Impacts of environmental condition on human social well-being

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Poster Abstract
Humans have wide ranging impacts on many of the world's ecosystems, but the reciprocal effects of changes in ecosystem condition on humans are poorly understood. Dynamic modelling provides a useful tool to investigate the ways in which specific aspects of well-being might be impacted by changes in the condition of surrounding ecosystems. Understanding the positive linkages between ecosystem condition and human well-being can potentially reduce the apparent conflict between environmental improvement and human interests, thus improving management of local ecosystems.

Based on existing literature, it is hypothesised that changes in coastal ecosystem condition may impact on aspects of social and community relations through affecting people's sense of place, degree of involvement in the community and the extent to which they undertake recreation in the coastal environment. Changes in these aspects of social relations can have flow-on impacts on social capital, social networks, levels of trust and physical and mental health. All of these are important components of human well-being. The links between coastal ecosystem condition, use of coastal systems and aspects of social well-being have been supported by statistical modelling of available data; however, dynamic modelling is required to examine interactions and feedback between these components.

The aim of the model presented here is therefore to examine the impacts of changes in coastal waterway condition on social aspects of human well-being. The model was designed to examine the sensitivity and response time of social well-being to changes to in coastal ecosystem condition and to examine feedback and interactions between components of social well-being. As there are currently few examples of modelling of social well-being, one of our aims is to present this model as a basis for further discussion and exploration of possible approaches to modelling social structures and their interactions with local environments. Further stages of the project aim to incorporate impacts on human health and regional economic production and employment.

Project proposal (whole project)

Impacts of environmental condition on human social well-being

Research area:
Interactions between ecosystem health and human quality of life, using systems modeling.

Background and Significance
Across the world, ecosystems are continuing to degrade, despite a growing awareness of the impacts of many human activities on ecosystem health. This awareness has failed to change individuals' and governments' behaviours sufficiently to slow or reverse the extent of environmental damage. One of the reasons for this lack of change is the limited understanding of the myriad of benefits, goods and services that humans derive from ecosystems, without which humans could not exist (Daily 1997; Rapport, Costanza et al. 1998; Cork, Shelton et al. 2001). Decisions about natural resource use continue to be made on the basis of economic

efficiency (that is, least total cost or greatest economic gain), irrespective of the impact, potential or actual, on reduction of essential life support services. Given the inevitable human-centric focus of decision and policy making in most western philosophies, a greater understanding of the impacts of changes in ecosystem condition on human well-being would contribute to a greater value being placed on ecosystem goods and services.

Services delivered by ecosystems include waste processing, clean air and water, pollination, soil fertility and structure, climate maintenance, pest, disease and weed control, erosion control, water, nutrient and chemical cycling, provision of cultural, spiritual, religious, educational values, and recreational opportunities (Daily 1997; Bolund and Hunhammar 1999; Holmlund and Hammer 1999; Ronnback 1999). Goods provided by ecosystems include food, fibre, fuel, building materials, habitat and medicines (Costanza, d'Arge et al. 1997; Daily 1997; Bolund and Hunhammar 1999; Holmlund and Hammer 1999; Cork, Shelton et al. 2001). Human requirements for survival are drawn from these goods and services, and include adequate food, water, shelter and companionship. In societies in developed countries, other factors also contribute to human well-being, including good health, financial security, educational opportunities, lack of discrimination, lack of violence, trust and good social relationships (Gerdtham and Johannesson 2001). These requirements are interlinked, and are dependent on goods and services provided by surrounding ecosystems. Changes in the condition of the surrounding ecosystems affect the provision of goods and services, and therefore impact on human well-being. Possible consequences of changes in environmental quality include economic losses, deterioration in human health, and disruption or breakdown of social and cultural norms (Rapport 1999).

An improved understanding of the impacts of changes in ecosystem health on human welfare clearly has wide application across policy and decision making processes. Such information could be used in evaluating new developments that potentially degrade ecosystems, as well as evaluating the costs and benefits associated with ecosystem rehabilitation. One approach would be to measure or estimate all benefits and costs in terms of human well-being (social, health, and economic aspects) of having an ecosystem in a particular condition. It would then be possible to estimate or predict the benefits from rehabilitation, or costs from ecosystem degradation, in terms of direct impacts on human well-being. This approach would build on the understanding of ecosystem goods and services already developed, and on interactions between ecosystem health and socio-economic well-being that have already been identified. Measuring impacts in this way would be meaningful and relevant to both the general public and decision makers, and could be used within existing decision making frameworks.

The focus of this project is on the impacts of changes in water quality in estuaries and coastal areas on human well-being. Coastal ecosystems are the most productive per unit area of all systems on the planet (Costanza 1993; Costanza, d'Arge et al. 1997). Approximately 37% of the world's population lives within 100km of the coast (Cohen, Small et al. 1997), and this percentage is increasing (Costanza 1993). In Australia, coastal areas are experiencing the fastest rate of population growth. The quality of the environment plays an important role in attracting people to a coastal region, and has a strong influence on individual activity and industry development in the region. Water quality is one of the most visible attributes of a coastal ecosystem, and one which has many impacts on other aspects of ecosystem health. Water quality in coastal ecosystems could therefore be expected to have a strong relationship with human well-being in the immediate area. The focus of this study will be on the impacts of ecosystem health of estuarine and coastal ecosystems on human health, social and economic well-being.

Aims and expected outcomes

The aims of this project are therefore to:

- Quantify the impacts of aquatic ecosystem health on three aspects of human well-being: economic productivity, human health and social capital.
- Develop quantitative models that can be used to predict the impacts on human well-being of changes in aquatic ecosystem health.

- Apply quantitative models to coastal management decisions.

This project will result in a better understanding of the impact that changes in their surrounds have on humans. The major outcomes from the project will be a quantitative model that can be used to assess the likely economic, human health and social impacts of a specified change in coastal ecosystem health, and a general method for applying this model to other situations. These outcomes will significantly improve environmental decision making, both in assessing likely impacts of new developments, and in assessing benefits of ecological rehabilitation. They will also lead to a greater scientific understanding of the dynamics of linked human-ecological systems.

Research plan, methods, techniques and timing

Summary of research objectives and hypotheses

Question	Objective
How is aquatic ecosystem health related to human well-being?	1 Develop conceptual models to show links between aquatic ecosystem health and human well-being using relationships established in the literature and hypothesised relationships
To what extent does aquatic ecosystem health affect human well-being?	2 Examine relationships between aquatic ecosystem health and specific aspects of human well-being using two case studies.
How do changes in aquatic ecosystem health impact on human well-being?	3 Using quantitative modelling based on data from case studies, investigate the potential impacts on economic productivity, social capital and human health of increases and decreases in aquatic ecosystem health.

Research plan and methods

Objective 1 Develop conceptual models

Initially, extensive literature research is required to identify links between various components of aquatic ecosystem health (water quality), human health, social capital and economic productivity. The interactions identified from the literature will be summarised in a matrix, which lists all the possible system components and their interactions. This matrix will be focussed by eliminating components that are not linked to aquatic ecosystem health; and a schematic conceptual model will be developed from this shorter list. This model is essential in recognising and understanding the range of possible interactions between coastal systems and human well-being. It will be used to identify specific questions regarding interactions between coastal condition and human well-being that are relevant in the case study areas and which require further study. The conceptual model will also be used to identify indicators and data required to answer these questions. Outputs from this objective will include a general conceptual model based on literature review that shows relationships between ecosystem health and human well-being, and that can be used to identify relationships relevant to specific situations.

Objective 2 Examine relationships between aquatic ecosystem health and human well-being using two case studies

There are three major aspects of human well-being that will be addressed in the project:

- Economic productivity
- Social capital
- Human health.

Specific questions identified from the conceptual model will be addressed for each aspect. Each of these issues will be addressed in the two case study areas, the Caboolture River/Pumicestone Passage area and Port Douglas. Each issue will be addressed using different methods and indicators, as described below.

Economic activity

What are the effects of increases and decreases on regional production and employment in water quality?

Input-output analysis is frequently used to estimate direct and flow-on effects of changes in industry output to regional productivity and employment (Jensen and West 1986). It records the production of consumption of goods in an economic systems for a given time period, for a number of industries (sectors). The number of sectors included is dependent on the aim of the model. Traditionally, input-output modelling has included only goods and employment in monetary units; however, recent attempts have been made to extend input-output modelling to include environmental effects (Alarcon, van Heemst et al. 2000; Moffatt and Hanley 2001). In this study, the major sectors potentially affected by water quality (for example, commercial fishing, aquaculture and tourism) will be identified in each case study, and the contribution of water quality to their productivity estimated using existing and new data. For example, if a change in water quality would decrease fish populations by 10%, a simple estimation of the effects of this would be to decrease production of the commercial fishing sector by the same amount. More complex functions may be included if data are available. Regional input-output analysis can then be used to calculate the flow-on effects in terms of productivity and employment to the regional economy as a whole.

Social capital

Social capital is a term used to describe aspects of community interaction. It is generally defined as including trust, reciprocity, connectedness and equality (Rudd 2000; Woolcock and Narayan 2000; Pretty and Ward 2001). Social capital is an important aspect of human well-being, as it affects public health, crime rates, economic productivity and the effectiveness of governance (Putnam, Leonardi et al. 1993; Kennedy and Kawachi 1998; Lomas 1998; Kawachi, Kennedy et al. 1999; Svendsen and Svendsen 2000; Uphoff and Wijayaratna 2000). Several aspects of social capital will be addressed; specific questions relating to each aspect are detailed below.

Does (perceived) water quality affect the amount of recreation undertaken in coastal areas? If so, to what extent?

Perception of water quality is likely to affect the type and amount of recreation undertaken in coastal areas (Smith, Croker et al. 1995; Pendleton, Martin et al. 2001). Types of recreation likely to occur in coastal areas include walking, socialising (picnics, gatherings etc), fishing, swimming, boating, and snorkelling or diving. This question will be addressed using survey data on the perception of water quality (which may differ from actual water quality (House 1996)), actual water quality, and extent, type and location of recreational activities in coastal areas. This indicator is included as it has the potential to contribute to social interaction and human health (see next section).

Does recreation in coastal areas lead to social interaction?

Social interaction is an important component of social capital, as it is through personal interaction that individuals develop trust and supportive networks (Lochner, Kawachi et al. 1999; Falk and Kilpatrick 2000; Svendsen and Svendsen 2000). Social interaction is more likely to occur during recreational activities, as the likelihood of encountering neighbours or acquaintances is greater in a public setting. This question will be addressed using survey data on recreational habits and types of social interaction.

Does (perceived) water quality contribute to sense of place?

Good ecosystem health may also contribute to a sense of place (Horwitz, Lindsay et al. 2001), and pride in local area. This can contribute to social and community capital, and may lead to increased concern about the local area and therefore greater involvement in local decision-making (for example through involvement in community or environmental groups). This will be examined by correlating indicators of sense of place with perception of environmental quality, taking into account factors such as length of residence. Data will be obtained through mail surveys.

Does water quality affect community involvement?

Individual involvement in community environmental groups may be influenced by aquatic ecosystem health – perception that ecosystem health is poor or deteriorating may provoke action to improve ecosystem health; conversely, good ecosystem health may increase feelings of sense of place, and thereby promote membership in community groups. Community involvement increases social capital, and has the potential to significantly

improve the local environment. This question will be addressed using mail surveys to assess sense of place and community environmental group membership, as well as interviews with members of local environment groups.

Human health

Several aspects of human health will be investigated; these are described below.

Does coastal recreation contribute to exercise and therefore to overall health?

The existence of nearby coastal areas in good condition has the potential to influence the amount and type of recreation residents undertake, and therefore the type and amount of exercise (Ball, Bauman et al. 2001). As exercise has proven health benefits, recreation in coastal areas may contribute to the overall health of individuals. This will be assessed by using surveys to assess the amount and type of recreation undertaken by individuals, together with data from the literature on the contribution of exercise to general health.

Does water quality affect mental health?

It has been shown that exposure to natural environments may reduce stress in both chronic and short-term stressful situations (Ulrich 1984; Wankel and Berger 1990; Ulrich, Simons et al. 1991; Parsons, Tassinary et al. 1998). The condition of nearby coastal areas therefore has the potential to affect the long-term or background stress levels of the population. This will also be assessed using surveys, including questions on self-assessed stress and general well-being, and perceptions of the surrounding coastal environment.

Does the current (future) level of toxicants affect human health (through direct exposure and consumption of contaminated foods)?

Toxicants (pesticides and heavy metals) have the potential to affect human health through direct exposure and through ingestion of contaminated foods. The potential effects on human health will be assessed by comparing ambient concentrations of toxicants with established guidelines and risk assessment procedures (for example, Australian and New Zealand water quality guidelines, (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand 2000).

Does the current (future) bacterial abundance affect human health?

Bacterial and viral contamination of coastal waters can lead to respiratory, gastrointestinal, dermatological and other infections in users of the waters (Corbett, Rubin et al. 1993; Henrickson, Wong et al. 2001). Consumption of aquatic foods with bacterial contamination can also lead to illness. The health risk from bacterial contamination of coastal waters will be assessed through comparison of current levels of contamination with established guidelines and risk assessment procedures.

The major outcome from this stage of the project will be an understanding of the relationships between ecosystem health and human well-being that can be applied and further tested in other systems. This will form the basis of the quantitative modelling described in the next section.

Objective 3 Quantitative modelling

Objective 3 requires the development of quantitative models. These will be developed using *Stella* (High Performance Systems) and/or *VenSim* (Visual Solutions), which are ideal for conducting basic quantitative modelling to test and generate hypotheses (Hannon and Ruth 1994). The aim of developing these models is to try and represent in sufficient detail the processes which link ecosystem health to human well-being, and to use these models to further test and generate hypotheses. It is expected that the models will be developed in sufficient detail to be used in local environmental decision making.