Identifying social indicators for water resource management: insights and issues for natural resource managers

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Abstract
Natural resource institutions, with the responsibility of planning and managing the health of waterways and water resources, often implement decisions in the absence of understanding social and community impacts of management actions. New tools are vital to assist natural resource managers to make informed choices, promote sustainability and incorporate the social dimension of resource change. Indicators offer one way of simplifying complex information and can give early warning about changes for monitoring and reporting purposes. While water resources are essential to social and economic well-being, there are relatively few known social indicators available relating to the water environment (Seager 2001) and even fewer validated relationships between individual ecological changes and their associated social pressures, impacts and responses.

Case studies on water flows and water quality from two catchments in Central Queensland were used to identify a validated suite of social indicators. Instead of a technical, scientific orientation to indicator selection and validation; a social impact assessment process was used for this study with social data collected from local and regional stakeholders. In this paper, we report on the process undertaken to identify and validate social indicators of freshwater flow change in one of the study areas, the Fitzroy Catchment, and the important methodological issues requiring further attention.

Keywords
Community health, impact assessment, social impacts, social indicators, validation

Introduction

A question frequently asked by natural resource managers is how best to track the impacts of changes in water resource management and resource condition on human communities. This is no simple task. The variable impact of change within communities, the numerous intervening variables between management action, ecological change and social outcomes, and the cumulative impacts of multiple management actions all conspire to make the identification and interpretation of appropriate indicators a complicated and challenging undertaking (Lockie et al. 2002). Thus, while water resources are essential to social and economic well-being, there are relatively few known social indicators available relating to the water environment (Seager 2001), and even fewer validated relationships between individual ecological changes and their associated social pressures, impacts and responses. Specific social information and understanding of water resource change are needed to support policy-making and environmental management. With limited resources monitoring, it is essential that natural resource institutions obtain value from social monitoring

and undertake only that which delivers priority information. A streamlining and refinement of assessment methods is essential if natural resource institutions are to maintain the health of waterways and future water resources, satisfy community expectations, and inform State of the Region reporting.

In this paper we report on the process undertaken to identify and validate social and community health indicators, and find important issues requiring further attention. A social impact assessment process suitable for use by water resource managers is used for the identification of social and community health indicators linked to changes in coastal and waterway resource management and condition. A set of social and community health indicators for use by stakeholders is presented as an example for monitoring impacts from changes in the use, condition and management of water resources. The underlying purpose is to demonstrate the identification process and practicality of social and community health indicators to water resource managers, policy-makers and planners through a P-S-I-R monitoring and reporting framework.

Conceptual issues and framework

Indicators are routinely used to monitor those aspects of a system that provide the most reliable clues as to its overall well-being over time (Slobodkin 1994). They offer one way of simplifying complex information and giving early warning about changes for monitoring and reporting purposes. Such monitoring is essential to support the Adaptive Management of natural resources; that is, the linking of scientific knowledge, decision tools, participatory processes and planning to coordinate monitoring and management of coastal catchments, waterways, and other natural resources (www.coastal.crc.org.au/amf/amf_index.htm). Adaptive Management thus stresses the importance of linking integrating social, economic and biophysical monitoring programs and incorporating this information into decision-making through an on-going process of social learning (Lockie et al. 2004). Importantly, therefore, while indicators generally take the form of quantitative measures of key system attributes, their definition, interpretation and use may best be undertaken through more participatory approaches to management. Indeed, in the case of social indicators, key system attributes such as the knowledge communities have of social and natural resource issues may only be available through participatory processes that are inclusive of all affected interests.

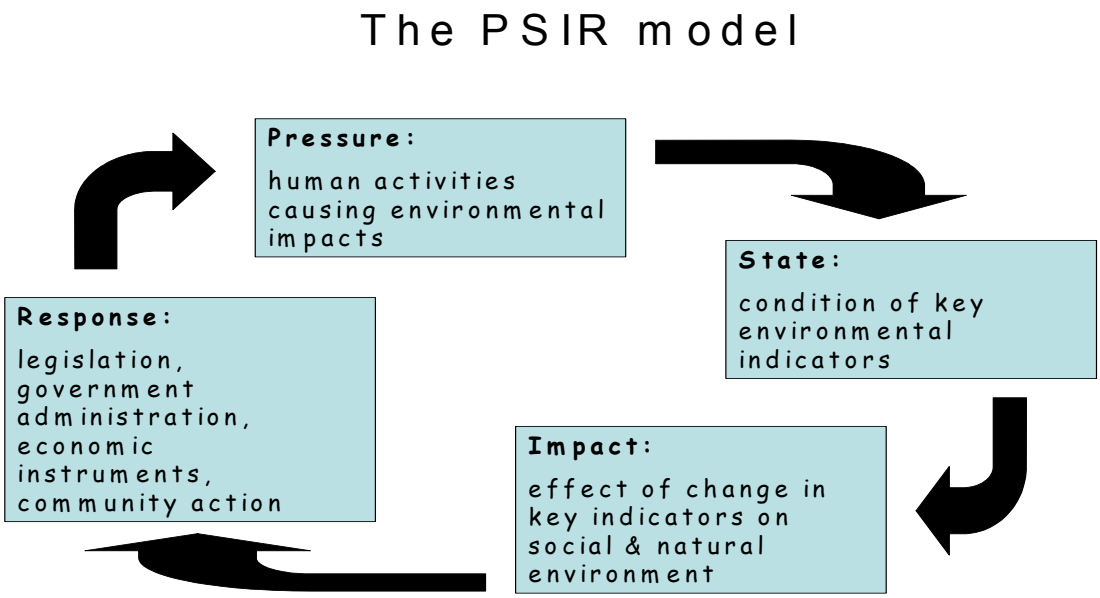
In addition to the inherent challenges involved in defining and interpreting social indicators, recent research into their use in current regional natural resource management highlighted some important practical issues (see Rockloff et al. 2005). These include:

- Current identification of social indicators for natural resource monitoring and reporting is frequently not linked to, or integrated with, biophysical stressors and changes;
- Lack of development and use of an integrated indicator framework, particularly among regional natural resource management (NRM) groups and resource managers;
- Absence of accessible decision support systems (eg. web-based) to guide the identification and use of integrated sets of indicators for monitoring and reporting; and,
- Lack of understanding about the social vulnerability of groups and communities, and using indicators to monitor and report on this concept (including variables of risk, exposure and sensitivity).

This research suggested that in order to understand and articulate the linkages between social, economic and biophysical processes and indicators, an adaptation of the Pressure-State-Response (P-S-R) monitoring and reporting framework may be useful. A further variation of this simple model is the Pressure-State-Impact-Response (P-S-I-R), which allows natural resource managers to better manage the environment and retain important environmental values (e.g. clean water,

productive food systems). This model is concerned with: a) What is exerting pressure on the ecosystem? b) What is causing change in measurable characteristics of the ecosystem? c) What are the impacts of change in condition on human communities? and d) What should be done about it? Conceptualising the social and biophysical environments as one co-evolving eco-social system makes it possible for natural resource managers to focus attention on issues of social and community health most relevant to NRM (see Figure 1). The rational approach used by this model allows indicator identification and an understanding of the pressures and effects of socio-economic drivers (e.g. demand for water due to industrial expansion). It provides the ability to assess changes between water resource use and condition and social and community health, and the institutional and societal response to those impacts. Conceptually, the model allows us to understand the causes and effects of environmental change from an integrated or "whole-of-system" perspective.

Figure 1. Conceptual PSIR model for an eco-social decision framework (taken from Lockie and Rockloff, 2004)



Process for investigating the social aspects of change in water resources

The study involved two coastal catchments as case studies to illustrate a potential process for identifying prospective social indicators. These coastal catchments represented examples of both industrialised and agricultural/urban areas. The management challenges facing these catchments are thus likely to be shared by many other coastal catchments across Australia with issues of water quality decline, greater water extraction and freshwater flow changes, and human pressures on the coastal environment. A full description of these two case study areas is given in Lockie et al. (2004) – *A Conceptual Framework for Selecting and Testing Potential Social and Community Health Indicators Linked to Changes in Coastal Resource Management or Condition*.

Case study method was used for empirical inquiry into indicator development in the Port Curtis and Fitzroy catchments of Central Queensland as contemporary changes were occurring within a real-life context (Crosthwaite et al. 1997). The use of case studies of two coastal communities was the most appropriate strategy for studying the effects of natural resource use, condition and management changes on social and community health of local communities. The advantage of case

studies was the ability to isolate the effects of natural resource change more easily at a local level, without the requirement of examining aggregated data at higher scales. In this study, we conceptualised community along the same lines as Jackson et al. (2004) in terms of a conventional community of place (e.g. coastal town), communities of interest (or culture)(e.g. Indigenous community, recreational fishing community), and occupational communities (e.g. industry, commercial fishers). These communities of place were central towns within the Central Queensland region, servicing a variety of businesses in the immediate coastal zone and also surrounding rural areas.

Taking some of the indicators identified from the preliminary assessment for the Fitzroy and Port Curtis catchments (see Lockie et al. 2004), and with the social data sources available, we sought to explore and validate the relationship between individual ecological changes and their associated social pressures, impacts and responses. The process of social and community health indicator identification and verification involved:

1) Scoping of existing and future biophysical changes and stressors in the Lower Fitzroy and Port Curtis catchments to identify preliminary social impacts and issues through review of the literature (e.g. Environmental Impact Statements, scientific reports) and stakeholder focus groups;
2) Conducting a social impact assessment of changes in natural resource condition and use. The impact assessment phase was narrowly focused on only a few social impacts in each of the catchments because of the limited resources available to undertake a more comprehensive social impact assessment of all identifiable social impacts. Stakeholder interviews were used to gather detailed information on social impacts from biophysical changes caused by water quality and freshwater flow changes;
3) Documenting current monitoring activities and the collection of social data by the regional NRM group and industry; and,
4) Identifying a list of social indicators of community health and well-being for future examination.

Investigation of the social impacts from biophysical changes to water quality in Port Curtis and altered freshwater flows in the Lower Fitzroy covered: contamination effects from marine activities (e.g. marine spillage); effects of land use change due to economic development and population pressure; effects of pollutants from industry, agriculture and urban activities on human use of water resources; effects of reduced fish and seafood availability and consumption; effects on Indigenous hunting and fishing activities; and the effects of associated NRM policy changes on human use of the natural resource (see Rockloff et al. 2005 for full details on individual social impacts).

The use of social impact assessment (SIA) method was amenable to exploring the social consequences of new alternative management actions or policies. It provided valuable insight into how changes will affect the quality of people's lives. The purpose and logic of the SIA parallels environmental impact assessment in that it determines social conditions in areas or human populations likely to be affected by the action or policy; attempts to project future social effects of continuing the current condition; and then estimates social effects that will result on local, regional, and national scales if new alternative actions are implemented. The SIA began with a scoping process involving a literature review, during which problems were identified and all known management and mitigation strategies were described.

The social assessment and indicator identification process was focused at the community-level and explored aspects such as: 1) Who are affected or are likely to be affected? 2) What is happening or

will happen to the people affected? 3) What social changes are occurring or will occur? 4) How are or will any changes affect the social fabric and stability of communities, in their various forms? Information on what data existed on each of the social impacts identified was collected. It included the format of the information, accessibility of the information, spatial scale data (local government area, river system, regional, state etc.), frequency of monitoring and period of monitoring. Basic variable information regarding the social impact was also collected and included the spatial scale of the impact, geographical area affected, temporal scope of the impact (timing and duration), magnitude and frequency of the impact, and the social aspects (what geographical or discrete communities of interest are affected). A matrix table was used to summarise the interview data and to enable information collected to be streamlined across all of the social impacts investigated.

Participatory processes in the form of semi-structured stakeholder interviews were used or much data collection because much of the knowledge communities have of social issues and impacts from management decisions is inaccessible to quantitative demographic and survey methods. For the purposes of these interviews, all groups whose way of life, economic well-being, culture, health, recreational pursuits, or other perceived interests were likely to be affected by relevant changes in water resource management were defined as stakeholders. Stakeholder consultation was used to identify the social impacts of natural resource changes and accessible sources of data to inform measures of indicators. The involvement of stakeholders in this manner was advantageous in guiding the selection of indicators that were most useful. Mayoux (2002) summarises the value and importance of stakeholder input in terms of credibility, relevance, stakeholder acceptance, relevance to policy and planning, and ensuring indicator selection is focused on those biophysical and social impacts most important to stakeholders. In this study, the involvement of stakeholders required widespread consultation to ensure representation of the more disadvantaged stakeholders. The consideration of the local differences was important in interpretation of impacts and issues by the various stakeholders involved.

Case study of Fitzroy Catchment freshwater flow impacts

The following discussion is a summary of the social impact assessment data collected through stakeholder interviews. Resource use and extraction changes in the Fitzroy Catchment due to water storage infrastructure extends across a spatial area covering the upper and lower Fitzroy River and associated waterways and coastal areas, including mangrove and mudflat areas. The cumulative effects of delayed and declining environmental flows from drought conditions and human intervention has impacted on the catchment's fishery resource over nearly two decades, resulting in a steady decline in fish availability and episodic decline in other estuarine and river fishery resources. The magnitude and frequency of the change is widespread and on-going, and characterised by problems with fish movement, water quality, spread of weeds along waterways, unregulated groundwater harvesting, biodiversity loss, and impeded recreation access to waterways (fishing, boating, water skiing). Information on biophysical changes as a result of water management actions include locality specific data for commercial and recreational catch and activity held by state government and research data on fish stock quantity, environmental flows and fish breeding habitats in the Fitzroy Catchment.

The range of stakeholders affected by changed freshwater flows includes local and Indigenous communities, and recreational and commercial fishers. The upper catchment communities and recreational fishers have reduced opportunity to access and use the waterways and fishery. Changed river structure affects waterholes for recreation, and social and cultural use of waterways by Indigenous people. Reduced fish and seafood availability from modified river and estuarine environments in the catchment affect commercial catch and consumption due to delayed

environmental flows in dry years and altered natural systems favouring less desirable fish species. Management responses to these changes include restriction on access to fishery areas and limits on fish catch. Mitigation strategies to manage impacts on the fishery resource encompass fish restocking activities in the Upper Fitzroy for recreational fishing, maintenance of fish ladders on water impoundments by local council, and regulation on building of water storage infrastructures to impede water flows. Stakeholders reported that social impacts of mitigation actions of fish stocking benefit recreational fishers and tourists.

Data sources available on changed environmental conditions and resources, and social impacts include anecdotal information, short and long term monitoring data for the fishery resource, research on social issues of fishing, and social assessment of the Great Barrier Reef Marine Park (GBRMP) management changes (e.g. re-zoning).

Change in the resource condition and use potentially affect the number and type of linkages of community dependency on the environment. Specifically, when a large dependency exists, this may result in the community being particularly vulnerable to changes including both natural and human-induced changes. These changes may be the result of management intervention or an episodic event.

Challenges in using social indicators for water resource monitoring and reporting

A set of indicators are presented in Table 1 based on the P-S-I-R conceptual framework devised for the purpose of integrating monitoring and reporting. The indicators are classed as pressure, state, impact and response, and are selected according to the type of social impact. This set of potential indicators represents measures for social impacts of reduced fish and seafood availability and consumption. The majority of indicators selected for monitoring the effects of the natural resource change are impact and response indicators, suggesting that this social issue has many impacts warranting management attention. These indicators include direct measures of pressures (or drivers), indirect measures and subjective measures of attitudes to understand impacts on health, quality of public access experience, Indigenous well-being and quality of life. Each indicator relates to a physical, chemical or biological stressor, which are major components of the environment that, when changed by natural or human-induced factors, can result in degradation of natural resources.

In this indicator list, some measures are used to inform more than one indicator, and this raises questions of validity and usefulness (e.g. number and frequency of fish kills). It was also necessary to use physical measures as surrogates due to a lack of available or reasonably reliable primary and secondary social data. When water measures are used, Moreton and Padgitt (2005) suggest the use of water quality data collected from water treatment plants as a valuable time series data set capable of linking water conditions and human activities. For example, blue-green algae outbreaks can be used as an indirect measure of change to the visual aesthetic value of waterways and beaches. For some social issues we found there were very few sources of useful social data that could be translated into indicators.

Table 1. Potential social indicators for monitoring the effects of reduced fish and seafood availability and consumption

Social Impact	**Potential Indicators**	**Limitations**
Pressure/Driving Force		
Environmental health - water quality decline from reduced flows	No. & frequency of fish kills No. & frequency of blue-green algae outbreaks	No data on contaminant or cause of death
Impact		
Natural resource condition & availability - effect on pricing, availability, catch effort/location	Commercial catch per unit effort Commercial fishery biomass Seafood wholesale price Fisheries closure periods – No of days Cost of accessing alternative fishing locations	Relies on voluntary reporting by fish & seafood retailers & recreational fishers Estimation of recreational fish catch is difficult Other factors may cause changes in fish availability, pricing, etc., other than polluted river & estuary
Cultural traditions & areas - Indigenous water resource access & use - Indigenous traditional resource access respected	No. of accessible public recreational amenities/opportunities No. protected Aboriginal sites along waterways No. agreements to access areas on private property	No visitor numbers on usage of meeting places along waterways Inadequate data & data only on sites where development is occurring Need to capture amount, location & quality of open space
Quality of life Community amenity to water-based recreation (access, use & perceived quality of recreation space)	Transport cost of accessing alternative locations to recreate No of closures of waterways & recreational areas Usability of public waterway areas – access, location & quality of surrounding environment No. & quality of public coastal & waterway recreational areas (accessible with & without boat)	Requires specific data on types of recreational space affected & how accessibility for different groups is changed. Data on waterway closures due to safety reasons is limited Lack of data on visitor use of recreational areas, especially for water based activities Subjective rating on usability Only anecdotal information on impact on Indigenous communities Original survey data needed on recreational needs & uses of recreational facilities – Sports & Recreation Queensland
Community values - visual aesthetic value of polluted beaches & waterways	No. & frequency of fish kills No & frequency of blue-green algae outbreaks	Difficult to measure visual aesthetics & rely on indirect indicators
Response		
Community perceptions of waterway/river	Institutional response	Require community survey to determine success of

health & water quality	- Implementation of stormwater quality & quantity control measures - Adoption of sustainable forestry practices to protect waterways	mitigation strategies to manage stormwater
Tourism maintenance & growth	Satisfaction level for quality of destinations in GBR Incidences of conflict of use Fish biomass & diversity Level of retail fish supply	Require survey data for visitor satisfaction & to disaggregate to local level Difficult to determine visitor consumption of fishery resource Fish catch data based on voluntary reporting Difficult to access individual retailer records on fish supply
Recreational fisher satisfaction	Resource availability – catch effort & location Fish restocking biomass	Relies on indirect measure of stocking levels to determine fisher satisfaction
Management of resource availability - Limits on access & extraction - Compliance with management plans & rezoning regulations	Catch per unit effort Satisfaction with availability & size of target species Recreational fisher uptake of bag & size limits - No. fines for exceeding limits Fish restocking numbers in Upper Fitzroy No. recreational fishers involved in voluntary reporting Amount of commercial fisher quotas/total allowable catch, no. of fishing days & license buyback Level of unemployment within commercial fishery	Limited to prosecution data Survey data may not disaggregate down to local level Costly to monitor fishing activities & enforcement of rules Difficult to monitor commercial fishers when accessing non-local resources Quotas & effort units are transferable & traded Necessary to distinguish between fishery groups as differential effects across groups Difficult to identify the effects of Great Barrier Reef zoning plan, such as potential loss of ability to catch fish in areas closed to fishing & availability of local alternative areas Low response rate to biannual survey & limited information

The limitations given for the potential social indicators are varied, and many reflect the absence of time-series data that allows for comparisons and the spatially disjointed nature of the social data. The reliance on indirect measures and primary data collection in the form of surveys to supplement current data makes monitoring of responses by institutions less than desirable. Acquiring specifically tailored primary data on social impacts is difficult and needs to occur through rigorous design, rather than by chance. Use of data sources simply because of their availability or tenuous link to a concept leads to confusion and uncertainty for policy and decision-makers. The upfront identification and management of uncertainty surrounding some social impacts, social indicators, and data sources can occur and a plan can be devised to protect communities at risk. This may involve the use of greater stakeholder participation in the process to deal with uncertainty of information and other actions to manage and minimise visible risks.

Unfortunately, in some sectors (e.g. tourism) which interface with natural resources, the primary data produced has been collected for other purposes. The patching together of data from various sources, in various formats, for various time periods and with various qualities describes the method used when standardised data is unavailable. While these difficulties with the data exist, a degree of cooperation and coordination between organisations would assist in addressing some of the current data limitations.

The fundamental challenge is operationalising and measuring social issues, particularly those of a cultural or complex nature. An appropriately developed survey tool with questions related to key components of concepts would likely provide useable primary data on key issues, but the very subjective nature of some concepts compounds the task of defining them and setting measures. When the exact nature of the relationship is not empirically well understood, this too can add further uncertainty to the data. There is also the cost of collection and utility of rich, qualitative data for decision-makers. In the list, three particularly challenging indicator measures are Indigenous well-being, protection of Native Title rights, and quality of life. Discussions with Indigenous people on the basic questions of "what constitutes well-being?" and "how might well-being be best evaluated?", would guide understanding and definition of these concepts, in addition to the formal legislative interpretations. Employing mixed methods to represent these concepts is an option and includes use of historical, survey and interview methods (Moreton & Padgitt 2005). Other difficulties exist in monitoring changes to some of these concepts. Specifically, these are substantiating the relationship between changes in the resource use, and condition and measures of social and community health and disentangling the multiple intervening variables.

In terms of information on the social environment, much of the knowledge communities have of social issues and impacts from management decisions is inaccessible to quantitative methods, but can be provided through participatory processes. As mentioned, the use of survey tools to collect data is needed and has been suggested for many of the response indicators because other data sources are either inadequate or are indirect measures. Recognising what information is more critical than others, through the assignment of different weights to the data, is a way of streamlining primary data collection and minimising costs. However, the difficult issue is determining who decides what are the critical areas and their assigned weightings.

The weighting of values to help guide the selection of appropriate indicators and management action is important. Using values and weights determined through consultation with stakeholders, protects valued resources and activities of high importance (e.g. prawn fishery habitat, traditional cultural practices). For example, assigning weightings for the various resource uses – livelihood, sustenance, recreation, aesthetic, cultural/spiritual value – aids in assigning significance to these uses and guiding decision-making. However, adjustment to weightings is necessary over time to

capture changing social and community values and levels of significance. The weighting is intended to give each indicator an appropriate level of influence on the decision-making outcome. Therefore, each social factor can be weighted to reflect its relative importance to the community. Finally, when combining indicators it is important that the weighting of indicators reflect policy directions and objectives, and this also assists with the comparison of 'conflicting' indicators (e.g. of human or ecosystem well-being) (Garcia & Staples 2000).

We found stakeholder attention to social impacts, and particularly to measurement of these impacts, was lacking. Most stakeholders were able to link dimensions of change to a general social impact; however, few were able to provide specific details relevant to the local social context and demonstrate a good understanding of the associated effects of changes to stakeholder groups. As well as a lack of understanding about the connections and complexities associated with social issues and impacts, it was apparent that monitoring of social impacts in a meaningful way by stakeholders was limited or non-existent. Most information on social activities and impacts was collected and compiled in an ad hoc manner, relied on voluntary collection and was documented in an anecdotal form. Generally, this monitoring information was subjective and not publicly available. Stakeholders' lack of attention to monitoring of social impacts was attributed to: 1) being viewed as outside the responsibility of the organisation which?; 2) funding or other reasons; and, 3) intention to do monitoring in the future.

In the absence of social monitoring data, other potential data sources were identified. These monitoring programmes existed for biophysical variables, such as water and air quality data or fish kills data, and data is publicly available and collected over a long time frame. While such data do not directly measure social impacts, they may have some utility in interpreting and monitoring change and social impacts. The aggregation of available indicators (including biophysical indicators) offers a useful 'preliminary' measure of change in the absence of more informative indicators. There is also the opportunity to extent existing monitoring activities to gather additional information on social impacts. For example, boat license renewal data offers the chance to collect information on fishing activities.

Scoping of potential secondary sources of social data from relevant government and non-government organisations is an option, particularly when baseline primary data is unavailable or provides limited insight into trends. While secondary data can act as surrogates or proxies for some indicators, it should only be used when faced with no opportunity to collect primary data (Macgregor & Carey 2002). Yet the secondary data can serve an important role when used in rapid and inexpensive assessment methods, where information drawn from secondary data in readily available datasets can draw attention to socio-economic and socio-demographic area requiring more detailed examination (see Macgregor & Carey 2002 SCRAM – Social/Human Capital Rapid Appraisal Model) or allow comparison of alternative policies for sustainability of a natural resource (see Pitcher & Preikshot 2001 RAPFISH – rapid appraisal technique).

The ultimate goal of this set of indicators is their application to an integrated eco-social monitoring and reporting program within a region such as the Central Queensland. However, for this to occur, continued refinement of the indicators is needed through consultations with interested stakeholders, and a joint evaluation of methodological and practical constraints to their actual application. The creation of opportunities and resources for vulnerable and impacted communities to participate is fundamental to sustainability, but is difficult and often overlooked. From a democratic perspective, communities should play a role in identifying and assigning social values, informing data interpretation, guiding indicator weighting, and managing uncertainty and risk. Gaining meaningful input into indicator development and policy-making is proving a very real

challenge to water resource managers and NRM institutions, and subsequently, this contributes to and underlies the difficulty of identifying clear relationships between the condition and management of natural resources and social impacts.

Conclusions

The P-S-I-R model offers a framework for identifying indicators and avoids ad hoc indicator selection. Used together with social impact assessment, the model builds our understanding of complex human-biophysical interactions associated with water management, especially from the view of how social factors affect and are affected by the biophysical environment. To advance our understanding of the nature of the relationship between the biophysical – social environments, and to demonstrate the sequence of social effects, a series of flow diagrams for relevant estuarine and freshwater stressors are useful. These flow diagrams can link biophysical and social research activities and provide a starting point for integration across the disciplines. A number of biophysical stressors have already been identified and defined in the Coastal CRC's *User's Guide to Estuarine, Coastal and Marine Indicators for Regional NRM Monitoring* (Scheltinga et al. 2004).

The next step after identifying a set of potential indicators is that of validation using an evaluation tool. The modified SMART filter (Simple-Measurable-Accessible-Relevant-Timely; Taylor et al. 2000) is one tool available to assess the suitability and usefulness of indicators for monitoring and reporting on resource change. Other methodologies for indicator validation are available and exist for the purpose of improving the quality, utility and credibility of environmental and social studies. One such methodology is the 3S Methodology tested by Cloquell-Ballester et al. (2005) to improve the appropriateness of indicators for impact quantification during impact assessment.

While considerable effort was invested in identifying and collecting primary and secondary data on the social impacts, there probably exist many 'less visible' impacts, which may have been overlooked. Continued monitoring of the social impacts and revision of the set of social and community health indicators is necessary to ensure full assessment of changes in natural resources occurs. These indicators should be viewed as only a guide to predicting and managing social and community health and wellbeing. It must be recognised that there are societal and cultural aspects that may be beyond what can realistically be monitored in an environment of limited resources. For those aspects less amenable to measurement there may be other means of contributing information that doesn't rely on quantifying the change, such as process indicators (see Lockie et al 2004; Rockloff et al. 2005).

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