questionnaire consists of both close-ended and open-ended questions.

Surveys were conducted in person, in Mauritian Creole (only one questionnaire was filled in English). A pre-test conducted with 30 households allowed for refinement of the survey instrument. Of the 490 households targeted, 281 questionnaires were fully completed while the rest were either incomplete or declined. Based on the last census (Statistics Mauritius, 2011), the survey accounted for 5.2% of Trou d'Eau Douce households (83 surveyed households for a total of 1,590), 5.0% of Poste de Flacq households (118 surveyed households for a total of 2,361) and 8.7% of the South-East villages households (80 surveyed households for a total of 921). Households were selected randomly by walking in different areas of each village and seeking participation from every third household encountered on each side of streets.

2.3. Data analysis

The survey data was encoded in Microsoft Excel and subjected to distribution analysis. To clarify results, the data on the mangroves-related activities, the perception of changes and the benefits of each village residency were systematised. An evaluation of the contributions of mangrove ecosystem services to human well-being was carried out. Eigenvalues were calculated through a multiple correspondence analysis (MCA) (function *MCA* package "FactoMineR" (Lê et al., 2008) using variables related to four cultural and provisioning categories of ecosystems contributions to human well-being: income generation, food support, medicinal use and support for recreational activities. Prior to the analysis, the household survey dataset was filtered to ensure completeness on all variables, resulting in 13 respondents' questionnaire data being discarded, and a total number of 268 observations for each variable. Based on the MCA eigenvalues, a score of mangroves contribution to each respondent's well-being was calculated and respondents were assigned to four levels of dependency: None; Low; Medium; High. A multinomial logistic regression was performed, using the function *multinom* package "nnet" (Ripley et al., 2016), to estimate the probabilities for individuals to reach different levels of mangroves contributions to their well-being using socio-economic characteristics as explanatory variables. Work conducted on Excel was complemented using R 3.6.1 software (using the RStudio platform) to run the distribution analysis, the MCA and the logistic regression analysis.

3. RESULTS

3.1 Demographics and socio-economic profiles

Table 1 provides the respondents' demographic and socio-economic data. The sex-ratio of the householders is close to 1:1, women are slightly overrepresented with 51.5% women and 48.5% men. A household size of five to eight persons was the most represented in the survey at 44.0% closely followed by a household size of three to four persons at 34.0%. The most represented monthly income range is between MUR 5,000 and MUR15,000 [1 EUR = 48.6 MUR as of 21:00PM UTC 05 Dec 2021] accounting for 57.1% of the investigated households, followed by the income range between MUR 15,001 and MUR 25,000 at 13.8%. In terms of education 44.8% of respondents studied up to 18 years old (secondary education), while 33.5% of respondents studied only up to 11 years old (primary education). Fewer respondents owned land (49.3%) than those who did not (50.7%). The majority of respondents (84.3%) had no socio-political role in their respective villages, while only 10.5% were involved in community outreach and 5.2% had an administrative or political role. Most respondents live between one and three km of a mangrove patch with proportions of 30.6% and 27.6% respondent' living between 100 to 500 m to a mangrove patch.

Table 1: Demographic and socio-economic characteristics of all surveyed respondents according to their respective inhabited village. The monthly income is given in Mauritian rupees (MUR) [1 EUR = 48.6 MUR as of 21:00PM UTC 05 Dec 2021].

Demographics and socio-economic variables	Categories	Proportion of respondents (in %)
Age	18–29 years old	13.8
	30–39 years old	12.7
	40–49 years old	19.0
	50–59 years old	25.8
	60 years old and above	28.7
Sex	Man	48.5
	Woman	51.5
Number of people in the household	One person	2.6
	Two persons	14.9
	3 to 4 persons	34.0
	5 to 8 persons	44.0
	More than 8 persons	4.5
Education level (based on ISCED – 2011)	No education	10.5
	Primary education	33.5
	Secondary education	44.8
	Tertiary education	11.2
Monthly income (MUR)	No income	9.0
	< 5,000	10.1
	5,000–15,000	57.1
	15,001–25,000	13.8
	> 25,000	10.1
Source of income decrease	No income decrease	49.3
	COVID-19 pandemic	31.3
	Wakashio oil spill	6.0
	Multiple related crisis	13.4
Land possession	Yes	49.3
	No	50.7
Role in the village	No role	84.3
	Administrative or political role	5.2
	Community outreach	10.5
Distance to a mangroves patch	Less than 100 m	13.8
	100 m to 500 m	27.6
	500 m to 1 km	17.2
	1 km to 3 km	30.6
	More than 3 km	10.8

3.2. Mangroves cultural and provisioning services

Recreational activities account for 65.2% of respondents' mangrove-based activities in Poste de Flacq, 43.4% in Trou d'Eau Douce and 32.5% in the South-East villages (Figure 2a). The recreational activities listed by respondents in open-ended format, are classified in different categories (Figure 2b), the 'Walks, visits and strolls' category being the most represented (34.1%), followed by the 'Leisure activities' category (13.2%) and the 'Take a break and socialize' category (6.1%). Figure 2a also shows that 50.0% and 45.8% of respondents have no activities in mangroves in the South-East villages and in Trou d'Eau Douce respectively, while this proportion is much lower in Poste de Flacq, accounting for 20.3%. No respondents are supported by mangroves for tourism activities in the South-East villages, while they account for 8.4% of the respondents in Trou d'Eau Douce and 4.2% in Poste de Flacq. Even if this activity is prohibited, 8.5% of the respondents in Poste de Flacq collect mangrove plant parts, while this proportion falls to 5% in the South-East villages and 3.6% in Trou d'Eau Douce. For fisheries-related activities in mangroves, the proportion of respondents collecting seafood in mangroves is higher in Poste de Flacq at 28.0%, compared to 22.5% in the South-East villages and 18.1% in Trou d'Eau Douce, and the proportion of respondents collecting fishing bait in mangroves is 20.0% in the South-East villages, 14.4% in Poste de Flacq and 10.8% in Trou d'Eau Douce. Fish collection is higher outside mangroves and in mixed areas outside and inside mangroves than exclusively in mangroves, respectively accounting for a proportion of 11.4%, 11.0% and 5.7% of the respondents (Figure 2c). The proportion of respondents collecting seafood other than fish from within mangroves is higher at 19.2% as compared to 1.4% outside mangroves and 0.4% in mixed areas. Mangroves support local fisheries with a wide variety of crustaceans, fish, molluscs and other invertebrates. The mean assessed quantity of fish collected in mangroves every week is 5.3 kg while the mean reported quantity of fish collected in other parts of the lagoon every week is 54.4 kg. Non-fish seafood collection is typically very low (less than one kg) and unreported.

Table 2: Mangroves dependency for ecosystem services contributions to the multiple correspondence analysis (MCA) as raw contributions and as weighted by eigenvalues contributions. The results are given in proportions (in %).

Mangroves dependency for ecosystem services variables	Contribution to the MCA (proportion in %)	Weighted by Eigenvalue (proportion in %)
Mangroves visit frequency	26.6	18.5
Fisheries activities in mangroves	5.6	9.1
Main income from fisheries in mangroves	9.0	8.3
Secondary income from fisheries in mangroves	6.0	8.2
Most seafood catches in mangroves	9.7	5.8
Direct alimentary dependency to mangroves	5.1	9.0
Indirect alimentary dependency to mangroves	3.9	8.1
Main income from tourism in mangroves	7.5	9.1
Secondary income from tourism in mangroves	8.8	9.1
Medicinal use of mangrove plants	7.6	5.8
Leisure activities in mangroves	10.3	8.9

Table 3: Estimated effects of the explanatory demographic, socio-economic and external events variables on the levels of mangroves dependency for ecosystem services using multinomial logistic regression.

Variables	Categories	Levels of mangroves contribution to human well-being								
		Low			Medium			High		
		Coefficient	RRR		Coefficient	RRR		Coefficient	RRR	
Age	18–29 years old (ref.)	-	-	-	-	-	-	-	-	-
	30–39 years old	1.25	(1.13)	3.49	-1.47	(1.40)	0.23	0.65	(1.42)	1.91
	40–49 years old	0.04	(1.02)	1.04	-0.82	(1.13)	0.44	-0.56	(1.27)	0.57
	50–59 years old	-0.17	(0.98)	0.85	-1.49	(1.07)	0.23	-1.38	(1.23)	0.25
	60 years old and above	-2.65	(1.32)	0.07	-2.98	(1.47)*	0.05	-4.24	(1.61)**	0.01
Sex	Man (ref.)	-	-	-	-	-	-	-	-	-
	Woman	0.74	(0.65)	2.09	1.90	(0.71)**	6.71	3.07	(0.81)***	21.45
Number of people in the household	One person (ref.)	-	-	-	-	-	-	-	-	-
	Two persons	1.52	(1.49)	4.56	14.21	(3.85)***	1.49e+6	16.09	(3.73)***	9.77e+6
	3 to 4 persons	3.02	(1.49)**	20.48	13.90	(3.82)***	1.09e+6	16.56	(3.69)***	1.55e+7
	5 to 8 persons	2.03	(1.45)	7.59	14.68	(3.82)***	2.37e+6	15.53	(3.70)***	5.53e+6
	More than 8 persons	15.58	(2.92)***	5.83e+6	28.83	(1.27)***	3.30e+9	30.11	(1.17)***	1.19e+13
Education level (based on ISCED – 2011)	No education (ref.)	-	-	-	-	-	-	-	-	-
	Primary	0.04	(1.03)	1.04	-0.85	(1.07)	0.43	0.11	(1.29)	1.12
	Secondary	0.74	(1.03)	2.09	-0.65	(1.13)	0.52	1.24	(1.35)	3.44
	Certificate	0.62	(1.54)	1.85	-1.62	(1.65)	0.20	0.08	(1.96)	1.08
	Diploma and above	-0.19	(1.46)	0.83	-3.45	(1.86)*	0.03	-27.62	(0.00)***	0.00
Monthly income (MUR)	No income (ref.)	-	-	-	-	-	-	-	-	-
	< 5,000	3.24	(1.90)	25.53	3.69	(2.32)	39.94	5.42	(2.42)**	225.55
	5,000–15,000	0.89	(1.12)	2.43	2.45	(1.67)	11.63	2.50	(1.79)	12.20
	15,001–25,000	1.64	(1.42)	5.17	2.05	(1.93)	7.77	2.09	(2.06)	8.09
	> 25,000	0.38	(1.63)	1.47	2.89	(2.06)	17.96	2.36	(2.22)	10.57
Source of income decrease	No income decrease (ref.)	-	-	-	-	-	-	-	-	-
	COVID-19 pandemic	0.89	(0.65)	2.43	0.62	(0.73)	1.85	-0.37	(0.86)	0.69

Variables	Categories	Levels of mangroves contribution to human well-being								
		Low			Medium			High		
		Coefficient	RRR		Coefficient	RRR		Coefficient	RRR	
	Wakashio oil spill	-1.08	(2.03)	0.34	-0.08	(2.15)	0.93	-0.87	(2.19)	0.42
	Multiple related crisis	2.95	(1.29)*	19.08	2.24	(1.32)*	9.42	2.72	(1.41)**	15.24
Land possession	Yes (ref.)	-		-	-		-	-		-
	No	1.22	(0.60)**	3.37	0.05	(0.65)**	1.05	1.57	(0.72)**	4.82
Role in the village	No role (ref.)	-		-	-		-	-		-
	Administrative or political role	22.45	(0.69)***	5.63e+9	22.09	(0.90)***	3.91e+9	22.35	(0.86)***	5.08e+6
	Community outreach	-0.83	(0.93)	0.43	0.87	(0.99)	2.38	0.37	(1.14)	1.45
Distance to a mangroves patch	< 100 m (ref.)	-		-	-		-	-		-
	100 m to 500 m	0.09	(1.21)	1.09	-0.96	(1.25)	0.38	0.34	(1.32)	1.41
	500 m to 1 km	1.32	(1.34)	3.75	-1.02	(1.42)	0.36	0.71	(1.48)	2.04
	1 km to 3 km	0.84	(1.28)	2.33	-0.68	(1.31)	0.51	-0.77	(1.40)	0.46
	> 3 km	4.44	(1.64)***	84.88	1.38	(1.73)	3.96	-0.07	(2.19)	0.93
Constant		-7.50	(4.38)*		-30.53	(12.09)**		-37.85	(11.88)***	
Akaike Inf. Crit.		624.14			624.14			624.14		
Ref.- Reference category; RRR- Relative Risk Ratio; Inf. Crit.- Information Criterion; *p < 0.10; **p < 0.05; ***p < 0.01; standard errors given within brackets.										

3.3. Mangrove's dependency to ecosystem services

The first five dimensions of the MCA accounted for 70.6% of the global variance. The variables' individual contributions to each dimension were summarised in a single numeric value, and these values were weighted according to the eigenvalues associated with each MCA dimension (Table 2). The variables with the strongest contribution to the MCA, after being weighted by the eigenvalues, are respectively 'Mangroves visit frequency' at 18.5%, 'Fisheries in mangroves' at 9.1% and 'Main income from mangroves tourism' at 9.1%. The variables 'Most fish catch in mangroves', at 5.8%, and 'Medicinal use of mangrove plants', at 5.8%, contributes the least to the MCA, and the respondents associated to these variables are underrepresented in the household survey. The weighted variables values were then used to attribute an individual score of mangroves ES contribution to each respondent's well-being.

3.4. Socio-economic determinants of mangroves dependency to ecosystem services

In the studied sample, 36.5% of respondents have no dependency to mangroves ecosystem services, 37.2% have a low level of dependency, 10.6% have a medium level of dependency and 15.7% have a high level of dependency. The logistic regression analysis shows that all the selected explanatory variables have a statistically significant influence on the dependency levels (Table 3). More specifically, respondents who are at least 60 years old are significantly less likely to reach a medium or high level of dependency ($P=0.07$; $P=0.04$) as compared to younger respondents. Female respondents have significantly greater likelihood to reach a medium or a high level of dependency ($P=0.02$; P

< 0.01) as compared to males, as well as respondents with an administrative or political role have to reach any level of dependency as compared to respondents those without any social or political role in the village. Household size also significantly increases the chance for a household to reach a medium or high level of dependency ($P < 0.01$ for all categories) to mangroves ES. There is a lesser chance for respondents with a diploma or higher education level to reach medium or high levels of dependency as compared to respondents without formal education. Respondents with a monthly income lower than 5,000 MUR have a significantly higher chance to reach a high level of dependency ($P = 0.04$), as well as respondents without land possession as compared to respondents possessing land for low, medium or high level of dependency ($P = 0.046$; $P = 0.01$; $P = 0.03$). Respondents living more than 3 km to mangroves have higher probability of low level of dependency when compared to respondents living less than 100 m from mangrove patches ($P = 0.04$). Respondents attesting to an income drop caused by multiple related crises have a statistically significantly higher chance to reach each level of mangroves dependency to ecosystem services as compared to respondents with no income drop ($P = 0.06$; $P = 0.095$; $P = 0.03$), while there is no significant probability difference for respondents impacted only by one crisis.

3.5. Perception of changes affecting mangroves and fisheries

A majority of respondents perceived a decrease in mangroves cover in all villages, accounting for 71.0% in Trou d'Eau Douce, 63.9% in the South-East villages and 51.7% in Poste de Flacq. The perceived changes in seafood quantity exhibit similar trends, with most respondents perceiving a decrease in seafood quantity in the last decade in all villages, accounting for proportions of 90.4% in Trou d'Eau Douce, 88.8% in the South-East villages and 72.0% in Poste de Flacq. Different reasons for the decreases in mangroves cover and seafood quantity are perceived, these results are presented in Fig. 3. In Trou d'Eau Douce 21.7% of respondents blame litter pollution and tourism for declines in seafood and mangrove area, while 30% of respondents in South-East villages and 25.4% in Poste de Flacq blame residents' activities. Tourism impact category is associated with the clearing of mangroves for the development of tourism infrastructures and the activities related to touristic tours and nautical activities. The resident's activities category includes mangroves clearing by local inhabitants, and local inhabitants' activities on the seashore. The Oil spill is strongly perceived as a reason for decline in mangrove cover by 13.8% of respondents in South-East villages, which have been categorised as highly impacted. Comparatively Poste de Flacq and Trou d'Eau Douce have been less impacted by the oil spill with only 1.7% and 1.2% of respondents respectively assigning it as a cause for mangrove declines. The most perceived reason for decrease in seafood quantity is litter pollution in Trou d'Eau Douce with 45.8% of responses, followed by South-East villages at 13.8% and Poste de Flacq at 13.6%. Poste de Flacq respondents cited fishing pressure (33.0%) while South-East villages (36.3%) and Trou d'Eau Douce (16.8%) respondents cited the Oil spill, as causes for declines in seafood quantity, though only 7.6% of Poste de Flacq respondents considered the oil spill a factor. In South-East villages and Trou d'Eau Douce, fishing pressure are frequently cited as a reason for reduced seafood quantity overall, with a proportion of 27.5% and 26.5% along with environmental changes at 31.3% and 32.5% respectively.

4. DISCUSSION

4.1. Mangroves ecosystem services

Mauritian mangroves, despite occupying only 0.07% of the island, support coastal communities with a wide range of services. Ecosystem services provided by mangroves to the studied villages play a major role in terms of cultural values, food security, fisheries support, income generation, human health and well-being, and intangible heritage value.

Recreational activities are the most cited mangrove-based activities in all villages, and therefore reveal a previously unreported cultural importance of mangroves on the east coast of Mauritius. Mangroves support leisure activities, like picnicking, leisure fishing or playing, as well as various social and cultural activities. Similar results have also been reported recently in Mayotte (Longépée et al., 2021). Even if not represented in the recreational activities survey results, the spiritual values associated to mangroves are physically embodied in the various shrines and other religious structures found in or near mangroves. The high proportion of respondents having recreational activities in mangroves suggests that even greater cultural services are provided by mangroves, as stated in other studies (James et al., 2013; de Souza Queiros et al., 2017; Pearson et al., 2019). Aesthetic values encompassed by mangrove landscapes likely play a role in the cultural services provided by the ecosystem, but more importantly support tourism for hotel scenery and tourist tours operators, even if it is a minor mangroves-related activity.

Seafood collection in mangroves is practised by roughly a quarter of all respondents, and more than 10% of each village respondents collect fishing bait in mangroves, highlighting the crucial role of this ecosystem for local fisheries and alimentary support, which echoes global literature (Manson et al., 2005; Santos et al., 2017; Zu Ermgassen et al., 2020). Mangroves plant parts collection is a minor activity in the surveyed area, and is practiced mainly for medicinal uses. These results contrast with another island of the region, Madagascar, where mangrove wood is harvested at a small scale for fuel and construction (Rakotonavalona et al., 2009; Scales & Friess, 2019), but seems similar with the case of Mayotte (Longépée et al., 2021). The minor use of mangrove plants parts in Mauritius is likely due to factors that

include environmental changes and the changes in lifestyle, in addition to the legislation meant at preventing such harvests as a means to protect remaining mangrove patches.

4.2. Socio-economic determinants of mangroves dependency for ecosystem services

The ecosystem services assessed through this study do not encompass regulation and support services, which are also provided by mangroves ecosystems (Vo et al., 2012; Barbier, 2017; Mitra, 2019), and could have increasing importance regarding Mauritius' vulnerability to climate change (Williams *et al.*, 2019; Boojhawon & Surroop, 2021). The focus on cultural and provisioning services helps to identify the linkages between individual dependencies to mangroves ecosystem services, and the impacted populations' socio-economic determinants, which constitute a major issue in light of economic and environmental crises (De Rosnay et al., 2021). Nearly two thirds of all respondents have low to high dependency on mangroves ecosystem services, when this ecosystem only covers small patches in three out of four surveyed villages, suggesting a disproportionate contribution of mangroves to human well-being and livelihoods where they occur.

Dependency on mangroves ecosystem services is strongly influenced by socio-economic parameters. Lower monthly incomes and the lack of assets like land, increase the chances for an individual to have a stronger level of dependency, as does a higher household size. On the other hand, higher education levels and being at least 60 years old increases the chances for individuals to have no dependencies on mangrove ecosystem services. These results align with another study in the Sundarbans, in Bangladesh (Mallick et al., 2021), and may similarly suggest that limited livelihood opportunities lead to a stronger dependency on mangroves ecosystem services and natural resources. A higher number of people in the household may be linked to scarcity issues, increasing the chances of natural resource extraction, but the linkages between natural resource collection and household livelihoods are complex and controversial (Barbier, 2010; Mildner et al., 2011; Angelsen et al., 2014; Robinson, 2016).

Women have a higher chance to experience higher levels of dependency on mangrove ecosystem services as compared to men. This result may be explained by a higher preponderance of women collecting seafood other than fish in the east and south-east coast villages of Mauritius (Naggea et al., 2021), a practice strongly associated to mangrove fisheries. In parallel to subsistence or artisanal mangrove-based fishing or seafood collection, women lack recognition of their contribution to the fishery sector, with only 35 out of 1,902 registered fishers listed as women (Naggea et al., 2021). At national scale, a feminisation of poverty is apparent in Mauritius and is likely to have been exacerbated by the COVID-19 pandemic, the MV Wakashio oil spill and their socio-economic consequences (De Rosnay et al., 2021).

4.3. Multiple crisis and mangroves dependency for ecosystem services

Multiple crises as a driver of drop in income is a significant factor of mangrove dependency for ecosystem services, while the MV Wakashio oil spill and the COVID-19 pandemic might have had lesser significant consequences had one occurred without the other. Our findings suggest a role for mangrove ecosystems in mitigating socio-economic and ecological crises in the studied area. Indeed, previous studies concur on the importance of ecosystem services during the COVID-19 pandemic (Grima et al., 2020; Beckmann-Wübbelt et al., 2021), supporting our findings that mangroves are essential for local livelihoods. The MV Wakashio oil spill had severe impacts on mangrove ecosystem and their related services (Gurumoorthi et al., 2021; Scarlett et al., 2021; Seveso et al., 2021), but generally, even when coastal ecosystem services are highly impacted by oil spills, they are not usually accounted for in impact assessments (Depellegrin and Blazauskas, 2012; Mayer et al., 2013; Kennedy and Cheong, 2013).

The Oil spill is the highest ranked perceived reason for seafood quantity decreases in the south-east villages, and the second perceived reason for mangrove cover decrease in the same area. On the other hand, residents in both Poste de Flacq and Trou d'Eau Douce attributed declines in mangrove cover to residents' activities, suggesting perceptions of a phenomenon with regional impacts, along with more locally-specific sources of changes affecting the ecosystem. Similar trends are apparent concerning the perceived reasons for declines in seafood quantities, the most cited one being litter pollution in Trou d'Eau Douce and fishing pressure in Poste de Flacq. Nevertheless, over half of the respondents perceive a decline in mangrove cover and 70% perceive a decline in seafood quantity in all villages. These results, even if a result of subjective risk perception when facing extreme events (Slovic and Weber, 2002; Lechowska, 2018), attest to a local apprehension regarding loss of mangrove ecosystems and their associated services at the national (Sobhee, 2004; Hammond et al., 2015; McClanahan & Muthiga, 2021) and global scales (Barnosky et al., 2011; Pievani, 2014; Ceballos et al., 2015).

4.4. Conclusion and perspectives

The multi-dimensional approach adopted in this study has revealed the complex interactions between mangrove ecosystems, coastal communities' livelihoods and well-being, and changes at a local and national scale. Mangroves provide multiple underreported provisioning and cultural services to surrounding inhabitants, and have a direct importance in building local and regional adaptation and resilience to stochastic events and climate change. This study provides novel insights in designing and implementing coastal management policies in

crisis contexts in insular environments. Socio-economic, ecological and climatic crises are expected to worsen rapidly in frequency and intensity in the coming decades (IPBES, 2019; IPCC, 2022), and SIDS like Mauritius, which are disproportionately vulnerable to these events, have an urgent need to implement mitigation and adaptation strategies for coastal areas (Scobie, 2019; Gheuens et al., 2019) both because they harbour centers of economic importance (ports, tourism) and are often home to marginalised populations. Households that are the most vulnerable to crisis and mangrove degradation, as reported locally (De Rosnay et al., 2021) and as this present study suggests, are the ones with limited livelihood opportunities. Cascading events may lead to increasing the number of households falling in poverty traps in the region. Management approaches such as nature-based solutions (Pontee et al., 2016; O'Hogain & McCarton, 2018; Ferreira et al., 2020) and co-management (Wallace et al., 2003; Glaser & da Silva Oliveira, 2004; Makino et al., 2009) may help take into account resource-users' and local inhabitants' constraints and needs in management policies, as well as mitigating the impacts of multiple crises through co-constructed resilience scenario implementation (McNamee et al., 2014; Benett et al., 2016).

Declarations

Acknowledgement

We are thankful to the University of Mauritius for hosting R. Merven during his Master thesis internship, in which this study was carried out. We would like to acknowledge the contribution of Parinishta CHUMMUN, Ophelie DUPRÉ, Sanjana RAMBOJUN, Laetitia LE BRETTE, Hemshika WOODIT, Winifred CASIMIR, Alice WONG TAI YUN, Visagen BEEMADOO, Vashist SOORUYAH to the household survey data collection. We would also like to kindly thank Fabiola MONTY, Josheena NAGGEA, François BAGUETTE and Shafiiq ABIB for their help, their advices and their decisive insights for our study implementation. We would finally like to thank all the people who participated to the household survey.

Ethical Approval

The study received Institutional Review Board approval (IRB #072121-1) from the University of Nebraska at Kearney.

Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Author's contributions

All authors contributed to the methodology design and implementation. Data was principally collected by RM. All authors contributed to the data analysis and the main manuscript text. All authors reviewed the manuscript.

Funding

This work was financially supported by the French Development Agency (UoM Code K0557).

References

1. Abib S. & Appadoo C. 2021. Local people and mangroves: Ecosystem perception and valuation on the south west coast of Mauritius. *Western Indian Ocean Journal of Marine Science*, 20(1), 11-19.
2. Alongi D.M. 2012. Carbon sequestration in mangrove forests. *Carbon Management*, 3(3), 313-322.
3. Alongi D.M. 2002. Present state and future of the world's mangrove forests. *Environmental Conservation*, 29(3), 331-349.
4. Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N.J., Bauch, S., ... & Wunder, S. 2014. Environmental income and rural livelihoods: a global-comparative analysis. *World Development*, 64, 12-28.
5. Anisimov A., Magnan A.K., & Duvat V.K. 2020. Learning from risk reduction pilot projects for enhancing long-term adaptation governance: The case of Mauritius Island (Indian Ocean). *Environmental Science & Policy*, 108, 93-103.
6. Anon. 1991. State of the Environment in Mauritius. *Ministry of Environment and Land Use. Government of Mauritius*, 3, 403.
7. Appadoo C. 2003. Status of mangroves in Mauritius. *Journal of Coastal Development*, 7(1), 1-4.
8. Bandaranayake W.M. 1998. Traditional and medicinal uses of mangroves. *Mangroves and Salt Marshes*, 2(3), 133-148.
9. Barbier, E.B. 2010. Poverty, development, and environment. *Environment and Development Economics*, 15(6), 635-660.
10. Barbier, E.B. 2017. Marine ecosystem services. *Current Biology*, 27(11), 507-510.

11. Barnosky A.D., Matzke N., Tomiya S., Wogan G.O., Swartz B., Quental T.B., Marshall C., McGuire J.L., Lindsey E.L., & Maguire K.C. 2011. Has the Earth's sixth mass extinction already arrived? *Nature*, 471(7336), 51-57.
12. Beckmann-Wübbelt, A., Fricke, A., Sebesvari, Z., Yakouchenkova, I. A., Fröhlich, K., & Saha, S. 2021. High public appreciation for the cultural ecosystem services of urban and peri-urban forests during the COVID-19 pandemic. *Sustainable Cities and Society*, 74, 103240.
13. Bennett, N. J., Kadfak, A., & Dearden, P. 2016. Community-based scenario planning: a process for vulnerability analysis and adaptation planning to social–ecological change in coastal communities. *Environment, Development and Sustainability*, 18(6), 1771-1799.
14. Blanco-Libreros J.F. & Estrada-Urrea E.A. 2015. Mangroves on the edge: Anthrome-dependent fragmentation influences ecological condition (Turbo, Colombia, Southern Caribbean). *Diversity*, 7(3) 206-228.
15. Boojhawon, A., & Surroop, D. 2021. Impact of climate change on vulnerability of freshwater resources: A case study of Mauritius. *Environment, Development and Sustainability*, 23(1), 195-223.
16. Bosire J.O., Mangora M.M., Bandeira S.O., Rajkaran A., Ratsimbazafy R., Appadoo C., & Kairo J.G. 2015. *Mangroves of the Western Indian Ocean: Status and management*.
17. Brondizio E.S., Settele J., Diaz S., & Ngo H.T. 2019. *IPBES: Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn, Germany: IPBES secretariat, 1148 p.
18. Ceballos G., Ehrlich P.R., Barnosky A.D., García A., Pringle R.M., & Palmer T.M. 2015. Accelerated modern human–induced species losses: Entering the sixth mass extinction. *Science Advances*, 1(5), 140-253.
19. Cheke A. & Hume J.P. 2010. *Lost land of the dodo: the ecological history of Mauritius, Réunion and Rodrigues*. T & AD Poyser, London.
20. Cheke A., Bissessur P., & Probst J. 2020. The Rivulet Terre Rouge Estuary, a Mauritian Ramsar Site for migrant shorebirds, sees a serious decline in bird numbers over 25 years. *Bulletin Phaeton*, 51, 50-63.
21. Cormier-Salem M.-C. 1994. *Dynamique et usages de la mangrove dans les pays des rivières du sud, du Sénégal à la Sierra Leone*. IRD Editions
22. Davidson N.C. 2014. How much wetland has the world lost? Long-term and recent trends in global wetland area. *Marine and Freshwater Research*, 65(10), 934-941.
23. Dawson N. & Martin A. 2015. Assessing the contribution of ecosystem services to human wellbeing: A disaggregated study in western Rwanda. *Ecological Economics*, 117, 62-72.
24. Depellegrin, D., & Blažauskas, N. 2013. Integrating ecosystem service values into oil spill impact assessment. *Journal of Coastal Research*, 29(4), 836-846.
25. De Rosnay A., Le Breton T., Naggea J., Seetah K., & Iranah P. 2021. *Social Impact Assessment of the compounding impacts of COVID-19 and the Wakashio oil spill*. Mauritius: Dynamia Associates & Developers, 100 p.
26. Donato, D. C., Kauffman, J. B., Murdiyarto, D., Kurnianto, S., Stidham, M., & Kanninen, M. 2011. Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience*, 4(5), 293-297.
27. Doney, S. C., Ruckelshaus, M., Emmett Duffy, J., Barry, J. P., Chan, F., English, C. A., ... & Talley, L. D. 2012. Climate change impacts on marine ecosystems. *Annual Review of Marine Science*, 4, 11-37.
28. Duke N.C., Meynecke J.-O., Dittmann S., Ellison A.M., Anger K., Berger U., Cannicci S., Diele K., Ewel K.C., & Field C.D. 2007. A world without mangroves? *Science*, 317(5834), 41-42.
29. Fairhead J., Leach M., & Scoones I. 2012. Green grabbing: A new appropriation of nature? *Journal of Peasant Studies*, 39(2), 237-261.
30. FAO. 2020. *Global Forest Resources Assessment 2020: Main report*. Rome, Italy: FAO, 184 p. Available at: <https://www.fao.org/documents/card/fr/c/ca9825en/> (Accessed 2 December 2021)
31. Fenner D., Clark T.H., Turner J.R., & Chapman B. 2004. A checklist of the corals of the island state of Rodrigues, Mauritius. *Journal of Natural History*, 38(23-24), 3091-3102.
32. Ferreira, V., Barreira, A. P., Loures, L., Antunes, D., & Panagopoulos, T. 2020. Stakeholders' engagement on nature-based solutions: A systematic literature review. *Sustainability*, 12(2), 640.
33. Florens, F.B.V. 2013. Conservation in Mauritius and Rodrigues: challenges and achievements from two ecologically devastated oceanic islands. *Conservation Biology: Voices from the tropics*, 40-50. Wiley Blackwell.
34. Florens, F.B.V., Baider, C., Seegoolam, N. B., Zmanay, Z., Strasberg, D. 2017. Long-term declines of native trees in an oceanic island's forests invaded by alien plants. *Applied Vegetation Science*, 20, 94-105.
35. Glaser, M., & da Silva Oliveira, R. 2004. Prospects for the co-management of mangrove ecosystems on the North Brazilian coast: Whose rights, whose duties and whose priorities? *Natural Resources Forum*. 28, (3), 224-233.

36. Gheuens, J., Nagabhatla, N., & Perera, E.D.P. 2019. Disaster-risk, water security challenges and strategies in Small Island Developing States (SIDS). *Water*, 11(4), 637.
37. Godoy M.D. & Lacerda L.D. de. 2015. Mangroves response to climate change: A review of recent findings on mangrove extension and distribution. *Anais da Academia Brasileira de Ciências*, 87, 651-667.
38. Gosling, W.D., de Kruif, J., Norder, S.J., de Boer, E.J., Hooghiemstra, H., Rijdsdijk, K.F., & McMichael, C.N. 2017. Mauritius on fire: Tracking historical human impacts on biodiversity loss. *Biotropica*, 49(6), 778-783.
39. Grima, N., Corcoran, W., Hill-James, C., Langton, B., Sommer, H., & Fisher, B. 2020. The importance of urban natural areas and urban ecosystem services during the COVID-19 pandemic. *PloS One*, 15(12), e0243344.
40. Gu, Y., Onggo, B. S., Kunc, M. H., & Bayer, S. 2022. Small Island Developing States (SIDS) COVID-19 post-pandemic tourism recovery: A system dynamics approach. *Current Issues in Tourism*, 25(9), 1481-1508.
41. Gurib-Fakim A. & Brendler T. 2004. *Medicinal and aromatic plants of Indian Ocean Islands: Madagascar, Comoros, Seychelles and Mascarenes*. Medpharm GmbH Scientific Publishers.
42. Gurumoorthi K., Suneel V., Rao V.T., Thomas A.P., & Alex M.J. 2021. Fate of MV Wakashio oil spill off Mauritius coast through modelling and remote sensing observations. *Marine Pollution Bulletin*, 172, 112892.
43. Hammond D.S., Gond V., Baider C., Florens F.B.V., Persand S., & Laurance S.G.W. 2015. Threats to environmentally sensitive areas from peri-urban expansion in Mauritius. *Environmental Conservation*, 42(3), 256-267.
44. Himes-Cornell A., Pendleton L., & Atiyah P. 2018. Valuing ecosystem services from blue forests: A systematic review of the valuation of salt marshes, sea grass beds and mangrove forests. *Ecosystem Services*, 30, 36-48.
45. Hogarth P.J. 2015. *The biology of mangroves and seagrasses*. Oxford University Press.
46. IPCC, 2022. *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegria, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press.
47. IPBES, 2022. *Summary for policymakers of the methodological assessment of the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. [U. Pascual, P. Balvanera, M. Christie, B. Baptiste, D. González-Jiménez, C.B. Anderson, S. Athayde, R. Chaplin-Kramer, S. Jacobs, E. Kelemen, R. Kumar, E. Lazos, A. Martin, T.H. Mwampamba, B. Nakangu, P. O'Farrell, C.M. Raymond, S.M. Subramanian, M. Termansen, M. Van Noordwijk, A. Vatn (eds.)] IPBES secretariat, Bonn, Germany. 37 p.
48. James G.K., Adegoke J.O., Osagie S., Ekechukwu S., Nwilo P., & Akinyede J. 2013. Social valuation of mangroves in the Niger Delta region of Nigeria. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 9(4), 311-323.
49. Kadaverugu R., Dhyani S., Dasgupta R., Kumar P., Hashimoto S., & Pujari P. 2021. Multiple values of Bhitarkanika mangroves for human well-being: Synthesis of contemporary scientific knowledge for mainstreaming ecosystem services in policy planning. *Journal of Coastal Conservation*, 25(2), 1-15.
50. Kelman, I., Ayeb-Karlsson, S., Rose-Clarke, K., Prost, A., Ronneberg, E., Wheeler, N., & Watts, N. 2021. A review of mental health and wellbeing under climate change in small island developing states (SIDS). *Environmental Research Letters*, 16(3), 033007.
51. Kennedy, C.J., & Cheong, S.M. 2013. Lost ecosystem services as a measure of oil spill damages: A conceptual analysis of the importance of baselines. *Journal of Environmental Management*, 128, 43-51.
52. Kim, N. 2020. *How long will it take for LDCs and SIDS to recover from the impacts of COVID-19?* United Nations, Department of Economic and Social Affairs.
53. Laurance S.G., Baider C., Florens F.B.V., Ramrekha S., Sevathian J.-C., & Hammond D.S. 2012. Drivers of wetland disturbance and biodiversity impacts on a tropical oceanic island. *Biological Conservation*, 149(1), 136-142.
54. Lê, S., Josse, J. & Husson, F. 2008. FactoMineR: An R Package for Multivariate Analysis. *Journal of Statistical Software*, 25(1), 1-18.
55. Lechowska, E. 2018. What determines flood risk perception? A review of factors of flood risk perception and relations between its basic elements. *Natural Hazards*, 94(3), 1341-1366.
56. Longépée E., Ahmed Abdallah A., Jeanson M., & Golléty C. 2021. Local Ecological Knowledge on mangroves in Mayotte Island (Indian Ocean) and Influencing Factors. *Forests*, 12(1), 53.
57. Makino M., Matsuda H., & Sakurai Y. 2009. Expanding fisheries co-management to ecosystem-based management: a case in the Shiretoko World Natural Heritage area, Japan. *Marine Policy*, 33(2), 207-214.
58. Mallick B., Priodarshini R., Kimengsi J.N., Biswas B., Hausmann A.E., Islam S., Huq S., & Vogt J. 2021. Livelihoods dependence on mangrove ecosystems: Empirical evidence from the Sundarbans. *Current Research in Environmental Sustainability*, 3, 100077.

59. Mamoun C.M., Nigel R., & Rughooputh S.D. 2013. Wetlands' inventory, mapping and land cover index assessment on Mauritius. *Wetlands*, 33(4), 585-595.
60. Manson F.J., Loneragan N.R., Skilleter G.A., & Phinn S.R. 2005. An evaluation of the evidence for linkages between mangroves and fisheries: a synthesis of the literature and identification of research directions. *Oceanography and Marine Biology*, 493-524.
61. Mayer, L. A., Boufadel, M. C., Brenner, J., Carne, R. S., Cooper, C. K., & Deming, J. W. 2013. An ecosystem services approach to assessing the impacts of the deepwater horizon oil spill in the Gulf of Mexico. *Report Brief. Washington, DC: National Academy of Sciences*.
62. McCauley D.J. 2006. Selling out on nature. *Nature*, 443(7107), 27-28.
63. McClanahan, T.R., & Muthiga, N.A. 2021. Oceanic patterns of thermal stress and coral community degradation on the island of Mauritius. *Coral Reefs*, 40(1), 53-74.
64. McNamee, K., Wisheropp, E., Weinstein, C., Nugent, A., & Richmond, L. 2014. Scenario planning for building coastal resilience in the face of sea level rise: The case of Jacobs Avenue, Eureka, CA. *Humboldt Journal of Social Relations*, 36, 145-173.
65. Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being: Synthesis*. Washington DC: Island Press, 155 p.
66. Mildner, S. A., Lauster, G., & Wodni, W. 2011. Scarcity and abundance revisited: A literature review on natural resources and conflict. *International Journal of Conflict and Violence*, 5(1), 155-172.
67. Mitra A. 2020. Ecosystem services of mangroves: An overview. *Mangrove Forests in India*, p. 1-32.
68. Nagendra H. 2009. Reforestation and regrowth in the human dominated landscapes of South Asia. *Reforesting Landscapes*, Springer, 149-174.
69. Naggea J., Wiehe E., & Monroe S. 2021. Inequity in unregistered women's fisheries in Mauritius following an oil spill. *SPC Women in Fisheries Information Bulletin*, 33, 50-55.
70. O'Hogain, S., & McCarton, L. 2018. Nature-based solutions. *A Technology Portfolio of Nature Based Solutions*, Springer, 1-9.
71. Ollivier L. 1993. Les pêches artisanales mauriciennes. Mutations récentes d'une activité séculaire. *Les Cahiers d'Outre-Mer*, 46(183), 325-348.
72. Pearson J., McNamara K.E., & Nunn P.D. 2019. Gender-specific perspectives of mangrove ecosystem services: Case study from Bua Province, Fiji Islands. *Ecosystem Services*, 38, 100970.
73. Pievani T. 2014. The sixth mass extinction: Anthropocene and the human impact on biodiversity. *Rendiconti Lincei*, 25(1), 85-93.
74. Pontee, N., Narayan, S., Beck, M.W., & Hosking, A.H. 2016. Nature-based solutions: Lessons from around the world. In *Proceedings of the Institution of Civil Engineers-Maritime Engineering*, 169(1), 29-36.
75. Rakotonavalona D., Renoux E., & Noel J. 2009. Traditional and modern uses of mangrove forest along northwest coast of Madagascar: Towards a sustainable management. *WIOMSA Scientific Symposium, 6th edition*.
76. Raymond C.M., Singh G.G., Benessaiah K., Bernhardt J.R., Levine J., Nelson H., Turner N.J., Norton B., Tam J., & Chan K.M. 2013. Ecosystem services and beyond: Using multiple metaphors to understand human-environment relationships. *BioScience*, 63(7), 536-546.
77. Redford K.H. & Adams W.M. 2009. Payment for ecosystem services and the challenge of saving nature. *Conservation Biology*, 23, 785-787.
78. Reyes-Arroyo N., Camacho-Valdez V., Saenz-Arroyo A., & Infante-Mata D. 2021. Socio-cultural analysis of ecosystem services provided by mangroves in La Encrucijada Biosphere Reserve, southeastern Mexico. *Local Environment*, 26(1), 86-109.
79. Ridder B. 2008. Questioning the ecosystem services argument for biodiversity conservation. *Biodiversity and Conservation*, 17(4), 781-790.
80. Ripley, B., Venables, W., & Ripley, M.B. 2016. Package 'nnet'. *R package version*, 7(3-12), 700.
81. Robinson, E.J. 2016. Resource-dependent livelihoods and the natural resource base. *Annual Review of Resource Economics*, 8, 281-301.
82. Robinson, S.A. 2020. Climate change adaptation in SIDS: A systematic review of the literature pre and post the IPCC Fifth Assessment Report. *Wiley Interdisciplinary Reviews: Climate Change*, 11(4), e653.
83. Sagoff M. 2008. On the economic value of ecosystem services. *Environmental Values*, 17(2), 239-257.
84. Sandilyan S. & Kathiresan K. 2015. Mangroves as bioshield: An undisputable fact. *Ocean & Coastal Management*, 103, 94-96.
85. Santos L.C.M., Gasalla M.A., Dahdouh-Guebas F., & Bitencourt M.D. 2017. Socio-ecological assessment for environmental planning in coastal fishery areas: A case study in Brazilian mangroves. *Ocean & Coastal Management*, 138, 60-69.
86. Scales I.R. & Friess D.A. 2019. Patterns of mangrove forest disturbance and biomass removal due to small-scale harvesting in southwestern Madagascar. *Wetlands Ecology and Management*, 27(5), 609-625.

87. Scarlett A.G., Nelson R.K., Gagnon M.M., Holman A.I., Reddy C.M., Sutton P.A., & Grice K. 2021. MV Wakashio grounding incident in Mauritius 2020: The world's first major spillage of Very Low Sulfur Fuel Oil. *Marine Pollution Bulletin*, 171, 112917.
88. Scobie, M. 2019. Sustainable development and climate change adaptation: Goal interlinkages and the case SIDS. *Dealing with climate change on small islands: Towards effective and sustainable adaptation?* 101.
89. Seveso D., Louis Y.D., Montano S., Galli P., & Saliu F. 2021. The Mauritius oil spill: What's next? *Pollutants*, 1(1), 18-28.
90. Slovic, P., & Weber, E. U. 2002. Perception of risk posed by extreme events. *Regulation of Toxic Substances and Hazardous Waste (2nd edition)*(Applegate, Gabba, Laitos, and Sachs, Editors), Foundation Press.
91. Sobhee, S. K. 2004. Economic development, income inequality and environmental degradation of fisheries resources in Mauritius. *Environmental Management*, 34(1), 150-157.
92. Soondron S. 2010. Coastal livelihoods in the Republic of Mauritius. *NOSF Forum, University of Mauritius*, 84 p.
93. de Souza Queiroz L., Rossi S., Calvet-Mir L., Ruiz-Mallén I., García-Betorç S., Salvà-Prat J., & de Andrade Meireles A.J. 2017. Neglected ecosystem services: Highlighting the socio-cultural perception of mangroves in decision-making processes. *Ecosystem Services*, 26, 137-145.
94. Spalding M.D. & Leal M. 2021. The State of the World's Mangroves 2021. *Global Mangrove Alliance*, 41 p.
95. Statistics Mauritius. 2022. *International Travel and Tourism Highlights for year 2021*. Available at: https://statsmauritius.govmu.org/Pages/Statistics/ESI/Tourism/Tourism_Yr21.aspx (Accessed 9.7.2022).
96. Statistics Mauritius. 2011. *General National Statistics and index for year 2022*. Available at: <https://statsmauritius.govmu.org/SitePages/Index.aspx> (Accessed 9.7.2022).
97. Statistics Mauritius. 2011. *Census 2011*. Available at: <https://statsmauritius.govmu.org/Pages/Censuses%20and%20Surveys/Census-2011.aspx> (Accessed 12.7.2021).
98. Terauds K., Zhuawu C. 2021. Identifying alternative economic development strategies for diverse SIDS. United Nations Conference on Trade and Development, background material for the seminar on « Building economic resilience in small island developing States ». Available at:
99. <https://unctad.org/meeting/seminar-building-economic-resilience-small-island-developing-states>
100. Turnhout E., Waterton C., Neves K., & Buizer M. 2013. Rethinking biodiversity: from goods and services to « living with ». *Conservation Letters*, 6(3), 154-161.
101. Uddin M.S., Shah M.A.R., Khanom S., & Nesha M.K. 2013. Climate change impacts on the Sundarbans mangrove ecosystem services and dependent livelihoods in Bangladesh. *Asian Journal of Conservation Biology*, 2(2), 152-156.
102. United Nations Development Program. 2015. *The Millennium Development Goals Report 2015*.
103. UNEP E.A. 2014. *United Nations Environment Programme: report of the United Nations Environment Assembly of the United Nations Environment Programme*. Nairobi : United Nations Environment Assembly
104. Vo Q.T., Künzer C., Vo Q.M., Moder F., & Oppelt N. 2012. Review of valuation methods for mangrove ecosystem services. *Ecological Indicators*, 23, 431-446.
105. Wallace J.S., Acreman M.C., & Sullivan C.A. 2003. The sharing of water between society and ecosystems: From conflict to catchment-based co-management. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 358(1440), 2011-2026
106. Walters B.B., Rönnbäck P., Kovacs J.M., Crona B., Hussain S.A., Badola R., Primavera J.H., Barbier E., & Dahdouh-Guebas F. 2008. Ethnobiology, socio-economics and management of mangrove forests: A review. *Aquatic Botany*, 89(2), 220-236.
107. Wheeler, T., & Von Braun, J. 2013. Climate change impacts on global food security. *Science*, 341(6145), 508-513.
108. Williams, D.S., Rosendo, S., Sadasing, O., & Celliers, L. 2020. Identifying local governance capacity needs for implementing climate change adaptation in Mauritius. *Climate Policy*, 20(5), 548-562.
109. Zu Ermgassen P.S., Mukherjee N., Worthington T.A., Acosta A., da Rocha Araujo A.R., Beitz C.M., Castellanos-Galindo G.A., Cunha-Lignon M., Dahdouh-Guebas F., & Diele K. 2020. Fishers who rely on mangroves: Modelling and mapping the global intensity of mangrove-associated fisheries. *Estuarine, Coastal and Shelf Science*, 247, 106975.
110. Kundzewicz, Z. W., Krysanova, V., Benestad, R. E., Hov, Ø., Piniewski, M., & Otto, I. M. 2018. Uncertainty in climate change impacts on water resources. *Environmental Science & Policy*, 79, 1-8.

Figures

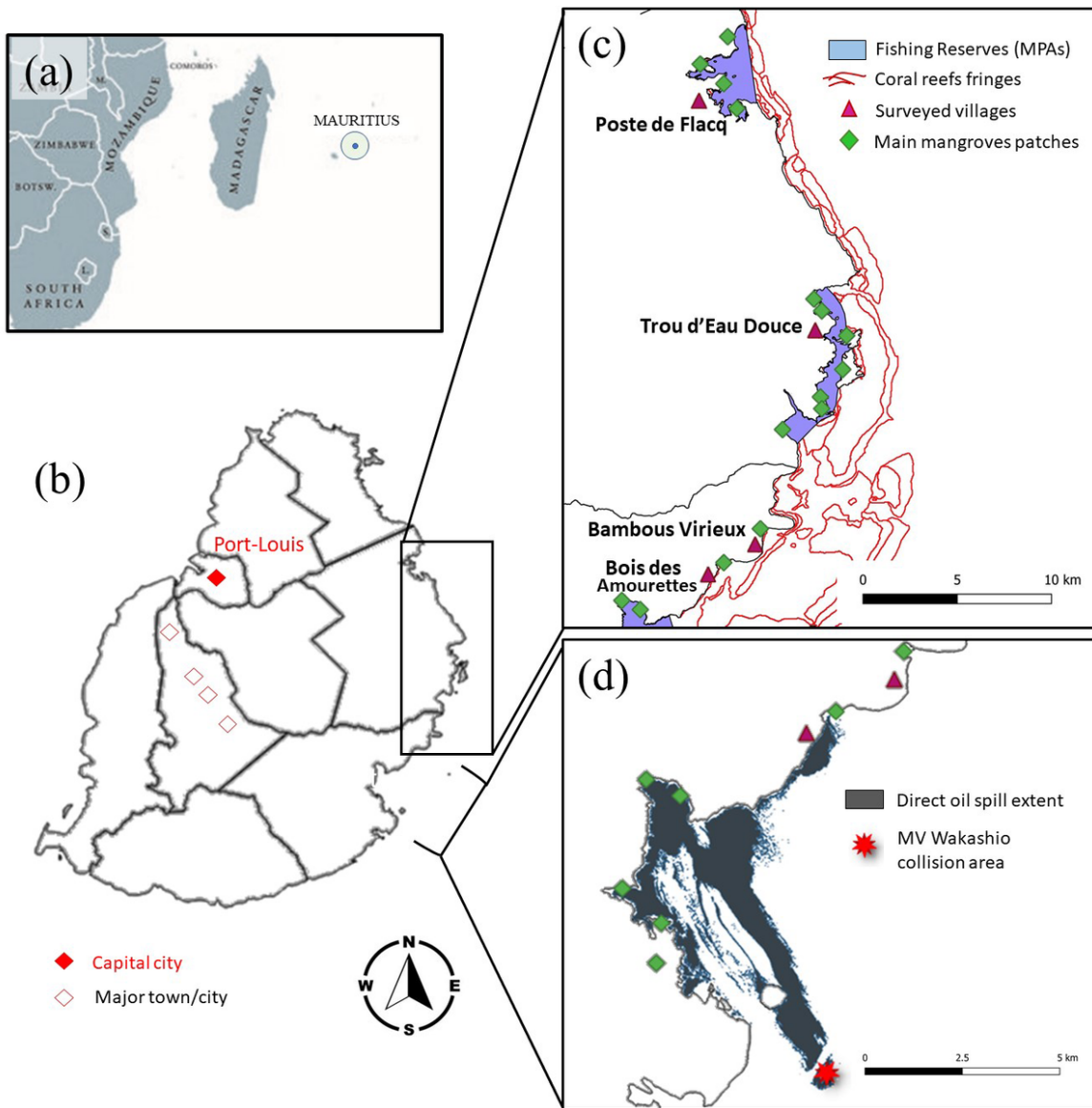


Figure 1

Maps showing (a) the position of Mauritius in the Western Indian Ocean; (b) Mauritius main island and its district administrative division; (c) the surveyed parts of the east coast and (d) the extent of oil spill following the MV Wakashio shipwreck (spatial data taken from: <https://unitar.org/maps/map/3097>). The data on coral reef extent and protected marine areas followed respectively UNEP-WCMC, 2021a and 2021b, mangroves patches were situated following Mamoun et al. (2013) and Hammond et al. (2015).

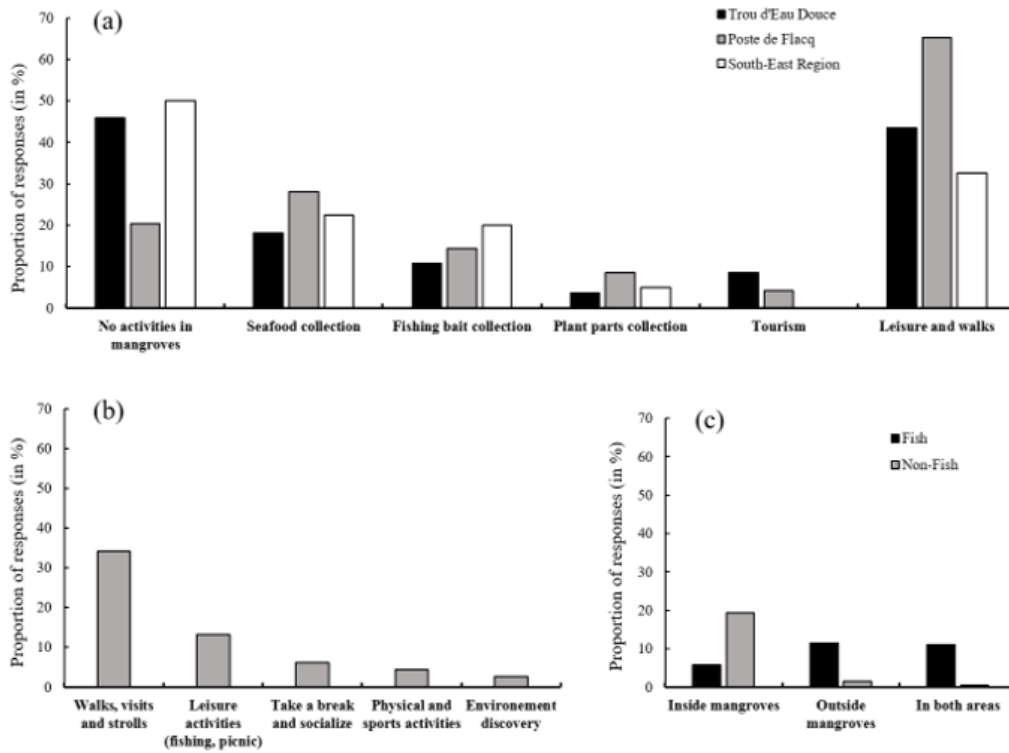


Figure 2

The proportion of responses in % depending on (a) the type of mangroves-related activity practiced in each village, (b) the type of recreational activity in mangroves and (c) the type of fishing activity in different area of seafood collection and depending on the seafood type (n=268).

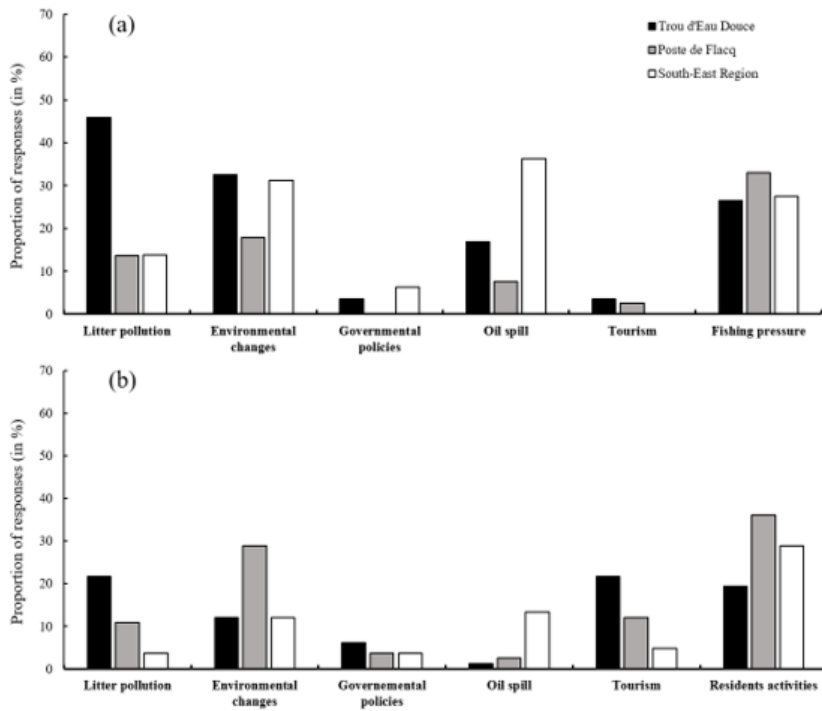


Figure 3

Proportion of responses in % in each village according to (a) the perceived reason for mangroves cover decrease and (b) the perceived reason for seafood quantity decrease (n=268). Each respondent may have given no answer, or one answer, or multiple answers.