

1 **Building Resilience in Practice to Support Coral Communities in the Western Indian Ocean**

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21 **Key words**

22 Resilience strategies, ecological, social, coastal, marine

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24 **Highlights**

25 Multiple strategies used to build resilience of coral reefs and reef dependent communities.

26 Intended and realised social and ecological implications of strategies explored.

27 Disaggregated understanding of ecological and social resilience is needed.

28 Policy must encourage strategies contributing across the social-ecological spectrum.

29 Clear opportunity to strengthen knowledge networks and sharing.

30

31 **Abstract**

32 Global environmental change and other site specific pressures (e.g. over fishing and pollution) are
33 threatening coral reefs and the livelihoods of dependent coastal communities. Multiple strategies are
34 used to build the resilience of both coral reefs and reef dependent communities but the
35 effectiveness of these strategies is largely unknown. Using the Western Indian Ocean (WIO) as a case
36 study, this paper combines published literature and expert opinion elicited through a multi-
37 stakeholder workshop to assess the intended and realised social and ecological implications of
38 strategies commonly applied in the region. Findings suggest that all strategies can contribute to
39 building social and ecological resilience, but this varies with context and the overall strategy
40 objectives. The ability of strategies to be successful in the future is questioned. To support effective
41 resilience policy development more nuanced lesson learning requires effective monitoring and
42 evaluation as well as a disaggregated understanding of resilience in terms of gender, agency and the
43 interaction between ecological and social resilience. Opportunities for further lesson sharing
44 between experts in the region are needed.

45 1. Introduction

46

47 Building the resilience of coral reef ecosystems to global environmental and climate change, and the
48 resilience of the coastal communities who are dependent upon them, are issues of international
49 concern (SDG 14 2016, IYOR 2018). Such socio-ecological resilience thinking has attracted
50 considerable academic interest, focused on defining and refining the concept (e.g. Walker et al.
51 2004, Folke et al. 2010) or on characterising the features of social-ecological systems that are
52 necessary to ensure resilience (e.g. Folke et al. 2002). Use of resilience concepts in policy and
53 practice has also grown, especially in the context of disaster reduction and adaptation to climate
54 change (Tanner et al. 2017). At the global level, the ambition to increase resilience is explicit in
55 Sustainable Development Goals (SDGs) 1, 11, 13, and 14 relating, respectively, to poverty alleviation;
56 safe and sustainable settlements; combatting climate change; and sustainable use of the oceans
57 (United Nations, 2015).

58

59 A number of tools have been developed to encourage the design of strategies that put resilience
60 concepts into practice (e.g. Resilience Alliance 2010). Policy and management interventions may,
61 however, deliberately or inadvertently reduce the resilience of a system (Davoudi et al. 2012).
62 Attention is therefore turning to evaluating the impact of resilience building strategies and the
63 identification and measurement of resilience outcomes. Communities of practice are coming
64 together to share experiences and lessons learnt (Gregorowski et al. 2017), but the effectiveness of
65 many resilience building programmes and strategies is largely unknown.

66

67 Resilience to change will differ according to the magnitude and duration of the shock or disturbance,
68 the ability of the social-ecological systems to self-organise and the capacity for learning and
69 adaptation (Folke et al. 2002). Different strategies will be needed according to the characteristics of
70 the disturbance, the ecological and social components of the system of interest and the desired
71 outcomes (Walker et al. 2004). Many common strategies applied in coral reef management and
72 community development have not explicitly considered the resilience of the social-ecological
73 system. Their implications for resilience outcomes remain an important research gap. This paper
74 contributes new knowledge to the literature on resilience building by systematically identifying
75 strategies in practice and assessing the intended and realised implications for both social and
76 ecological resilience of coral reef social-ecological systems.

77

78 We focus our analysis on the Western Indian Ocean (WIO), home to approximately 16% of the
79 world's coral reefs (Obura et al. 2017). These reefs are highly vulnerable to stresses associated with
80 climate change and other site specific pressures such as fishing, pollution and coastal development
81 (Cinner et al. 2012, Obura et al. 2017). Significant changes to coral reefs are potentially devastating
82 to communities in the WIO due to their high dependence on these ecosystems (Cinner et al. 2009,
83 Lalljee et al. 2018). Small island states face particular challenges in balancing economic growth,
84 sustainable development and resilience building (Government of Mauritius, 2014). National policy in
85 WIO countries echoes the aspirations of the SDGs. For example, strengthened resilience to disaster
86 risk is one of the five strategic pillars of Madagascar's National Development Plan, as well as
87 identifying resilience to climate change as a national priority, noting the need to increase resilience
88 in the most vulnerable sectors of society (IMF, 2017). Similarly, Mauritius seeks to "increase the
89 resilience of our nation to unpredictable and shifting external factors such as climate change or

90 global crises” and recognises that the ocean has a role in resilience at a national level (particularly
91 through economic development) (MESD, 2013). Policy documents tend to propose high level
92 strategies and intentions rather than offering detail on specific approaches. Implementation is left to
93 actors working at more local levels with many strategies being widely applied by government
94 institutions, NGOs and communities throughout the WIO to manage coral reefs, their associated
95 resources and the users that depend upon these resources (Cinner 2014). All of these strategies,
96 intentionally or unintentionally, have implications for the resilience of both coral reefs and their
97 dependent communities.

98

99 Through a combination of literature review and expert knowledge elicitation, this paper explores the
100 available evidence on strategies that can build reef and community resilience across the WIO. Many
101 of the strategies identified have been developed independent of resilience frameworks, but their
102 outcomes can be anticipated to contribute to both social and ecological resilience. Evidence is
103 presented for the social and ecological impacts of the different strategies, who benefits from them
104 and whether the strategies are future proof. Cross-cutting themes are identified and discussed, as
105 are lessons learnt and barriers to future success.

106

107 **2. Methods**

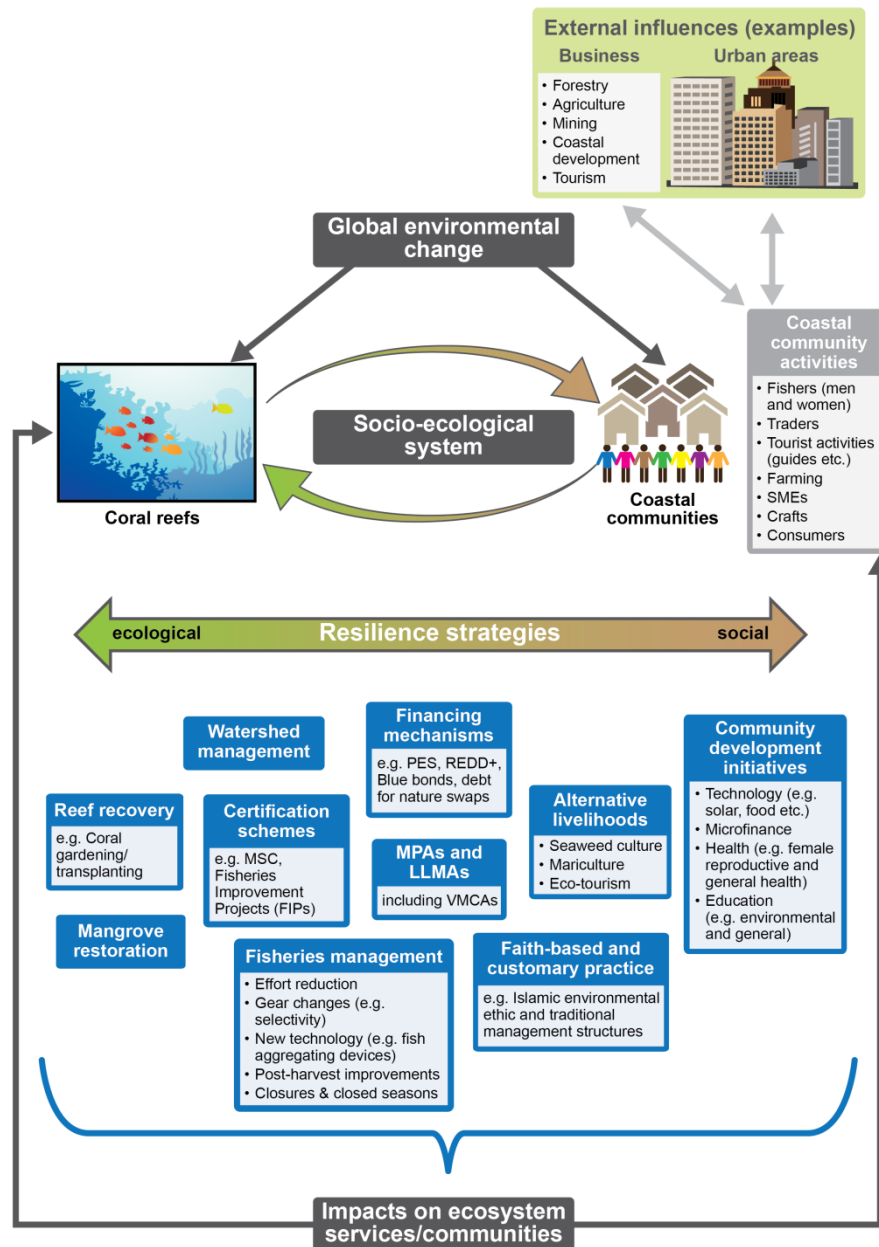
108 Based on discussions with stakeholders from the WIO and evidence from the literature review (e.g.
109 Folke et al. 2010), resilience was presented as the ability to resist, recover, adapt and bounce back
110 from any kind of pressure, but not necessarily to the same state. Ecological resilience was explored
111 in terms of changes to ecosystem services, while any evidence of social and economic change at the
112 individual, household and community level was considered to impact social resilience.

113 **2.1 Literature review**

114 Drawing upon the knowledge of the project team (involving academics and practitioners), resilience
115 building, coral reef management and coastal development strategies implemented with
116 government, donor, Non-Governmental Organisations (NGO) or Community-based Organisation
117 (CBO) support were identified for inclusion in the literature review. We reviewed fourteen strategies
118 with the potential to build resilience even if this was not an explicit or primary objective: coral reef
119 restoration; mangrove restoration; certification schemes such as eco-labelling of fish and fish
120 products; fisheries management including fishing gear change and effort restriction, fish aggregating
121 devices and post-harvest improvements in fisheries; marine protected areas (MPAs) and locally
122 managed marine areas (LMMAs); financing mechanisms such as payments for ecosystem services
123 (PES); ethics, faith-based and customary practices; alternative livelihoods; and community
124 development initiatives including environmental education, micro-finance and population,
125 reproductive health and environment (PHE) approaches. This list, whilst not exhaustive, illustrates
126 commonly used strategies across the social-ecological spectrum (i.e. some strategies directly target
127 coral reef management, while others focus on social issues within reef-dependent communities)
128 (Fig. 1).

129 We undertook a targeted review of each strategy (*sensu* Brown 2014; Hamann et al 2018). We
130 identified literature for each strategy (English language only) using keyword searches of academic
131 databases, including Web of Science and Google Scholar, as well as the wider Internet. This allowed

132 the inclusion of both peer reviewed and online grey literature. The search terms used were specific
 133 to each strategy. For instance, TOPIC: [various terms used to describe the strategy] AND TOPIC (fish*
 134 OR marine* OR coast*) AND TOPIC (resilienc* OR health OR well-being OR wellbeing OR income OR
 135 poverty). A search of global literature and literature specific to the Western Indian Ocean was
 136 performed. Between five to fifteen papers were reviewed for each strategy to gain a sufficiently
 137 comprehensive understanding of the strategy, including existing review papers and publications or
 138 reports detailing the implementation and outcomes of the strategy.



139

140 **Figure 1: Conceptual framework illustrating the coral reef-community social-ecological system and the**
 141 **resilience-building strategies included in the literature review.** MPAs = Marine Protected Areas; LLMAs =
 142 Locally Managed Marine Areas; VMCA = Voluntary Marine Conservation Areas; MSC = Marine Stewardship
 143 Council; PES = Payment for Ecosystem Services; REDD+ = Reducing Emissions from Deforestation and forest
 144 Degradation supporting conservation, sustainable management and enhancement of forest carbon stocks.

145 Each strategy was analysed using a review matrix developed by the project team to ensure
146 consistency among authors conducting the review (Table 1). The analysis sought to document both
147 the assumed or intended impacts of a particular strategy and record any available empirical
148 evidence of its outcomes. Where possible, evidence of impacts specific to the WIO were highlighted.
149 An overview of each strategy was then presented to WIO regional experts in a multi-stakeholder
150 workshop as a series of report cards for further discussion and analysis (see Results). A further round
151 of review was then conducted to fill any noted gaps and identify any literature supporting the
152 opinions and experiences expressed by regional experts in the multi-stakeholder workshop. In total,
153 over 110 papers were reviewed across all fourteen strategies.

154 **Table 1: Review matrix used to extract evidence from the literature of how identified strategies impact coral**
155 **reefs and dependent communities.**

Review criteria

Description of strategy and purpose, including assumptions on route to and/or implications for resilience.

Impacts on ecosystem services*

Implications of impacts for ecological resilience

Impacts on coastal communities*

Implications of impacts for social resilience

Spatial scale of impacts (local, national, regional)

Temporal scale of impacts (short term <5yrs, medium term 5-10yrs, long term >10yrs)

156 * Distinguish if evidence (E) is provided or whether impacts are based upon supposition (S)

157 **2.2 Expert elicitation in a multi-stakeholder workshop**

158 Findings from the literature review (Tables 2 and A1) were presented to regional experts on coral
159 reef management, coastal development, and resilience building at a two-day multi-stakeholder
160 workshop in Mauritius (10-11 May 2017). Workshop participants (20 in total) included
161 representatives from NGOs, government and academics from Mauritius, Rodrigues, Zanzibar, Kenya,
162 the Comoros, Madagascar and the Seychelles (Table A2). The participants invited were secondary
163 stakeholders, those whose well-being is not directly affected by the ecosystems, but who represent
164 institutions and social groups that have some type of influence in coastal decision-making and policy.
165 The workshop aimed to i) understand how resilience practices are applied in the region; ii) prioritise
166 resilience strategies of interest to WIO stakeholders and collate evidence of success and best-
167 practice in, as well as barriers to, their implementation; and iii) identify opportunities to improve
168 resilience-building strategies in the future. The workshop combined plenary sessions with facilitated
169 small group discussions to elicit expert opinion. Priority strategies were identified for detailed
170 discussion on day two. This method has been used elsewhere to garner expert insight into the on-
171 the-ground or in-practice outcomes of governance and adaptation interventions (*sensu* Evans et al.
172 2016). It is particularly well suited to research on issues that are urgent but complex, have high
173 uncertainty and lack data (Fazey et al. 2006; Martin et al. 2012; Rai 2013). On obtaining consent
174 from each participant, discussions were digitally recorded and detailed notes were taken for
175 analysis.

176

177 **3. Results**

178 **3.1 Impacts of strategies on resilience**

179 The detailed findings from the literature review are presented as report cards (available at
 180 https://pml.ac.uk/Research/Projects/Coral_Communities) that summarise information for marine
 181 managers and development practitioners (Fig 2). Here we report overall and illustrative findings
 182 from the review (Tables 2 and A1) alongside data from the expert elicitation workshop.
 183

Community-based management of small-scale fisheries

Community-based management of small-scale fisheries occurs when local communities collectively take responsibility for marine resource management. This may be community-led or in collaboration with government and non-state actors (e.g. NGOs, scientists) who facilitate management through the provision of technical support and financing. Management decisions support sustainable use of marine resources and may include, for example, gear restrictions and the designation of marine protected areas (temporary and permanent).

Current strategies come under a variety of different names but include:

- **Territorial User Rights for Fisheries (TURFs)**: fisher's user rights are strengthened and decision-making devolved to them to encourage sustainable stewardship.
- **Locally Managed Marine Areas (LMMAs)**: management measures introduced are context specific, but local control over decision-making is a key characteristic.

Assumptions for resilience: It is assumed that more sustainable behaviour and innovative conservation actions can be encouraged by strengthening fisheries governance through increased local participation in decision-making, clarification of property rights and collaborative management between resource users, government agencies, scientists and other relevant stakeholders.

Ecological Impacts

Positive
 The link between ecological impacts and community-based management is not always clear as changes in management structure are often accompanied by other management actions (e.g. gear changes). Documented examples have shown that effective community-based management:

- Has positive impacts on biomass and numbers of commercially important species.
- Can result in wider ecosystem benefits.

Negative
 No documented evidence was found that community-based management has negative impacts on marine ecosystems. It has been suggested in the literature that:

- Where fish biomass and numbers have increased, so may illegal fishing behaviours where enforcement is weak.

Implications for ecological resilience

- Community-managed areas may not be as effective for ecosystem recovery as no-take zones, but have higher biomass than non-managed areas.
- The management actions introduced and their level of enforcement will impact the sustainability of fisheries activities and their impacts on the wider marine ecosystem.

Social Impacts

Positive
 The link between social impacts and community-based management is not always clear as changes in management structure are often accompanied by other management actions (e.g. gear changes). Documented examples have shown that community-based management can, in some circumstances, lead to:

- Increased fishing yield, household income and well-being.
- Increased participation, inclusion and empowerment of local communities in management decisions.
- Decreased illegal behaviours where enforcement is strong.
- Reduced conflict and increased cooperation between stakeholders.
- Trialling of new methods and alternative livelihoods (e.g. mariculture).
- Quick community response to develop and influence wider co-management.

Negative
 It has been suggested that community-based management could:

- Create social inequality by favouring more wealthy resource users.
- Lead to tension within families, households and villages where support for management is not widespread.

Implications for social resilience

- Establishing effective local governance supports local communities to make decisions in the face of change, which is critical for building resilience.
- Encouraging poorer households to engage may have the greatest payoff in terms of wealth creation and social resilience.
- The presence of motivated, respected and entrepreneurial leaders can support success, but training may be needed to build such skills.

Case-study: Locally Managed Marine Areas in Kenya and Tanzania

Collaborative Fisheries Management Areas (CFMAs) or Community Conservation Areas (CCAs) are an emerging approach to fisheries management and marine conservation that are gaining strength in the WIO. The approach takes inspiration from the concept of Locally Managed Marine Areas (LMMAs) that has developed throughout the Pacific and elsewhere. In Kenya CCAs and in Tanzania CFMAs connect a network of villages which co-operate through their Beach Management Units (BMUs). They identify a shared management area, develop and implement a management plan and set of bylaws to improve fisheries sustainability and reef conservation. Management tools can include permanent, temporary or seasonal closures thereby combining spatial management with other fisheries management (see Report Card 8).

Has it been successful? LMMAs are proliferating in the region. There appears to be greater social acceptance of these areas than of government-implemented regulation, even when LMMAs involve closures. Community ownership and control are identified as key to this success. Successful cases include the octopus zones in Zanzibar, which report relatively rapid improvements in stocks allowing communities to view the benefits in the short-term.

Sustainable financing is important for the success of LMMAs. In Kenya and mainland Tanzania BMUs or fisheries association committees are able to collect revenue through fishing and in some places tourism fees collected at landing sites. In Tanzania the District Government provide tender over a landing site to the BMU to facilitate collection of fees.

Finally, the composition of BMU committees and thus of LMA governance structures was identified as important for success. In Kenya, for example, BMUs can comprise fishermen and women, fish buyers, fish consumers, boat makers, and other fisheries stakeholders.

Challenges: Success is not guaranteed in all locations. In Zanzibar, for example, legislation is currently not detailed enough to adequately support the establishment of co-management, specifically the process of local fisher committee formation and operation as well as the process of by-law formulation and approval. This presents a major challenge for the effectiveness and sustainability of emerging LMMAs. Furthermore the Shehia management body is restricted to ten members, all fishermen, and there are no recommendations on gender representation. Management committees also lack a sustainable source of resources, especially for enforcement.

Future application: projects have been initiated in Zanzibar to revise the legislation to adequately support community-based collaborative fisheries management.

Further reading

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Spatial scale: typically small-scale, but large LMMAs can be effective e.g. Velondriake LMA in Madagascar which spans nearly 1000km².

Temporal scale: impacts can occur in short-term (e.g. within 3 months for octopus fishery), but often take much longer.

Resilience Report Card 10 - Community-based management of small-scale fisheries January 2018

Images courtesy of Mwanbaa Coastal Community Network.

184
 185 **Figure 2: Example report card presenting literature review and workshop findings for community-based**
 186 **management of small-scale fisheries. Each report card provides a brief description of the strategy, the**
 187 **documented and/or supposed ecological and social impacts resulting from the strategy, the implications of**
 188 **this for social and ecological resilience, a case study from the WIO and further reading. 14 report cards are**
 189 **available in total.**

190 **Table 2: Resilience strategies identified through the literature review and during the stakeholder workshop, their assumptions for resilience and their links to coral**
 191 **reefs.**
 192

Strategies	Assumptions for resilience	Link to coral reefs	
Reef recovery: Coral gardening and reef restoration	Coral reef restoration is assumed to increase the health of reefs and support resistance to pressures such as climate change and human activity allowing continued provision of ecosystem services (Rinkevich 2014).	Coral heads or nursery-reared corals are transplanted to restore coral reefs (Mbije et al. 2013).	
Mangrove restoration	Restored mangroves are assumed to trap run-off and provide habitat, increasing the health of coral reef ecosystems, and supporting resistance to climate change and human activity (Gorman and Turra 2016).	Mangroves are important nursery areas for coral reef species, they also bind sediment and contaminants preventing them reaching coral reefs (Moberg and Rönnbäck 2003, Berkström et al. 2012).	
Certification schemes: Ecolabelling of fish and fish products	Consumers reduce the demand for, and consequently, the pressure on overfished stocks; sustainably managed fish stocks support improved catch and income for fishers (Sampson et al. 2015).	Schemes leading to MSC certification (e.g. fisheries improvement projects, fair trade schemes) are being applied to small-scale coral reef fisheries (Long 2017).	
Fisheries management:	Gear change and effort restrictions	Effort and gear management can improve fisheries sustainability thereby enhancing fishers' livelihoods and income (Mbaru and McClanahan 2013).	Reducing effort and fishing selectivity thereby protects fish biomass and avoids tipping points in coral reef ecosystems (McClanahan et al. 2011).
	Fish aggregating devices (FADs)	Artisanal or nearshore FADs improve catches of pelagic fisheries which could contribute to increased incomes and/or enhanced food security; and reduce cost per unit effort of catching fish by reducing fuel costs and time at sea (Bell et al. 2015).	FADs may reduce fishing effort on coral reef fisheries as fishers concentrate more effort on FADs (Campbell et al. 2016).
	Post-harvest improvements in fisheries	Increases the availability, quality and price of post-harvest catch, which in turn improves livelihoods, and has health benefits (Adeyeye and Oyewole 2016).	Used together with other fisheries management aimed at reducing pressure on coral reefs resources (Allison and Horemans 2006).
MPAs and LMMAs	Locally Managed Marine Areas (LMMAs)	Strengthening fisheries governance through increased local participation in decision-making, clarification of property rights and collaborative management between relevant stakeholders encourages more sustainable behaviour and innovative conservation actions (Kawaka et al. 2017).	Increasingly applied in coral reef dependent fisheries in WIO region (Rocliffe et al. 2014).

Strategies	Assumptions for resilience	Link to coral reefs
MPAs	The provision of protection will increase reef health and support resilience to pressures such as climate change and human activity (Mellin et al. 2016).	MPAs are a common fisheries management and conservation tool for coral reefs in the WIO (IUCN 2004, Rocliffe et al. 2014).
Financing mechanisms: Payments for Ecosystem Services (PES)	PES schemes support environmental management and restoration, with income and resource benefits resulting for both user and provider of ecosystem services (Bladon et al. 2016).	Only working examples in the WIO relate to mangrove restoration (Locatelli et al. 2014), which should benefit coral reefs as identified for mangrove restoration.
Faith-based and customary practices	Conservation objectives can be met through customary and faith-based practices containing an environmental ethic (Cox et al. 2014).	Using the environmental ethic enshrined in e.g. Islam to encourage fishers to reduce their use of destructive fishing activities (Chernala et al. 2002) and support conservation activities.
Alternative livelihoods	Social resilience is assumed through increased income diversification and hence stability for fishing families and communities (Cinner 2014).	Diverting fishers away from fishing activity will decrease direct and indirect pressure on coral reefs (Cinner, 2014).
Community development initiatives:	Environmental education	Educated populations are more likely to be effective custodians of their natural resources and are assumed better able to adapt to change and engage in conservation strategies (Nordlund et al. 2013).
	Micro-finance	Improved incomes enable households to better withstand difficult times, e.g. when fish catch is low or weather is bad (Crona et al. 2010).
	Population, reproductive health and environment	Healthy, more engaged populations are more likely to be effective custodians of their natural resources and more able to adapt to change and engage in conservation strategies (Harris et al. 2012).
		Paying for fish through transactional sex is reported in many African countries (Béné and Merten 2008). Population health environment programmes have proved effective entry points into communities and upon which marine resource management can be built (Harris et al. 2012).

194 With the exception of Marine Protected Areas (MPAs), the literature review found limited evidence
195 evaluating the impacts of the different strategies in the WIO. Instead, the impacts of the strategies
196 presented (Table A1) largely builds on global literature. Of the papers or reports that do present
197 evaluation evidence, they typically focus on either social or ecological impacts (e.g. Turner et al.
198 2007). Notable exceptions include Crona et al. (2010) and Kittinger et al. (2012), who explicitly use a
199 resilience or social-ecological systems framework in their studies. Generally, the social or ecological
200 impacts, and any implications for resilience, are assumed or anecdotal in nature.

201

202 During the workshop, participants prioritised four strategies for further discussion on the basis of
203 interest: micro-finance, alternative livelihoods, reef restoration and payment for ecosystem services
204 (PES). The group focusing on micro-finance also discussed community-based management of small-
205 scale fisheries (also known as Community Conservation Areas or Tengefu in Kenya and Locally
206 Managed Marine Areas in the international literature, from herein LMMAs).

207

208 **3.2 What has been successful for social and ecological resilience building?**

209 The 14 strategies reviewed vary in the extent to which they have been applied in the WIO region.
210 Some are used extensively, such as the introduction of alternative livelihoods and the designation of
211 MPAs. Others are more niche, such as coral gardening, which is of considerable interest but typically
212 small-scale in terms of on the ground activity. Strategies such as PES schemes are relatively new to
213 the WIO region and are still to be fully-tested. Only one functional coastal scheme was identified in
214 Kenya (Mikoko Pamojo – Mangroves Together), although others are in development (e.g. Blue
215 Ventures Blue Forests project in Madagascar). LMMAs are not entirely new to the region (e.g.
216 Makoloweka and Shurcliff 1997), but have gained increased traction in the last two decades (Roccliffe
217 et al. 2014). Of the strategies prioritised by workshop participants, evidence of the positive impacts
218 on social and ecological resilience in the WIO was available for three: micro-finance, alternative
219 livelihoods and LMMAs. The fourth priority strategy, coral reef restoration, was thought to support
220 primarily ecological resilience, with only limited impact on social resilience, as suggested by Ng et al.
221 (2016). Community level benefits were only known when coral gardening is applied with other
222 strategies (e.g. creation of artificial reefs using reef balls and in conjunction with management
223 planning).

224

225 Micro-finance schemes were considered to be successful because all community members can
226 typically access them to invest in new or existing businesses or to help out in times of hardship (e.g.
227 Corona et al 2010). Success (in terms of resilience building) was reported to be more likely where
228 members are supported to develop by-laws to guide repayment of loans and where members are
229 trained in business or project start-up and management. Contributions to ecological resilience were
230 deemed possible but not guaranteed. Participants highlighted that micro-finance is not always linked
231 to incentives to discourage unsustainable behaviours.

232

233 The success of alternative livelihoods to fishing was reported to vary according to country. In low
234 income countries such as Comoros and Madagascar, eco-tourism and mariculture (e.g. seaweed
235 farming and sea cucumber production) were seen as important opportunities. The introduction of
236 seaweed and sea cucumber farming to fishing families in Madagascar by the NGO Blue Ventures
237 (Ateweberhan et al. 2014) was considered a particularly successful model, supporting marine
238 resource management and increasing the income of participating families. Women were reported to

239 particularly benefit. Women were commonly early adopters of mariculture looking to supplement
240 household earnings. In countries with higher wage expectations, participants doubted the
241 replicability of this strategy. In Mauritius and Seychelles, eco-tourism is promoted as an alternative
242 to fishing as well as professional level occupations, including 'green collar' jobs. Whatever the
243 alternative livelihood introduced, participants considered that its success depends upon it meeting
244 the needs, expectations and skills capacity of the communities involved; that there is a real
245 commercial market for the good or service resulting from the alternative livelihood; and that
246 communities can feel that their effort is real and has tangible success.

247

248 For LMMAs, literature review findings and workshop participants' observations concurred that
249 success varies by location and according to the ability of local communities to make decisions about
250 local resource use (e.g. Kawaka et al. 2017). Examples in Madagascar, Kenya and mainland Tanzania
251 were reported to build both social and ecological resilience following changes in legislation to
252 support local decision-making. Participants highlighted that early attempts to replicate this in
253 Zanzibar failed, largely because decision-making power was not held in local communities and
254 differing political allegiances affected collaboration between key stakeholders. Furthermore,
255 legislation supporting the establishment of LLMMAs is enabling rather than directive and relies on
256 communities choosing to implement it. Many communities, however, lack the knowledge, capacity
257 and confidence to do so. More recently, facilitated by NGOs, temporary closures for octopus and
258 other species with clear and rapid benefits for communities have required the establishment of by-
259 laws enabling local decision-making, consequently enhancing resilience. Appropriate legislation and
260 external support may therefore be important to resilience building.

261

262 **3.3 Who benefits?**

263 The objectives of the resilience-building strategy will determine who or what benefits. For example,
264 mangrove and coral reef restoration aim to create ecosystem benefits, but these benefits are also
265 anticipated to support the direct and indirect users of these ecosystems (Abelson 2006, Rönnbäck et
266 al. 2007, Okubo and Onuma 2015). In contrast, population health and environment (PHE) strategies
267 focus on improving community health and family planning, acting as an effective community entry
268 point and setting the foundations for engagement in resource management (Harris et al. 2012).
269 Similarly alternative livelihood strategies aim to support individual households and communities
270 while at the same time relieving pressure on fisheries resources and coastal ecosystems (Wibowo et
271 al. 2012, Cinner 2014).

272

273 Evidence from the literature indicates that all strategies reviewed can provide both ecosystem and
274 societal benefits (Table A1), but the degree to which they can achieve this as singular strategies
275 varies. For example, participants noted that micro-finance, while beneficial to the individual
276 receiving the credit (e.g. fishers), may have negative impacts on fish resources. Credit may
277 encourage further exploitation of vulnerable stocks unless associated with strategies to reduce
278 unsustainable fishing practices. The same may be true of earnings from alternative livelihoods.
279 Workshop participants highlighted, however, that strategies are rarely implemented in isolation and
280 often require, as a minimum, education, training and sensitisation, and may involve compliance
281 eligibility.

282

283 For some strategies, the literature indicated that only a small proportion of a community may
284 benefit. For example, alternative livelihoods and MPAs may not involve all community members (e.g.
285 Katikiro 2016). The importance of equitable distribution of benefits was recognised by workshop
286 participants. According to one participant, this is particularly so for PES schemes; how benefits are
287 distributed can be a source of conflict, even before any monies have been received. Participants
288 noted that the sharing mechanism needs to be transparent.

289
290 Other strategies, such as micro-finance, may potentially benefit all community members. Schemes
291 often target women, however, supporting them to develop businesses and other income sources.
292 Only one formal example of micro-finance was known to participants, the VICOBA (Village
293 Community Banks) in Tanzania (Kamat 2018), but participants reported that community saving
294 schemes are used in some coastal communities (e.g. in the Comoros and Madagascar). Participants
295 knew of little evidence beyond anecdotes about the benefits these schemes had created.

296
297 In some cases, not all benefits were reported to accrue to the communities involved with the
298 strategy. For example, the tourism sector was considered an important beneficiary of reef
299 restoration. Participants indicated how this provides opportunities for other strategies, such as the
300 development of alternative livelihoods, and further emphasises the need for multiple strategies for
301 successfully resilience building.

302 303 **3.4 Are the strategies future-proof?**

304 Global environmental change is likely to result in significant change to coral reefs in the WIO region,
305 with some reefs predicted to suffer severe annual bleaching by 2033 (van Hooidonk et al. 2016).
306 Evidence also indicates that the capacity of many reefs in the Indian Ocean region to keep pace with
307 rising sea levels is diminished (Perry et al. 2018), which will increase coastal wave exposure. While
308 strategies may demonstrate success in building resilience to present conditions, it is highly uncertain
309 how effective these strategies may be in the near-future.

310
311 Participants raised particular concern about reef restoration through coral gardening. Participants
312 were positive about selecting corals resilient to previous El Niño events for transplantation, but
313 highlighted how the causes of reef decline (e.g. climate change, fishing and pollution) remain
314 unmanaged. It was considered a mitigation measure. Similarly, micro-finance, when unlinked to
315 sustainable resource use, was considered a significant barrier to resilience building. Donor support
316 for micro-finance schemes was also recognised as a key weakness, with anecdotal evidence of
317 schemes collapsing once donors have departed. Workshop participants recommended a move
318 towards competitive grant schemes for specific community conservation related projects as an
319 alternative source of finance.

320
321 Strategies reliant on international markets (e.g. sea cucumber and seaweed production, carbon
322 trading and other potential PES schemes) also raised concerns. Participants blamed falling prices for
323 sea cucumber and seaweed farming on over promotion, supplier saturation and excess production.
324 The literature, however, suggests that this is more a consequence of low quality production and
325 processing, and the absence of Good Manufacturing Processes and Hazard Analysis Critical Control
326 Point methods (Perez and Brown 2012, Robinson and Lovatelli 2015). Both issues illustrate the need
327 to understand international market requirements and for external support for communities wishing

328 to engage with them. This includes Governmental support as well as from other agencies (such as
329 NGOs) for hard and soft resources (e.g. financial resources, policy promotion and knowledge
330 exchange).

331

332 Many participants viewed the development of LMMAs as important to the future resilience of coral
333 reefs and dependent communities, a view supported by the literature (Cinner and McClanahan
334 2012, Cinner et al. 2016). Community-level decision-making about local resource use in the face of
335 change was considered essential for resilience building and is relevant to the successful
336 implementation of many other resilience building strategies. Workshop participants suggested that
337 appropriate assistance needs to be in place for LMMA success including formal devolution of
338 decision-making power to local communities; creation of appropriate co-management relationships;
339 support for the development of resource management plans by communities; and availability of
340 resources for monitoring and enforcement.

341

342 **3.5 Cross-cutting themes**

343 Cross-cutting themes important to the success of all resilience building strategies emerged from the
344 literature review and workshop discussions. These included education, an awareness of local values
345 and customary practices, and improved monitoring and evaluation. Education was identified as
346 necessary in any resilience building strategy because it can lead to informed decision-making,
347 acceptance of resilience building measures, but also skills development. Participants recognised a
348 need for training in business, product or service development, but also for decision-making and
349 conflict resolution and avoidance.

350 Awareness of and influencing communities through faith-based and customary practices was
351 discussed at length between workshop participants. Although not relevant in all societies, faith and
352 customary leaders can be influential actors within communities (Cox et al. 2014; Steenbergen, 2016).
353 They can provide important entry points into communities and act as agents of change. Compliance
354 was considered greater with resilience building strategies that aligned with local values and priorities.

355 The general absence of monitoring and evaluation data hampered both the literature review and
356 workshop participants to articulate the successfulness of strategies at building social and ecological
357 resilience in the WIO. While recognising that monitoring can be resource intensive and may require
358 skilled personnel (e.g. reef monitoring), all participants considered that better monitoring and
359 evaluation data were urgently needed. They also highlighted how this must be accompanied by
360 sustainable sources of finance, skills training, and the sharing of experiences across the region.

361 **4. Discussion and implications for policy**

362 **4.1 Better monitoring, evaluation and lesson learning needed**

363 Our understanding about which strategies are successful in building resilience is challenged by the
364 relative absence of evidence for each strategy. The multi-stakeholder workshop helped fill gaps and
365 identify lessons, such as the need to link strategies to sustainable behaviours, adapting strategies to
366 context and the importance of decision-making at community levels. If resilience related policy
367 objectives are to be met, however, long-term monitoring and evaluation is needed to support more
368 effective decision-making (Ferraro and Hanauer, 2014; Stem et al. 2005). Existing monitoring and
369 evaluation efforts are often too short and undertaken within specific project lifetimes that rarely
370 reflect the scales of stress accumulation (Ferraro and Pattanayak 2006).

371

372 From a process perspective, programme success is often hard to assess because programmes are
373 rarely implemented with evaluation in mind. Evaluation must be planned from the outset, with both
374 social and ecological data collected before and after implementation (Stem et al. 2005).

375 Communities could contribute to monitoring and evaluation, enabling it to last beyond the lifetime
376 of a project and which may itself encourage engagement in the resilience building strategy
377 (Uychiaoco et al. 2005). Resilience however is complex, comprising objective as well as subjective
378 and relational aspects (Brown and Westaway 2011). Research evaluating how different local and
379 scientific knowledge systems reflect complexity thinking and capture information important for
380 understanding resilience trends found that many resilience 'indicators' were missed in local
381 knowledge and participatory monitoring approaches (Evans 2010). New evaluation methods are
382 needed that allow the capture of the multi-dimensional components of both social and ecological
383 resilience within the constraints experienced in many developing country contexts.

384

385 **4.2 Disaggregated understanding of resilience is missing**

386 Who benefits from resilience strategies remains unclear. Evidence in the literature rarely reports the
387 disaggregated ecological or social effects of strategies, yet this has implications for the design of
388 resilience policy. For example, fisheries management may restore biodiversity, but species function
389 may be more important to ecological resilience than overall biodiversity (Bellwood et al. 2003).

390 Marshall and Marshall (2007) suggest that social resilience should be measured in terms of
391 perception of risk, ability to plan, cope and level of interest in change yet no evidence was found
392 linking strategies to these themes. Gender equity is also largely missing from the social-ecological
393 resilience framework (Kawarazuka et al. 2017). Strategies to date have not sought to understand or
394 address the question of how men and women negotiate natural resources and how they are
395 affected by, and able to respond to, shocks in the ecosystem (Kaijser and Kronsell 2014, Kawarazuka
396 et al. 2017), yet gender mainstreaming is recognised as central to sustainable development and
397 environmental policy and practice (Arora-Jonsson, 2014). With the possible exception of PHE
398 initiatives, a similar critique may be leveled to the lack of focus on household dynamics and resource
399 allocation, with little consideration of how decisions made within individual households impact
400 wider resource management. For example, who has access to income within a household could have
401 a greater influence on household resilience than a simple increase in income (Weeratunge et al.
402 2014).

403

404 Resilience policies and the strategies implemented to deliver them therefore need to focus on ways
405 that different groups of actors construct ideas of resilience. Engaging with organisations that tap into
406 individual, household and community values (e.g. women's organisations, health services, faith-
407 based organisation, customary institutions) may be an important route for supporting the more
408 subjective and relational aspects of resilience building. Multifaceted strategies with mechanisms for
409 equitable benefit sharing and capture between individuals, communities and sectors are also
410 needed.

411

412 **4.3 Greater recognition needed of multiple people-nature interactions**

413 Strategies must take into account the myriad ways that people and nature co-exist, incorporating
414 both social and ecological resilience. For example, while evidence indicates that no-take marine
415 reserves may provide the best opportunity for increasing reef ecological resilience, they may lead to

416 growing inequality, loss of income and ultimately an erosion of social resilience (Bennett and
417 Dearden 2014). Similarly, strategies for increasing income (e.g. through improved access to micro-
418 finance or the development of alternative livelihoods) may provide a good opportunity for building
419 social resilience, but unless accompanied by strategies that encourage sustainable fishing practices,
420 they may lead to increased fishing pressure and a decrease in reef resilience (Crona et al. 2010).
421 Cinner et al. (2016) suggest that the most successful strategies may not generate the greatest social
422 or ecological gains but make a contribution across the social-ecological spectrum.

423

424 Consideration of the role of agency, the choices individuals make in determining which strategies
425 they undertake, is also needed. People and communities are not passive in the face of change; they
426 have their own priorities that may be distinct from those of the external organisations supporting
427 the implementation of resilience building strategies (McLaughlin and Dietz 2008). People's own
428 individual framings therefore affect the choices they make and the way they perceive and
429 experience vulnerability. Understanding individual and social values, as drivers of behaviour, is
430 central to building resilience in terms of identifying what might be acceptable strategies for an
431 individual and a community, and hence the policies needed to promote them.

432

433 **5. Conclusions**

434 This paper identified multiple strategies currently applied to improve ecological and social outcomes
435 for coral reefs and dependent communities. It documented how these strategies are assumed to
436 influence social and ecological resilience and evaluated the existing evidence, using the WIO as its
437 focus. It found that while numerous strategies are being implemented across the region, often in
438 combination, the mechanisms to document and share results and develop best practice to support
439 resilience building and effective policy design is currently missing. Practitioners in the region are a
440 wealth of expert knowledge but are not sufficiently connected to each other to share and compare
441 experiences. Systematic processes of monitoring, evaluation and data-sharing are also lacking.
442 Important insights into trade-offs between social and ecological resilience or the different
443 beneficiaries of key strategies remain ad hoc reducing the ability of decision-makers to design
444 policies targeted at resilience building. If the Sustainable Development Goals and regional resilience
445 objectives are to be achieved, there is a clear opportunity to strengthen knowledge networks,
446 processes and systems in this region with this paper providing a baseline of current understanding of
447 resilience in practice.

448

449 **ACKNOWLEDGEMENTS**

450 This work was supported through funding to the Coral Communities project from the UK's Global
451 Challenges Research Fund (GCRF) Building Resilience programme under grant agreement reference
452 NE/P016073/1. We would like to thank all participants at the workshop held in Mauritius for their
453 insight and enthusiasm as well as two reviewers for their helpful comments.

454

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