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Fisheries Performance in Africa

An Analysis Based on Data from 14 Countries

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Fisheries Performance in Africa: An Analysis Based on Data from 14 Countries

Abstract

The Fisheries Performance Indicators is a data collection tool that allows comparable fisheries data in the environmental, economic and community dimensions to be collected even in data-poor environments. In this paper, data collected for 35 fisheries in 14 African countries that make up 54.8% of Africa's reported fish landings are analyzed and compared to global averages. Similar to a previous global analysis, our results indicate no trade-offs between the different pillars of sustainability, as all are positively correlated. These results are even more pronounced for Africa than globally. The only exception is the relationship between environment and community in Africa, which is statistically insignificant, similarly to open access fisheries globally. The African average scores are lower than the global scores in all categories, which is not unexpected given the high number of open access fisheries. However, factors that are not fisheries-specific are most important for this result, suggesting that a country's development status is important for fisheries performance.

Keywords: fisheries performance; governance; management; Africa

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1. Introduction

It is generally recognized that seafood is the most important source of protein in many poor and vulnerable societies, and many countries in Africa fall into this category (Allison et al., 2009; Golden et al., 2016). Seafood is also an important source of nutritional security and livelihoods (Smith et al., 2010), as well as an important contributor to national income (Asche et al., 2015). This makes seafood particularly important in Africa despite the fact that African fish landings of 9.7 million metric tons (mt) in 2017 make up only 10.5% of global production. Aquaculture in Africa is even smaller, accounting for only 2.6% of global production in 2017 (FAO, 2018). Hence, although growth rates for aquaculture production in Africa are increasing (Anderson et al., 2019; Garlock et al., 2020), per capita seafood availability is likely to be reduced in many African countries given the anticipated high population growth in Africa (Kobayashi et al., 2015). As a consequence, reductions in fish landings may threaten human health and livelihoods, and good management is critical to harvesting existing resources in a beneficial and sustainable manner.

Globally, the situation for many fish stocks has improved in a number of places, and managed fisheries are generally sustainable (Hilborn et al., 2020). The status of unassessed and unmanaged fisheries, on the other hand, is not improving (Costello et al., 2012; Hilborn and Ovando, 2014), and in some cases they are subject to excessive and/or illegal fishing (Beddington et al., 2007; Agnew et al., 2009; Pomeroy 2012), which has economic and social implications in the form of lost revenue, reduced food security and poorer human health outcomes (Béné et al., 2010; Smith et al., 2010; Srinivisan et al., 2010; Sumaila et al., 2012). Unfortunately, fisheries in many African countries fall within the latter category and are increasingly encumbered by unregulated foreign industrial fishing (Belhabib, Sumalia and Le Billon, 2019).

In this paper, we will assess the status of fisheries in 14 African countries using data collected with the Fishery Performance Indicators (FPI). The FPIs (Anderson et al., 2015) are a rapid assessment instrument designed to measure fishery performance along the environmental, economic and social dimensions, and have been used to compare fisheries systems at a global scale (Asche et al., 2018), for specific species complexes (McCluney et al., 2019) and for specific projects (Chu et al., 2017). Such data has been collected for 35 fisheries in 14 countries that make up 54.8% of Africa's reported fish landings (FAO, 2018). An important feature of the FPI data is that they focus on all three pillars of sustainability – the environmental, the economic and the social. This allows the importance of factors beyond only fish stocks to be investigated. The analysis of this paper will focus on two main questions: 1) How do fisheries in Africa compare to global averages? and 2) How much variation is there within Africa?

2. Background

Table 1 provides fish landings in 2017 for the 14 African countries for which FPI data have been collected. In addition to the expected coastal nations, there are also nations where inland fishing is important (Uganda, and partly Kenya and Tanzania), and island nations (Guinea-Bissau and the Seychelles). The data are not representative, but rather reflect what has been contributed voluntarily to the FPI database from different projects. However, there is significant variation in the type of nations represented with respect to resource availability as well as population and socio-economic development.

Morocco is the largest fishing nation by landings, followed by Nigeria, which is consistent within our sample.[1] In our sample, Nigeria is followed by a group consisting of South Africa, Senegal and Uganda, with about one-half million mt each. The importance of inland fishing is well illustrated by Uganda, which is the fourth-largest harvesting nation in our sample, and where all fishing is carried out in fresh water. The Lake Victoria fisheries sector is large enough for there to be a highly diverse fishing industry, which includes a significant export sector (Eggert et al., 2015). It is also of interest to note the variation in the landed quantity between the island nations, where Guinea-Bissau is the smallest harvesting nation in our sample, while the Seychelles is quite significant.

[1] During 2018 and 2019, researchers affiliated with EfD centers in Ghana, Nigeria, South Africa and Tanzania collected FPI data and added 10 more fisheries to the existing 25 in the FPI data base. For more information about the Ghana, Nigeria, South Africa and Tanzania fisheries, see the appendix.

Table 1. Total Landings within Sampled Countries (1,000 mt)

Country	Landings
Gambia	60.5
Ghana	381.9
Guinea-Bissau	6.7
Kenya	122.2
Liberia	14.8
Malawi	199.5
Morocco	1,377.5
Nigeria	916.3
Senegal	497.7
Seychelles	135.7
Sierra Leone	202.1
South Africa	523.6
Tanzania	387.4
Uganda	502.0
Total	5,327.7

An important feature of African fisheries is the limited number with effective management. Of the 35 fisheries that make up the sample, 25 are classified as open access. *Open access*, as defined in FPI, does not necessarily mean total absence of management. However, it implies an inefficient management system that is not able to limit open access incentives or to provide any effective protection for the fish stocks. Somewhat surprisingly, the second most represented management system in the data is *catch shares*, where a total allowable catch is divided into individual fishing quotas (IFQs). However, this accounts for only five fisheries, of which four are in South Africa and one in Morocco. There are four *limited entry* fisheries and one managed with a Territorial Use Right for Fishing (*TURF*). The *TURF* fishery is an oyster fishery.

3. The Fishery Performance Indicators (FPIs)

The FPIs are developed to be a user-friendly, multi-dimensional data collection tool to obtain information on the performance of fisheries management systems in achieving environmental, economic and social outcomes. The FPIs consist of two main indicator categories: (1) 68 output indicators, such as degree of overfishing and annual landing volatility, that reflect success or failure of the fishery management system; and (2) 54 input factors, such as quality of management system and market conditions, which enable or hinder achievement of good environmental, social, and economic outcomes (Anderson et al., 2015).

All the indicators are coded from 1 to 5 to allow experts to characterize the fishery system within a broad range even when precise data are unavailable. Information used to score the indicators can be quantitative or qualitative, and the evaluator assesses the degree of uncertainty for each measure by also giving the estimate a quality score (A, B, or C) to indicate the scorer's confidence in the accuracy of the chosen score. A user-friendly Excel spreadsheet has been developed along with a detailed manual to explain each indicator and the scoring, and to provide some examples (Anderson et al., 2015). The individual measures are designed to be quantifiable and accurate while also being easily scored by a person knowledgeable about the fishery, distribution system and region, even under conditions of limited or no data. The metrics vary from specific indicators related to fisheries management to general indicators of the society or the environment in which the fishery operates. This allows evaluation based on the narrow indicators mostly considered in fishery science as well as a wider set of indicators that allow more general impacts to be taken into account.

Although individual metrics may be imprecise, using multiple metrics for each performance dimension will cancel out poor measures. Metrics are aggregated into 15 input and 14 output dimensions with the intent to reduce the potential mismeasurement and triangulate more reliable values. These procedures make the FPIs more robust, particularly in data-poor fisheries. These dimensions are further designed to be aggregated to a framework of indicators that captures key dimensions of environmental, economic and social sustainability (also known as the triple bottom line), or of harvest sector and post-harvest sector performance.

FPI data have been collected on 145 fishery systems around the globe, providing the reference averages. Thirty-six percent of the sample is from developed countries and sixty-four percent is from developing countries. Asia represents 35% of the sample, North America, 23%, Africa, 24%, Europe, 8% South America, 6%, and Oceania, 4%. The sample of fisheries is diverse and comprises multispecies (51%) and single-species fisheries that operate in various ecosystems: nearshore (58%), offshore (34%) and inland (8%); and target a wide range of species: finfishes, (70%), crustaceans (20%), bivalves (3%), and others (7%). When it comes to management systems, 64 fisheries are *open access*, 40 are managed with *limited entry*, 29 fisheries are managed with *catch shares* and 12 fisheries with *TURF*s.

4. African Fisheries

Sustainability is generally recognized to have three pillars: an environmental, an economic and a social pillar. Asche et al. (2018) show that, for the total FPI data base, these pillars on average are complementary. Hence, in general there is not a trade-off where, for instance, one can improve economic performance by degrading the fish stocks. This intuitively makes sense, because if the tragedy of the commons were allowed to play out and the fish stocks became degraded, there would be few fish to land, giving rise to poor economic performance. Moreover, the complementary relationships tend to be stronger the stronger the management system, but are weakest in relation to the community dimension.

Figure 1 show the scores for the 14 African countries for the three pillars. As one can see, the lines do not cross very much, indicating that the complementary relationship largely holds true in Africa. There are some crossovers in the economic and community dimensions, but, as they have very similar scores in most cases, this does not signal clearly different outcomes. However, while there are no countries where the economic score is clearly better than the environmental score, Uganda, Tanzania and Gambia have an environmental score which is clearly higher than the economic score. Interestingly, the community score is clearly better than the other two pillars in most countries, with relatively low scores only in Nigeria and Gambia.

More formally, the correlations coefficient (with *p*-values in parenthesis) between the environmental and economic pillar is 0.53 (<0.01), economic and community is 0.59 (<0.01) and environment and community 0.09 (0.57). The similar correlation coefficients for the global sample reported by Asche et al. (2018) are 0.52, 0.50 and 0.23. Hence, two of the correlations are slightly stronger in Africa, while the relationship between environment and community is not only weaker but also statistically insignificant. However, this is not surprising given that the majority of African fisheries are classified as *open access*. Asche et al. (2018) report a correlation coefficient of 0.09 that is also statistically insignificant for open access fisheries globally. However, the other two relationships are also statistically insignificant in open access fisheries globally, while they are highly significant in Africa. Hence, there is no evidence in the data that one can improve performance for one pillar by giving up performance in another. Moreover, while the data does not allow us to make causal inferences, it appears that better economic performance can be achieved by either better environmental performance or better community performance.

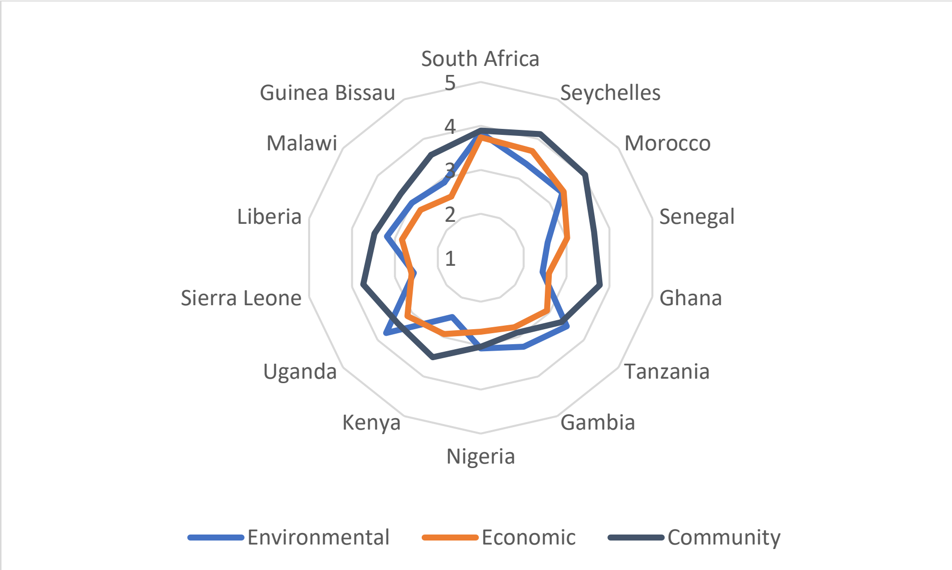

Figure 1. Performance with Respect to the Three Pillars of Sustainability

South Africa is the country with the best performance; its scores are among the highest for all three pillars. This may not be too surprising given that the country probably has the most advanced fisheries management system in Africa. It is also worthwhile to note that the community scores tend to be highest in countries with higher income levels. However, there are clear exceptions, like Sierra Leone, which has high community scores but low income. Here, it is different factors that are driving the score, primarily related to higher local participation, as all Sierra Leone fisheries in our sample are small-scale and artisanal.

The FPIs can also be aggregated by sector to assess the performance of the harvest sector and the post-harvest sector. This is important because the focus of fisheries policy often is not the fleet as such, but the coastal communities it supports (Kroetz et al., 2015; Bertheussen and Dreyer, 2019; Cojocaru et al., 2019; Nielsen et al., 2018). In Figure 2, these performance measures are shown for the 14 countries. As one can see, the two performance measures appear correlated, with a few outliers. However, in general these performance measures support the notion that there is interdependence between the fleet and the processing sector. Correlation coefficients confirm this; they are 0.65 (<0.01) for the 35 fisheries and 0.58 (<0.01) for the 14 countries. For Malawi, Nigeria and Morocco, the harvest sector does much better than the post-harvest sector. A challenge, of course, is that the FPI data does not allow any assessment of causality. Accordingly, one cannot say whether investments related to the fleet, such as improved management, or investments in coastal communities, such as infrastructure, are best for development.

South Africa and Seychelles are the countries with the best-performing harvest and post-harvest sectors, and the harvesting sector in Morocco is doing equally well. From a development perspective, this can be a challenge, as these fisheries use relatively large vessels, and the data include all the fisheries with the most capacity-demanding management systems (i.e., *catch share* management).

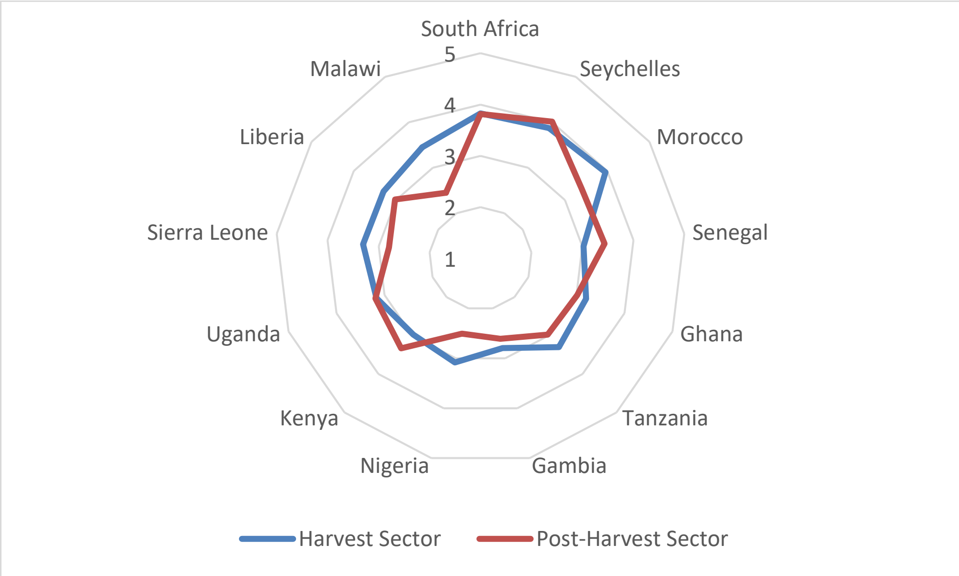

Figure 2. Harvest Sector and Post-Harvest Sector Performance

5. Africa vs. Global

In this section, the overall average performance of the African fisheries will be compared to the global averages for the three pillars of sustainability as well as harvest and post-harvest sector performance.[2] To shed more light on the potential differences, we will also show the average scores for Africa and the world in the 14 output and 15 input dimensions.

Figure 3 shows the three pillars of sustainability as well as harvest and post-harvest sector performance. Africa scores lower than the global averages in all categories, although the differences do not appear very large. Lower scores for Africa in the environmental category are not too surprising, given the high share of *open access* fisheries in Africa. 71.4% of the African FPI fisheries are *open access*, while that share is 44.1% for all FPI fisheries. As discussed by Costello et al. (2012) and Hilborn and Ovando (2014), *open access* is not conducive to healthy fish

[2] The global averages also contain the African data.

stocks or stock recovery. It is expected that poor environmental status and weak fisheries management systems also limit economic performance, as poorer stock status increases harvesting costs and limits market opportunities (Homans and Wilen, 2005; Costello et al., 2012; Kroetz et al., 2015; Asche and Smith, 2018; Birkenbach et al., 2019). Given that it is implicit in the three-pillar definition of sustainability that all three dimensions are positively correlated, and this is shown to be the case for fisheries in general (Asche et al., 2018), it is not surprising that Africa also scores low in the social dimension. It is very difficult to do well in the social pillar if neither the environmental nor the economic pillar is very strong.

Africa also scores lower in harvest and post-harvest performance compared to global database averages. The difference in post-harvest performance is large relative to the difference in harvest performance. This is most likely due to the fact that as many as 71.7% of the fisheries globally are characterized as either open access or limited entry. Because neither of these governance systems corrects any of the economic incentives related to the tragedy of the commons (Wilen, 2006), it implies that harvest governance is not that much better globally than in Africa.

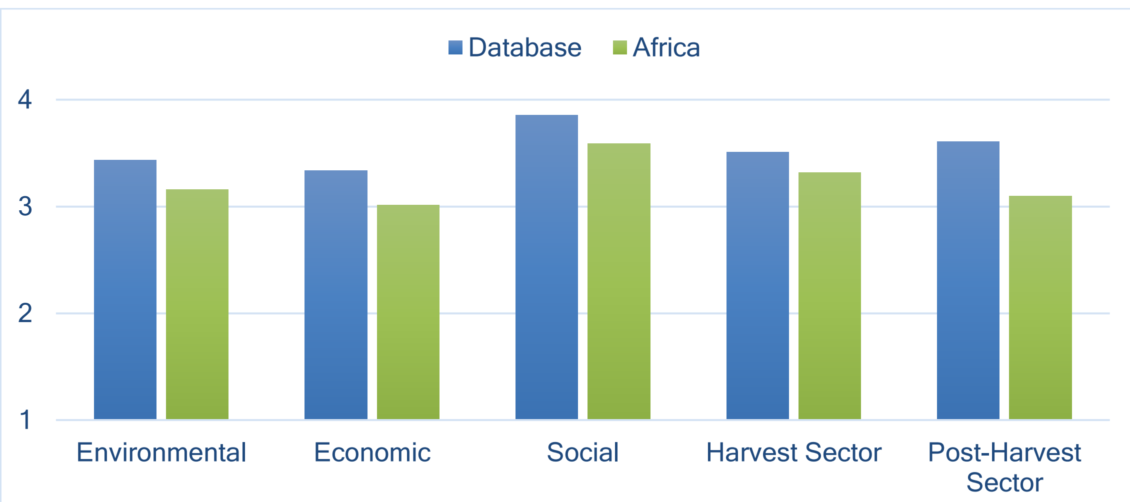

Figure 3. Average Scores of the Three Pillars of Sustainability and Harvest and Post-Harvest Sector Performance: Rest of the world and Africa.

Given that there are some countries in Africa, in particular South Africa, that have more advanced fisheries management systems, it is worthwhile to note that the average scores would be even lower if these countries were removed. Similarly, with as many as 41% of the fisheries assessed globally being characterized as open access, there are also a number of poorly performing fisheries in other parts of the world. With the positive correlation in performance for the three pillars of sustainability, this suggests that the potential to improve performance for the majority of fisheries that are characterized as *open access* is significantly larger than what is suggested by the relatively small differences in the average scores.

Figure 4 provides the scores for the 15 input dimensions. Most of these are scored with increasing strength of a phenomenon which can be good or bad depending on perspective on the issue. For instance, most economists will regard stronger harvest rights as good (e.g., Costello et al., 2012), while social scientists in favor of co-management approaches will regard it as problematic (e.g., Young et al., 2018). Note that the gender category also has a 5-digit scale, but with 3 as equal gender representation, 1 as male dominance and 5 as female dominance. Hence, African fisheries in our sample are more equal than fisheries in the rest of the world.

The most striking differences are in inputs that are completely unrelated to the specific fishery. The largest differences are in the dimensions of national economic strength, general environmental health, and, to a lesser extent, national governance and infrastructure. Hence, fisheries in Africa start with a disadvantage in that they operate in less developed countries. This becomes particularly obvious by the limited ability of national governments in Africa to manage and enforce international agreements with foreign fleets. It is also interesting to note that differences are relatively small in non-governance-related factors that are fisheries-specific, such as leadership and cohesion, collective action, market institutions, and participation and support. Finally, the importance of women in African fisheries also shows up clearly, with a markedly better gender balance because women dominate onshore handling and processing of fish.

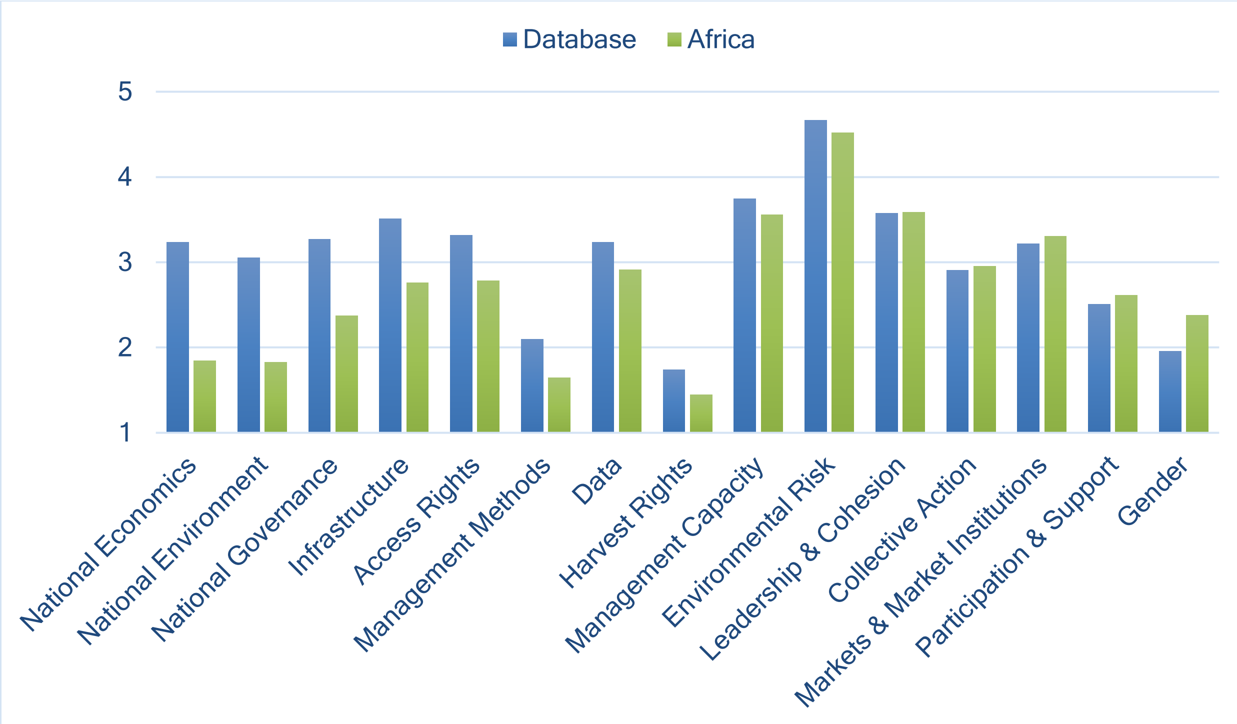

Figure 4. Input Dimensions

The 14 output dimensions are shown in Figure 5. Generally, the differences are smaller here, but the dimensions with larger differences are again mostly related to factors that are not fisheries-specific. Better access to international markets, measured by the trade dimension, is likely a function of better governance and infrastructure. This also holds true for the African fisheries, as shown by the strong positive correlation between infrastructure and trade in Figure 6. Health and sanitation and community services are outputs that largely are facilitated by inputs such as national economy, environment and governance. However, they also facilitate fisheries-specific outputs by enabling the production and sale of higher-value products to better-paying markets, both by improving product quality (Asche and Smith, 2018) and reducing phyto-sanitary risks and the associated trade issues (Chen et al., 2018; Oglend and Straume, 2019; Wang et al., 2019). It is interesting that larger differences were not found with respect to the health of fish stocks. This is perhaps reflective of the fact that domestic landings are usually misreported and the majority of harvest by foreign fleets is not reported (Belhabib et al., 2015). It is also of interest that local ownership is less prevalent in Africa but this does not seem to influence the labor force very much, as Africa scores similarly to the global average with respect to local labor.

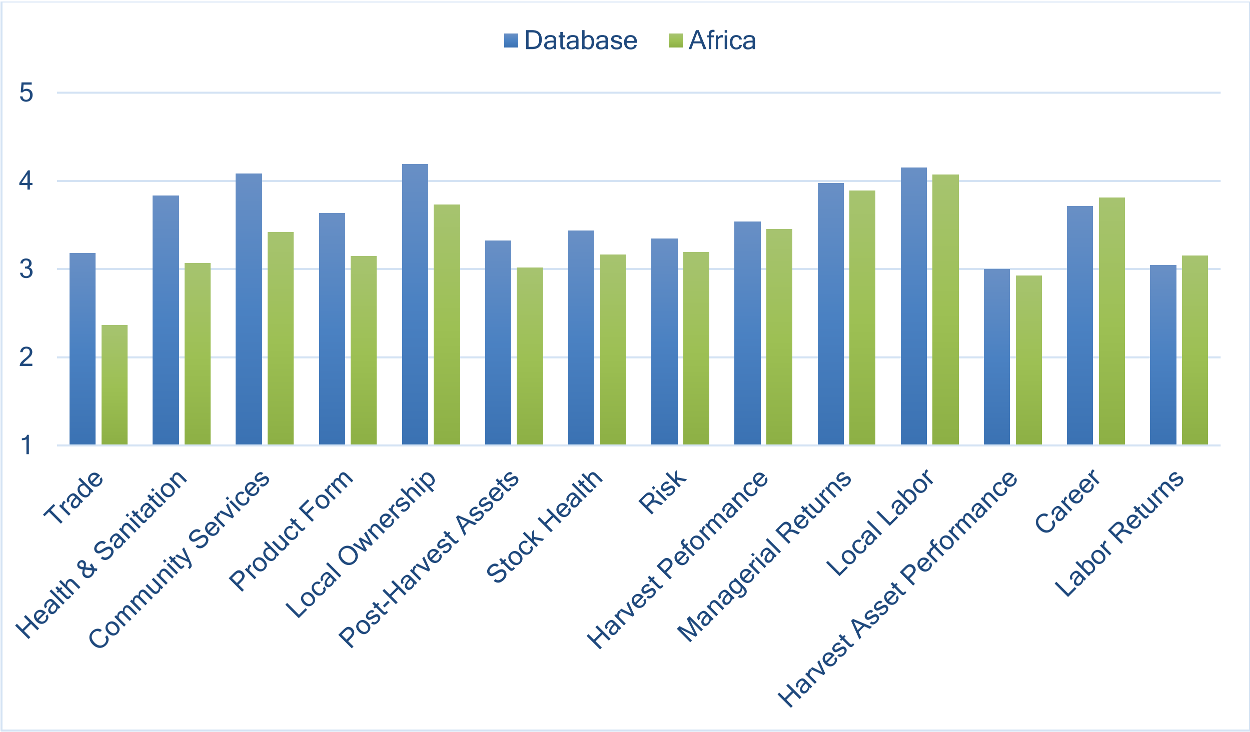

Figure 5. Output Dimensions

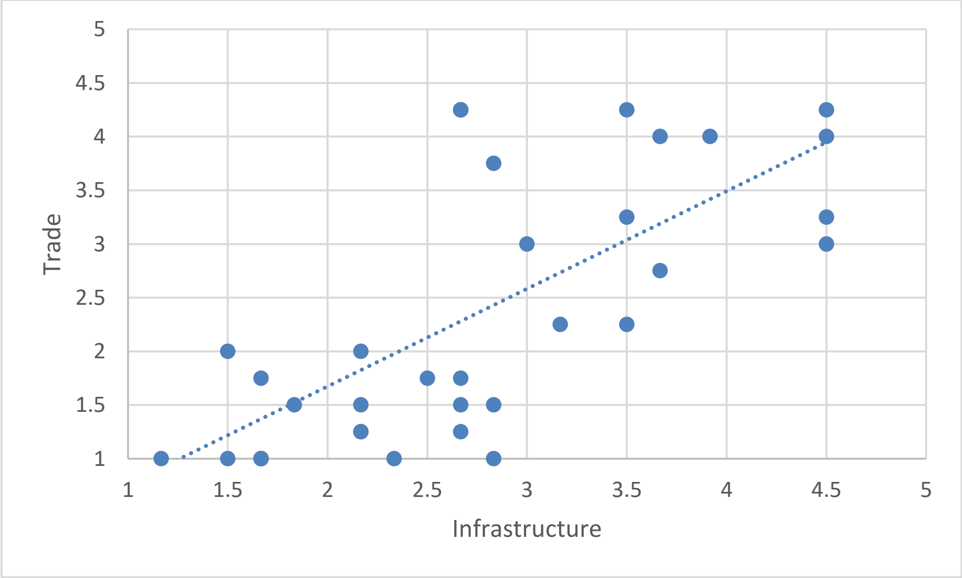

Figure 6. The Relationship between Trade and Infrastructure

6. Concluding Remarks

The FPIs have been used to collect data for 35 fisheries in 14 countries in Africa. The structure in African fisheries governance differs significantly from the rest of the world in that 71% (25 of 35) of the fisheries, compared to 44% (64 of 145) globally, are characterized as *open access*. Hence, fisheries management systems are to a large extent absent. Given this result, it is somewhat surprising that there are significant and very strong positive correlations in Africa between economic and environmental performance and between economic and community performance, while these measures are statistically insignificant globally for open access fisheries. In line with what is reported globally, the correlation between environment and community for African fisheries is statistically insignificant. However, all correlation coefficients are positive, indicating that on average there are no trade-offs where performance for one pillar of sustainability could be improved by sacrificing sustainability in another. It is also worthwhile to note that there is a strong positive correlation between harvest sector performance and post-harvest sector performance, and that the countries with management systems classified as *catch shares* do better.

When comparing the African performance averages to the global averages, Africa scores lower in all three pillars of sustainability, as well as in harvest sector performance and post-harvest sector performance. This may not be too surprising given the high share of fisheries that are classified as *open access*. However, when looking at the 15 input and 14 output dimensions, societal factors unrelated to fisheries seem to be more important, and accordingly a country's development status appears to be more important than its fisheries management system. For instance, there is a strong positive correlation between infrastructure and trade, indicating that fishers in countries with access to international markets create more monetary value. The importance of the factors that are not fisheries-specific suggests limits on how much one can achieve with only fisheries-related measures.

References

Agnew, D. J., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J. R., and Pitcher, T. J. (2009). Estimating the worldwide extent of illegal fishing. *PLoS One*, *4*(2), e4570. doi: 10.1371/journal.pone.0004570.

Allison, E. H., Perry, A. L., Badjeck, M. C., Neil Adger, W., Brown, K., Conway, D., … Dulvy, N. K. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries*, *10*(2), 173–196.

Anderson J. L., Anderson, C. M., Chu, J., Meredith, J., et al. (2015). The fishery performance indicators: A management tool for triple bottom line outcomes. *PLoS One*, *10*(5), e0122809.doi:10.1371/journal.pone.0122809.

Anderson, J. L., Asche, F., and Garlock, T. (2019). Economics of aquaculture policy and regulation. *Annual Reviews of Resource Economics*, *11*, 101–123.

Asche, F., Garlock, T., Anderson, J., Bush, S., Smith, M., Anderson, C., Chu, J., Garrett, K., Lem, A., Lorenzen, K., Oglend, A., Tveteras, S., and Vannuccini. S. (2018). The three pillars of sustainability in fisheries. *Proceedings of the National Academy of Sciences*, *115*(44), 11221–11225.

Asche, F., Bellemare, M., Roheim, C., Smith, M. D., and Tveteras, S. (2015a). Fair enough? Food security and the international trade of seafood. *World Development*, *67*, 151–160.

Asche, F., and Smith, M. D. (2018). Induced innovation in fisheries and aquaculture. *Food Policy*, *76*(April), 1–7.

Beddington, J. R., Agnew, D. J., and Clark, C. W. (2007). Current problems in the management of marine fisheries. *Science*, *316*(5832), 1713–1716.

Belhabib, D., Sumalia, U. R., Lam, V. W. Y., Zeller, D., Le Billon, P., Kane, E. A., and Pauly, D. (2015). Euros vs. yuan: Comparing European and Chinese fishing access in West Africa. *PLoS ONE*, *10*(3), e0118351. doi:10.1371/journal.pone.0118351.

Belhabib, D., Sumaila, U. R., and Le Billon, P. (2019). The fisheries of Africa: Exploitation, policy and maritime security trends. *Marine Policy*, *101*, 80–92.

Béné, C., Hersoug, B., and Allison, E. (2010). Not by rent alone: Analysing the pro-poor functions of small-scale fisheries in developing countries. *Development Policy Review*, *28*(3), 325–358.

Bertheussen, B. A., and Dreyer, B. M. (2019). Is the Norwegian cod industry locked into a value-destructive volume logic? *Marine Policy*, 103, 113–120.

Birkenbach, A. M., Smith, M. D., and Stefanski, S. (2019). Taking stock of catch shares: Lessons from the past and directions for the future. *Review of Environmental Economics and Policy, 13*(1), 130–139.

Chen, R., Hartarska, V., and Wilson, N. L. W. (2018). The causal impact of HACCP on seafood imports in the US: An application of difference-in-differences within the gravity model. *Food Policy, 79,* 166–178.

Chu, J., Garlock, T. M., Sayon, P., Asche, F., and Anderson, J. L. (2017). Impact evaluation of a fisheries development project. *Marine Policy*, *85,* 141–149.

Cojocaru, A., Asche, F., Pincinato, R. B., and Straume, H-M. (2019). Where are the fish landed? An analysis of landing plants in Norway. *Land Economics, 95*(2), 246–257.

Costello, C., Ovando, D., Hilborn, R., Gaines, S. D., Deschenes, O. and Lester, S. E. (2012). Status and solutions for the world's unassessed fisheries. *Science, 338,* 517–520.

Eggert, H., Greaker, M., and Kidane, A. (2015). Trade and resources: Welfare effects of the Lake Victoria fisheries boom. *Fisheries Research*, *167,* 156–163.

FAO. 2018. The State of World Fisheries and Aquaculture. Rome.

Garlock, T., Asche, F., Anderson, J. L., Bjørndal, T., Kumar, G., Lorenzen, K., Ropicki, A., Smith, M. D., and Tveterås, R. (2020). A global blue revolution: Aquaculture growth across regions, species, and countries. *Reviews in Fisheries Science and Aquaculture, 28*(1), 107–116. doi.org/10.1080/23308249.2019.1678111.

Golden, C. D., Allison, E. H., Cheung, W. W .L., Dey, M. M., Halpern, B. S., McCauley, D. J. ... Myer, S. S. (2016). Nutrition: Fall in fish catch threatens human health. *Nature*, *534,* 317–320.

Hilborn, R., Amoroso, R. O., Anderson, C. M., Baum, J. K., Branch, T. A., Costello, C., de Moor, C. L., Faraj, A., Hively, D., Jensen, O. P., Kurota, H., Little, L. R., Mace, P., McClanahan, T., Melnychuk, M. C., Minto, C., Osio, G. C., Parma, A. M., Pons, M., Segurado, S., Szuwalski, C. S., Wilson, J. R. and Ye, Y. (2020). Effective fisheries management instrumental in improving fish stock status. *Proceedings of the National Academy of Sciences,* https://doi.org/10.1073/pnas.1909726116.

Hilborn, R., and Ovando, D. (2014). Reflections on the success of traditional fisheries management. *ICES Journal of Marine Science*, *71*(5), 1040–1046.

Homans, F. R., and Wilen, J. E. (2005). Markets and rent dissipation in regulated open access fisheries. *Journal of Environmental Economics and Management*, *49,* 381–404.

Kobayashi, M., Msangi, S., Batka, M., Vannuccini, S., Dey, M. M., and Anderson, J. L. (2015). Fish to 2030: The role and opportunity for aquaculture. *Aquaculture Economics & Management*, *193*, 282–300.

Kroetz, K., Sanchirico, J. N., and Lew, D. K. (2015). Efficiency costs of social objectives in tradable permit programs. *Journal of the Association of Environmental and Resource Economists, 2*(3), 339–366.

McCluney, J. K., Anderson, C. M., and Anderson, J. (2019). The fishery performance indicators for global tuna fisheries. *Nature Communications*, *10*(1641).

Nielsen, M., Asche, F., Bergesen, O., Blomquist, J., Henriksen, E., Hoff, A., Nielsen, R., Viðarsson, J. R., and Waldo, S. (2018). The myth of the poor fisher: Evidence from the Nordic countries. *Marine Policy, 93,* 186–194.

Oglend, A., and Straume, H.-M. (2019). Pricing efficiency across destination markets. *Aquaculture Economics and Management*, *23*(2), 188–203.

Pomeroy, R. S. (2012). Managing overcapacity in small-scale fisheries in Southeast Asia. *Marine Policy, 36,* 520–527. doi: 10.1016/j.marpol.2011.10.002.

Smith, M. D., Roheim, C. A., Crowder, L. B., Halpern, B. S., Turnipseed, M., Anderson, J. L., Asche, F., Bourillón, L., Guttormsen, A. G., Kahn, A., Liguori, L. A., McNevin, A., O'Connor, M., Squires, D., Tyedemers, P., Brownstein, C., Carden, K., Klinger, D. H., Sagarin, R., and Selkoe, K. A. (2010). Sustainability and global seafood. *Science, 327,* 784–786.

Srinivisan, U. T., Cheung, W. W. L., Watson, R., and Sumalia, U. R. (2010). Food security implications of global marine catch losses due to overfishing. *Journal of Bioeconomics*, *12*(3), 183–200.

Sumaila, U. R., Cheung, W., Dyck, A., Gueye, K., Huang, L., Lam, V., Pauly, D., Srinivasan, T., Swartz, W., Watson, R., and Zeller, D. (2012). Benefits of rebuilding global marine fisheries outweigh costs. *PLoS One*, *7*(7), e40542. doi:10.1371/journal.pone.0040542.

Wang, P., Tran, N., Wilson, N. L. W., Chan, C. Y., and Dao, D. (2019). An analysis of seafood trade duration: The case of ASEAN. *Marine Resource Economics*, *34*(1), 59–76.

Wilen, J. E. (2006). Why fisheries management fails: Treating symptoms rather than causes. *Bulletin of Marine Science, 78,* 529–546.

Young, O. R., Webster, D. G., Cox, M. E., Raakjær, J., Blaxekjærd, L. Ø., Einarsson, N., Virginia, R. A., Achesong, J., Bromley, D., Cardwell, E., Carothers, C., Eythorsson, E., Howarth, R. B., Jentoft, S., McCay, B. J., McCormack, F., Osherenko, G., Pinkerton, E., van Ginkel, R., Wilson, J. A., Rivers III, L., and Wilson. R. S. (2018). Moving beyond panaceas in fisheries governance. *Proceedings of the National Academy of Sciences*, *115*(37), 9065–9073.

Appendix

Part 1: Industrial Trawl and Semi-industrial Inshore Fishing in Ghana

Industrial Trawl Fishing in Ghana: An Introduction

Industrial trawl fishing is one of the four capture marine fishing sub-sectors in Ghana. The others are the artisanal or small-scale fishery, the semi-industrial or inshore fishery, and the tuna fishery. Currently, the industrial trawlers land about 6% and over 30% of total marine capture and industrial production, respectively (Akpalu et al., 2018; Akpalu and Okyere, 2018). Only Ghanaians can own trawl fishing licenses and the vessels are only permitted to bottom-trawl and target bottom-dwelling species offshore (i.e., waters outside of the nation's inshore exclusive zone (IEZ)) (Akpalu, et al., 2018). However, owing to lack of domestic capital to invest in the industry, the Fisheries Act (Act 625) provides for the nationals to acquire the vessels through hire-purchase agreements. This has inadvertently intensified fishing efforts, and consequently catch per trawler. (See Figure A1.) By 2013, the number of vessels had risen to 103, while the corresponding figure that maximizes economic yield is about 50 (MoFAD, 2015). The fishery has no catch quota, but it is illegal to land juvenile stocks.

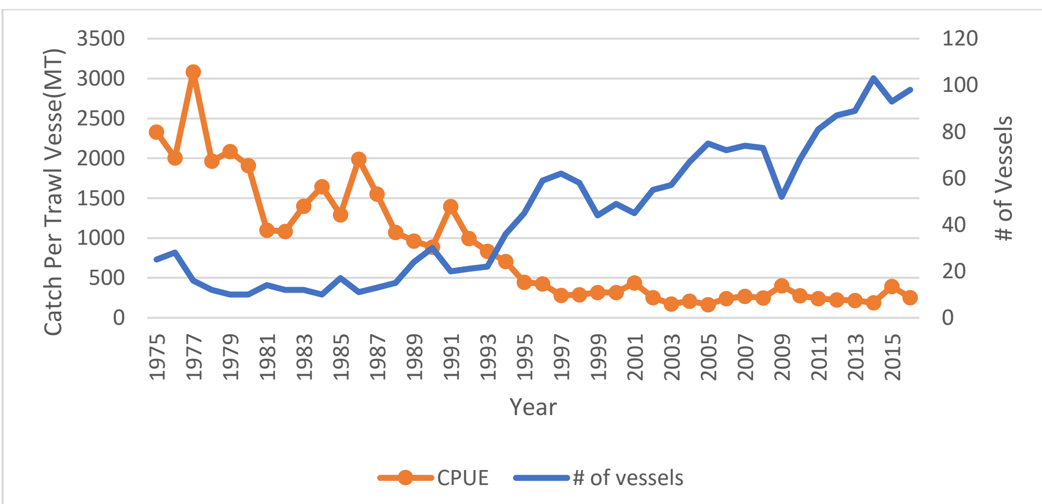

Figure A1. Catch Per Industrial Trawl Vessel and Number of Trawl Vessels in Ghana (1971-2016)
(Source: Fisheries Scientific Survey Division of MoFAD, Ghana)

The FPIs for Trawl Fishing in Ghana

On the Triple Bottom Line (TBL) of the trawl fishery – i.e., ecological, economic and social performance (Anderson et al., 2016) – the ecological indicator had the lowest score (42%). This is because the fishery is overcapitalized and biologically overexploited. The economic performance of the fishery is also quite low (50%) owing to overfishing, limited restriction on the season length, the moderate revenue from landings, and low proportion of catch exports. On the other hand, the community indicator had a remarkably high score (80%). This is primarily due to local ownership and the use of local labor, as well as the affordable health care and educational services enjoyed by the fishermen and fish processors. The two complementary wealth-enabling outcomes (harvest sector and post-harvest performance) had moderate scores of over 60%. On the other hand, the enabling conditions that produced the outcomes – i.e., environmental and other exogenous factors, resource governance and post-harvest infrastructure and institutions – performed at one-half of global standards.

Inshore or Semi-Industrial Fleet in Ghana: An Introduction

The inshore or semi-industrial fishery bears the characteristics of artisanal and industrial fisheries. Like the artisanal fishers, the operators use wooden boats, which are longer (up to 30m) and are powered by inboard engines of 90-400 hp. Like the industrial trawlers, the vessels are licensed. They can either trawl or do purse seining, targeting both pelagic and demersal species such as sardinella, mackerel, sea breams, cassava fish, burrito, triggerfish, red mullet, and flying gurnard. However, sardinella remains the dominant species targeted by the fleet, constituting over 60% of total landings. The crew size ranges from 12 to 35 men, depending on the size of the vessel and the fishing gear deployed (Mensah and Koranteng 1988). Figure A2 shows the evolution of the number of inshore boats from 1990 to 2014. Over 24 years, the fleet capacity increased by 90% on average. Using catch and effort data (1986 – 2016), the number of boats corresponding to the MSY was estimated at 276, and the fleet capacity that maximizes economic rents was estimated at 250 boats.

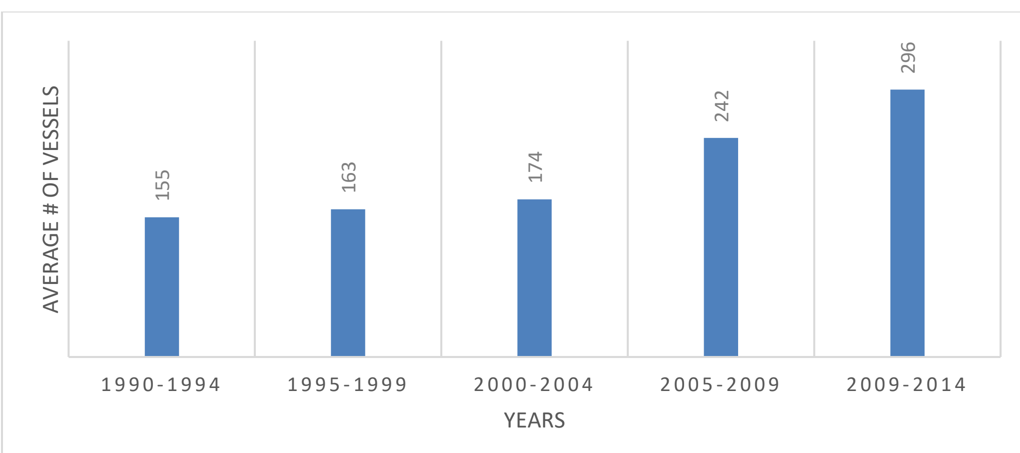

Figure A2. The Fleet Capacity of Inshore Fishery in Ghana (1990-2014). (Source: Fisheries Scientific Survey Division)

The FPIs for the Inshore or Semi-Industrial Fleet in Ghana

A Fishery Performance Indicator (FPI) has been constructed to verify the ecological, economic and community sustainability of the inshore fishery in Ghana. Compared to the industrial trawling within the nation's waters, the stocks targeted by the inshore fleet are in good health, scoring 70% of global standards. The high score is due to the low impact of the fishing activities on the benthic floor of the ocean, the absence of discards and the moderate levels of stock overfishing. Furthermore, the landings are for domestic consumption and the prices of the targeted species are quite high, compared to historic values; hence, the economic performance of the fishery is rated at almost 60%. Finally, the social or community outcome has the highest score owing to full local participation in fishing and fish processing. In addition, as noted earlier, the fishers enjoy good public health care and formal education, which is currently free through the high school level. The performance of the TBL is also supported by the two wealth creation indicators, i.e., harvest sector performance and post-harvest performance, which registered appreciably high scores of over 70% and 60%, respectively. The most important factors responsible for generating the wealth in the fishery are the institutions and infrastructure within the post-harvest sector. These are coupled with low environmental risks, good leadership and overall management strategies.

References for Part 1

Akpalu, W., Eriksen, S. S., and Vondolia, G. K. (2018). The fisheries sector in Ghana. A political economy analysis. Norwegian Institute of International Affairs. Vol. 7.

Akpalu, W., and Okyere, M. (2018). Socio-economic analysis of the fisheries sector in Ghana. Draft report. Washington, D.C.: World Bank.

Anderson, J. L., Anderson, C. M., Chu, J., and Meredith, J. (2016). Fishery Performance Indicators Manual (Version 1.4). http://isfs.institute.ifas.ufl.edu/projects/new-metrics/fpi-manual.

Mensah, M. A., and Koranteng, K. A. (1988). A review of the oceanography and fisheries resources in the coastal waters of Ghana. Marine Fisheries Research Report No. 8, Fisheries Research and Utilization Branch. Tema, Ghana.

MOFAD. (2015) Fisheries Management Plan of Ghana: A National Policy for the Management of the Marine Fisheries Sector (2015–2019). Ministry of Fisheries and Aquaculture Development, Government of Ghana.

Part 2: Marine and Inland Artisanal Fisheries in Nigeria

Nigeria's Marine Artisanal Fishery: A Profile

Nigeria is endowed with marine fishery resources which contribute directly to the livelihoods of over 1.45 million people who are employed in the sector. With 382,964.0 metric tonnes in catches in 2015, a drop from 435,384 metric tonnes in 2014 (FDFA, 2017) (see Figure A3), Nigeria has the largest fishing sector in the Guinea Current Large Marine Ecosystem. The predominant fishery is artisanal and the target species are both pelagic and demersal and include croakers, bonga shad, barracuda, catfish, snapper, flat sardinella, shrimps, sharks, African red snapper, and others. Fishing in Nigeria is open access with limited regulation. Management methods – for example, the use of total allowable catch (TAC), territorial use rights for fishing (TURFs), quotas, fishing seasons, and fishing zones – do not exist. However, a new bill for the fisheries sector is being proposed that would include some measure of regulation. The fishing methods used by artisanal fishermen include drift nets, gill nets, encircling gill nets, fixed gill nets (on stakes), bottom set nests, cast nets, boat seines, lift nets and set longlines.

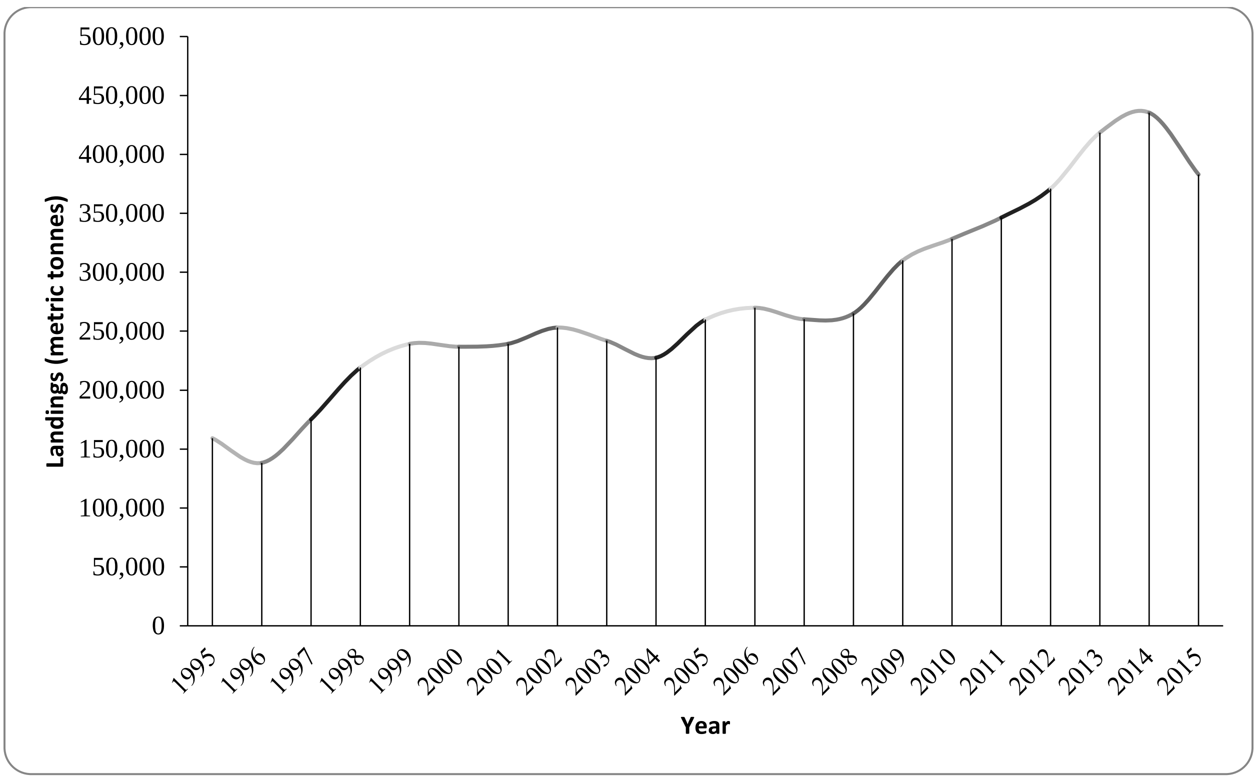

Figure A3. Landings in Artisanal Sector from Coastal and Brackish Water (metric tonnes)
(Source: Nigeria Federal Department of Fisheries and Aquaculture, Federal Ministry of Agriculture, 2017)

The Fishery Performance Indicators (FPIs) for Nigeria's Marine Artisanal Fishery

On the Triple Bottom Line (TBL) of the trawl fishery (Anderson et al., 2016), that is, ecological, economic and social performance, the ecological indicator had a score of 3.13 (63%). This suggests that the fishery stock is gradually experiencing overfishing and needs to be better managed to avert stock decline. Also, the findings suggest that the habitat is being degraded. Oil pollution may have contributed to this degradation given the high rate of oil exploration and the many oil spills that have occurred in the Nigerian marine area. The economic performance was lowest, with a score of 2.97 (59.4%). The harvest asset performance showed the fishery is moderately successful in generating wealth. However, fishing effort is not generating wealth commensurate with its potential, because property rights for fishing and harvest access are not clearly defined. Also, market performance of the fishery is poor, as not much value is added in the supply chain, and it does not attract international trade. The community indicator had the highest score of 3.40 (68%), showing fairly good participation by the locals of the fishing grounds, and also integration of the fisher folk within the communities.

An Inland Artisanal Fishery in Nigeria: The River Niger

Nigeria is endowed with a lot of inland water resources. Nigerian inland fisheries are multispecies; about 260 different species inhabit over 34 inland water bodies in Nigeria (lakes, rivers, reservoirs) (Olopade et al., 2017). One of the water bodies, River Niger, enters Nigeria from Niger Republic and cuts across several states in Nigeria. The stretch of the river between Anambra and Delta states were the focus of this assessment. Fishing activities in communities lying along the river bank were at different intensities. Generally, small-scale artisanal fishery is practiced. The indigenous fisher folk combine fishing with agriculture. The migrants, mainly from Nigeria's northern states, for example, Taraba, Nassarawa and Niger States, are in the majority in the fishing activities, and they are full-time fishers. The predominant species targeted by fishermen in the river are mudfish, African bony tongue, catfish, tilapia and Nile perch. Fishing in River Niger is open access, although some regulations are stipulated in the Inland Fisheries Act, while some are imposed by state governments, which are in charge of inland fisheries resources. With little surveillance and monitoring, these regulations are rarely obeyed. Although fishing takes place almost all year round, fishing activities are bimodal, mainly within the months of May, June, July and August and then in November and December.

The Fishery Performance Indicators for the River Niger

On the Triple Bottom Line (TBL) of the trawl fishery (Anderson et al., 2016), that is, ecological, economic and social performance, the ecological indicator had a score of 3.00 (60%).

This score is less than that of the marine fishery, suggesting that the fishery stock is gradually experiencing overfishing and needs to be better managed to avert stock decline. The economic performance had the lowest score of 2.39 (48%). There was poor performance of the economic dimensions, especially harvest assets and trade. The community indicator score was also poor, at 2.64 (53%). The use of local labour is limited, as most of the fisher folk along this stretch of River Niger are migrants from the northern parts of Nigeria. Processing worker wages are low compared to non-fishery wages, and earnings are low compared to the national average.

References for Part 2

Anderson, J. L., Anderson, C.M., Chu, J., and Meredith, J. (2016). Fishery Performance Indicators Manual (Version 1.4). http://isfs.institute.ifas.ufl.edu/projects/new-metrics/fpi-manual.

Federal Department of Fisheries and Aquaculture (FDFA). (2017). Fisheries Statistics of Nigeria. Abuja, FDFA, Federal Ministry of Agriculture and Rural Development.

Olopade, O. A., Taiwo, I. O. and Dienye, H. E. (2017). Management of Overfishing in the Inland Capture Fisheries in Nigeria. LimnoFish. 3(3):189-194. doi: 10.17216/LimnoFish.335549.

Part 3: Four South African Fisheries

Small Pelagic Fishery in South Africa

The South African small pelagic fishery developed in the 1940s with sardines (*Sardinops sagax*) primarily targeted by purse-seine vessels along the west coast. Catches peaked in the early 1960s at around 400,000 tonnes but collapsed thereafter, thought to be a direct result of overfishing. The industry switched to smaller mesh nets and began targeting anchovy (*Engraulis encrasicolus*), which dominated the catches from about 1964 to the mid-1990s, when recovery of the sardine stock was achieved under a stock rebuilding management strategy. Catches of both species are managed under a joint Operational Management Procedure (OMP) that sets annual TACs. Catches of the target species were at similar levels (around 250,000 tons) as biomass increased from the mid-1990s until ~2004, when a boom (1997-2004) and bust scenario took place (crash in sardine biomass from ~2005 onwards). A prolonged period of low sardine recruitment since 2004 resulted in a rapid decline in the size of the sardine stock, with sardine TACs and catches dropping to levels on the order of 90,000t between 2008 and 2014, to only 45,560t in 2017, 65,000t in 2018, and 12,500t in 2019.

The small pelagic industry targets adult sardine (>140 mm total length) for human consumption (~80%) and, to a lesser degree, for frozen bait. However, as juvenile sardine and anchovy frequently shoal together, a substantial bycatch of juvenile sardine can be made in anchovy-directed fishing operations that largely target anchovy recruits for fish meal production. This juvenile sardine bycatch is managed by means of annual Total Allowable Bycatch (TAB) allocations for both anchovy- and adult sardine-directed fishing. Both the principal species are relatively short-lived pelagic species (maximum age of 8 years for sardine and 5 years for anchovy). In the South African context, the small pelagic purse-seine fishery is considered a large-volume, industrial fishery with relatively high barriers to entry. There is limited access, with 92 long-term (15 year) fishing rights allocated and considerable consolidation of rights holding. The sector is dominated by six big, vertically integrated companies that operate the catch for shore-based canning and fish meal production plants. These six companies catch, process and market most of the annual TAC. About 15 smaller companies focus on freezing and packing sardines for bait. The annual landed catch value in 2018 was estimated at approximately USD 75 million.

The FPI assessment was completed in 2018, with the fishery performing relatively well in most areas (> 4), except for Trade, Local Ownership and Post-harvest Asset Performance (score of 3). The dramatic decline in sardine biomass and TAC in 2019 means that, should this fishery be reassessed now, the Triple Bottom Line score for Ecology would be lower than that allocated in 2018.

Hake Deep Sea Trawl in South Africa

Shallow-water hake (*Merluccius capensis*) and deep-water hake (*M. paradoxus*) are harvested by demersal trawl (inshore and deep-sea sectors), longline and handline fisheries. It is difficult to distinguish between the two Cape hake species, so they are generally processed and marketed as a single commodity. For stock assessment and management purposes, catches are split into species using a species-splitting algorithm that uses spatially explicit species composition information derived from research surveys. Deep sea trawl fishing takes place between Namibia and East London, with the hake deep sea trawl (HDST) sector accounting for around 88% of the catch. Catches are dominated by deep water hake along the west coast (90%) and shallow water hake along the south coast (70%).

Commercial access to South Africa's hake stocks is restricted to a limited number of rights holders with rights valid for a 15-year period. In the HDST sector, catch limits in the form of Precautionary Upper Catch Limits (PUCLs) are also set for important bycatch species, namely monkfish, kingklip and horse mackerel. An annual permit is required by rights holders, who receive a fixed proportion of the hake TAC that is determined annually by application of an Operational Management Procedure (OMP). The revision of recent OMPs takes into consideration MSC certification of the SA hake trawl fishery. The fishery was first certified in 2004, and recertified on two occasions (2010 and 2015). The fishery is currently undergoing assessment towards a third recertification under the new MSC fishery standard. The South African HDST industry consists of 30 "wetfish" trawlers and 21 freezer trawlers. The fishery is highly industrialised, with high barriers to entry, and capital owners are mostly large, vertically integrated companies that control all aspects of catching, processing and marketing the fish. This is South Africa's most valuable fishery, with an estimated landed catch value of approximately USD 300 million and approximately 7,300 employees. Catches in the sector have remained relatively stable over the last 40 years. For the 2019 fishing season, the TAC was increased by 10% with the total allocation to the hake deep-sea trawl fishery of 122,430.737 tonnes (excluding the longline and handline allocation). The stock status of *M. paradoxus* is considered optimal, i.e., fluctuating around B_{MSY}, whilst the *M. capensis* stock is considered abundant, with spawner biomass estimated to be well above the $B_{MSY.}$

The HDST fishery was assessed as performing highly (>4) in most indicators, with the weaker areas being Local Ownership, Labour Returns and Post-Harvest Asset Performance. In terms of TBL outcomes, the HDST sector outperformed the other fisheries assessed, except for the Community outcome, where it was scored slightly lower than the small pelagic sector.

Hake Longline in South Africa

Hake longlining (HLL) takes place between Namibia and East London on the continental shelf off South Africa. The hake longline fishery is allocated 6.6 % of the overall hake TAC, which includes catches of both hake species, shallow water hake (*Merluccius capensis*) and deep-water hake (*M. paradoxus*). The most important and valuable "bycatch" (may be targeted) species in the HLL sector is kingklip (*Genypterus capensis*), which accounts for 3-5% of the catch by mass. At least 17 bycatch species, including Chondrichthyans (0.73%) and teleosts (2.13%), are landed in the HLL fishery but the majority of these are released alive (if possible) or discarded. Only about five of these are retained (Jacopever *Helicolenus dactylopterus*, Panga *Pterogymnus laniarius*, skate spp. Rajidae, and Cape dory *Zeus capensis*); these have a relatively low commercial value. The Hake Longline Sector has the greatest participation amongst the hake fishing sectors, with 119 active rights holders.

Vessels used in the South African HLL industry are wooden or fibreglass displacement hull, decked vessels 10-20m in length. Almost all the vessels are "wetfish", i.e., the catch is iced at sea and sold fresh, with trip lengths of 7-8 days. Barriers to entry for new entrants in the HLL sector are substantially less than for the trawl sector, but are still relatively high (although the vessel is often cross-subsidized by participation in other fisheries). Capital owners in the HLL industry are mostly independent boat owners or companies that fish for their own and other's allocations. There are approximately 46 vessels active, with 1,080 sea-going staff, who are involved in HLL for 3-7 months of the year; thereafter, most vessels will switch to targeting different species, e.g., tuna pole, and rock lobster. Seafood processors and wholesalers who deal in HLL catches typically process products from multiple sectors (including demersal trawl, squid, handline, tuna pole, etc.). Typically, most of the hake TAC is landed every year; the 2018 HLL allocation was 8,434 tonnes and had a landed catch value estimated at USD 21 million.

Despite operating under the same management structure, and indeed under the same OMP, the less industrialised HLL sector performed worse than the trawl sector in several Fishery Performance areas, particularly Local Labour, Labour Returns and Trade. These differences are reflected in the slightly lower TBL scores compared to the HDST sector. Overall, TBL performance was still relatively good, with all three being scored close to 4.

West Coast Rock Lobster in South Africa

Commercial west coast rock lobster (WCRL) *Jasus lalandi* fishing in South Africa is split into several sectors: a nearshore component (comprising nearshore commercial and small-scale sectors) that uses hoop nets deployed from small vessels (< 6m) and an offshore component that uses traps deployed from larger deck boats (7-15m) equipped with hydraulic winches. Recreational permit holders account for 4-8% of the TAC and may harvest four rock lobsters per day during season using hoop nets and poles, or by diving without the use of scuba. Until recently (2012), about 20% of the WCRL resource was harvested by hoop nets from small boats in the nearshore sectors and 80% by offshore trap vessels operating up to water depths of greater than 100m. In recent years, management has allocated an increasing proportion of the TAC to the nearshore sectors, with the proportion allocated to the offshore sector decreasing to 63% over the period 2010-2018. The maximum lifespan of *J. lalandi* is 30-40 years. Due to the slow growth of females and the imposition of minimum size limits in 1933, the catch is almost entirely males.

There are 286 rights holders in the offshore WCRL sector, and about 2,500 participants in the inshore sector. Capital owners in the WCRL offshore sector are a combination of large, vertically integrated companies that catch, process and market lobster (and usually a variety of other seafood) and smaller independent companies and operators. Due to the seasonal nature of WCRL fishing and the large declines in TAC over the preceding decades, many rights holders and capital owners are involved in multiple fishing sectors. An OMP was implemented in 1997 with the aim of rebuilding stocks to 20% above the 1996 level by 2006. The commercial TAC was gradually reduced to 2000-3000 tonnes over the period 1999-2014, and to just under 2,000t during 2015-2018 (despite scientific advice in recent years recommending much lower TACs). Unsurprisingly, there has been little evidence of recovery. To date, recovery targets have not been achieved due to a combination of environmental factors leading to poor recruitment, and increased fishing pressure due to the allocation of more inshore rights and increasing illegal fishing (poaching). An updated assessment in 2016, which included re-evaluation of the illegal fishery (a doubling of poaching over the three preceding years was indicated), revealed that the recovery target could not be met even with zero legal catch. The resource is currently assessed as heavily depleted, with the biomass of male rock lobster above the minimum size limit estimated at only 2% of pristine biomass in 2018. The 2018/19 offshore sector allocation of ~575 tonnes had a landed catch value estimated at USD 9.6 million (ex-vessel price of USD17/kg) and a processed value of USD 20.7 million. This is substantially down from the estimated value of the offshore sector catch in 2013 of ~USD 30 million, when the offshore sector allocation was 1,356 tonnes and WCRL was South Africa’s fifth most valuable fishery.

The FPI scoring was undertaken for the Offshore WCRL sector only. This commercial fishing sector with the broadest access, high levels of IUU fishing, and a target species with life history characteristics associated with low resilience to exploitation, performed the worst of the four SA fisheries assessed. Stock health, Harvest Assets and Post-Harvest Asset Performance values were particularly low, around 2, whilst labour returns and local ownership were also poorly performing areas (scores ~3). Given the collapsed stock status, Ecology was the poorest performing TBL indicator, with a score of 2.

Part 4: Tanzania Fisheries

Dagaa (Freshwater Sardine) in Tanzania

In Tanzania, dagaa is one of the most abundant of the freshwater fishing species, with over 1,000 species. Dagaa is indigenous to East Africa, and it is the largest of the fishery resources in Lake Victoria, where its biomass is estimated to be over 1.3 million tonnes. The Ministry of Agriculture, Livestock and Fisheries (MALF) is responsible for the preparation, implementation, monitoring and reviewing of national fisheries policies and regulatory frameworks in Tanzania. In addition, there are district fisheries offices responsible for implementation and monitoring of fisheries policies and regulatory frameworks at district level. At village/landing site level, there are Beach Management Units (BMUs) established to collaborate with fisheries authorities in management of fisheries activities at village or landing site level.

Dagaa is mostly caught by artisanal fishers using a range of fishing gear, along with artificial light generated by kerosene pressure lamps attached to a float. Fishing gear commonly used (with estimated catch rate in parentheses) include gill nets, cast nets, and drag nets (60kg/boat/day), scoop nets (1-2kg/trap), basket traps (12-100kg/trap), fixed traps, handlines, longlines, troll lines, mosquito net, trawl net, machete and torch (7kg/day) (Jiddawi and Ohman 2002). The number of licenses and vessels in the fishery industry has been steadily on the rise in the past few years. Specifically, the number of fishers and crafts/fishing vessels targeting dagaa has increased by more than 50% in the period 2005-2016; the number of fishers increased from 133,197 to 203,529, while the number of vessels increased to 8,727 in 2016. The annual rate of increase of entrants into the dagaa sector is 5.4% (Fujimoto 2018).

The annual production of dagaa is 130,000 tonnes, accounting for about 42% of inland fish production (MALF 2016). For this reason, dagaa fishing is a source of employment and an income-generating activity for many people in Tanzania. Dagaa plays a key role in the livelihood of women in Tanzania. Dagaa has significant commercial value, especially to the local markets, with most of the fishing activities carried out by artisanal fishermen. The price range for dagaa is from US$ 0.91 for 200 gram packets to US$ 4.24 for a kilogram packet (Odongkara et al. 2014).

Dagaa is mainly sun-dried on sand and grass, which results in high post-harvest losses. It is challenging to process the fish during the rainy season. The method that produces a cleaner and better quality dagaa with higher post-harvest yields is to use drying racks with covers. However, this is more expensive and buyers are often reluctant to pay a premium price for a better product. Processing and trading are mostly undertaken by women. Dried dagaa is distributed in sacks through a network of traders who transport the fish to almost every region in Tanzania. Major regional trading centers are located in Mwanza and Geita, where buyers purchase the product for export. Major importing countries include DRC, Burundi, Zambia, South Sudan, Rwanda, Kenya and Malawi.

Nile Perch Species in Tanzania

The Nile perch species is native to lake basins in East, Central and North Africa, with its dominant home along the Rift Valley lakes of Lake Turkana, down to Lake Volta, up north in Lake Chad, and in several lakes in Congo, Senegal and Niger. Nile perch is a high-value species because of its use within Tanzania and for export purposes. One of the key habitat and extraction areas of Nile perch is Lake Victoria, which covers about 68,800 square kilometers, with most of its shoreline in Tanzania. Nile perch is one of the largest freshwater fish species; a fully mature fish can be up to 2 meters long and weigh up to 200 kg. The adult fish is dominant in the deeper parts of the water, while the juveniles are found in shallow waters.

The Nile perch is caught mostly from small, traditionally designed wooden canoes (paddle, sail or outboard powered) and is fished with gillnets and longlines (MALF 2016). Fishing gear commonly used (with estimated catch rate in parentheses) include gill nets, cast nets, and seine nets (500-3000kg per net), drag nets (60kg/boat/day), scoop nets (1-2kg/trap), basket traps (12-100kg/trap), fixed traps, handlines, longlines, troll lines, and harpoons (2-20kg/net), mosquito nets, trawl nets, and octopus spearing (4-7/person/day), and machete and torch (7kg/day) (Jiddawi and Öhman 2002).

For freshwater fishing of Nile perch, there are about 39,881 vessels estimated as of 2006. The number of Nile perch fishers has been on the rise because of the increased landings. The estimated figure was about 38,000 fishermen in 2015 (National Bureau of Statistics 2015). There has been accelerated entry into Nile perch fishing activity; the annual increase rate was at 15.6% in 2015 (National Bureau of Statistics 2015).

Commercially, Nile perch is one of the most sought-after fish species in the country, with tens of thousands of tons being extracted every year (Balirwa, Njiru and Aloo, 2017). For this and other reasons, fishing Nile perch is a source of employment and an income-generating activity for many people in Tanzania. The lakeside price of Nile perch ranges between US$ 2 and US$ 2.5 per kg. In addition, Nile perch is a key export, which means that it is expected to meet international standards such as the EU standards, which include methods of harvest and environmental indicators (Mkumbo and Marshall, 2015). Tanzania is the number-one exporter of Nile perch; it has exported over 12,400 tonnes to the EU.

Nile perch within East Africa is quickly moving towards the endangered list of species. This has encouraged several management and control changes regarding access to the lake and harvest practices, which are geared to reversing this threat and increasing sustainability. This is done under the leadership of the Ministry of Agriculture, Livestock and Fisheries (MALF), with the support of districts (district fisheries offices) and villages (Beach Management Units).

References for Part 4

Aloo, P., Balirwa, J., Njiru, J., and Nyamweya, C. (2017). Impacts of Nile Perch, lates niloticus, introduction on the ecology, economy and conservation of LakeVictoria, East Africa. *Lakes and Reservoirs, 22*(4), 320–333.

Fujumoto, M. (2018). Economic Impact of the Dagaa Processing Industry on a Coastal Village in Zanzibar, Tanzania. *African Study Monographs. Supplementary Issue, 55,* 145-162.

Jiddawi, N. S., and Öhman, M. C. (2002). Marine fisheries in Tanzania. *Ambio: A Journal of the Human Environment, 31*(7), 518–527.

Mkumbo, O. C., and Marshall, B. E. (2015). The Nile perch fishery of Lake Victoria: Current status and management challenges. *Fisheries Management and Ecology, 22*(1), 56–63.

Odongkara K., Akumu, J., Mbilingi, B., Namatovu, S., Okwong, C., Naula, E., Olokotum M., and Nasuuna, A. (2014). Strategies to Improve Profitability and Market Access for Fisheries Enterprises on Lakes Albert, Kyoga and Victoria, Uganda. NaFIRRI.

Ministry of Livestock and Fisheries Development. (2016). Fisheries Annual Statistics Report, Dar es Salaam, Tanzania.