Participatory and Integrative Techniques in Fisheries Vulnerability Measurement

Sajeev MV[1] and AK Mohanty[2]
[1]Senior Scientist, [2]Principal Scientist & Head,
ICAR-Central Institute of Fisheries Technology, Cochin -29
sajeev.mv@icar.gov.in

Vulnerability

From relatively limited and narrow uses two decades ago, the concept of vulnerability has emerged as a key dimension of the development debate, often discussed and analyzed along with its counterpart: resilience (Miller et al., 2010). Be it in relation to climate change, disasters, globalization and economic development, and social–ecological system changes more generally, vulnerability is a complex and multifaceted concept that has attracted the attention of scholars and development practitioners from all disciplines. The many interpretations of vulnerability and its many scales (e.g. individual, community, ecosystem, countries and continents) and fields of application have led to a wide array of propositions regarding ways and means by which vulnerability could be studied, characterized, understood, and acted upon. The basic IPCC model of vulnerability can be adapted to the context of fisheries as: **Vulnerability** = Exposure + Sensitivity – Adaptive Capacity.

Vulnerability can be defined as 'Degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes' and also as 'A function of potential impacts resulting from exposure and sensitivity of a system to climate change and of its adaptive capacity'.

Vulnerability assessment

Vulnerability assessments (VAs) can be used for many different purposes, including improving adaptation planning (designing of policies and interventions), raising awareness of risks and opportunities, and advancing scientific research (Patt *et al.*, 2009). This document assumes that the main purpose of understanding vulnerability and, therefore, of undertaking a VA is to improve the targeting and effectiveness of adaptation actions. Through a VA, one seeks to answer the basic question of "who (or what) is vulnerable to what?" by asking:

- Who are the vulnerable people / species / production systems and how can their vulnerability be reduced?
- Where are the vulnerable ecosystems? Can their capacity to adapt be supported by resource management?
- Where will the economic and social consequences of vulnerability of fishery or aquaculture systems be felt most? How can one plan to minimize those consequences?
- Where will climate change create new opportunities and bring benefits? For whom? How can one ensure these opportunities improve human well-being?

Depending on the context, a VA may be concerned about the vulnerability of people at different scales (individuals, social groups, households, communities, provinces, nations, regions) or the vulnerability of different human activities (e.g. agriculture, fisheries, aquaculture, tourism, transport, habitation). In addition, a vulnerability assessment may be concerned with specific places (e.g. lake and river basins, low-lying coasts, enclosed seas, deltas, upwelling systems) or vulnerabilities to particular stressors/hazards (i.e. natural disasters, global environmental change, or change in general).

Vulnerability in fisheries and aquaculture

Many economies and people are dependent on fisheries and aquaculture for food, livelihoods and revenue generation. Greenhouse gas accumulation, climate change and the associated impacts in terms of sea-level rise, ocean acidification and changes in salinity, precipitation, groundwater and river flows, water stresses and extreme weather events are changing the productivity of aquatic habitats, modifying the distribution and productivity of both marine and freshwater fish species. Such changes are affecting the seasonality of biological and biophysical processes as well as increasing direct risks to human well-being, infrastructure and processes throughout the fisheries and aquaculture production chain.

These changes are in addition to the multiple drivers of change already faced within the sector, such as changes in markets, management frameworks, fishing practices and demographics. However, it may not always be possible to associate a given driver of change (such as increases in water temperatures) to perceived or documented changes (such as decreases in fish stocks) given the current state of knowledge of the social–ecological system and unknown cumulative impacts of different drivers of change (e.g. overfishing and natural variability). However, even in the face of such uncertainty, a VA may enhance understanding of how the sector and its dependent economies and communities are unable to cope with (or take advantage of) existing and projected changes, so facilitating action to support human and ecosystem well-being.

Specific adaptation actions will be guided by the VA – depending on the answers to the vulnerability questions asked – and could include actions such as: incorporating uncertainty into decision-making and management process; supporting transitions to alternative species, production and post-harvest processes; supporting the development of alternative or diversified livelihoods; enhancing natural barriers, protecting fish habitats through adaptive spatial management; and incorporating climate change into trans-boundary water and natural resource planning across sectors.

Vulnerability measures, indicators and indices

As vulnerability is a complex issue, there is consensus that a single aggregate measure of vulnerability will probably not provide useful information for adaptation planning because it is not possible to disaggregate precise factors leading to vulnerability (Alwang, Siegel and Jorgensen, 2001; Schröter, Polsky and Patt, 2004; Hinkel, 2011). For example, Adger (2006) suggested that measures of vulnerability should strive to simultaneously capture:

- the dynamic nature of vulnerability (changes over time and places);
- the severity of vulnerability (includes risk and thresholds);
- the perception of vulnerability.

Innovations have been made to capture such complexity through the development of composite indices like Livelihood Vulnerability Index (LVI), Coastal Vulnerability Index (CVI), Multi-scale Coastal Vulnerability Index (MCVI), Climate Sensitivity Index (CSI), Physical Process Vulnerability Index (PVI), Composite Vulnerability Index, Socio-economic Vulnerability Index (SVI) (Table 1).

Index name	Description, components	Origin and example reported applications
Livelihood Vulnerability Index (LVI)	Combines seven components: livelihoods, sociodemographics, social networks, health, natural disasters and climate variability, food and water security.	Hahn, Riederer and Foster (2009)
Coastal Vulnerability Index (CVI)	Incorporates geological and physical indicators (geomorphology, shoreline change rate, mean significant wave height, mean tide range, coastal slope and sea-level rise) to identify risks related to sea-level rise.	Gornitz (1990) ; McLaughlin, McKenna and Cooper (2002); Dwarakish *et al.* (2009); Duriyapong and Nakhapakorn (2011)
Multiscale CVI	Integrates the impacts of coastal erosion in the CVI. Uses indicators of coastal characteristics, coastal forcing and socio-economic status.	Mclaughlin and Cooper (2010)
Climate Sensitivity Index (CSI)	Includes two components that represent the influence of extreme events on agriculture (dryness and monsoon dependence) in order to measure sensitivity under exposure to climate change.	O'Brien *et al.* (2004)
Physical Process Vulnerability Index (PVI)	Formed by four variables: coastal erosion rate, coastal slope, mean tidal range, and mean wave height. Used combined with the SVI to assess coastal vulnerability.	Duriyapong and Nakhapakorn (2011)
Composite vulnerability index	Incorporates 16 separate natural and socio-economic variables to measure the disparity between communities and regions exposed to related hazards.	Szlafsztein and Sterr (2007)
Socio-economic Vulnerability Index (SVI)	Composed of four variables: land use, population density, roads/railways, and cultural heritage. Used combined with the PVI to assess coastal vulnerability.	Ebert *et al.* (2008); Duriyapong and Nakhapakorn (2011)

Table: 1 Composite Indices

However, capturing cause-and-effect relationships between vulnerability variables and their consequences on social–ecological systems and well-being remains a challenge, along with the determination of thresholds and the influence of institutional set-ups (governance), all of which are compounded by culture and context-specific perceptions (Adger, 2006) as well as disciplinary perspectives (Alwang, Siegel and Jorgensen, 2001).

Participatory/integrative methodologies for Fisheries vulnerability management.

Agent-based modelling

An agent-based model is a programme of self-contained entities called agents each of which can represent real-world objects such as individuals or households. Simulation of social agents is included in the generic term, multi-agent-based simulation (MABS). The data required for such a model are ideally suited to data-intensive fieldwork. Hence, the representation of place-based understanding of the dynamics of

vulnerability and adaptation in MABS is a natural yet innovative approach. Participatory techniques provide a robust and effective method to formalize and verify qualitative ethnographic data, for use in an agent-based model. Agent-based modelling illustrates how macro–level behaviour can emerge from various types of rules which inform decisions at the local, individual level. An agent-based model can be used to establish which patterns of strategic behaviour emerge as a result of local responses and whether such emergent phenomena account for a clearer understanding of the original field data.

The adaptive dynamics involved in climate-change-related behaviour within agriculture, human–environment interaction and impacts for the individual and the group can be investigated. MABS can explore social and environmental scenarios that do not exist at present, providing an experimental laboratory on the same level of sophistication as models of the global climate system. The use of even simple agent-based models can help to illuminate field-based descriptions. The benefits of mapping and modelling a complex adaptive system using this framework lie in the ability to identify characteristics – macro level patterns – that are important to the functioning of a successful system and its essential underlying components. Micro level effects can also be easily identified within an agent-based modelling environment, which can then allow the analysis of the interaction of models of adaptation developed from the social sciences domain with environmental models from the physical sciences domain. That is, simulations illustrate how systems of different orders interact with each other, and one may often be more interested in the structure, organization and interaction of these sub models than in their content.
Furthermore, agent-based models allow examination the consequent behaviours of individual strategies on a group. They permit the representation of incremental complexity (i.e. where models include more and more factors and their contextual interactions) and facilitate the identification of critical situations that can lead to prediction outside the simulation; that is, the ability to demonstrate that some values for the system under study are salient enough to drive phenomena and not simply be a contributing factor. Nevertheless, a simulation is only a descriptive model and its explanatory power is constrained by the assumptions made, including the researchers' understanding of the field data and the level of implementation of the model. Moreover, such a model will be a simplification of the system under study and in many cases will not represent any "real" system but will be intended to generate model data for an "ideal" world, against which real data can be compared, noting where it corresponds to, and departs from, the ideal world. This can help to establish a sense of important contextual drivers within the domain and new areas for investigation, which can be further validated with the model.

Delphi method

The purpose of the Delphi technique is to elicit information and judgments from a group to facilitate problem-solving, forecasting, planning, and decision-making (Neuman, 1994). Its name comes from the city of Delphi was where people came to consult the oracle (housed in the temple of Apollo) who forecasted the future. It often involves consulting a group of experts on a particular topic to determine consensus on an issue. This method is used both for information acquisition and in processes. There are many variations of the Delphi method, and while some can be used in face-to-face meetings, most seek to avoid physically assembling the experts. Instead, information may be exchanged via e-mail. This takes advantage of experts' creativity while facilitating group involvement and interaction. Delphi is designed to reap the benefits, but reduce the liabilities, of group problem-solving. This is important in the ecosystem approach to fisheries (EAF) because ordinary meetings of diverse experts with different disciplinary backgrounds and academic or professional status can be difficult to manage even with a facilitator. Such meetings are expensive to organize if the experts reside in different parts of the world.

Institutional analysis

Institutional analysis is the investigation of how formal and informal social rules (institutions) shape human behaviour. Institutional analyses focus on how individuals and groups construct institutions, how institutions operate by patterns of interaction, how they are linked and the outcomes generated by institutions. Institutional analysis has been employed for example for research into co-management arrangements and conditions for success, through the investigation of the set of contextual variables that describe the fishery system, the influence of external factors on the system, the incentives for fishery actors to interact or not, and the observable outcomes that feedback into a system that is constantly adapting. Without institutional analysis, a clear understanding of the complex interactions and relationships among the actors in fisheries is not likely to be achieved. This understanding is even more important as the EAF encompasses a greater number of actors, including those in other sectors.

The Institutional Analysis and Development (IAD) framework, developed by the Universities of Indiana and Colorado, the United States of America, stems from the works of D. North and E. Ostrom on the how institutions function and structure social order and cooperation mechanisms among individuals. The "Institutional Grammar Tool" offered by the IAD framework is a method for conducting a micro-level analysis of institutions. It can be adapted to a range of contexts and situations where the systematic identification of the rules that govern the behaviour of people in collective action situations is needed in order to further policy design and implementation effectiveness.

Focus groups

Focus groups are an interactive form of group interviewing. Group interviewing involves interviewing a number of people at the same time, the emphasis being on questions and responses between the researcher and participants. However, focus groups rely on interaction within the group based on topics that are supplied by the researcher. The focus group is important in providing a means of collecting data that more closely resembles daily interactive conversation and information sharing than the standard individual interview, especially in some cultures. Often, a focus group may be the best way to solicit information when, for a variety of reasons, respondents may be reluctant to participate in individual surveys. Unlike the latter or simple group interviews, focus groups encourage the respondents to react to one another, share knowledge, trade opinions and so on, all without the obligation to reach a group decision or consensus.

Focus Group Discussion with women fish entrepreneurs

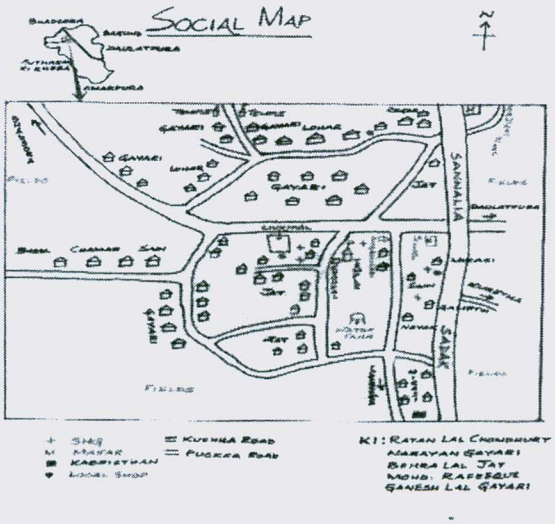
Gender analysis

A gender analysis weighs up and recognizes gender-differentiated identities, roles, responsibilities, value and resources. A gender analysis enables one: to gauge the extent to which the needs and priorities of women and men are reflected in development oriented action; to organize information in order to pinpoint gaps relating to gender inequalities; and to generate gender-disaggregated information. A detailed gender analysis makes visible: the different needs, priorities, capacities, experiences, interests, and views of women and men; who has access to and/or control of resources, opportunities and power; who does what, why, and when; who is likely to benefit and/or lose from new initiatives; gender differences in social relations; the different patterns and levels of involvement that women and men have in economic, political, social, and legal structures; that women's and men's lives are not all the same and often vary depending on factors other than their sex, such as age, ethnicity, race and economic status; and assumptions based on one's own realities, sex, and gender roles.

As such, a gender analysis will map the differences socially assigned to men and women in the household, in the economy, in the political realm and within society. It is an essential part of any diagnostic work before implementing corresponding development initiatives. It is important that it be conducted at three levels: at the macro level (socio-economic and gender issues are introduced into the policy process, usually at the national level); at the intermediate level or meso-level (where the focus is on the place and role of women and gender relations in institutions, structures and services that operationalize the links between macro and field levels), and at the field level or micro-level (where the focus is on individuals, households and communities).

Multi-criteria decision analysis

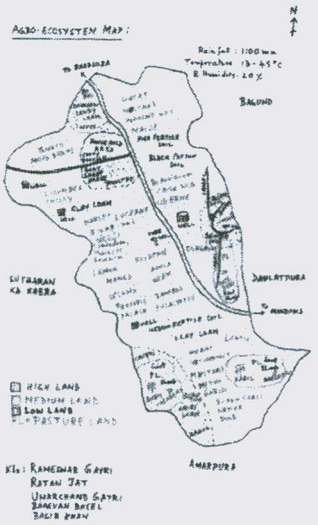
Multi-criteria decision analysis (MCDA) is an umbrella term to describe a collection of formal modelling approaches that seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter. It seeks to take explicit account of multiple, conflicting criteria, it helps to structure management problems, it provides a model that can serve as a focus for discussion, and it offers a process that leads to rational, justifiable and explainable decisions. In the context of fisheries and other natural resources where data are seldom complete, known or fully understood, MCDA can conveniently deal with mixed sets of data, thus accommodating knowledge gaps and filling them with qualitative data, expert opinions or experiential knowledge. It is also structured to enable a collaborative planning and decision-making environment. This participatory environment accommodates the involvement and participation of multiple experts and stakeholders in assessments, but needs to be complemented with more flexible modelling paradigms in order to overcome the inherent rigidity of some of the traditional MCDA algorithms.



Social mapping

Social mapping is a visualization technique closely related to stakeholder analysis and cognitive mapping. It allows stakeholders to draw maps illustrating their inter relationships and their relationships to natural

resources or other features of a particular location. The importance of social mapping, as with many other visualization tools, lies in the ability to elicit information from stakeholders in a format that is easily understood and shared. This can serve as the basis for fruitful discussions and decision-making.

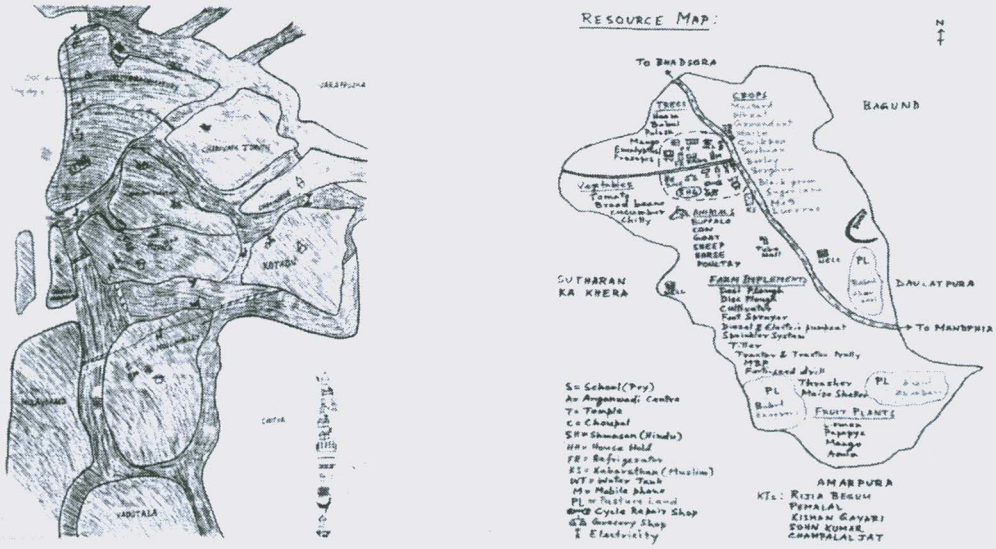


Agro ecosystem map

Agro-ecological or agro-ecosystem map shows the macro and micro ecological (sub-systems) features in a village. The meteorological parameters like rainfall, temperature, relative humidity and the major flora and fauna of the village and the basic land use pattern such as crops, agro-forestry, forest cover, wasteland, animals and the natural resources like soil type, water resources (wells, river, channel, ponds etc.), common property resources (CPRs), use of locally available resources are depicted in this map. This map helps in the preparation of perspective planning for the village development. Here the villagers were encouraged to draw the major land marks such as roads, boundaries, household area, low lying land and high lands first. Then based on the land topography they were asked to indicate soil types, crops, trees, animals, fisheries, water resources etc.

Resource Map

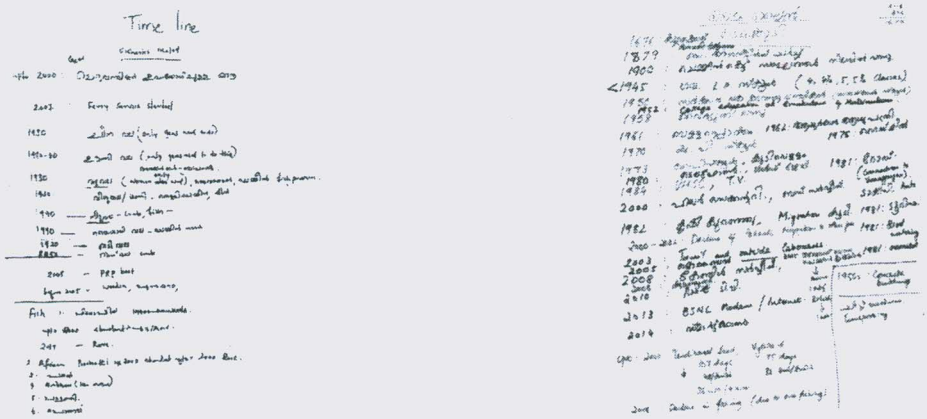
Resource map was drawn after collecting information by the active participation of KIs of different age groups including female. Resource map describes regarding main crops grown in the village, trees, animals, common property resources (CPRs), types of houses, school, farm implements, luxury and communication items, social resources like women groups, self-help groups (SHG), local self-government etc.



Resource map of a fishery based and agriculture based village

Time Line

Historical analyses have been found to be a good icebreaker for field exercises and include detailed accounts of the past, of how things have changed, particularly focusing on relationships and trends. These include technology histories and review, crop histories and biographies, livestock breed histories, fishery time line, labor availability, trees and forest histories, education change, and population change. Folklore and songs are valuable resources for exploring history.

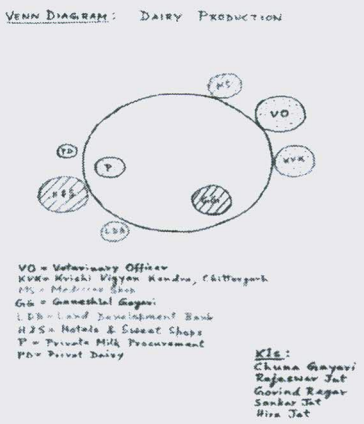


Time Trends

Time trend shows quantitative changes over the period of time and can be used for many variables of fish production, and catch.

Mobility map

The mobility map indicates the places to which the villagers go outside of their village for various purposes like purchasing agricultural inputs, family needs, animal husbandry needs, getting higher education, medical needs, social relations and recreation etc.



Venn diagram

Venn diagram is used for understanding institutional relationship with village and the villagers for a particular enterprise. Each circle represents individual/ institution and the size indicates the magnitude of influence. Venn diagram is drawn to indicate the contributions of outside and inside agencies, organizations and individuals in the decision making process of the inhabitants as perceived by the villagers themselves.

Matrix Ranking

Matrix ranking is used for learning about local people's categories, criteria, choices, and priorities. Matrix scoring takes criteria for the rows in a matrix and items for columns, and people complete the boxes row by row. The items may be ordered for each of the criteria (e.g., for six trees, indicate from best to worst for fuel wood, fodder, erosion control, and fruit supply); or participants may put stones, seeds, or berries into piles for relative scoring. For example, the popular fish varieties in a village can ranked based on the yield, price in market, taste, meat quality and disease resistance (criteria given by the farmers).

Stakeholder analysis

Stakeholder analysis helps to determine systematically who needs to be a partner in the management arrangement, and whose interests are too remote to make this necessary. In doing this, it also examines power, conflict, relative incentives and other relationships. The importance of stakeholder analysis lies mainly in its ability to ensure that the many actors in a vulnerability assessment are properly identified and characterized in terms of their interests in the particular circumstance and some of their interactions that relate especially to power. Without stakeholder analysis being done at the start of the policy and planning

cycles, it is likely that critical actors will be omitted from the processes and that this will lead eventually to problems with the implementation of the assessment, its results, and follow-up actions. It is an important analytical tool that also helps to promote transparency.

Knowledge elicitation tools (KnETs)

KnETs is an experimental computer-based interview method. It is an interactive activity that represents various environmental, socio-economic and climate scenarios in order to identify the specific variables required for the farmers' process of decision-making about adaptation to proceed. The selection of participants aimed to obtain a distribution of profiles in terms of the gender of the head of household, age and wealth groups (poor, average and better-off farmers) that had been established using the survey data on income and household assets. This process was used to identify drivers and possible heuristics or decision-making rules, particularly as responses to seasonal forecast information. This is essentially a method that allows one to "tune in" to tacit knowledge that is otherwise difficult to access. It also provides robustness to the collection of qualitative data, by providing processes of verification and validation of knowledge as it is collected. The scenarios and actions used in the knowledge elicitation activity will be based on the outputs from the participatory exercises already taken up.

Conclusions

Vulnerability is a complex and multifaceted concept that has attracted the attention of scholars and development practitioners from all disciplines. The many interpretations of vulnerability and its many scales (e.g. individual, community, ecosystem, countries and continents) and fields of application have led to a wide array of propositions regarding ways and means by which vulnerability could be studied, characterized, understood, and acted upon. In recent years, a number of initiatives have implemented different approaches to better characterize and understand the broad threats and underlying issues facing fisheries and aquaculture. This chapter builds on previous work and reviews of vulnerability concepts and approaches for assessments. Therefore, the purpose of this document is to shed light on the different VA methodologies that have been developed, how these are conditioned by the disciplinary traditions from which they have emerged, and how they have been applied in the context of fisheries and aquaculture.

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