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Participatory Approaches in Developing a Model to Assist Water Resource Management in a Catchment in the Solomon Islands

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Abstract: This paper describes the practical application of a participatory approach currently being used in the development of a model for assisting water resource management in the Kongulai catchment in the Solomon Islands. In collaboration with local water resource managers, the Kongulai was selected as the study site as it provides up to 60\% of the water for Honiara, the capital. Management of this resource is complex, with potentially competing uses for the water and the catchment, including drinking, domestic, agricultural and industrial uses, as well as multiple threats from contamination, changing land-use and variable hydrology. Additional system considerations come from the multifaceted socio-economic and institutional arrangements. Stakeholder consultation was a key element in the model development process. The three main stakeholder groups, the customary landowners, the government, and non-governmental organisations, were consulted separately in May 2007, to ensure openness in identifying stakeholder concerns and to elicit each groups’ understanding of the catchment and how it worked with respect to water resources. During a further visit in October 2007 all stakeholder representatives were brought together and preliminary results combining outputs from the May consultations were presented for discussion and feedback, and prioritisation of concerns and issues to be included in a quantitative model. Because of its intuitive graphical basis, a Bayesian belief network was considered an appropriate tool, and is being developed based on the stakeholders’ conceptual diagrams. Involvement of representative stakeholders and accounting for their concerns as well as using their local knowledge of the system was intended to build trust in the model development process and in any outcomes, as well as facilitate relationships between the different groups affecting, and affected by, the catchment. Inclusion of local knowledge is also essential to model development in cases such as this, where little quantitative data is available.

Keywords: Participatory Approaches; Conceptual Model; Catchment; Water Resources.

1. INTRODUCTION

This paper describes the practical application of a participatory approach currently being used in the development of a model for assisting water resource management in the Kongulai catchment in the Solomon Islands. Local water resource managers identified the Kongulai as the priority catchment, as it provides up to 60\% of the water for Honiara, the capital. Management is complex due to multiple uses for, and threats to, the water, and as managers need to evaluate, prioritise and find solutions to the multiple, potentially serious hazards, a risk assessment approach was deemed appropriate [e.g. Hart et al. 2006]. As part of this approach, a quantitative model is needed to integrate these issues and allow prioritisation of on-ground management actions. Quantification will also provide a more
solid comparison against competing interests (for example, logging) for funding improved water management.

Transfer of modelling technologies to environmental managers and ensuring their application in improving management is a challenge [Matthews et al. 2006], and much of the process described in this paper was intended to address this. Stakeholder consultation is a key element in model development processes. Increasing the involvement of on-ground managers and local communities in developing models of a particular system is an important factor in encouraging uptake of models and their outputs [Castelletti and Soncini-Sessa 2007]. Because of its intuitive graphical basis, a Bayesian network (BN) is intended as an appropriate tool to develop, based on the stakeholders’ conceptual diagrams. Bayesian techniques are also appropriate in this case because of the scarcity of data, incomplete understanding of the relatively inaccessible system, and the high uncertainties involved [Cain 2001]. The quantitative model development is currently underway.

2. METHODOLOGY

2.1 Study Site

A situational analysis of the Solomon Islands and discussions with local water managers indicated that Kongulai catchment, just west of Honiara, the capital of the Solomon Islands, on the island of Guadalcanal, was an appropriate study site [Wairiu and Powell 2006]. The catchment is under traditional, or customary or ownership. It is approximately 50 km², and is mainly comprised of mountainous forest, although there has been some logging, and there is subsistence agriculture near the settlements that occur toward the coast. In addition to the values, threats and catchment complexity being of interest, the accessibility of the site and considerations of data availability were also important in site selection.

2.2 Ecological Risk Assessment

A catchment-based Ecological Risk Assessment (ERA) approach similar to that used by Hart et al. [2006] is being used to guide development of a model to quantitatively assess threats and hazards to water in the catchment and to fit into the management process. The ERA approach is illustrated in Figure 1. It can be considered to be made up of two primary phases, the Problem Formulation phase and the Risk Analysis and Characterisation phase.

The Problem Formulation phase involves consulting the stakeholders to determine the scope and focus of the risk investigation and ensure the relevancy of the project. Stakeholder consultation gives stakeholders an understanding of the risk assessment process, encourages their input, and provides a basis for ownership of the project and its outcomes. Group discussion and selection of the key value helps the stakeholders gain consensus on the management objectives and narrows the project scope, and discussion of the threats in the region identifies the primary risks that should be considered. Diagrams of stakeholder understanding (“conceptual diagrams”) of the system can be constructed around the key values, incorporating the primary threats/hazards, and revealing what the stakeholders consider important and also how they understand the system to work.
The Problem Formulation is then used as the basis for the Risk Analysis and Characterisation phase of the ERA, analysing the consequences and likelihood of each of the risks identified in the Problem Formulation. These are then combined (in this case, by conversion to a Bayesian network, which is being done based on work done by Cain [2001]) to compare, rank and prioritise the risks on the basis of seriousness relative to management objectives. This phase is iterative, as understanding of the catchment improves during analysis and characterisation of risks, the model can be improved.

The Risk Analysis and Characterisation then feeds into Risk Management, involving identification and implementation of the best on-ground management actions. Monitoring and review of any management actions implemented makes the entire ERA process iterative and cyclic. Once the risk in the current cycle is successfully managed for, a next iteration of Problem Formulation can identify the next focus for management to address, i.e. the process results in adaptive management.

This paper focuses on the role of the participatory process in the risk assessment project, primarily occurring in the Problem Formulation phase, and how it assists in model development. It should also be noted that because of the developing and foreign context, the environmental/ecological aspects of the region were secondary to human health issues and needs.

3. STAKEHOLDER PARTICIPATION

Participatory processes are the key element of the Problem Formulation phase, which determines the scope of the risk investigation and the type of management information it needs to provide. This also provides the basis for the quantitative modelling of the following phase. Part of the interdisciplinary research team also focused on the qualitative aspects of the stakeholder input to gain an integrated qualitative system understanding of the catchment. The initial situational analysis reviewed the relevant literature, particularly local studies and reports, to prevent repetition of effort, and to provide an idea of the issues and a basis for discussion with stakeholders. This review also provided a first step in identification and mapping of the stakeholder groups and possible representatives.

3.1 Stakeholder engagement

An initial site visit in September 2006 built relationships with local partners, the Solomon Islands Water Authority (SIWA) and the Division for Water Resources, and helped identify further interest groups within three main areas: government and resource management, non-governmental organisations (NGOs), and the catchment community. A list of potential stakeholder groups and representatives was gathered from contacts in the Australian Agency for International Development (AusAID) and the local partners. Discussions with these organisations and individuals identified further potential stakeholder representatives, which subsequently revealed yet more parties of interest. The preliminary discussions with these networks of people were very important in identifying the most appropriate stakeholder groups and representatives. The discussions also helped delineate appropriate methods for culturally sensitive initiation of contact. Finally, this networking put us in contact with a respected government employee who was also related to the Kongulai landowner clan, and who was willing and able to act as a cultural interpreter, and facilitate our contact and interactions with them as well as act as translator where necessary.

There is a history of tension between the three main stakeholder groups, and as a result, three separate sets of stakeholder consultations were held in May 2007, firstly with the customary landowners, secondly with representatives from the relevant government departments and water management groups, and finally with non-governmental organisations (NGOs). Separate consultations also ensured openness in identifying stakeholder concerns and in elicitation of each groups’ understanding of the catchment and
how it worked with respect to water resources. As these sessions progressed, perspectives and information from the other stakeholder groups were also introduced and discussed, and the common aspects between groups emphasized to set the stage for combined consultations in October 2007.

3.2 Community consultations

Two large information sessions were held with the two sub-tribes of the Kongulai customary landowner group (30-35 people each). Although almost all participants understood and spoke English, some felt more comfortable in their local dialect, particularly when speaking, so the community facilitator also translated each way where necessary. The procedure for these consultations began with our community facilitator introducing us to the community group. The research team then introduced the project, with pauses for translation, setting out our ethics procedures, describing our aims in identifying how to improve management of the catchment, how they could help us, how the project might help them, and how it might be generally useful. We were explicit that we were independent researchers and not working on behalf of the local authorities with whom they might normally interact on land and resource issues. We also explained that we had no say over further funding beyond this particular project. Questions and discussion followed. Subjects discussed included: whether it was in their interest to be involved, the problems and tension they have with the local authorities, and possible compensation for their time. These large information sessions were vital in clarifying what the project was about and allowing the stakeholders to air their concerns. Much of the discussion was within their group and did not require input from the researchers. Finally, over a communal lunch, each of the sub-tribes selected male and female representatives with a range of ages for four subsequent, small-group consultation sessions (6-9 people each).

The small group discussions were held with male and female representatives separately, at times and venues convenient to them over the following week, and were based around a large map of the catchment with only a few primary features displayed. The participants were asked what more they knew about the catchment, particularly with regard to water. Additional features were gradually added. Note that although mapping by the Department of Lands covers this area, much of the official detail has not been ground-truthed. The landowners are the only people who regularly visit the area and a number of discrepancies from the official map were revealed by this exercise. Questions were used to encourage further discussion, these included prompts about catchment features and landuse; how water moved through the catchment; the location and behaviour of rivers, springs, sinkholes and runoff; personal water collection and use; other local uses for water; threats to water; what they valued in the catchment and any associated threats; and what relationships they saw between different factors.

A primary finding was the significant differences in identification of the location and extent of logging operations by those familiar with the area, which when combined by a lack of government monitoring is of concern. Additionally, some rivers thought to be perennial were discovered to be intermittent, and there was significant uncertainty in the location of sinkholes and springs affecting the water supply.

3.3 Government and NGO consultations

The government and NGO consultations were more structured because of the educational and work backgrounds of the participants, and there was more time available due to less remote venues and because there was no need for translation. In addition to discussions similar to those described for the community consultations, elicitation of explicit conceptual maps or influence diagrams for how these groups understood the Kongulai Catchment to work, also occurred.
Government (19 representatives) and NGOs (16 representatives) each had a one-day workshop. After project and team introductions, ethics clearances and catchment map discussions to elicit details as described in §3.2, discussion of values for water in the Kongulai was followed by a formal (blind) vote to identify the priority value.

Discussion of the threats to water was followed by discussion of known or suspected sources of data for any aspects of the Kongulai. Smaller groups of 5-8 stakeholders were formed (3 groups for the government workshop, 2 for the NGOs) to construct conceptual diagrams of how the stakeholders understood the water in the catchment to work, based around the priority value selected earlier, and including those threats they thought were most significant for the Kongulai, as well as any additional factors they considered important. The conceptual diagrams were then presented and discussed in the larger group.

3.4 Stakeholder conceptual diagrams

The small-group conceptual diagrams were merged for government and NGO groups, and community stakeholder variables and linkages added where these were not already included, producing the diagram shown in Figures 2 and 3. This overall stakeholder diagram is too complex for direct use as a Bayesian network structure, and also requires refinement where certain aspects may have been overlooked because they were too obvious, e.g. lack of a link between rainfall and water quantity, or because of the limited timeframe of the stakeholder consultations. However there are several elements of interest in these diagrams.

Figure 2 highlights the differences in the views and focuses between the stakeholder groups. There is a strong government focus on infrastructure such as leakage, pipes and pumping; technical aspects such as geology, and also on the problems they see with end-users, such as overuse (the blue variables). In contrast, the NGOs (in red) focused more on socio-economic aspects such as the costs to end-users and community values, and political factors such as leadership. The landowner focus (in yellow) was more at small-scale use and impacts of water. Additionally, because of the shorter consultation time with the landowners (see §3.3), fewer variables were obtained from them overall, although as discussed below, many of the central features of the diagram were shared with the other stakeholders. Differences in perspective were acknowledged and discussed with the
stakeholders to get them to think about whether outlier variables were vital factors, and understand why certain factors may not be included in further model iterations.

The overlap in the viewpoints of the different stakeholder groups is highlighted in Figure 3. A number of elements are common to all groups (in grey), including the most central aspects (linking directly to the priority value) water quality, water quantity, sustainability and availability, and affordability. Additionally, all groups regarded the key threats as population growth, the impact of geological change such as earthquakes and landslides, and the landuse impact of logging and agriculture. These similarities were emphasized in the separate consultations to build common ground, and to make it more difficult for some groups to dismiss the viewpoints of others as coming from ignorance rather than from different priorities. Additionally, these common variables represented consensus on the important factors in the catchment, to be used in the next model iteration.

### 3.5 Stakeholder follow-up and variable prioritisation

During the subsequent visit in October 2007, a selection of the original stakeholder representatives (28 people) were brought together and preliminary results from the May consultations were presented (note, the fully merged diagrams were not yet complete), emphasizing commonalities while acknowledging the different priorities amongst stakeholders, and also providing reassurance that the problems they’ve encountered are common to water resource management around the world. A series of small-group tasks, combined with a gradual remixing of the initially self-selected groups, was used to encourage interaction between the different stakeholder groups. The exercises also provided an opportunity for the exchange of views (for example on the relative importance of different factors to water), and also to discuss valid alternative conceptual models of the same system, while promoting consensus and collaboration.

One of the tasks was to simplify the overall conceptual diagram. As there were too many stakeholders to directly go through the network and pare/restructure, clusters of variables were organized into categories such as: water quality, water quantity and human activities. Six mixed sub-groups of three to five stakeholders ranked up to three clusters of variables
each in order of importance to water resources in the Kongulai. The rankings were then averaged across groups, and some of these results are presented in Table 1.

**Table 1. Variable prioritisation.**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Water Quality</th>
<th>Water Quantity</th>
<th>Human Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sanitation</td>
<td>Rainfall</td>
<td>Population increase</td>
</tr>
<tr>
<td>2</td>
<td>Logging</td>
<td>Sinkholes/springs</td>
<td>Water management</td>
</tr>
<tr>
<td>3</td>
<td>Pollution/rubbish/waste</td>
<td>Geology/natural disasters</td>
<td>Land management</td>
</tr>
<tr>
<td>4</td>
<td>Animal waste</td>
<td>Season</td>
<td>Pollution/rubbish/waste</td>
</tr>
<tr>
<td>5</td>
<td>Agriculture</td>
<td>Pipes/infrastructure</td>
<td>Sanitation</td>
</tr>
<tr>
<td>6</td>
<td>Flooding</td>
<td>Climate</td>
<td>Logging</td>
</tr>
<tr>
<td>7</td>
<td>Natural disasters</td>
<td>Logging</td>
<td>Agriculture</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Agriculture</td>
<td>Climate change</td>
</tr>
</tbody>
</table>

This prioritisation is intended to allow paring of variables in different sections of the diagram and allow conversion to a Bayesian network. The further steps required for this process are proposed in §4.

### 3.7 Ancillary Benefits

There were a number of ancillary benefits observed throughout the participatory process. A primary positive outcome was the re-establishment of contact and communication between government and community landowners, via the simple act of officially bringing together the different groups and providing an independent forum and facilitator to discuss water resource issues. This improved relationship was made concrete with funding provided by government for meetings between landowners to discuss water and catchment issues. During the May consultations there was recognition amongst the separate stakeholders that a partnership between government/resource managers and the landowners was needed, and during the October consultation the authors facilitated an initial brainstorming with the stakeholders on how to implement a shared management plan. In July 2007, logging in the Kongulai was halted, and one landowner working for the main logging company in the catchment claims it was a direct response to the May consultation, and that the landowners are waiting for the outcomes of this research before allowing logging to resume. Saw-milling of previously logged wood continues. Finally and unexpectedly, the community facilitator who works in the public health field recognized potential uses for the conceptual diagram in showing colleagues and patients the connections between what occurs in the catchment to water quality and human health.

### 4 FURTHER WORK

Streamlining of the conceptual diagram for conversion to a Bayesian network is currently underway, based on the variable prioritisation. It should also be noted that the development context of the Pacific region necessitated care in the selection of tools appropriate to the resources of the local community. The science or engineering educational background of many of the local managers was an important factor in deciding Bayesian networks were feasible. Additionally, the research team made arrangements with Norsys, the creators of the Bayesian network software Netica, to provide software access to the on-ground managers.

Further steps required to complete the Risk Analysis and Characterisation phase will involve a further site visit in May 2008, and consultations with a small group of water managers and local experts to confirm model structure plausibility and proposed measures and variable states. Expert elicitation is also required for initial conditional probability tables. A similar procedure to that suggested in Cain [2001] will be used. The available quantitative data for the Kongulai has already been sourced and will then be used for network learning. The trained network will be used to provide an assessment of risk from the potential threats. An analysis of network sensitivity, consequences to key values, and
comparison of different management scenarios will be run past the resource managers for plausibility and usefulness before presentation to the wider stakeholder group.

5 CONCLUSIONS

Involvement of representative stakeholders and accounting for their concerns as well as using their local knowledge of the system built trust in the model development process and facilitated relationships between the managers and others affecting and affected by the catchment. Inclusion of local knowledge is essential to model development in cases such as this where little data is available. A further field trip is planned in May of 2008 for final model refinements and testing with the on-ground managers, and to update the wider stakeholder group.

Lessons from the participatory process include:

- Stakeholder input will require interpretation (model refinement). Ideally, this interpretation should be checked with the participants, firstly to ensure the interpretation still represents their thinking, and secondly to bring them along the process of model development so all stakeholder views develop concurrently.
- Relationship building is important in addressing problems of management and model use/uptake – possibly more than specific model-building processes.
- Expectation management of the participants is important – models are simplifications of reality, not everything can or should be represented.
- A wide range of stakeholders is important – e.g. the few stakeholders who knew of logging sites could easily have been missed in the consultation process.
- However, the larger the stakeholder group, the more unwieldy the results and the more difficult to reconcile different worldviews and aims. A balance is needed.

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