Exploring Indirect Environmental Risks That Impact Coral Reef Tourism In The East African Marine Ecoregion

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Abstract The east coast of Africa is renowned as an adventure tourism getaway destination and scuba dive tourists from around the world frequent the region to dive on its pristine coral reefs. Environmental change, however, is becoming a key driver for dive tourists' decisions to travel, and these tourists are avoiding areas where coral reefs are no longer pristine. Indirect environmental risks, occurring outside the borders of countries and outside the control of dive operators, impact on coral reef tourism within those countries and on the greater Blue Economy. Indirect environmental risks include climate change, industrialisation of coastal regions, increased shipping and boating activities, as well as marine and land-based pollution. This paper reports on the perceptions of dive operators on the indirect environmental risks which threaten the future of the dive tourism industry in the East African Marine Ecoregion. The research followed an exploratory and descriptive research design within a post-positivism paradigm. Via purposive sampling, surveys were conducted with 34 dive operators from Kenya, Tanzania, Mozambique and South Africa. Research findings indicate two overall areas of concern impacting on coral reefs – activities relating to climate change, followed by coastal development and industrialisation of coastal areas. In terms of specific indirect risks, marine pollution is significant, followed by coral bleaching and extreme weather events. There is an increasing level of concern that continued environmental disturbances will impact on business in future. This is not just a problem for the coastal tourism industry, but also for coastal communities who share this precious resource. It is vital to cast a spotlight on the turbulent waters of environmental risks, which ultimately affect the sustainability of marine tourism and wider Blue Economy. By doing so, regional plans can be shaped to respond to these threats in a more discerning way.

Keywords
Dive operators; East African Marine Ecoregion; Environmental change; Indirect environmental risks; Marine tourism; Scuba diving industry.

JEL Classification Q53 · Q54 · Z31 · Z32

1. Introduction

"*Code red for humanity*"! The August 2021 report released by the Intergovernmental Panel on Climate Change (IPCC) has triggered global shock waves, reporting that some aspects of climate change are irreversible (De Ferrer, 2021:1). Humanity's ecological footprint remains deeply unsustainable. The World Wide Fund for Nature's (WWFs) Living Planet Index continues to decline, showing an average decrease of 68% in population sizes of animals and fishes between 1970 and 2016 (WWF, 2020). The most recent report on our ocean's states that "*overfishing, pollution and coastal development, among other pressures, have impacted the entire ocean, from shallow waters to the deep sea, and climate change will continue to cause a growing spectrum of effects across marine ecosystems*" (WWF, 2020:70). Moreover, the effects of such environmental changes, such as the 2016 El Niño which caused the coral bleaching of Australia's Great Barrier Reef caused a mere 67% coral mortality rate, resulting in a dramatic drop in dive tourism numbers in the region (Coral Reef Studies, 2016; Smee, 2018).

Marine tourism is one of the fastest growing sub-sectors of the marine industry and is expected to be the largest contributor to the global ocean economy (Dwyer, 2018). Marine tourism can be defined as recreational activities who's focus is based on the marine environments such as coral reefs (Orams, 1999). Scuba diving is an important component of marine tourism and has become a key recreational activity in the East African Marine Ecoregion (EAME). Dive operators are located close to areas where dive tourists can access coral reefs and offer services that facilitate the scuba diving experience such as diving courses, scuba equipment, accommodation, and boating fleets to get to the reefs.

Coral reefs are the primary nautical assets for dive tourism. Yet, they are influenced by the continued barrage of environmental disturbances, which affects their ability to adapt to such changes (Buddemeier et al., 2004; Richmond, 2011). Environmental risk, in the context of coral reefs, concerns changes to the environment around which corals thrive that are influenced by environmental disturbances, and the coral reef and supporting ecosystem's ability to endure such changes. Indirect environmental risks, which form the focus of this paper, are those that occur further afield outside the borders of countries and outside the control of dive operators.

These risks compromise the quality of the tourist experience (Hinch & Higham, 2011). Once tourists perceive a degraded destination image, this will have implications on dive tourism, as these businesses depend on dive tourists being able to experience pristine reefs.

The dire situation has prompted the discussion of contemplating a reality without coral reefs. It is therefore essential to have an in-depth understanding of environmental risks. Part of this is the category of indirect environmental risks. This paper therefore reports on the perceptions of dive operators on the indirect environmental risks which threaten the future of the dive tourism industry in the East African Marine Ecoregion (EAME).

The paper commences with a literature review on indirect risks, followed by a description of the study area and methodology. The results are then presented and discussed. The paper ends with a conclusion and reflections on mitigating indirect environmental risks.

2. Literature Review

The literature review focuses on indirect environmental risks that affect the health of coral reef ecosystems and will consequently result in a poor experience for dive tourists. This affects the destination image, which will ultimately negatively impact dive operator's businesses in the region. Climate change and coral reefs will be discussed first, followed by coastal development and coral reefs.

2.1. Climate Change and Coral Reefs

Climate change refers to a change of climate which is attributed directly or indirectly to human activity that changes the composition of the global atmosphere and is observed over comparable time periods (UNFCCC, 1992). Climate change has far-reaching implications for the health and functioning of coral reef ecosystems (Anthony & Marshall, 2009; Hughes et al., 2003). Burke et al. (2011) suggest that the state of coral in the Indian Ocean has shown significant decline as a result of anthropogenic and climate-related episodes, where as much as 68% of coral reefs are under threat. Research has indicated that climate change in ocean temperatures could effectively kill off most hard coral species by mid-century, with unknown consequences for remaining coral communities (Wilkinson, 2008).

The effects of climate change on coral reefs and their associated ecosystems also threaten the coastal communities that derive benefits from the coral reefs themselves (Buddemeier et al., 2004; Burke et al., 2011; Gössling et al., 2008). The scuba diving industry will also be affected by coral mortality, as divers are less inclined to visit dive sites in areas where the once pristine marine environment has been degraded.

Climate change-related episodes include coral bleaching, extreme weather events, sea-level rise and ocean acidification. Each of these is discussed in turn below.

Coral Bleaching and Sea Surface Temperature (SST) Rise

Scientists observe coral bleaching to be one of the most destructive forces on coral reefs in the Western Indian Ocean. Rising sea surface temperatures appear to be the primary cause of mass coral bleaching events (Australia, 2016; Celliers & Schleyer, 2002; Cesar et al., 2003; Hoegh-Guldberg, 1999; Obura, 2017). In 2015 and 2016, ocean temperatures reached their highest levels, making it one of the strongest El Niño events ever recorded causing overall global warming (NOAA, 2016). Mass bleaching events are thought to have only occurred every decade or century prior to the 1980s, but from 1982 to the present, coral bleaching events worldwide have increased in frequency and are expected to increase to near-annual frequency in the next 20 to 50 years (Sealey-Baker, 2010).

Extreme Weather Events

Rising global average temperature is associated with widespread changes in weather patterns. Scientific studies indicate that extreme weather events such as heat waves and large storms are likely to become more frequent or more intense with human-induced climate change (Burke et al., 2011). A recent study by Fischer & Knutti (2015) suggests that the effects of warming will vary around the world. Tropical storms are also predicted to change in strength and frequency, as a result of rising sea surface temperatures (Knuston et al., 2008). Damaged corals will not be able to recover in time as frequent storms erode the coral reef structures, reducing reef resilience and damaging marine ecosystems (Perkins et al., 2012; Rahmstorf & Coumou, 2011; Wilkinson & Souter, 2008).

Sea-level Rise

Sea-level rise causes submergence and flooding of coastal land and erosion of beaches and near-shore developments (Ibe & Awosika, 1991; IPCC, 2007; Nicholls & Cazaneve, 2010). Long-term effects would include increased erosion of coastal zones; reduced ability of coral reef algae to adapt to lower levels of light; the reduction of coastal wetlands, saltmarshes, and mangroves; and changes in coastal development and infrastructure (Burke et al., 2011; Richmond, 2011). It also affects coral's ability to adapt to other changes, such as coral bleaching and coral disease (Kleypas et al., 1999).

Ocean Acidification

Coral reefs mortality increases as a result of ocean acidification (Jury et al., 2010). The increase in anthropogenic CO^2 since the beginning of the industrial revolution has led to the ocean becoming more acidic. This decreases habitat quality and diversity, and the reefs' ability to absorb wave energy, which is instrumental for coastal protection (Richmond, 2011). Reduced effectiveness of coral reefs is detrimental to coastal populations, as fish species may decline as the reefs die. It also has dire implications on dive tourism, as businesses depend on dive tourists being able to experience healthy reefs.

2.2. Coastal Development and Coral Reefs

Africa's marine and coastal resources have traditionally supported livelihoods through artisanal fisheries and subsistence agriculture. At present, the EAME is experiencing rapid urban and industrial growth, with the development of harbours and ports, urbanisation, industrial fisheries, oil and gas exploration and tourism (Kitheka et al., 2011). Much of the region's natural coastal assets have supported a growth in tourism, bringing substantial economic benefits to local communities.

Marine Pollution: Land-Based Pollutants, Micro-Plastics and Floating Marine Debris

Indirect environmental effects resulting from marine pollution have various sources, some of which are land-based and others originating deep in the ocean. Sources of pollution are difficult to establish given that contaminants often travel far distances before they settle on or near coral reefs where they are likely to do harm. Sources include land-based run-off such as industrial and agricultural waste, and ocean-based pollution from shipping and boating activities resulting in marine debris and plastics (Obura, 2017; Richmond, 2011). Increased tourism and recreational activity is also a source, with additional sediments and chemicals such as effluents, bilge water and engine oil from boats and cruise ships (Danovaro et al., 2008).

Industrialisation of Coastal Regions

Rapid urbanisation of coastal regions in the EAME causes loss of biodiversity, habitat degradation, and the modification of mangrove and coral reef ecosystems to make provision for industrial growth (Burke et al., 2011; Pereira et al., 2014; Richmond, 2011).

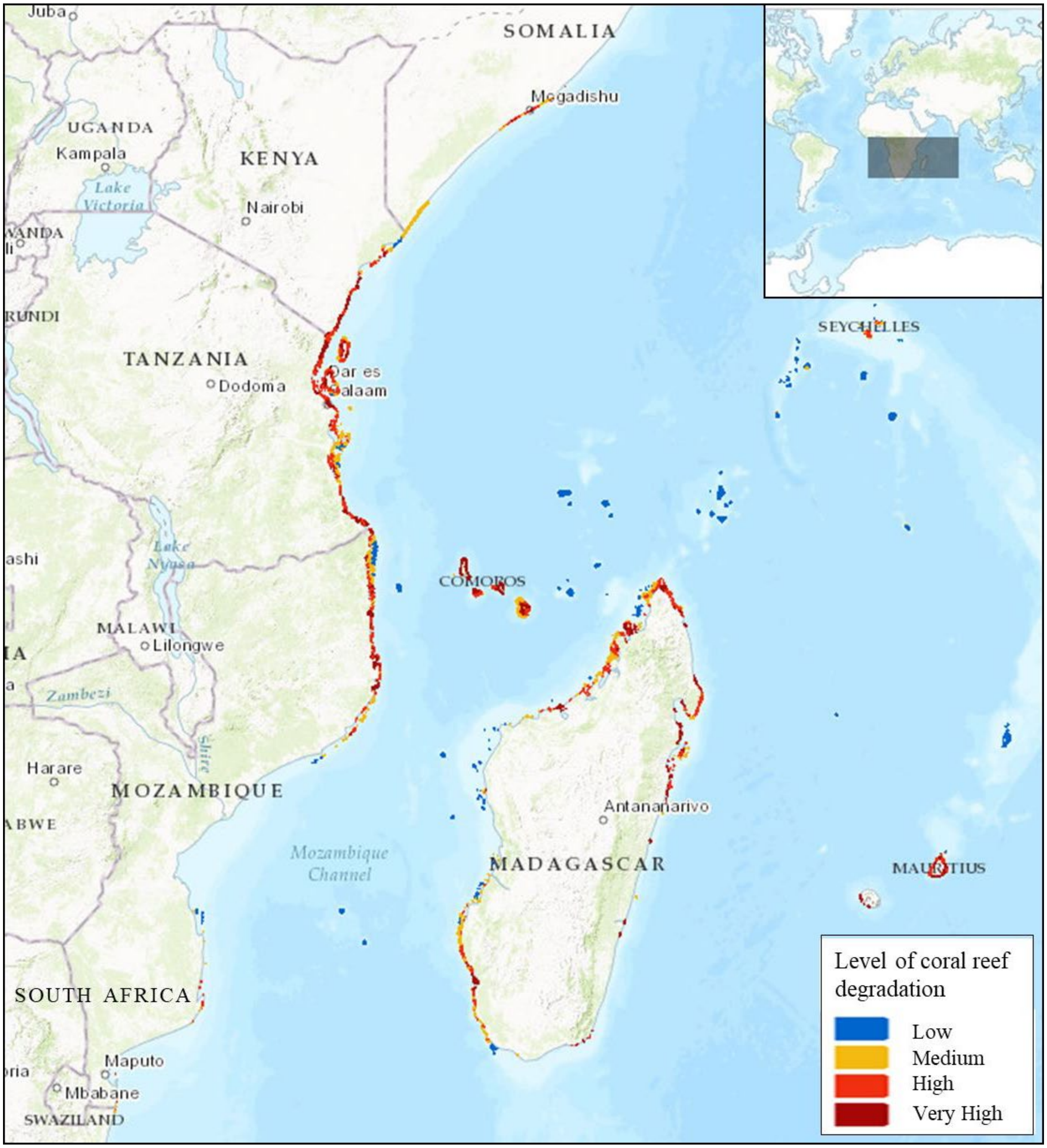
Increased Shipping and Boating

Increased shipping and boating traffic results in coral reef damage around the world (Scarlet & Bandeira, 2014). In the EAME, this is occurring at increasing rates with dredging of seabeds, shipwrecks, oil and gas exploration, and fishing fleets devastating large areas of coral reefs and their ecosystems (Burke et al., 2011; Jones et al., 2016).

3. Study Area and Methodology

The EAME includes the territorial waters from Somalia (10° North latitude), extending south along the East African coastline to north-eastern South Africa (28° South latitude) and the international waters within the 200-mile Economic Exclusion Zone (Oglethorpe, 2009). Kenya, Tanzania, Mozambique, and the north-eastern coast of South Africa fall within the EAME and are the countries of focus for this research. The distribution coverage of dive operators within these countries is limited to their proximity to coral reefs, since most dive operators operate from within or close to marine protected areas (MPAs) and marine reserves (Oglethorpe, 2009; Wilkinson, 2008). Figure 1 illustrates the geographical range of the EAME and the level of coral reef degradation in the region.

Figure 1.
Level of coral reef degradation along the east coast of Africa.



Sources: ArcGIS (2015) & Burke et al. (2011)

The research design was exploratory and descriptive, within a post-positivism paradigm. The methodology consisted of structured interviews and surveys. Four structured interviews took place between July and October 2015. One dive operator in each of the four focus countries was selected via purposive sampling. These findings, along with the literature review were used to shape the survey.

An online structured survey, using Survey Monkey©, was conducted between July and September 2016 with dive operators located in the dive tourism hotspots of the EAME. The sample size (63) was determined from a given population of 77 dive operators. To increase responses, the researcher travelled to the EAME and administered several surveys in person. In total, 34 responses were received. Data was prepared for analysis and interpretation using IBM SPSS©. Descriptive statistics are used to describe the characteristics of the sample (Leedy & Ormrod, 2010). The presentation of frequencies, measures of location (mean, median and mode) and measures of spread (standard deviation) were used to describe the outcome of this study (Cooper & Schindler, 2008). As this was mainly an exploratory study, many of the statistics are descriptive. Accordingly, a descriptive analysis was carried out on all valid data to determine the mean intensity and standard deviation for the responses.

To express the variable levels of impact, a Likert scale was used, ranging from very high impact (5), high impact (4), moderate impact (3), low impact (2) to no impact (1). This scale provided a rating of the respondents' perceptions on the level of impact for indirect environmental risks.

4. Results and Discussion

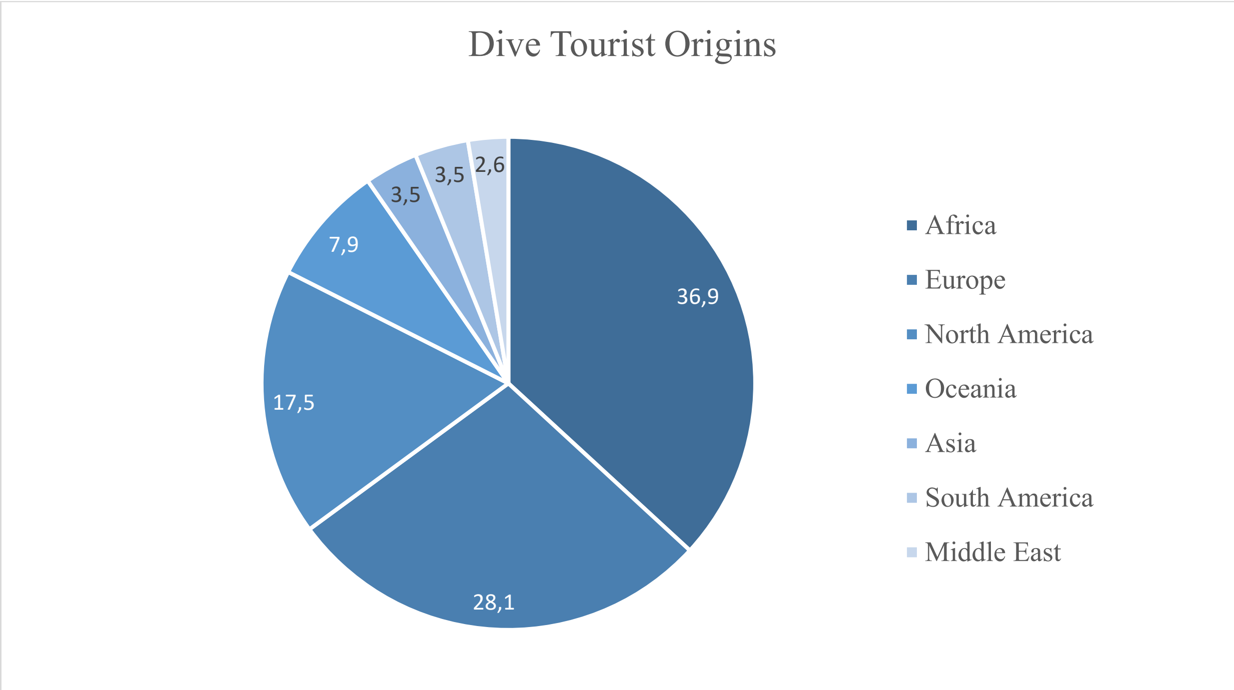
The research findings are discussed in this section and cover (1) biographical information, (2) an overall context of environmental risks and (3) a comparative analysis of indirect environmental risks.

4.1. Biographical Information

Dive operators have typically remained in business for a sustained period with the majority of dive operators (82.35%) in business for ten years or more. All of their scuba diving activities occur on coral reefs, with over 90% of dives taking place in the MPAs. Over 70% of these operators derive the majority of their revenue from scuba diving activities.

Dive operators were asked to indicate where their dive tourists come from, and Figure 2 illustrates these findings. The 36,85% hailing from Africa are mostly dive tourists from the four focus countries, either travelling domestically or crossing borders, in particular, South Africans going to Mozambique and Zanzibar in Tanzania.

Figure 2.
Origin of dive tourists by region.



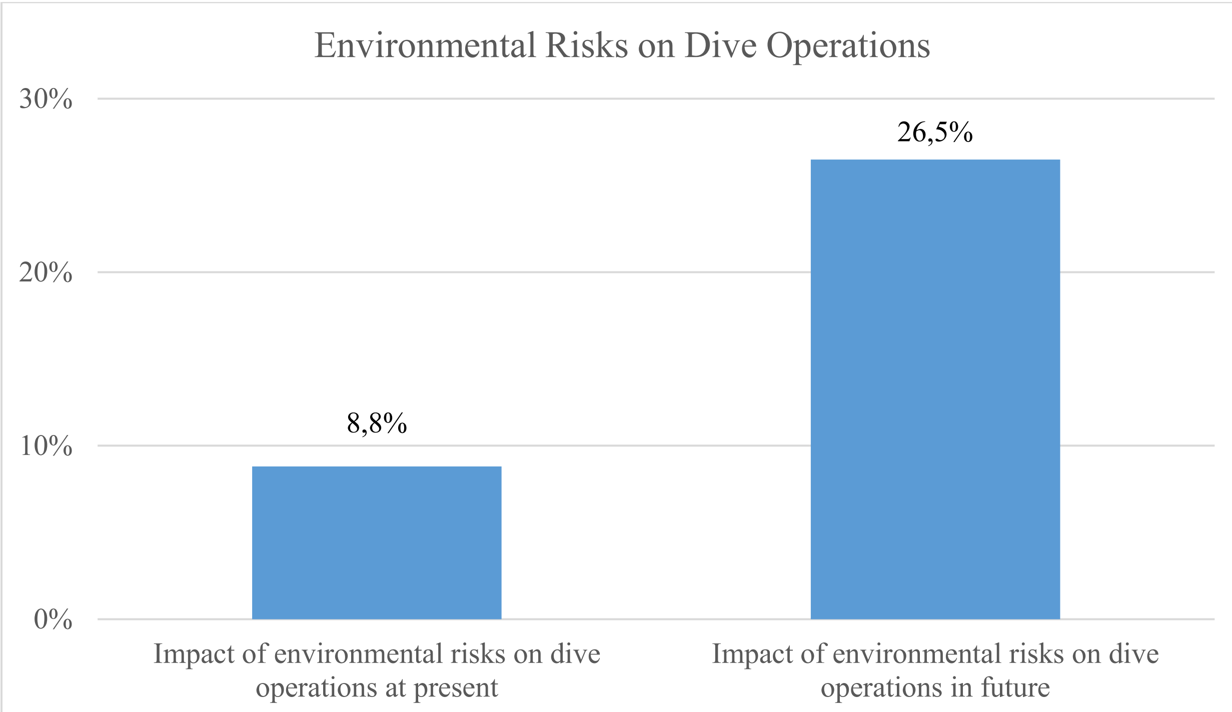
4.2. Overall Context of Environmental Risks

The introduction and literature review clearly indicated the importance of paying attention to environmental risks. This section considers the researchers findings in this regard.

Impact of Environmental Risks: Present Versus Future

Dive operators were asked what the impact of environmental risks was on their dive operations at present, and what they perceived it would be in future (Figure 3). While the current perceived impact was only 8,8%, the future impact rose to 26,5%. Historically, most dive operators in the EAME had not deemed environmental risks to have an impact on their businesses as they mostly operate within MPAs. However, they now see negative changes on the horizon.

Figure 3.
Perceived impact of environmental risks on dive operations: comparison between present and future.



Exploratory Factor Analysis: Climate Change and Coastal Development

The data collected for indirect environmental risks was subjected to an exploratory factor analysis (EFA) to explore relationships among variables measured using the five-point Likert scale to rate the impact of external risks (Table 1).

Table 1.
Indirect environmental risk factors.

Item	Indirect Environmental Risks	Factor	
		1	2
3	Ocean Acidification	0.906	
1	Coral Bleaching	0.699	0.432
4	Extreme Weather Events	0.604	
2	Sea-level Rise	0.593	
7	Marine Pollution	0.570	0.523
5	Industrialisation of Coastal Regions		0.940
6	Increased Shipping & Boating	0.334	0.828

The risks were rotated into two factors. The first relates to **climate change** related impacts. These occur on a global scale and negatively impact on coral reefs (items 1, 2, 3, 4 and 7). This factor is considered most important among dive operators. The second factor considers **coastal development** (industrialisation of coastal areas and increased development of ports and harbours to accommodate shipping and boating traffic) – items 5 and 6.

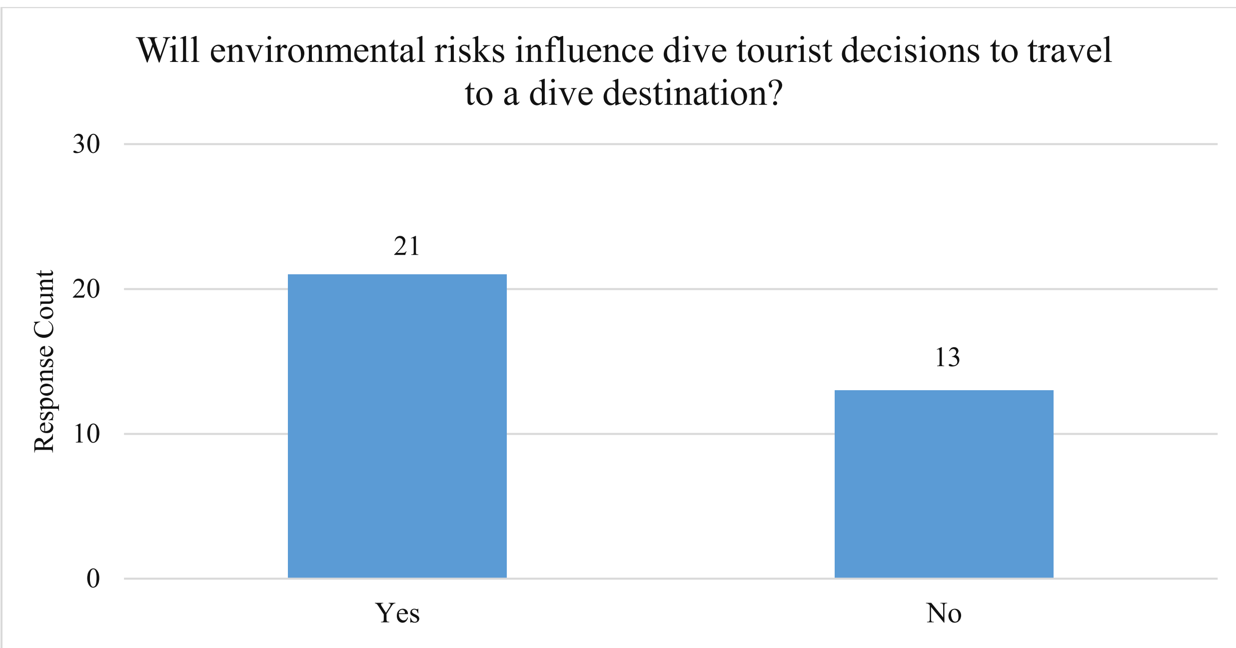
Coral Reef Degradation and Business Continuity

Dive operators were asked whether coral reef degradation would have an impact on their businesses, and how long they could continue to operate given the extent of coral reef degradation. 11.35% of the respondents felt that they would close their operations within five years, while 14.65% said their businesses could survive if there was no further coral reef degradation, which at this stage is unlikely. This is a key finding as it demonstrates that dive operators have a low resilience to indirect environmental change.

Dive Tourist Decisions

Finally, dive operators were asked whether environmental risks would influence the decisions of dive tourists to travel to a dive destination. Figure 4 shows that 21 out of the 34 dive operators (62%) felt that a negative environmental change on coral reefs is a major concern for dive tourists and is a determining factor when making a decision to travel to a scuba diving destination. This illustrates the importance of destination image for attracting dive tourists.

Figure 4.
The influence of environmental risks on the decisions of dive tourists.

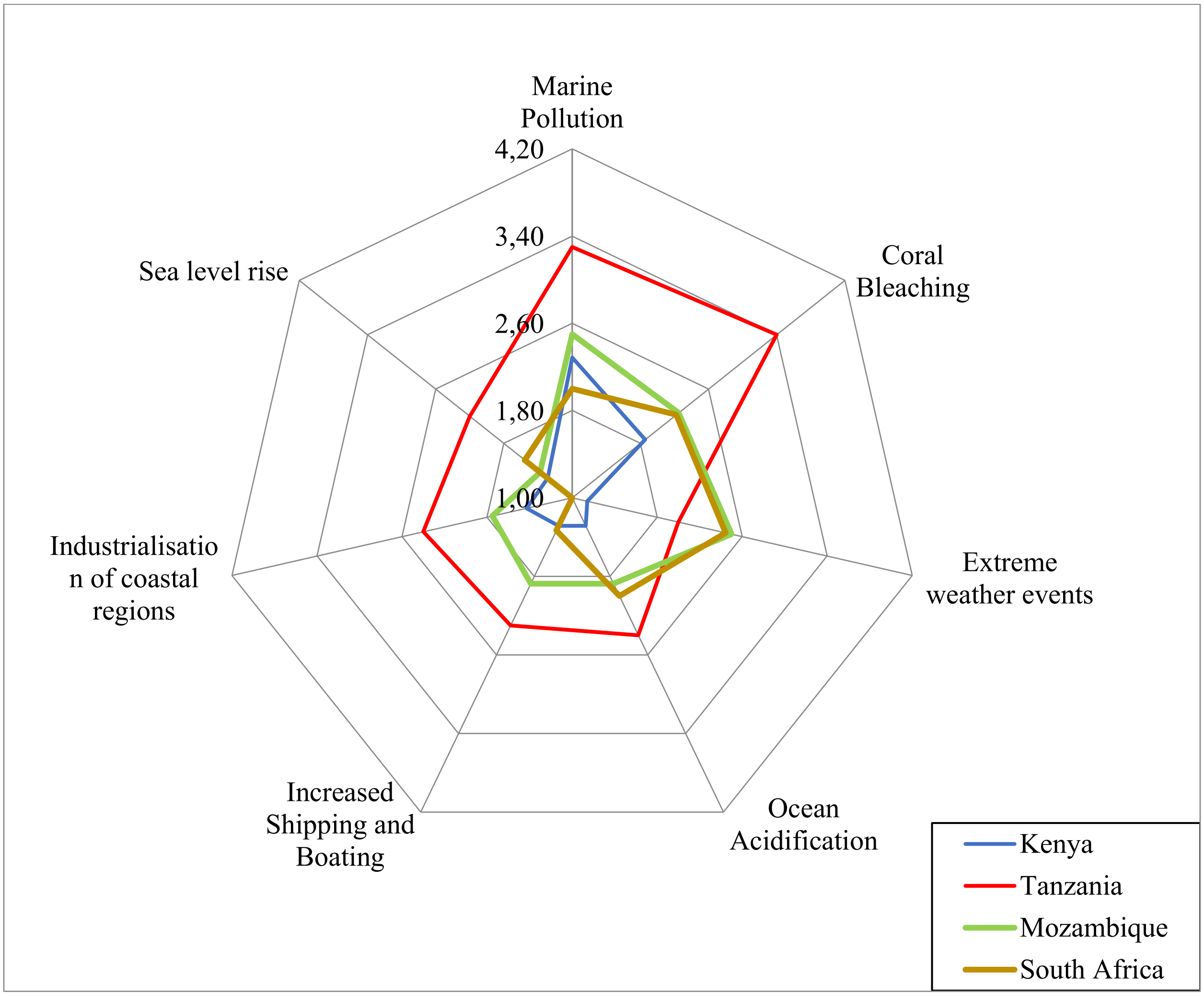


In closing Section 4.2, environmental risks are perceived to be a future threat in the EAME. Environmental degradation occurring on coral reefs would negatively affect the continuity of dive operations as well as negatively influence a dive tourist's decision to travel to a dive destination. These overall results have confirmed the literature – environmental risks matter and it is important to have an in-depth understanding of them. This in-depth stance is the focus of the next section's comparative analysis.

4.3. Comparative Analysis of Indirect Environmental Risks

Having set the context above of the importance of environmental risks, this section now dives into the individual risks and compares these for each country. Figure 5 illustrates the highest indirect environmental risks per country. The various risks surround the radar with each country having its own colour. It provides a glance into **which risks are most prominent per country**, with the numbers representing the Likert scale results per country.

Figure 5.
Risk ratings for indirect environmental risks.



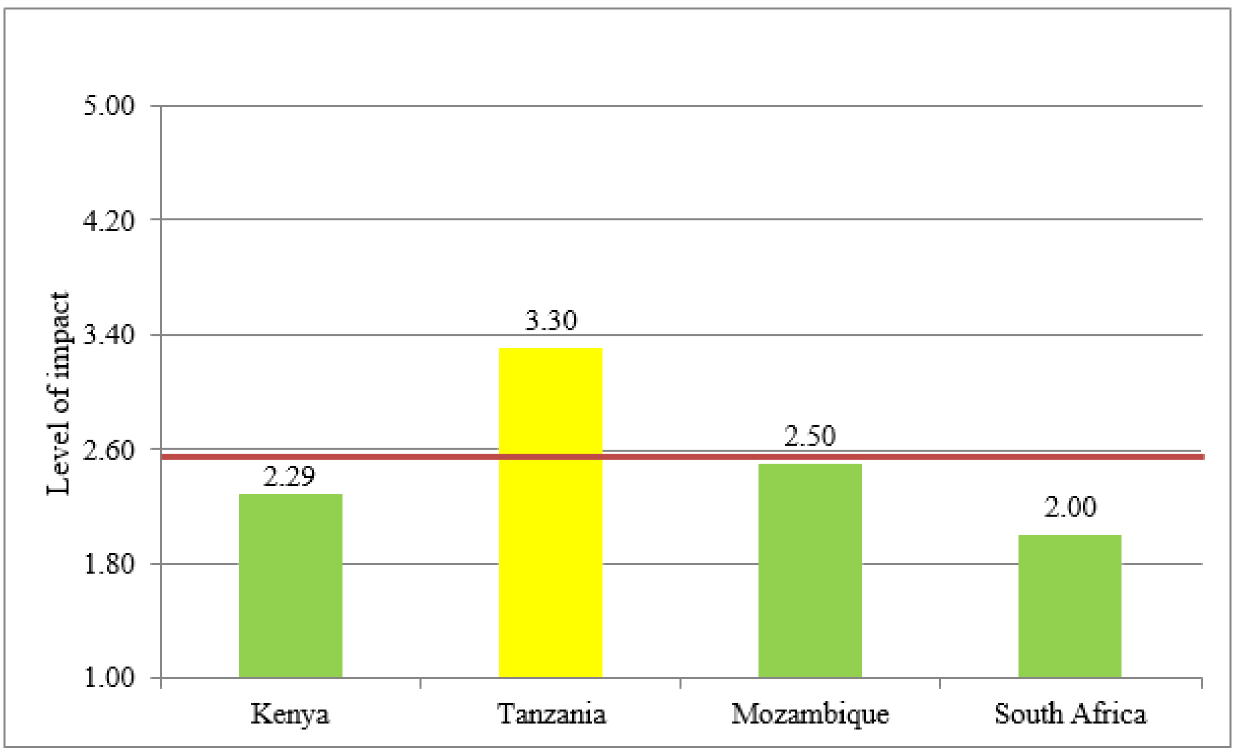
The risk radar diagram reveals that Tanzania is experiencing all the indirect environmental risks at a higher level than the other countries (except for extreme weather events). For South Africa and Mozambique, however, extreme weather events are the highest indirect environmental risk.

It is also important to consider **the overall mean per risk to compare how the individual countries fare against the overall mean.** These overall means are depicted in the bar graphs that follow. The three indirect environmental risks that fall above the mean are discussed next, namely marine pollution, coral bleaching and extreme weather events. Industrialisation of coastal regions, increased shipping and boating, sea level rise and ocean acidification all scored below the overall mean and are therefore not discussed in this paper. However, it is important to note that they cannot be ignored as the first two contribute toward marine pollution and the second two to climate change. As pointed out in section 4.2, these were the two factors emerging from the EFA.

Marine Pollution

Marine pollution (floating plastics and marine debris) ranked highest among the indirect environmental risks. Marine pollution originating from the open ocean has been shown to negatively affect coral reef ecosystems. Micro-plastics, floating plastics, fishing gear debris and rubbish thrown overboard ships all contribute to the mass of marine debris that finds its way to coastal shores by ocean currents. Figure 6 shows marine pollution responses by country. Dive operators in Tanzania (M = 3.30) (SD = 0.67) felt that marine pollution is a problem that needs to be addressed and viewed it as having a particularly high impact. Those in Mozambique (M = 2.50) (SD = 0.53) acknowledge there is a problem but do not consider marine pollution drifting onto reefs from other parts of the ocean to be impacting on their coral reefs. Marine debris is an increasing problem and, although much pollution is out at sea, ocean gyres are pushing this pollution towards coastal and shallow ocean regions (Danovaro et al., 2008). Pereira et al. (2014) indicate that marine pollution is becoming an increasing problem in Mozambique. South Africa (M = 2.00) (SD = 0.87) and Kenya (M = 2.29) (SD = 0.95) are seen as a low risk.

Figure 6.
Marine pollution (plastics, marine debris).



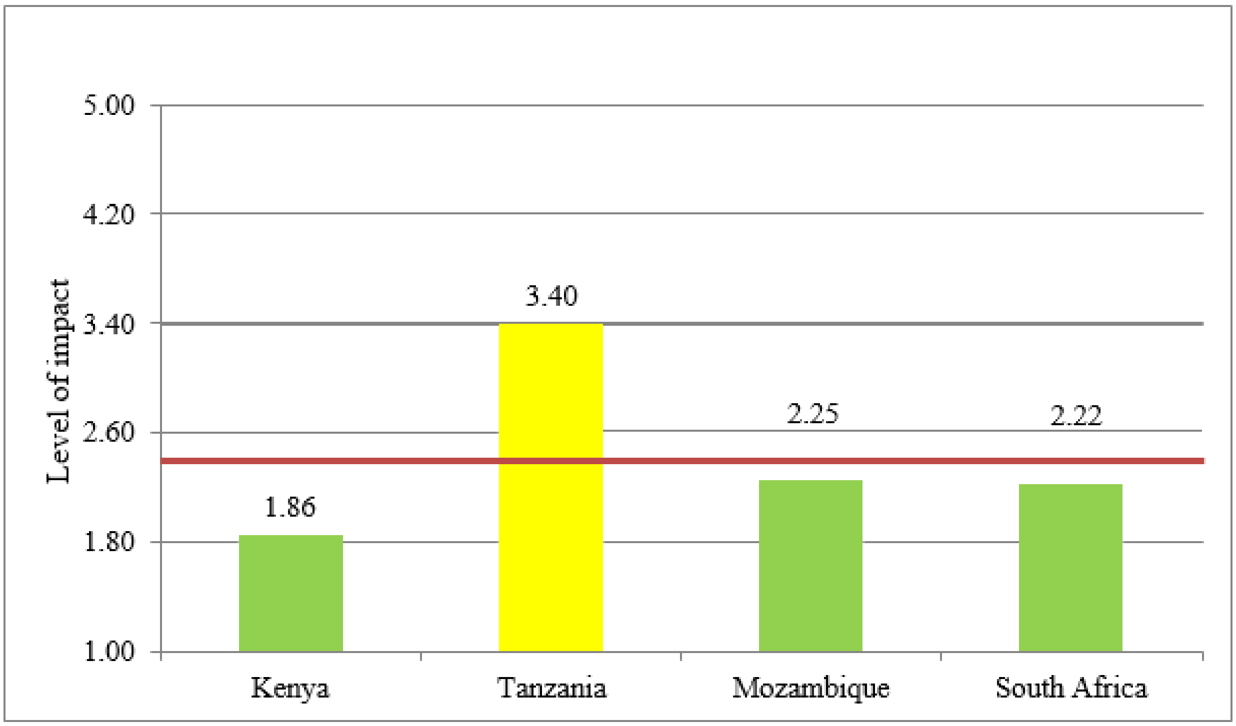
[Red line indicates the overall mean for Marine pollution (plastic, marine debris) (M = 2.56) (SD = 0.89)]

Coral Bleaching

Coral bleaching resulting from increasing sea surface temperatures (such as was caused by the recent El Niño event of 2015/2016) has had a devastating effect on coral reefs. The 1998 El Niño event destroyed much of the coral off the east coast of Africa. According to Obura (2005), there was a 50%

mortality on most reefs closer to the equator. Sustained sea surface temperature rises have been shown to cause irreversible harm to coral reef ecosystems and these effects can be seen long after such events have passed. Figure 7 shows the perceived impact that coral bleaching has on coral reefs. The coral reefs in Tanzania (M = 3.40) (SD = 0.52) have suffered extensively from previous coral bleaching episodes, and dive operators along the entire Tanzanian coast perceive this to be one of the greatest environmental impacts. This could be as a result that shallow reefs in Tanzania would be more sensitive to heat variations than reefs which are in deeper waters off fringing reefs such as in Kenya (M = 1.86) (SD = 1.21). In addition, the ocean currents are cooler where reefs occur at higher latitudes such as in southern Mozambique (M = 2.25) (SD = 0.71) and South Africa (M = 2.22) (SD = 1.30). Incidents of coral bleaching have, however, been observed in all countries along the east coast of Africa, but not all countries have reported high levels of coral bleaching, especially those in high latitude reefs.

Figure 7.
Coral bleaching.

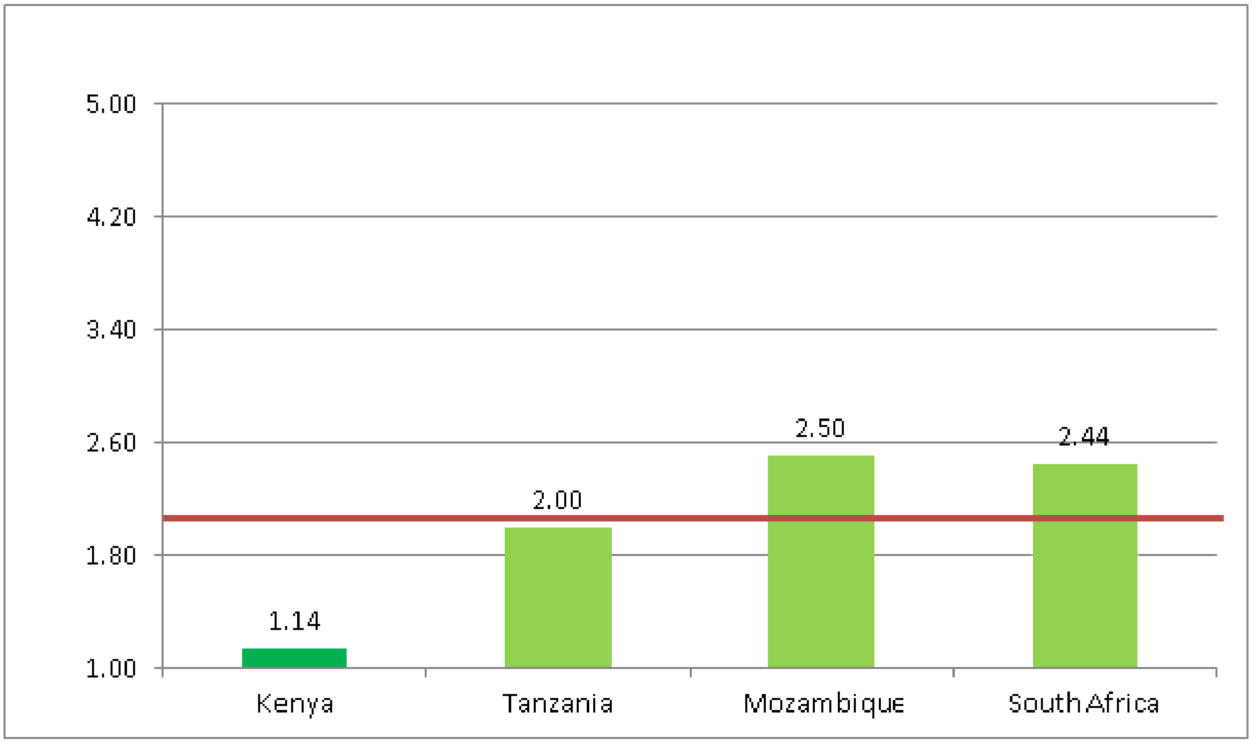


[Red line indicates the overall mean for Coral bleaching (M = 2.50) (SD = 1.11)]

Extreme Weather Events

Figure 8 shows the extent to which extreme weather events (tropical cyclones, severe storms, etc.) may cause the destruction of coral reefs. Overall, most dive operators felt that this was not a risk that would have an impact on their dive operations. Dive operators in Mozambique (M = 2.50) (SD = 1.20), however, rated extreme weather events as the highest impact, while South Africa (M = 2.44) (SD = 1.13) scored the second highest. Given that these two countries are in a similar geographical range, these stretches of coastline may be more susceptible to severe and damaging storms than other areas along the East African coast. However, there is evidence that climate change is causing more severe weather and that this is expected to occur at a higher frequency in future (Fischer & Knutti, 2015). The recent report released by the IPCC focuses on extreme weather events across the world that have been triggered by climate change. These in turn will damage coral reefs further. At this point in time, however, dive operators from Tanzania (M = 2.00) (SD = 0.38) and Kenya (M = 1.14) (SD = 0.38) expressed that it had little or no impact at present.

Figure 8.
Extreme weather events.



[Red line indicates the overall mean for Extreme weather events (M = 2.06) (SD = 1.01)]

Section 4.3 started by depicting which risks were most prominent per country. It then considered the three indirect environmental risks that scored the highest, and within those, discussed in-depth the risk level for each country.

5. Conclusion and Reflections

This paper has cast a spotlight on the turbulent waters of indirect environmental risks, which ultimately affect the sustainability of marine tourism and the wider Blue Economy. Findings reveal that indirect environmental risks have the potential to impact dive operator's businesses in the EAME in future. This change is attributed to climate change related events and the development of coastal regions. The highest indirect risks at present in the EAME are perceived to be marine pollution, coral bleaching and extreme weather events. As the quality of coral reefs decline, this will affect the destination image, resulting in less dive tourists.

Since indirect environmental risks fall outside of the control of dive operators, countries and even wider regions, it makes the response to these threats complex. In an attempt to explore possible responses to these threats, the paper ends by offering a few reflections in this regard. It is not easy to remain optimistic about the future of the marine environment when it has seen so many environmental disturbances in such a short space of time. Clear and decisive actions need to be taken to restore the health of coral reefs and to find ways to prevent further coral reef degradation.

Climate change is affecting the dive tourism industry at a global scale and it is therefore important to take examples and guidance from those who have implemented strategies to address these issues. The Paris Agreement's target to keep global atmospheric temperatures below 2°C is one of the most important accords ever implemented, but its effectiveness is yet to be quantified. Governments in the countries within the EAME need to urgently adapt their policy frameworks to align with the UN Sustainable Development

Goals, much like the European Union has done. These are hard measures designed to shock the systems currently in place to make significant changes towards current approaches to anthropogenic environmental change.

MPAs aim to offer protections through the implementation of policy at a local and at best, national level, however, they are not as effective in providing solutions at a regional or global scale where the cooperation of governments can help drive effective change. Dive operators understand full well that coral reef degradation is expected to continue and will have an impact on business continuity in future. Employing any adaptation strategies to counter the indirect environmental impacts have not been prioritised as such risks have not been easily recognisable and are not within the control of dive operators.

Yet, regional plans can be shaped to respond to these threats in a more discerning way. While carbon dioxide emissions from African countries are literally "*a drop in the ocean*", governments of EAME countries could take tough decisions to reduce these emissions that contribute to global warming. Strict action could be taken to curb land-based pollution that lands in the ocean, and boating and shipping activities that harm coral reefs.

Collaboration in the value chain of coral reef tourism is key! Governments, national park authorities, dive operators, dive training organisations, non-government organisations and local communities need to establish strong collaborations to draft sound economic and sustainable solutions, formulate new policy thinking and, at the same time, find ways to build capable and effective resilience.

To ensure continuity and sustainability for the dive tourism industry, and for the local communities who rely on coastal resources, coral reefs need to survive and thrive. With tourism as the largest global economic sector, and with marine tourism being a significant income earner, it should be "*all hands on deck*" so that we do not have to contemplate a future without coral reefs.

Yes, it may be code red for humanity, but "*if we combine forces now, we can avert climate catastrophe. But, as IPCC report makes clear, there is no time for delay and no room for excuses*" (António Guterres, the UN Secretary-General, in De Ferrer, 2021:1).

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