How Important are Social Networks in Times of Environmental Crises?

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How Important are Social Networks in Times of Environmental Crises?

*Michael Kriegl, Lotta Clara Kluger, Eike Holzkämper, Ben Nagel, Sophia Kochalski & Philipp Gorris**

Around the globe, extreme weather events like storms, droughts and floods get stronger and hit more often. In their struggle to overcome the impacts of such disasters, natural resource users (fishers, farmers) depend on knowledge and support coming from both within and outside their communities. To answer the question 'how to cope with crises?', we therefore have to find out 'whom to turn to when disasters hit'. We provide insights into two examples of ongoing research that investigate the role of fishers and farmers' social networks when dealing with and recovering from environmental disasters that brought drastic change to their respective communities in Peru and Bangladesh. Our findings indicate that the number and diversity of connections is crucial for coping with crises, and suggest the need for further research on the ways social networks are shaping individual and community responses to environmental impacts.

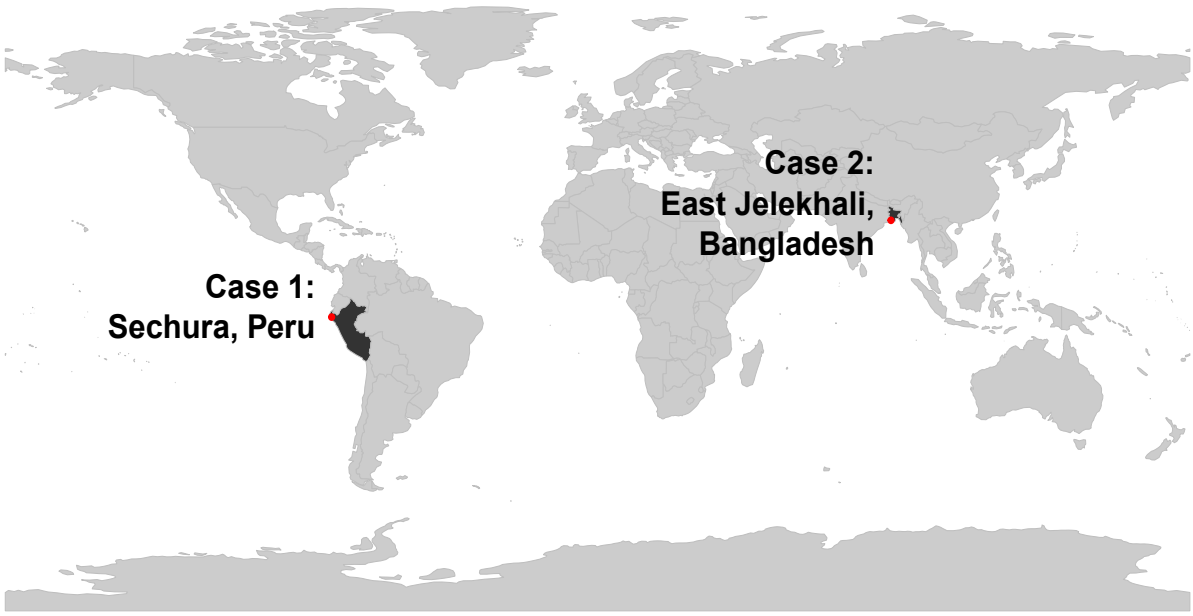
Keywords: social capital, natural disasters, natural resource management, climate change adaptation, El Niño Southern Oscillation (ENSO), Cyclone Aila

Extreme weather events, such as storms, droughts, and floods, can severely impact both natural systems as well as human societies. A changing climate significantly shapes the frequency, intensity, and duration of such natural disasters (IPCC, 2019). People who rely on natural resources are particularly vulnerable to the repercussions of environmental crises. In the struggle to respond to changes in environmental conditions, those affected depend on knowledge and resources coming from within as well as outside their communities. Here, we illustrate how two communities from opposite parts of the world cope with natural disasters: Scallop farmers in Sechura Bay in Peru and crop farmers living close to the Sundarbans mangrove forest in Bangladesh (Fig. 1).

Sechura Bay is a large bay in the North of Peru, where 25 000 artisanal fishers make their living based on the ocean. In recent decades, some fishers turned to small-scale aquaculture of the Peruvian bay scallop *Argopecten purpuratus* and are thus also known as "scallop farmers". Their harvest depends on the environmental conditions in the bay, which are, amongst other things, shaped by the different phases of the El Niño Southern Oscillation (ENSO). During the warm "El Niño" phase (as opposed to the cold "La Niña" phase), heavy rains and a rapid rise in ocean temperatures affect the region. Such El Niño events typically unfold every few years and it can take up to a year for environmental conditions to normalize. In 2017, a localized yet very strong

* All authors contributed equally to the present work.

Figure 1 Map showing the two study sites: Sechura Bay in Northern Peru (Case 1) and East Jelekhali in Southwest Bangladesh (Case 2).



El Niño event hit the region around Sechura Bay and turned the lives of scallop farmers upside down.

On the other side of the world lies the fertile coastal agricultural belt of the Ganges-Brahmaputra-Meghna river delta in Bangladesh, bordered to the southwest by the world's largest contiguous mangrove forest, the Sundarbans. Climate change is posing a growing threat to the predominantly agricultural region, including more frequent and stronger tropical storms. The particularly severe Cyclone Aila in 2009 led not only to the loss of life, property, and income, but also to storm surges which pushed saline seawater inland. This salinity intrusion continues to be a major crisis for rural livelihoods, contaminating water and inhibiting crop production.

Extreme weather events have changed the lives of the affected communities, adversely impacting their main income sources and ability to earn a living in the long run. Resource users must, therefore, find strategies to deal with environmental crises. And that is where the community comes into play.

Direct users of natural resources often organize in groups. They live and work in close proximity and – as they are exposed to the same pressures – can work together to overcome crises. Within such communities, social relationships play an important role: Scallop farmers rely on each other for the hard work at sea, while farmers depend on shared labor to plant and harvest their crops. Community members share not only food, money, and tools, but also non-tangible resources, like information and know-how. Relationships that stretch beyond the community (e.g., with governmental organizations or family members in other regions) are also highly important (e.g., to gain access to finances and alternative employment opportunities). This web of relations is called a "social network", and the assets it provides are part of the social capital that people can draw upon when facing environmental crises.

The analysis of social networks represents a valuable tool to understand human connectivity and its role during crises. It allows us to explore how social relations shape recovery after environmental disasters. In the following sections, we will dive deeper into the two

cases and use network analysis to investigate how land and ocean-based farmers cope with extreme weather events.

Case 1: How Scallop Farmers in Peru Dealt with a Coastal El Niño

In the region around Sechura Bay in North Peru, cold and nutrient-rich waters from the South meet warm, equatorial waters from the North. This unique setting leads to a highly productive ocean bordered by dry and barren land – the Peruvian coastal desert (Fig. 2). It is, therefore, not surprising that fishing has played a vital role since the early human settlements. The Peruvian bay scallop, an edible saltwater shellfish, used to be only one of many resources targeted by diving fisheries along the coast. However, in the last two decades, the bay transformed into an important scallop production site catering to US and EU markets. More and more people moved to the region to participate in this lucrative activity (for a historical overview of scallop culture in Peru, see Kluger et al., 2019a).

Scallop farmers organize in cooperatives to collect young scallops in the wild and place them in designated culture areas within the bay until they reach marketable sizes (> 65 mm) and can be harvested. This kind of "farming" does not require a cage or net structure, but a considerable investment of time and money, the latter often being supplied by banks and private investors. A loss of harvest thus implies a loss of a big financial investment.

In the first months of 2017, a strong Coastal El Niño (CEN) event unfolded in Northern Peru, including Sechura Bay. Torrential rains caused flooding and led to severe damage to the local infrastructure (Fig. 2). The heavy rains and the

Figure 2 The Peruvian Case

Note. *The arid coastal-marine nexus in Sechura Bay, Peru (top). A scallop diver preparing for his mission underwater (center). The Peruvian bay scallop, also known as "blue gold" in Peru (center insert). Flooding during the Coastal El Niño in 2017 (bottom; photograph by Luis Enrique Saldana / Ministerio de Defensa del Perú, distributed under a CC-BY 2.0 license). All other pictures taken by LC Kluger.*

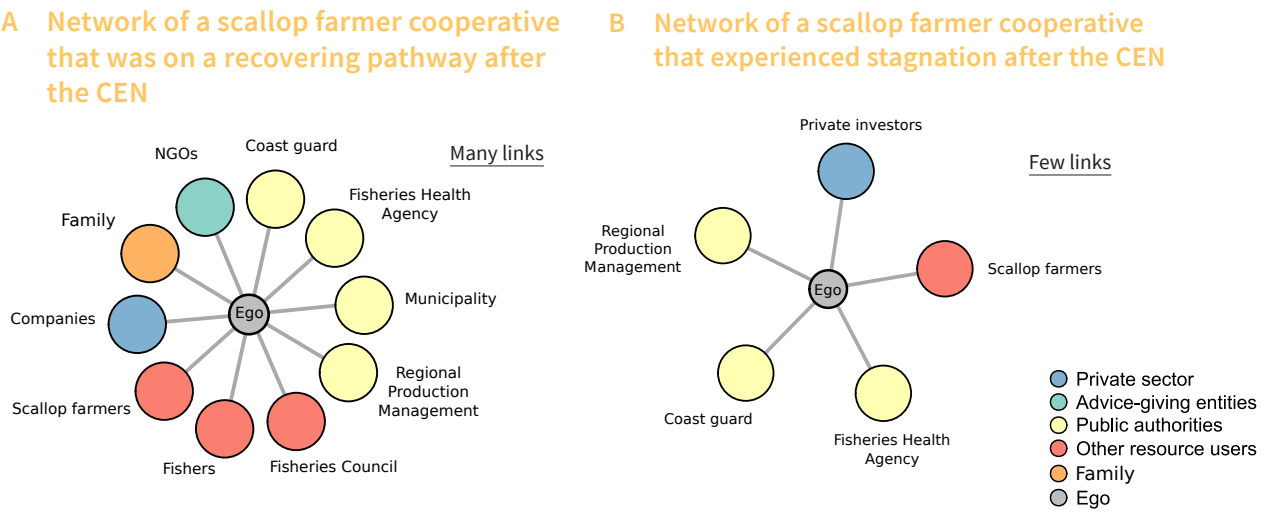
subsequently increased river discharge eventually reached the bay and rapidly reduced the salinity up to a degree that scallops could not withstand. Coupled with an abrupt warming of coastal waters, scallop farmers witnessed a complete die-off of all cultured scallops in Sechura Bay. Some had lost everything: scallops, boats, and houses.

To start growing scallops again, the environment had to "normalize" first, the natural scallop population required time to "bounce back", and scallop farmers needed new capital investment. One year after this disaster, we studied the repercussions of the CEN event for the small-scale aquaculture sector in this region (for a general overview and also a discussion of effects for small-scale fisheries in the region, see Kluger et al., 2019b). We noticed that some cooperatives were already doing well, while others were still struggling. This led us to the question of what role social capital played in the recovery process, speculating that relationships facilitate the flow of resources as well as the access to information. Had the presence of extensive social networks promoted recovery?

Representatives of 35 scallop farmer cooperatives were interviewed, equivalent to about one-fifth of all cooperatives working in the region at the time of the survey. We asked the interviewees about their interactions with different actors from the fisheries and aquaculture sectors, resource management institutions, and the private sector. More specifically, we asked how often they interacted with these different actors (looking back at the time before as well as during the CEN) and how helpful these interactions were. In addition, interviewees were asked to indicate the overall state of their cooperatives one year after the CEN event in order to see to what extent they had already recovered (answer categories *cf.* Marin et al., 2015).

From the collected information on interactions, we constructed individual social networks for each cooperative. These so-called "ego-networks" captured the relationships of scallop farmers with other relevant actors (Fig. 3). Based on these networks, we calculated the number of helpful relationships each cooperative had at two points in time (i.e., before and during the CEN). We compared these values, also known as "degree centrality" (Freeman, 1979; Borgatti & Everett, 2006), among groups of cooperatives exhibiting different recovery levels to see which cooperatives had coped

Figure 3 Representative examples of pre-disturbance ego-networks of two interviewed scallop farmer cooperatives that were A) on a recovering pathway and B) still stagnant after the Coastal El Niño hit in 2017 (i.e., at the time of interview in early 2018).



Note. *Ties represent helpful links. Circles represent actors (colored according to their functional groups), with scallop farmer cooperatives displayed as "Ego" in the center of each network.*

better or worse with the effects of the CEN, based on their connectivity.

We observed that cooperatives with more extensive social ego-networks coped better with the natural disaster. Disentangling the temporal aspect of this pattern, we found that this trend was driven by the number of relationships that scallop farmers had before the disaster. In other words, resource users embedded in a network of supportive relationships before the environmental disaster could draw upon their social ties in times of crisis and, thus, showed increased resilience towards the disturbance. Based on our findings, we conclude that social capital, describing relationships among actors that facilitate the flow of information or resources, seems to be a precursor or even an engine for recovery. Enhancing and nurturing social capital within communities can, therefore, be a viable way of increasing the resilience of resource users to abrupt environmental change.

Case 2: Crop Farmers in the Delta of Bangladesh and the Impacts of Cyclone Aila

For the second case, we want to take you to a place where two massive rivers join, then intersect with a third to spread into the world's largest river delta before finally meeting the sea. Imagine that most of this delta is only a meter or two above the sea level and place this landscape into the tropics, with a rainy monsoon season and regular drops in atmospheric pressure over the ocean: Welcome to Bangladesh, a country where intermittent flooding and storms have historically been a normal part of life for the more than 40 million people that earn their livelihoods off the fertile land and the productive sea.

However, with climate change advancing year by year, the "normal" has become anomalous. Storms and floods get stronger and hit more frequently, causing more severe and complicated problems than ever before. Flood surges from the coast push saltwater further and further inland, destroying crops and spoiling the supply of drinking water for the local communities. When the tropical storm Aila hit in 2009, people did not only lose their houses and belongings. The strong winds also brought a flood of saltwater, and while the flooding receded, the salt that remained severely limited crop production. These environmental crises have a major impact on the primarily agrarian Bangladeshi society, with high poverty rates and limited government capacity making the impact even bigger (Mahmuduzzaman et al., 2014).

To cope with the impacts of salinity intrusion from cyclones such as Aila, some of these farmers, however, underwent an impressive change in the way they used their land, planting saline-tolerant rice varieties, starting vegetable gardening projects, and implementing brackish water aquaculture. Various research institutes as well as aid and developmental organizations (often NGOs) have been developing these agricultural innovations and introduced them to the local communities (Sultana & Mallick, 2015). The innovations serve as both an adaptation strategy to the now saline conditions and a means of increasing household livelihood diversity. Livelihood diversity describes the variety of activities that people in a household take up to make a living. The diversity of activities is often linked to how successfully households adapt to changes (Ellis, 1998). Not all households in such communities have had the same access to these innovations. Research has shown that the ability to adapt a livelihood to changes is often linked to the household's socioeconomic conditions, in other words: with how well-off a household is (Hoque et al., 2017). The role of social networks is less understood. We framed our research question around the term "livelihood adaptation network", which we defined as: interconnections that help households adapt to the changes induced by climate change, such as Cyclone Aila. With

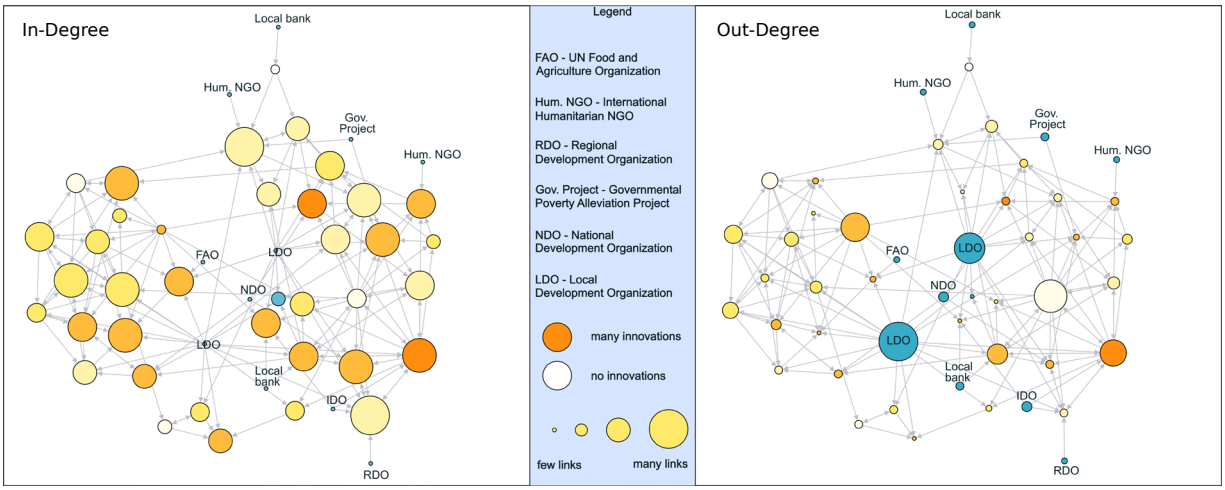
Figure 4 The Bangladesh Case

Note. *Rice fields in East Jelekhali, Bangladesh (top). Typical earthen-style house in East Jelekhali next to aquaculture pond (center left). Farmers planting rice seedlings (center right). Flooding after Cyclone Aila hit the region in 2009 (bottom; photograph by Ferdous, distributed under a CC BY-SA 3.0 license). All other pictures taken by B Nagel.*

our research, we asked: Are households with greater access to agricultural innovations also more highly connected within the community network?

In southwest Bangladesh, the small agrarian town of East Jelekhali has historically practiced traditional rice cultivation methods, which were severely impacted by Cyclone Aila (Fig. 4). Following interventions from aid and development organizations, innovations now range from farming saline-tolerant rice varieties to vegetable gardening, fish farming, and various non-agricultural labor activities. Households with more agricultural innovations were more likely to receive a greater range of benefits, as members of the communities reported: "Now, we are able to grow three products on one land [...] People have less poverty than before, they eat three meals a day and live in a better situation than before." We collected data on these "livelihood adaptation networks" in Mondol and Paramanik, two neighboring communities of 40-50 households in East Jelekhali. We used a social network survey, where respondents reported all social ties to neighboring households or external organizations (e.g., governmental organizations and NGOs) which were important for their ability to adapt their livelihoods. We collected data on the direction (e.g., giving vs. receiving information) and the type (e.g., information or labor) of each reported tie. Additionally, we conducted household surveys that gave us an understanding of each household's characteristics: its socioeconomic status, how much it had been affected by Aila, and the agricultural innovations it employed as an indicator of livelihood diversity. By merging

Figure 5 Mondol Livelihood Adaptation Network. Left: households/organizations sized after in-degree (incoming links). Right: households/organizations sized after out-degree (outgoing links).



Note. *Circles represent households or organizations. Organizations are blue. Households are yellow. The darker the color, the more agricultural innovations the household employs. Lines are support ties between actors, which were identified as important for climate adaptation. The larger the circle, the more connections this household has to other households and organizations.*

the data from these individual households, we analyzed a livelihood adaptation network of the entire community.

Figure 5 shows the resulting "livelihood adaptation" network for Mondol, including all households and relevant external NGOs or organizations. Based on this, we then explored how household characteristics related to position within the overall network and across different types of social ties. We identified three types of social ties that were particularly important for livelihood adaptation: *information* ties (i.e., knowledge exchange on agricultural innovations and training on these new cultivation practices), *moneylending* ties (i.e., exchanges in the form of borrowing between households and micro-loans from NGOs to pay for the capital costs of seed and equipment at the start of each growing season), and *labor* ties (i.e., exchanges between households which play a critical supporting role in labor-intensive agricultural livelihoods).

In one of our study communities, Paramanik, there were no discernible patterns between social network position and neither socioeconomic status nor engagement with agricultural innovations, perhaps due to the more dispersed and isolated nature of households in this community. In Mondol, where respondents emphasized the importance of social cohesion and ties to neighbors, we found a significant relationship between the number of innovations and the number of incoming social ties the household received from other households. This means that households with more supporting ties (specifically, more information ties) often have more agricultural innovations. For example, NGOs brought saline-tolerant rice varieties to the village and provided information (training) on how to grow them, and neighboring households shared knowledge, such as best cultivation practices for newly introduced rice and vegetable cultivars. As one Mondol farmer said, "Now, different NGOs have provided training for saline tolerant crops, and the farmers learn from each other also."

> ***Our findings suggest a link between social network connectivity and adaptation through innovations.***

Our findings suggest a link between social network connectivity (especially regarding

information links) and adaptation through innovations. However, the specific network patterns that evolve after a crisis might differ between communities as they depend upon many other factors (such as community demographics and physical distance between neighbors). In our opinion, further research is needed on the role of social networks in climate adaptation.

Connecting the Dots in Social Networks – Building Resilience to Cope with Crises

The two studies from opposite sides of the world reflect the importance of relationships and functioning social networks. Using two different approaches, either focusing on individual organizations ("ego-centric network approach", as applied in Peru, Case 1) or looking at the social network as a whole ("complete network approach", as applied in Bangladesh, Case 2), we can draw one general conclusion: The bigger and more diverse a resource user's social network, the better the individual can cope with natural crises. Building relationships and expanding support networks can help resource users to cope better with environmental disturbances.

In times of crisis, people turn to their personal and professional networks for help, financial support, and access to alternative sources of income. In Peru, the most helpful connections came from within the community (family members and other resource users), while NGOs and other external actors providing knowledge and training were of great importance for adaptation in the Bangladeshi case. Studying these support systems using social network analysis not only helps us gain insight into the dynamics of recovery pathways, it also enables us to identify leverage points for preparing communities for future crises.

Network Analysis and Sustainable Resource Management

Resource management often focuses on ecological and economic factors such as the reproduction of scallops or the market price of rice. The analysis of social connections of those people handling the resources opens up new possibilities. Studying complete networks allows us to identify key actors (e.g., information brokers) and helps to detect marginalized groups that may have limited access to critical information during times of crisis. It is also insightful, as in the Peruvian case, to investigate how networks change over time to separate cause and effect: Are actors with extensive networks more likely to have access to resources and innovations, or can actors with access to resources and innovations build better networks (Matous & Wang, 2019)?

> *In Sechura, there is only the desert and the sea. And us.*

Despite the ability of resource users to deal with crises, adaptation to and recovery from changing environmental conditions also have limits. As a fisher once put it: "In Sechura, there is only the desert and the sea. And us." When oceanic conditions no longer allow for scallops to be grown or, as in Bangladesh, water becomes too salty for crop cultivation and drinking water consumption, going back to business-as-usual becomes impossible, and a "new normal" has to be found. This process may range from harvesting a different species to migrating to another region. From a scientific perspective, using networks that connect the social and ecological domains (social-ecological networks) helps to understand such human-nature interactions and

dependencies (for a review on this topic, see Kluger et al., 2020).

We have learned that the quantity of links is important for resource users in times of crisis. The question remains as to which extent the type of relations and quality of links play a role. Is one link more "valuable" than another and in what context? Is the existence of certain types of relationships a prerequisite for successful recovery or adaptation? These aspects need to be part of future research to expand the frontier of network analysis in the resource use context.

What can Society Learn from our Research?

Climate researchers forecast that climate change will lead to increasingly stronger and more frequent environmental disasters worldwide (IPCC, 2019). To mitigate the negative impacts of these events, we urgently need to understand which factors enable resource users to deal with environmental crises effectively. Our analyses suggest that extensive support networks are going to be part of this equation. Understanding the network configurations and types of links needed to cope with environmental crises can be translated into actions that help to better prepare for future disturbances. At the same time, given the limits of these adaptation processes, a discourse on alternative sources of livelihood security for communities in the most affected regions is necessary if climate change advances and natural disasters keep intensifying.

With this joint contribution, we hope to stimulate discussions on the role of resilient livelihoods adapted to local needs for the development of crisis-resistant communities and to promote effective strategies that support local resource users in ensuring income and food security in the face of progressing climate change. In the end, it is the connections that count.

References

Borgatti, S. P., & Everett, M. G. (2006). A graph-theoretic perspective on centrality. *Social Networks*, 28(4), 466-484.

Ellis, F. (1998). Household strategies and rural livelihood diversification. *Journal of Development Studies*, 35(1), 1-38.

Freeman, L. C. (1979). Centrality in social networks conceptual clarification. *Social networks*, 1(3), 215-239.

Hoque, S. F., Quinn, C., & Sallu, S. (2018). Differential livelihood adaptation to social-ecological change in coastal Bangladesh. *Regional Environmental Change*, 18(2), 451-463. https://doi.org/10.1007/s10113-017-1213-6

Kluger L. C., Taylor M. H., Wolff M., Stotz W., & Mendo J. (2019a). From an open-access fishery to a regulated aquaculture business: the case of the most important Latin American bay scallop (*Argopecten purpuratus*). Reviews in Aquaculture. https://doi.org/10.1111/raq.12234

Kluger L. C., Kochalski S., Aguirre-Velarde A., Vivar I., & Wolff M. (2019b). Coping with abrupt environmental change: The impact of the coastal El Niño 2017 on artisanal fisheries and mariculture in North Peru. *ICES Journal of Marine Science*, 76(4), 1122-1130. https://doi.org/10.1093/icesjms/fsy171

Kluger, L. C., Gorris, P., Kochalski, S., Mueller, M. S., & Romagnoni, G. (2020). Studying human-nature relationships through a network lens: A systematic review. *People and Nature*, 2(4), 1100-1116.

Mahmuduzzaman, M., Ahmed, Z. U., Nuruzzaman, A. K. M., & Ahmed, F. R. S. (2014). Causes of salinity intrusion in coastal belt of Bangladesh. *International Journal of Plant Research*, 4(4A), 8-13. https://doi.org/10.5923/s.plant.201401.02

Marin, A., Bodin, Ö., Gelcich, S., & Crona, B. (2015). Social capital in post-disaster recovery trajectories: Insights from a longitudinal study of tsunami-impacted small-scale fisher organizations in Chile. *Global Environmental Change*, 35, 450-462.

Matous, P., & Wang, P. (2019). External exposure, boundary-spanning, and opinion leadership in remote communities: a network experiment. *Social Networks*, 56, 10-22.

IPCC (2019). Summary for policymakers. In IPCC special report on the ocean and cryosphere in a changing climate. Pörtner, H.-O., Roberts, D. C., Masson-Delmotte, V., Zhai, P., Tignor, M., Poloczanska, E., Mintenbeck, K., Alegría, A., Nicolai, M., Okem, A., Petzold, J., Rama, B. & Weyer, N. M. (eds.).

Sultana, Z., & Mallick B. (2015). Adaptation strategies after cyclone in southwest coastal Bangladesh–pro poor policy choices. *American Journal of Rural Development*, 3(2), 24-33. https://doi.org/10.12691/ajrd-3-2-2

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