Assessing the economic viability of small-scale fisheries

– an indicator based framework -

Anna Schuhbauer and Rashid Sumaila
in collaboration with Ratana Chuenpagdee

Fisheries Economic Research Unit and *Too Big To Ignore*

The University of British Columbia

February 22nd 2015

1. Introduction

Marine fisheries are estimated to contribute about 240 billion USD to the world economy, based on direct, indirect and induced impacts (Dyck and Sumaila, 2010). However, global fisheries are known to be underperforming, mainly due to overfishing (Sumaila et al., 2012). According to the FAO, over 90% of the 4.36 million vessels active in the world can be classified as small-scale fisheries (SSF). Teh and Sumaila, (2013) also estimated that SSF support up to 22 million fishers, who make up about 44% of all fishers in the primary production sector. Furthermore, Béné et al. (2007) report that over 90% of all recorded fishers globally are involved in SSF and an additional 100 million people are involved in the post-harvest sector of SSF.

Any economic system has to adapt to scarcity constraints and be balanced between supply and demand for the system to function viably (Aubin, 2011). The goal of most economic entities is profitability, the higher the profit, the better is the entity's status. A private entity is therefore considered 'financially viable' when its profit is positive. However, when considering economic viability, we refer not only to the sole profit of a private individual (or a private entity) but also to the whole society or the public sector, such that economic viability is accomplished when net benefit of an activity to society is positive. Net benefits are considered positive when the amount of total revenue exceeds the total costs.

Often, measures such as the return on investment (net cashflow/investment) are used as an indicator to judge about a system's economic performance. Furthermore, profit is necessary for a system to be economically viable, but it is not necessarily the sole measurement, particularly since a profitable system today may not be so tomorrow (Baumgärtner and Quaas, 2009; Tisdell, 1996). The term viability, describes the long term survival of a system, and especially for SSF measuring the pure financial performance of the fishery does not provide enough information to determine whether the fishery can be considered economically viable or not. Economic viability, therefore, needs to take other economic aspects into account that drive the fishery, such as for example subsidies.

SSF are often considered as fisheries tied to their cultural values and traditions where the goal for the participants is not always just profit (Berkes, 2012; Hospital and Beavers, 2012; Kronen, 2004; Pollnac and Poggie, 2008). Additionally, it is important to note that the institutional structure plays a key role. For instance, a decentralized management through co-management supported by participatory research is crucial to promote integrated and participatory decision making processes, strengthening the ability of the communities to cope, adapt and achieve prosperity (Jentoft et al., 1998; Lane and Stephenson, 1995; Sumaila and Domínguez-Torreiro, 2010; Trimble and Berkes, 2013), which has a direct effect on economic viability. While co-management brings its own challenges (see for example, Wilson et al., 2003), it important to consider that the isolation from policy and governance, which small-scale fishers often face (Chuenpagdee, 2012; Trimble and Berkes, 2013) play an important part for a SSF so economic viability can be achieved. Fisheries are very complex systems bound to many levels of uncertainty and ecological factors need to be taken into consideration. As described by Béné and Doyen, (2000) a fishery can be seen as a link between two systems, which are the fish stocks and the market. The fish stock needs to have a balance between its growth, reproduction, natural mortality and fishing mortality to sustain itself and survive in the long term. Therefore, fisheries will only fully function when all key aspects of the four different dimensions (economics, governance, social and ecosystem) are being recognized.

While maintaining a comprehensive view by considering the different dimensions that play a role in any fishery, the current framework focuses on assessing the components affecting economic viability, i.e., economic and possibly socio-economic attributes. At the same time other partners and contributors of the TBTI network of SSF research will address and focus their work on governance, livelihoods, rights, stewardship and ecosystem aspects of small-scale fisheries, which in the broader sense, as explained above, also affect the economic viability of a fishery.

Viability is a very broadly used term mainly to describe the long term survival of an entity, a sector, a social structure or a population of a given species. The objective of this document is to present a framework useful to assess economic viability of small-scale fisheries.

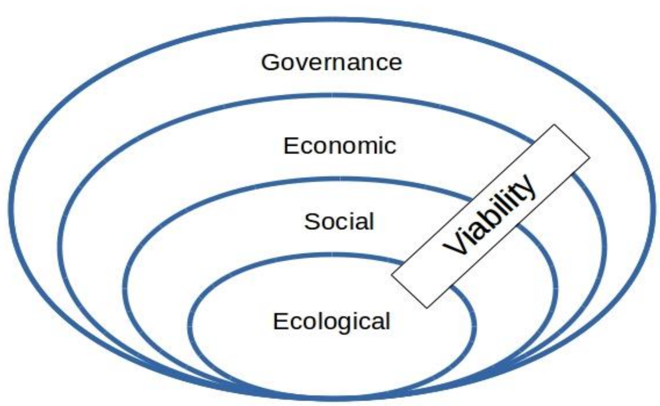

Figure 2: A framework describing viability for small-scale fisheries. All shown compartments (Ecosystem, social, economic and governance) need to be considered when assessing the viability of a small-scale fishery; they all influence each other and are important to the economic viability of the fishery.

1.1. Methods

In the following sections we present: 1. How economic viability of small-scale fisheries is defined; 2. a framework including a list of the most relevant attributes, their definition and measurability, to consider when assessing economic viability; and 3. three different but complimentary analytical techniques and approaches that would allow us to measure and analyze the impact of each attribute listed in Table 1 on economic viability of SSF.

1.1.1. Definition of economic viability in a static model

For the purpose of this study, we define economic viability as follows: How scarce resources can be used to produce valuable commodities and distribute them among people while these dynamics survive and maintain themselves in the long term. A small-scale fishery is therefore considered economically viable when it generates positive net benefits for society, which ideally need to be distributed in an equitable manner and maintained within the fishing community over the long-term. However, it is noted that the following models are static and as yet no temporal dynamics are taken into account. To further illustrate the difference between financial viability and economic viability, an example is presented here on how to calculate net benefits for a fishery unit (e.g., a boat or an individual fisher) compared to the net benefits received by society (the fishing community):

i) Financial viability

For the **fishing unit,** the net benefit (NB) is expressed as:

$$NB_{unit} = (TR_{unit} + S_{unit}) - TC_{unit} \tag{1}$$

where Total Revenue for the fishing unit (TR $_{unit}$) is the product of Ex-Vessel Price and Landings ;

TC = Total Cost, i.e., the sum of variable and fixed costs; and S = Subsidies, the amount of subsidies received from the government by the fishing unit, which is seen by the fishing unit as revenue.

ii) Economic viability

Considering the **society,** the net benefit (NB) is given by:

$$\mathrm{NB}_{\mathrm{society}} = \mathrm{TR}_{\mathrm{society}} - (\mathrm{TC}_{\mathrm{society}} + \sum_{\mathrm{i=1}}^{\mathrm{units}}(\mathrm{S}_{\mathrm{units}})) \tag{2}$$

where Total Revenue for the society (TR $_{society}$) is the product of the non-distorted Ex-Vessel Price and Landings. The non-distorted Total Cost = TC, i.e., the sum of non-distorted variable costs and fixed costs; and S = Subsidies, the amount of subsidies received from the government by the sum of all fishing unit in the fishing community. For society, the amount of subsidy paid to fishers is a cost. It should be noted that in formulating equation 1 and 2, I assume that the only distortion is the subsidy received by the fishing unit.

When calculating the net benefits for a single fishing unit, subsidies received by the unit are added to the net benefit as the individual directly benefits from the government support. In the case of net benefits to society, on the other hand, the subsidies are subtracted because tax payers (who form the society) foot the bill. It should be noted that subsidies are divided into three categories, i.e., beneficial, capacity enhancing or ambiguous (Sumaila et al., 2010), which will therefore have different impacts on the society. These calculations show how financial viability can be calculated based on a fishing unit, whereas a different calculation is needed when considering the economic viability of society as a whole.

1.2. Framework

Using attributes to measure the state of a fishery is a common technique used for a variety of goals, including assessing the sustainability of a fishery. For example, attributes were identified and used to describe and understand different SSF in Europe (Guyader et al., 2013). In Brazil, an analysis was performed using socio-economic indicators to assess and compare the performance of different fishing fleets for ecosystem-based management (Gasalla et al., 2010). In the context of marine protected areas, Edgar et al. (2014) identified five key attributes that need to be considered in order to optimize conservation outcomes. Finally, a study by Fulton et al. (2005) shows how ecological attributes can detect the effects of fishing on marine ecosystems. Based on these and other examples, we use attributes as the foundation of our methods to assess economic viability of SSF.

After a thorough literature review and several consultations with scientists with economic, social, governance and ecological expertise in SSF within the *Too Big To Ignore* (TBTI) partnership, I selected a set of key attributes that are considered essential when assessing economic viability, which are useful for both: a global and a case-study level (Table 1). The selection criteria includes relevance, availability, measurability, and objectivity, i.e., whether the same result is obtained when the attribute is measured by different scientists at different times (Boyd and Charles, 2006).

Table 1) Working list of attributes collected to assess the economic viability of SSF at both global and case-study levels. Depending on data availability and scale of assessment (global or case-study) the time component will be defined (e.g., day, month or year) for each attribute.

Nº	Economic Attributes (unit)	Definition	Sources and measurements
1	Landings (t)	Amount of fish in weight landed at port in a given period (e.g., a day or year).	For national numbers see FAO and SAUP[1] (*Sea Around Us Project*, specifically catch reconstruction data) database. For case studies check grey literature, e.g., government reports; conduct surveys; and monitor the landing.
2	Ex-vessel price ($)	Price received by fishers at the dock per unit weight of fish sold (Sumaila et al., 2007).	For national numbers see *Fisheries Economic Research Unit* (FERU) and SAUP database (Sumaila et al., 2007 and Swartz et al., 2013)[1] For case studies check grey literature e.g., government reports, conduct surveys, log book, buyer record
3	Total Cost of fishing ($)	Total cost represents the value of inputs at the next alternative best use. Cost is split up into fixed cost, which do not change with production (e.g., capital investment, sunk cost) and variable cost, which can vary based on the output (e.g., fuel, crew, maintenance) per tonne of catch. The total cost includes opportunity cost which makes it different from accounting cost. (Lam et al., 2011).	For national numbers see FERU database [1] (Lam et al., 2011). For case studies check grey literature, e.g., government reports and/or conduct surveys.
4	Subsidies ($)	Subsidies are defined here as financial transfers, direct or indirect, from public entities to the fishing sector which help the sector make more profit than it would otherwise (Sumaila et al., 2010).	For national numbers see Sumaila et al. (2010) For case studies check grey literature, e.g., government reports and conduct surveys and interview key informants.
5	Proportion of SSF to LSF landing (%)	Landings of SSF divided by total landings of a given fishery.	Calculate the ratio of SSF landings to total landings of the fishery .
6	Cost structure (ratio)	Cost structure is the ratio of fixed costs (e.g., capital investment) to variable costs (e.g., fuel).	For national numbers see FERU and SAUP database[1] (Lam et al., 2011). For case studies check grey literature, e.g., government reports and/or conduct surveys.

7	Discount rate (rate)	The economic discount rate (r) is a measure of the current value of future benefits, it allows us to convert values to be received in the future into values today ($1 received today is considered more valuable than $1 to be received in the future).	To take intergenerational justice into consideration it is suggested to use approaches such as the one proposed by Sumaila and Walters (2005) for both national and regional studies.
8	Multiplier (factor)	Describes indirect income (income multiplier) and induced effects on society (economic multiplier) through fisheries. A multiplier is a factor by which we can multiply the value of final demand for an economic activity's output to obtain its total contribution to economic output including activities directly and indirectly dependent on it.	For national numbers see FERU database and Dyck and Sumaila, (2010) for both income and economic multipliers. For case studies adjust the national multipliers (both income and economic multipliers) either using reports and/or surveys.

[1] Data bases from FERU and SAUP can either be found online (www.seaarroundus.org) and/or on UBC internal server.

Nº	Socio-economic Attributes (unit)	Definition	Sources and measurements
9	Number of jobs per employment type	Number jobs highlights the contribution of fisheries employment including both commercial and subsistence marine SSF. Employment type describes how a worker is employed. For example the International Labor Organization (ILO) classifications are: employees, employers, own-account workers, members or producer cooperatives, contributing family workers, workers not classifiable by status. These can be adjusted to fisheries (e.g., boat owner, paid by catch share, employed by a company/cooperative).	For national numbers see (Teh and Sumaila, 2013), ILO and FAO. For case studies review FAO, government reports and carry out surveys (government agencies, NGOs and/or fishers).
10	Degree of economic dependence on fishing (%)	It determines the fraction of total fishing unit or society income that is generated by the SSF sector.	Use GDP assessment and calculate both the income of family member fishing and income of whole household from fishing and compare to the total income of the fishing community. Assess reports (government agencies) and/or conduct surveys and interview key informants.
11	Distribution of benefit within the fishing community (coefficient)	A measure of equity among different groups in society or a community.	The gini coefficient could be calculated here to find out about the wealth distribution among the society.
12	Access to finance (various)	Denotes the extent to which fishers or fishing cooperatives can access financial services (e.g., credit, deposit, insurance).	World Bank: siteresources.worldbank.org/.../Resources/CalariParisSpeech.pdf (also see (Abila et al., 2006; Allison et al., 2012; Charles, 2011).
13	Fish consumption per capita (g/capita)	This is the amount of fish or seafood per capita being eaten by a fishing community in a given period (a month, a year, etc.)	For both national and case study level use existing data from FAO, government reports and conduct household surveys.

1.3. Analytical approaches

Three main methods will be used to analyze the collected data: 1) Compute net benefits from SSF to society and to the private sector, respectively; 2) A Principal Component Analysis; and 3) A Generalized Linear Model.

1.3.1. Economic viability

Economic viability, equal to the net benefits to society, will be computed using equation 2 (section 3.2.1.) and financial viability, equal to the net benefits to the private sector (the fishing unit) will be calculated using equation 1 (section 3.2.1). This can be carried out on a global level using national data as well as at a case study level. For this study the focus lies on the global assessment only and available data from attributes 1 to 4 for each coastal country will be used.

1.3.2. Principal Component Analysis

The Principal Component Analysis (PCA) is a form of multivariate statistics. Using PCA, patterns in data can be identified through highlighting similarities and differences, which is often difficult when using data with many dimensions. The PCA is used to reduce the original variables into a lower number of non-correlated synthesized variables (or factors) and the visualization of the correlation. Each measured attribute (table 1) forms a data point in the PCA. Hence, the approach will help us identify correlations and patterns of the assessed attributes.

1.3.3. Generalized Linear Model

To test attributes 5 to 13 and their importance and contribution to economic viability, a generalized linear model (GLM) will be created. Each measured attribute is considered a variable in the model and the goal is to understand each variable's relationship and how each specifically influences economic viability. It should be noted that both quantitative and qualitative data can be used in a generalized linear model, the latter through the use of a dummy variable, which can categorize information into, for example, Boolean indicators such as 0 and 1 or 'absence' and 'presence'.

2. Literature

Abila, R.O., Odongkara, K.O., Onyango, P.O., 2006. Distribution of economic benefits from the fisheries of Lake Victoria.

Allison, E.H., Ratner, B.D., Åsgård, B., Willmann, R., Pomeroy, R., Kurien, J., 2012. Rights-based fisheries governance: from fishing rights to human rights. Fish and Fisheries 13, 14–29.

Aubin, J.-P., 2011. Viability Theory - New Directions.

Baumgärtner, S., Quaas, M.F., 2009. Ecological-economic viability as a criterion of strong sustainability under uncertainty. Ecological Economics 68, 2008–2020.

Béné, C., Doyen, L., 2000. Storage and viability of a fishery with resource and market dephased seasonalities. Environmental and Resource Economics 15, 1–26.

Béné, C., Macfadyen, G., Allison, E.H., 2007. Increasing the contribution of small-scale fisheries to poverty alleviation and food security (FAO Fisheries Technical Paper No. No. 481). FAO.

Berkes, F., 2012. Implementing ecosystem-based management: evolution or revolution?: Implementing ecosystem-based management. Fish and Fisheries 13, 465–476.

Boyd, H., Charles, A., 2006. Creating community-based indicators to monitor sustainability of local fisheries. Ocean & Coastal Management 49, 237–258. doi:10.1016/j.ocecoaman.2006.03.006

Charles, A., 2011. Small-scale fisheries: on rights, trade and subsidies. Maritime Studies (MAST) 10, 85–94.

Chuenpagdee, R., 2012. World Small-Scale Fisheries: Contemporary Visions. World Small-Scale Fisheries: Contemporary Visions 383.

Dyck, A.J., Sumaila, U.R., 2010. Economic impact of ocean fish populations in the global fishery. J Bioecon 12, 227–243.

Edgar, G.J. et al., 2014. Global conservation outcomes depend on marine protected areas with five key features. Nature advance online publication.

FAO, 2014. State of World Fisheries and Aquaculture 2014. Food & Agriculture Org.

Fulton, E.A., Smith, A.D.M., Punt, A.E., 2005. Which ecological indicators can robustly detect effects of fishing? ICES J. Mar. Sci. 62, 540–551.

Gasalla, M.A., Rodrigues, A.R., Duarte, L.F.A., Rashid Sumaila, U., 2010. A comparative multi-fleet analysis of socio-economic indicators for fishery management in SE Brazil. Progress in Oceanography 87, 304–319.

Guyader, O., Berthou, P., Koutsikopoulos, C., Alban, F., Demanèche, S., Gaspar, M.B., Eschbaum, R., Fahy, E., Tully, O., Reynal, L., Curtil, O., Frangoudes, K., Maynou, F., 2013. Small scale fisheries in Europe: A comparative analysis based on a selection of case studies. Fisheries

Research 140, 1–13.

Hospital, J., Beavers, C., 2012. Economic and Social Characteristics of Bottomfish Fishing in the Main Hawaiian Islands (Administrative Report H-12-01 No. H-12-01), Pacific Islands Fisheries Science Center, Natl. Mar. Fish. Serv. NOAA, Honolulu, Hawaii.

Jentoft, S., McCay, B.J., Wilson, D.C., 1998. Social theory and fisheries co-management. Marine Policy 22, 423–436.

Kronen, M., 2004. Fishing for fortunes?: A socio-economic assessment of Tonga's artisanal fisheries. Fisheries Research 70, 121–134.

Lam, V.W.Y., Sumaila, U.R., Dyck, A., Pauly, D., Watson, R., 2011. Construction and first applications of a global cost of fishing database. ICES J. Mar. Sci. 68, 1996–2004.

Lane, D.E., Stephenson, R.L., 1995. Fisheries management science: the framework to link biological, economic, and social objectives in fisheries management. Aquat. Living Resour 8, 215–221.

Pollnac, R., Poggie, J.J., 2008. Happiness, well-being, and psychocultural adaptation to the stresses associated with marine fishing. Human Ecology Review 15, 194.

Sumaila, U.R., Cheung, W., Dyck, A., Gueye, K., Huang, L., Lam, V., Pauly, D., Srinivasan, T., Swartz, W., Watson, R., Zeller, D., 2012. Benefits of Rebuilding Global Marine Fisheries Outweigh Costs. PLoS ONE .

Sumaila, U.R., Domínguez-Torreiro, M., 2010. Discount factors and the performance of alternative fisheries governance systems. Fish and Fisheries 11, 278–287.

Sumaila, U.R., Khan, A.S., Dyck, A.J., Watson, R., Munro, G., Tydemers, P., Pauly, D., 2010. A bottom-up re-estimation of global fisheries subsidies. Journal of Bioeconomics 12, 201–225.

Sumaila, U.R., Marsden, A.D., Watson, R., Pauly, D., 2007. A Global Ex-vessel Fish Price Database: Construction and Applications. J Bioecon 9, 39–51.

Sumaila, U.R., Walters, C., 2005. Intergenerational discounting: a new intuitive approach. Ecological Economics 52, 135–142.

Swartz, W., Sumaila, R., Watson, R., 2013. Global Ex-vessel Fish Price Database Revisited: A New Approach for Estimating "Missing" Prices. Environ Resource Econ 56, 467–480.

Teh, L.C.L., Sumaila, U.R., 2013. Contribution of marine fisheries to worldwide employment. Fish and Fisheries 14, 77–88.

Tisdell, C., 1996. Economic indicators to assess the sustainability of conservation farming projects: An evaluation. Agriculture, Ecosystems & Environment 57, 117–131.

Trimble, M., Berkes, F., 2013. Participatory research towards co-management: Lessons from artisanal fisheries in coastal Uruguay. Journal of Environmental Management 128, 768–778.

Trimble, M., Johnson, D., 2013. Artisanal fishing as an undesirable way of life? The implications for governance of fishers' wellbeing aspirations in coastal Uruguay and southeastern Brazil.

Marine Policy 37, 37–44.

Wilson, D.C., Nielsen, J.R., Degnbol, P., 2003. The Fisheries Co-management Experience: Accomplishments, Challenges and Prospects. Springer.