VPSIRR (Vulnerability – Pressure – State – Impact – Risk And Response): An Approach To Determine The Condition Of Estuaries And To Assess Where Management Responses Are Required

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EXTENDED ABSTRACT

Estuaries are highly variable in terms of type and geomorphic classification. The condition of these systems is often a reflection of activities taking place in their catchments and the susceptibility of these systems to each particular pressure. Effective management intervention can be achieved when there is an understanding of the current condition of the estuary or component of the estuary and of the pressures likely to affect them. If this can be linked to the susceptibility of the estuary to the pressure (risk), the management activity can be prioritised.

A framework based on the Pressure-State-Impact-Response model, but which also includes the vulnerability of the system to each of the pressures has been developed. A key feature of this framework is that the links between indicators of pressure, state and impact are clearly identified ensuring that only indicators relevant to the local situation are selected. In addition, a risk assessment process has been developed. This approach is called a VPSIRR (Vulnerability – Pressure – State – Impact – Risk – Response) approach.

Application of this method increases the likelihood of being able to identify the causes of any observed changes in condition, making it easier to identify appropriate management actions. It also enables information to be provided to the community in a user-friendly manner. We have developed a user friendly computer package which enables the risk that each estuary is under from various pressures to be assessed and linked to condition. The package enables the certainty about various data used to inform the process, to be reported.

Importantly, the package enables indicator information to be updated as better information becomes available. It also enables new indicator information to be incorporated into the software should better knowledge become available. This component would only be made available to software administrators.

The package produces a colour coded and numeric report card comprising of 5 colours or numbers which is designed to be easily understood and interpreted by users from a variety of backgrounds. The software can be used to inform managers of where to focus management investment, but can also be used to educate people about natural resource issues and the implications of different catchment and estuary based activities.

Fact sheets imbedded within the software provide details about the various indicators. These include how to collect data and where necessary, how to analyse them in order to use the software. The fact sheets also provide information on management responses to a variety of issues.

1. INTRODUCTION

Estuaries in the eastern states of Australia are under increasing pressure from catchment-related activities. To obtain information about directing management activities effectively, it is necessary to have information about activities in and around the estuary and about the actual or potential impact that these activities have on estuarine condition. Estuary managers have used condition indicators for a variety of reasons in the past and have attempted to focus management decisions on condition indicator values. It has become apparent that many indicators can be influenced by a variety of factors making it difficult to determine the cause of the effect. It has also become known that many indicators were based on information from Europe or the USA and were not useful in an Australian context. More recently a process known as Pressure-State-Response has been used where it was considered that pressures (or driving forces) reflect the human and principally economic activities that affect the environment. State variables describe the condition of the environment and response indicators describe the societal and policy responses to environmental change (i.e. management actions).

The PSR approach has been developed further to fulfill a broader range of objectives. An example of this is the adaptation to a DPSIR approach (Driving Pressures – State – Impact - Response Framework) (Turner et al. 2003). Other studies have considered the brittleness or resiliance of various systems to pressures (e.g. Bricker et al. 2003). Bricker et al. focused on eutrophication and the susceptibility of various systems to nutrient loading. This paper focuses on the development of techniques which extend that approach and also the development of a user-friendly software tool that enables links between pressures, the vulnerability of the systems and the resultant condition of the system and also enables the risk of the system to a variety of pressures to be assessed.

The approach outlined below is termed the VPSIRR (Vulnerability-Pressure-State-Impact-Risk-Response) approach. The approach is based on our belief that to effectively manage a waterway it is necessary to have an understanding of the problem and in the way the problem has manifested itself on the waterway. It is also necessary to have an idea of the sensitivity of the waterway to each of the pressures.

Our software has been developed to be accessible to a wide range of users of varying technical backgrounds. Users can produce a simple colour coded report card for their system or part of their system of interest. The software provides information about the various indicators suggested as well as how to collect and manipulate data.

2. CONCEPTUAL MODELS

Before using the software users are advised to develop a conceptual understanding or model about the way their system functions. This enables them to consider existing information and to integrate this information to understand how their system operates and how it might respond to changes in the catchment.

Users are also advised to have a good knowledge of the issues of concern to stakeholders and community about their waterway of interest and to make decisions about the scale (temporal and spatial) they want to use in their assessment.

3. VPSIRR APPROACH

The approach is an issues- and value-driven approach which is outlined in the figure below. Issues and values of stakeholders and community can be defined and used to determine stressors. Stressors are defined as the variables which lead to the issues of concern to the community. Stressors in turn can be used to identify pressures which are the variables that can be measured to assess the level of the stressor. The extent that a pressure can affect the waterbody being considered can be determined by the vulnerability of that particular system to the pressure. Ultimately the pressure (modified by the vulnerability) results in the waterbody having a particular condition. There are a variety of indicators of pressure, vulnerability and condition and these can be quantified. Pressure and vulnerability can be used to determine risk.Risk is generally what ultimately

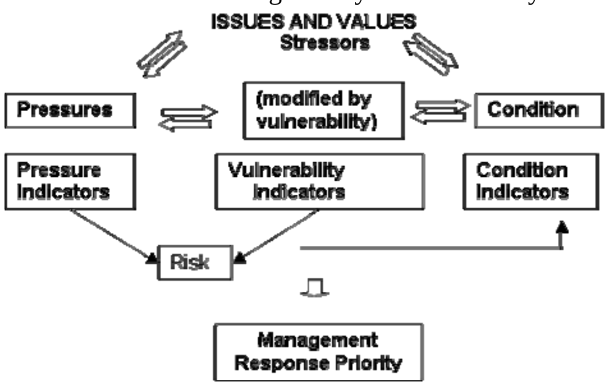

Figure 1. Flow diagram showing basic principles that underpin the VPSIRR approach and its associated software.

defines condition. Linking these variables can provide a clear signal of where a management response is required. Management responses can also be prioritised according to the level of risk associated with each attribute.

Issues can be established by the community and stakeholders. Through the use of conceptual models that link issues to stressors to pressures and then to condition, stakeholders can develop an understanding of the manner in which their system of interest responds. The software will entail the use of a number of different indicators (pressure, vulnerability and condition) which are identified for each stressor using an indicator selection framework. This provides a comprehensive list of indicators that would be appropriate to monitor in that system. Further information, such as how data should be collected, analysed and interpreted is provided for each indicator.

Pressure indicators assess those activities, actions and processes external to the estuary that have (or can potentially have) an impact on estuarine condition. Pressures will be rated from 1-5 with 1 indicating low pressure and 5 indicating high pressure (see Table 1). Vulnerability indicators are aspects that are inherent or internal to the system that modify the effect of a pressure on condition. Vulnerability indicators are therefore relevant to specific pressures and condition – ie you need to consider the vulnerability of what (e.g. fish populations) to what (e.g. fishing pressure). Vulnerability is rated on scale from 1 to 5 with a score of 1 indicating low vulnerability and a score of 5 indicating a highly vulnerable system (Table 1).

Condition is the status of the waterbody (including biota and habitat), it provides an indication of the way in which the waterbody has responded to catchment pressures. Examples include biomass or productivity measures (phyto, macro, epiphytes). Condition is rated from 1 to 5, with 1 indicating good condition and 5 indicating poor condition (see Table I).

Table 1 indicates the approach for the development of all categories with category 1 being the lowest pressure, the least vulnerability, the best condition and category 5 being the greatest pressure, the most vulnerable and the worst condition.

On selection of appropriate variables, the software will prompt for data input. Once data of each variable have been entered (in the format suggested in the package), the package would compare the data against the data groups that are housed internally in the system (as a black box). These relationships allow the vulnerability, pressure or condition to be assessed on a scale of 1 to 5 as discussed above. The assignment of ranges to groups and the values of each group are a component of the black box. These will be capable of being changed by password enabled administrators to make them more system specific or when better data become available.

The quality (certainty) of data/information used to assess each variable should be assessed. This should be possible at two steps. An assessment of the quality of data that are entered into the program by users should be assessed (see Table 2 for an example). In addition, the certainty of the relationships / data ranges used in the black box should be assessed on a similar scale. These steps will enable a degree of certainty of final outcomes to be provided.

Table 1. Pressure, vulnerability and condition categories

Level (pressure, vulnerability, condition)	**Score**	**Colour**
Low, low, best	1	
	2	
Medium, medium, medium	3	
	4	
High, high, worst	5	

Table 2. Summary indicating how data quality / certainty can be assessed and rated

Data quality	**Definition**
High	High quality data collected according to excellent protocols, good temporal and spatial replication.
Medium	Good data, poor temporal or spatial replication
Low	Data quality or replication questionable or of dubious quality, educated guesswork used.

A simplified approach has been adopted for representing the level of certainty. This makes the concept of certainty accessible to users of all levels of expertise, ensuring that it is accounted for in the determination of management actions. The three categories of certainty / data quality enable the certainty to be reported following calculation of risk, with the lowest level of certainty or data quality being made to dominate.

A second stage, in development, of the software will enable the information on values (1-5) to be used in a risk assessment approach using vulnerability-pressure matrices. These matrices enable a risk category for each variable to be determined (on a 1-5 basis). Risk is considered as combination of pressure and vulnerability. It can be assessed using a simple model, from equations using actual numbers (e.g. kg of Nitrogen and flushing rates), or using a matrix approach. There is a requirement for risk to be expressed as a value between 1 and 5. The risk assessment will be based on a pressure – vulnerability risk matrix. Pressure / vulnerability risk matrices assess each pressure against the vulnerability to give an indication of risk. For example, assessing nutrient load against the vulnerability of the system to nutrients would indicate a low risk if there were small loads and good flushing, medium risk if high loads but excellent flushing or medium loads and poor flushing, but high loads and poor flushing would equate to a high risk.

An assessment of the risk classification is then run as a third stage of the model with the level of risk being compared against the appropriate condition variable. This is done to assess whether the condition of the estuary is the result of its high risk value or whether it is a natural phenomenon and requires more work to be conducted to assess it.

Table 3. Risk matrix derived from pressure and vulnerability (where 1 is low pressure, vulnerability and risk, and 5 is high pressure, vulnerability and risk). A system that has low pressure and low vulnerability is at low risk, while a system with high pressure and high vulnerability is at high risk.

Risk		**1 Pressure**				
		1	**2**	**3**	**4**	**5**
Vulnerability	**1**	1	1	1	2	3
	2	1	1	2	3	4
	3	1	2	3	4	5
	4	2	3	4	5	5
	5	3	4	5	5	5

Table 4. Assessment check. Comparison of the risk and the observed condition provides a check of the pressure and condition assessment. Where 3 = As expected – the results of the condition monitoring match the expected risk to the system. 2 = The observed condition differs slightly from expected. 1 = The observed condition does not match the expected in relation to the risk. These situations need to be examined in more detail.

		Observed Condition				
		1	**2**	**3**	**4**	**5**
Risk	**1**	3	3	3	2	1
	2	3	3	2	1	2
	3	3	2	1	2	3
	4	2	1	2	3	3
	5	1	2	3	3	3

4. VPSIRR SOFTWARE

The VPSIRR software is written as a Windows-based Delphi application. Figures 2-5 show example views of the software.

Figure 2. VPSIRR Welcome screen.

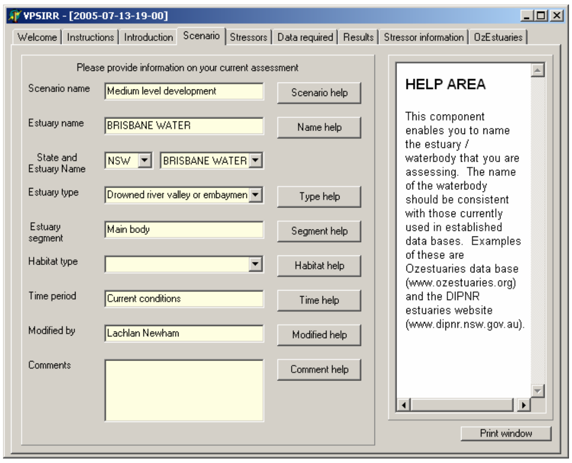

Figure 3. VPSIRR scenario screen.

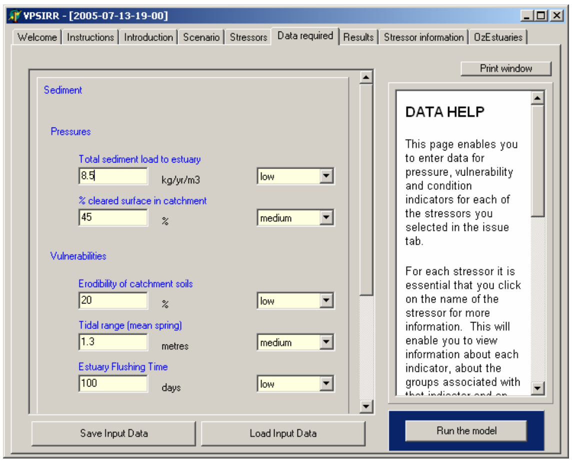

Figure 4. VPSIRR data entry screen.

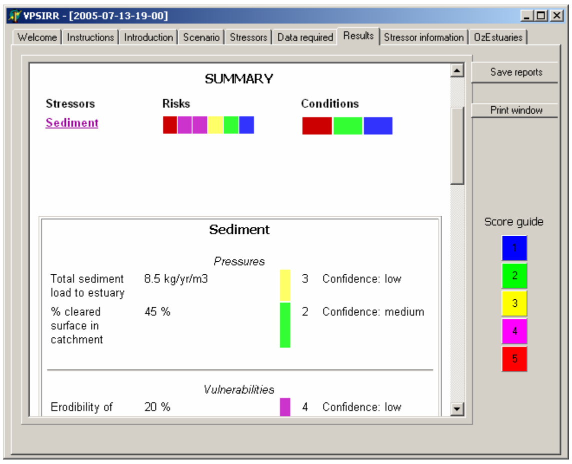

Figure 5. VPSIRR results screen.

Users can easily construct their own scenarios using the VPSIRR software. They are also able to save model inputs to file and export results in a html-based file format. VPSIRR also provides users with a link to the OzEstuaries database as a potential information source for VPSIRR.

5. SPATIAL AND TEMPORAL TRANSFER

The data underpinning the VPSIRR software can be updated in response to new information or to make the software suitable for different systems. A separate software component enables an administrator to change the values of the 5 categories in each indicator. They are also able to generate additional indicators should they be required. Once changes are made the assessment software is updated. Users are required to update information sheets and other static software components if that occurs.

6. INTERPRETATION OF DATA

The output from the software is a colour coded and numeric report card (see Table 1). The report card also provides an indication of the certainty associated with each result. Pressure, vulnerability and condition are reported on as is risk. Where the results of the risk and condition matrix are not expected, the software provides an indication that this has occurred and a pop-up box suggests that users look in more detail at the quality of the information they have used.

The information file sheets in the software provide information about each indicator. They also provide details about fairly generic, suggested management responses.

7. SUMMARY AND CONCLUSIONS

Estuaries and coastal lakes have varying susceptibility to different catchment and waterbased pressures. To effectively use pressure and condition indicators to direct management responses requires the vulnerability of the system to pressures to be understood. We have produced a simple user friendly software approach which enables users to select appropriate indicators for their system and to assess the risk of their system or component of their system to those particular pressures. This enables management responses to be prioritized effectively. The software enables the underlying data and groupings (assumptions) to be updated over time or for additional indicators to be uploaded.

8. REFERENCES

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