



Strategic Framework for Integrated Natural Resource Knowledge Management

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Strategic Framework for Integrated Natural Resource Knowledge Management

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Foreword

Effective natural resource management relies on knowledge across many themes. The Victorian Catchment Management Council (VCMC) has for a long time advocated for improved knowledge management. This has been reflected in recent policy documents, including 'Securing Our Natural Future – A White Paper for Land and Biodiversity at a Time of Climate Change' (White Paper).

A key role of the VCMC is to report on Catchment Condition across the state every 5 years. To complete this task the VCMC has been reliant on the monitoring and reporting frameworks in use by the key authorities involved in catchment management at any point in time. The VCMC (including the Catchment and Land Protection Council predecessor) has produced three reports on Catchment Condition – in 1997, 2002 and 2007. The corporate knowledge, historical context and ongoing need for knowledge on catchment condition mean that few organisations are as well placed to input into the development of new performance indicators for NRM knowledge management at a state-wide level.

This document has been developed by the Catchment Condition and Knowledge Committee of the VCMC, with assistance from an Expert Panel that includes the Chief Scientist and relevant representatives from the Sustainability Commissioner, DSE, DPI and CMAs.

An integrated knowledge management framework (encompassing knowledge sharing, monitoring and reporting, and research and development) was proposed in Policy 3.4 of the White Paper. Action 3.4.1 required the development of performance indicators to measure the effectiveness of integrated knowledge management. The lead and sole responsibility for this action was the Natural Resource and Catchment Council (NRCC). The White Paper indicated that this was a new body that would take on the current responsibilities of the Council and some additional functions. Following the change of Government in November 2010, the NRCC was not established.

The first and fundamental step in the development of the integrated knowledge management framework and its performance indicators is the establishment of key principles and objectives.. Hence, VCMC proposed that it would develop a 'Strategic Framework for Integrated Natural Resource Knowledge Management' (Strategic Framework) prior to embarking on performance indicators. This approach was endorsed by the Minister, who acknowledged the Council's and the Committee's efforts and experience on integrated knowledge management. He stated that the proposed approach is a valuable first step in developing the performance indicators described in Action 3.4.1 and for improving knowledge management as a whole.

This Strategic Framework sets out key principles and objectives for knowledge management. It is the first step in what could be a multi-stage process. It is envisaged that the next step could be the development of performance indicators at one or more levels.



Mick Murphy OAM

Chair, Victorian Catchment Management Council

1 Policy Context

'Securing Our Natural Future – A White Paper for Land and Biodiversity at a Time of Climate Change' (White Paper) establishes a long-term Vision for NRM in Victoria:

"Victorians acting together to ensure that our land, water and biodiversity are healthy, resilient and productive"¹.

The White Paper recognises the importance of effective knowledge management for achieving its Vision. Specific policies are set out under Outcome 3.4 (pp. 33–39). Key points include:

- Sustainable management of Victoria's land, water and biodiversity requires appropriate information and knowledge;
- Effective knowledge management is required to inform policy, planning and investment; and
- Knowledge and information needs to be shared across the range of sectors, organisations and communities involved in the management of land, water and biodiversity.

This Strategic Framework is the first step towards White Paper Action 3.4.1: "to develop performance indicators to measure effectiveness of integrated knowledge management".

Key planning initiatives that would be expected to benefit from improvements in knowledge management include:

- The Victorian NRM Plan;
- State-wide sectoral strategies – e.g. VSHREW, Biodiversity Strategy; and
- Regional strategies – e.g. Regional Catchment Strategies.

Institutional change (and personnel change) presents particular challenges and opportunities for knowledge management. There are significant risks of knowledge and information being lost in the transition process, as occurred with previous institutional change in this sector. However, the opportunity exists for establishing more effective systems for knowledge management.

The Strategic Framework outlined in this paper has brought a relevance to Government policies relating to NRM. However, this requires buy-in from those responsible for developing and implementing relevant strategies. Examples include:

- "Our Water Our Future" and associated policies and planning documents (e.g. Sustainable Water Strategies);
- "Victorian Climate Change White Paper";

¹ White Paper, p. viii.

- “Our Environment Our Future”;
- “Our Forests Our Future”;
- “Victorian Biodiversity Strategy”; and
- “Victorian Coastal Strategy”.

2 The Strategic Framework

The Strategic Framework for integrated NRM knowledge management is outlined in this section.

- Section 2.1 defines the key concepts of “knowledge” and “knowledge management”.
- Section 2.2 outlines the purpose of the Strategic Framework.
- Section 2.3 discusses the role of knowledge in the NRM decision-making process.

More detailed information about specific parts of the framework is presented in subsequent sections.

The Strategic Framework is based on the knowledge and experience of the Catchment Condition and Knowledge Committee, with assistance from the Integrated Knowledge Management Expert Panel.

2.1 Definitions/ Key Concepts

“**Knowledge**” does not have a single universally-agreed definition². For the purposes of this Strategic Framework, knowledge is defined in relation to the “knowledge hierarchy” (Figure 1). The Strategic Framework is concerned with the management of knowledge as well as the information and data underpinning it. The various different types of knowledge that are relevant to natural resource management are outlined in Section 3.

“Knowledge management” has been defined as “getting the right information to the right people at the right time, and helping people create knowledge and share and act upon information”³

“Knowledge management” is also an emerging scientific discipline, linked to the fields of business administration and information systems⁴. This Strategic Framework aims to address practical issues relating to the incorporation of knowledge into NRM decision-making by capturing the experience of the authors and contributors. It does not attempt to review scientific discourse on knowledge management.

² “What is knowledge” is a central question for debate in philosophy (epistemology).

³ NASA Website, <http://km.nasa.gov/whatis/index.html>, viewed 30/08/10.

⁴ For example, see Stankosky, M. (2005) *Creating the Discipline of Knowledge Management*. Butterworth-Heinemann. There are a number of journals on knowledge management, including the *Journal of Knowledge Management* (UK), *International Journal of Knowledge Management* (USA), *IUP Journal of Knowledge Management* (India), and *Journal of Knowledge Management Practice* (Online – international).

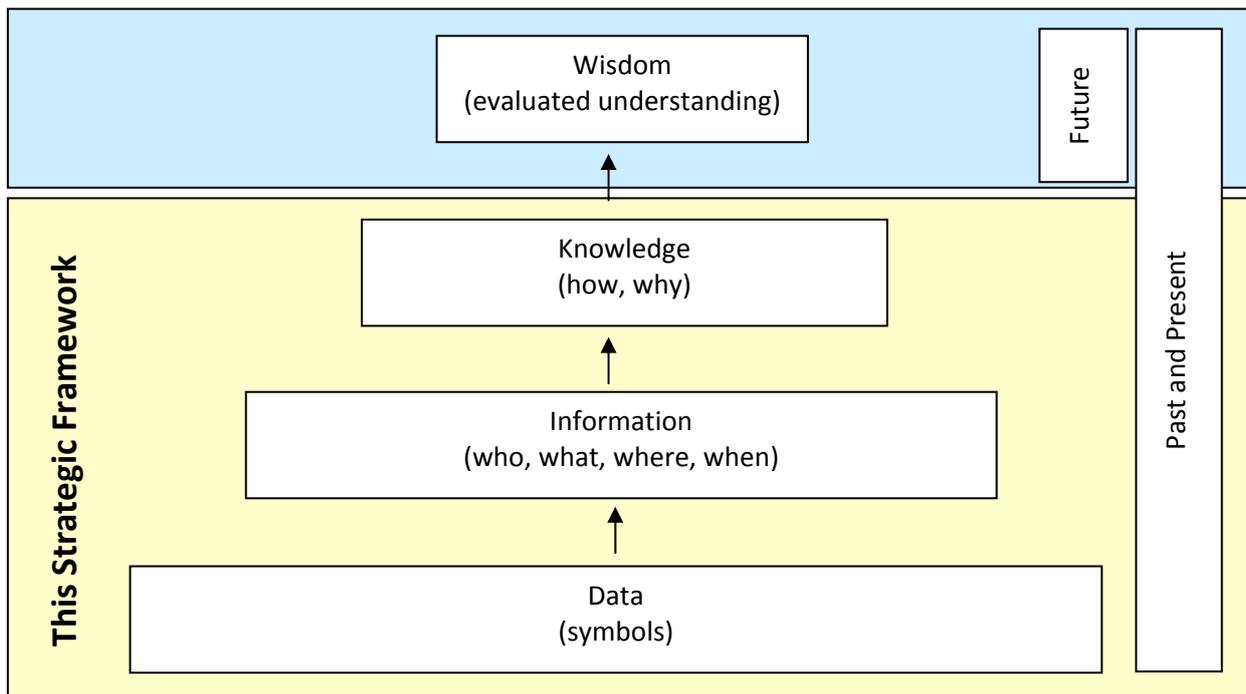


Figure 1. The Knowledge Hierarchy⁵

2.2 Purpose

The aim of VCMC's work on integrated natural resource knowledge management is:

to enable better-informed NRM decision-making through improved access to knowledge.

The role of this Strategic Framework in relation to the knowledge management system proposed in the White Paper is illustrated in Figure 2. The Strategic Framework encompasses all knowledge management relevant to NRM in the State of Victoria, but with a particular focus on the role of Government.

This Framework is intended as a first step towards the future development of performance indicators for the Victorian Government's Integrated Natural Resource Knowledge Management system. The role of this knowledge management system in an adaptive management cycle for policy, planning and investment is described in the Land and Biodiversity White Paper (Figure 3.1, p.33).

⁵ Adapted from Ackoff (1989). Ackoff proposed 5 levels by separately identifying "knowledge" and "understanding", whereas "understanding" is considered to be part of "knowledge" in this paper.

A practical outcome from the perspective of the VCMC is a system which will generate a better basis for the delivery of future Catchment Condition Reports and the State NRM Plan, as well as many other purposes.

Risks posed by poor knowledge management and opportunities presented by good knowledge management are highlighted in Section 4.

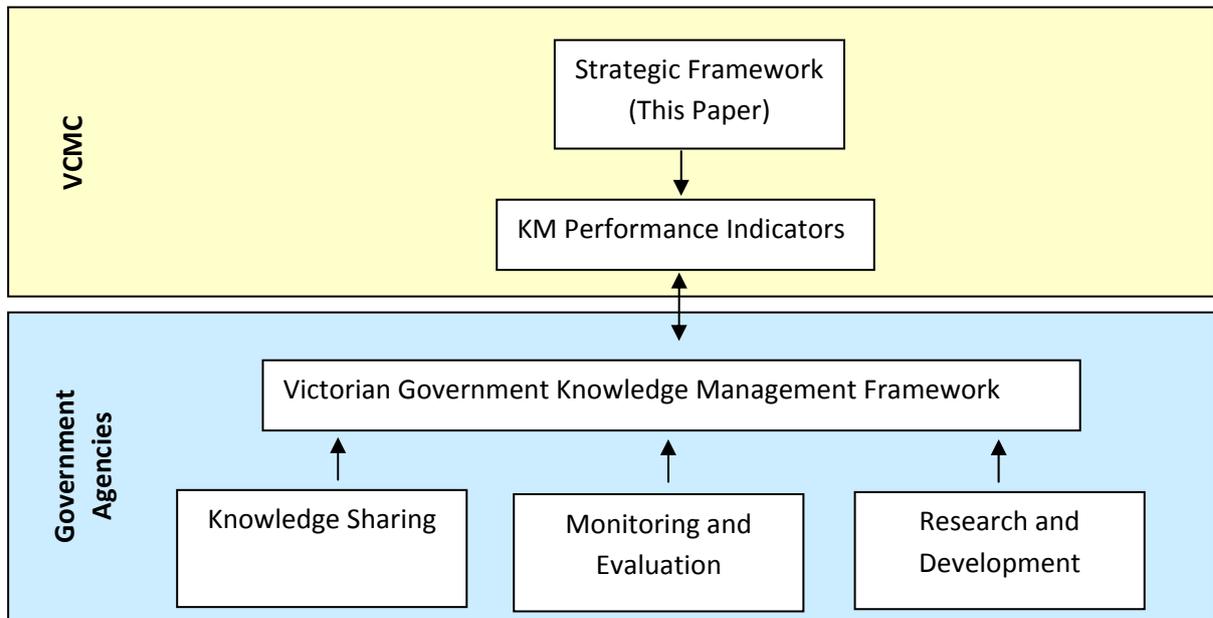


Figure 2. Role of this Strategic Framework in the knowledge management system proposed in the White Paper

2.3 Knowledge in the NRM Decision-Making Process

The purpose of knowledge management in NRM is to improve decision-making (Figure 3).

Three main areas of application are identified in Figure 3: policy, practice and research. Amongst the many decisions that need to be made in all of these areas, investment decisions are of key importance and require improvement to increase transparency.

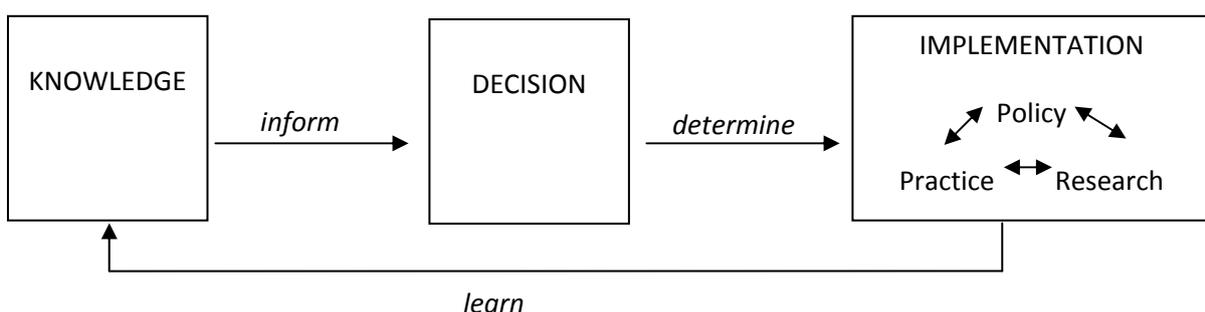


Figure 3. Knowledge in the NRM Decision-Making Process

The flow of information between knowledge owners and decision makers can be characterised in terms of an “NRM Knowledge Economy” (Section 5).

NRM knowledge management can be evaluated from two major viewpoints:

- Assessment of the decision-making process (Section 6); and/or
- Assessment of the knowledge management system (Sections 7-10).

These approaches are complementary. For a comprehensive evaluation, both need to be used.

3 Types of Knowledge

Various taxonomies of knowledge have been proposed in the knowledge management literature⁶. In this Strategic Framework, NRM knowledge is divided into four major categories (Figure 4).

Existing	Formal
	Tacit
New	Monitoring and Evaluation
	Research and Development

Figure 4. Types of NRM Knowledge

3.1 Existing/Formal Knowledge

Formal knowledge comprises knowledge that is written down or otherwise formally recorded. Examples include:

- Published books, papers and reports;
- University theses;
- “Grey” literature (unpublished written materials including consultants’ reports, internal government reports and unpublished papers); and
- Data, including records held in databases and spatial data such as maps and remote-sensed imagery.

3.2 Existing/Tacit Knowledge

Tacit knowledge comprises unwritten knowledge held by individuals and groups. Examples include:

- Information held by individual NRM practitioners (including government and agency staff, and consultants);
- Corporate “knowledge” and corporate “memory”;
- Informal knowledge held by local people and communities; and
- Indigenous knowledge held by Traditional owners and other indigenous people.

3.3 Monitoring and Evaluation

Monitoring and evaluation is a key component of the adaptive management cycle. The White Paper identifies three priority issues to be addressed by NRM monitoring and evaluation:

⁶ Zack (1999) at 132.

- Changes in resource condition;
- Economic and social factors affecting ecosystem resilience; and
- Performance of Government and other partners in NRM.

3.4 Research and Development

Research and development is undertaken to produce new knowledge.

The Victorian Government undertakes in-house research relevant to NRM (e.g. by the Arthur Rylah Institute (DSE) and Future Farming Systems Research Division (DPI)). It is also a participant in research joint ventures with external partners.

Other parties actively involved in NRM research include universities (staff and students), industry, CSIRO and some consultants. Some of the research they undertake is applied or “contracted” research, partly or wholly funded by a third party, such as Government. They also undertake “pure” or curiosity-driven research that is conducted solely for the aim scientific advancement. However, such curiosity-driven research may lead to important spin-off benefits including many for NRM.

4 Opportunities and Risks

Knowledge management is central to natural resource management. There are significant opportunities for good knowledge management (Section 4.1) but poor knowledge management brings many risks (Section 4.1). VCMC's experience with accessing knowledge for catchment condition reporting is briefly reviewed in this context (Section 4.3).

4.1 Opportunities

Key opportunities for good NRM knowledge management include the following:

- The growing volume and complexity of information regarding the environment presents significant opportunities to provide improved knowledge, provided that data and information are well-managed;
- Development of a knowledge management system that is robust in face of institutional change and personnel change;
- Development of an organisational structure to protect and house the results and champion the robust system;
- Good knowledge management will provide the basis for the development of "wisdom".

4.2 Risks

Examples of risks arising from poor knowledge management include the following:

- Loss of data / records / information;
- Loss of tacit knowledge due to staff churn;
- Lack of coordination – data gaps, overlap/duplication;
- "Data overload" due to increasing volume and complexity of information regarding the environment;
- Collection of useless data – poor methodologies/protocols, inadequately qualified/experienced personnel;
- Poor design, including lack of consistency over time in methodology or application of data collection, making it difficult or impossible to determine temporal trends;
- Inaccessibility of data because of hoarding;
- Decisions made in the absence of existing knowledge due to knowledge sharing barriers (e.g. not knowing specific knowledge exists, knowledge not shared);
- Waste of money and resources;
- Loss of life and limb⁷.

Even in the best-managed knowledge system, there will be residual risks. These risks can be minimised (but not eliminated) by good management.

⁷ 2009 Victorian Bushfires Royal Commission. Final Report, July 2010.

4.3 VCMC's Previous Discussions of Knowledge Management

In the Catchment Condition Report 2002, VCMC wrote a chapter on Knowledge Management and concluded that while there were some very positive knowledge initiatives at that time, there were major gaps across three important areas: knowledge generation, knowledge synthesis and knowledge exchange.

In the Catchment Condition Report 2007, VCMC included the following as one of its six recommendations: "Develop a Victorian Integrated Catchment Management Knowledge Strategy". This recommendation was based on the problems that VCMC faced in assessing the condition and management of Victoria's land and water resources, in both 2002 and again in 2007. The problems included: lack of data, lack of benchmarking, irregular monitoring, inconsistency in methodologies, inaccessible databases, lack of analysis and evaluation, inconsistency across the State, inadequate resources, and lack of continuity over time. This list reflects many of the risks outlined in Section 4.2.

These experiences have led VCMC into the continued championing of knowledge management.

5 The NRM Knowledge Economy

The White Paper vision of “Victorians acting together” to achieve better NRM requires a knowledge management system that encompasses the whole of Government and also extends beyond Government. This system is characterised in this Strategic Framework in terms of an NRM “Knowledge Economy”⁸. A clear understanding of the knowledge flows that support NRM decision-making will assist in developing an improved knowledge management system delivers better outcomes, efficiencies and accountability.

If we consider knowledge management in terms of information flows between “knowledge owners” and “decision-makers”, a simplified representation of the NRM Knowledge Economy might be as shown in Figure 5.

Knowledge owners include knowledge producers, custodians and investors.

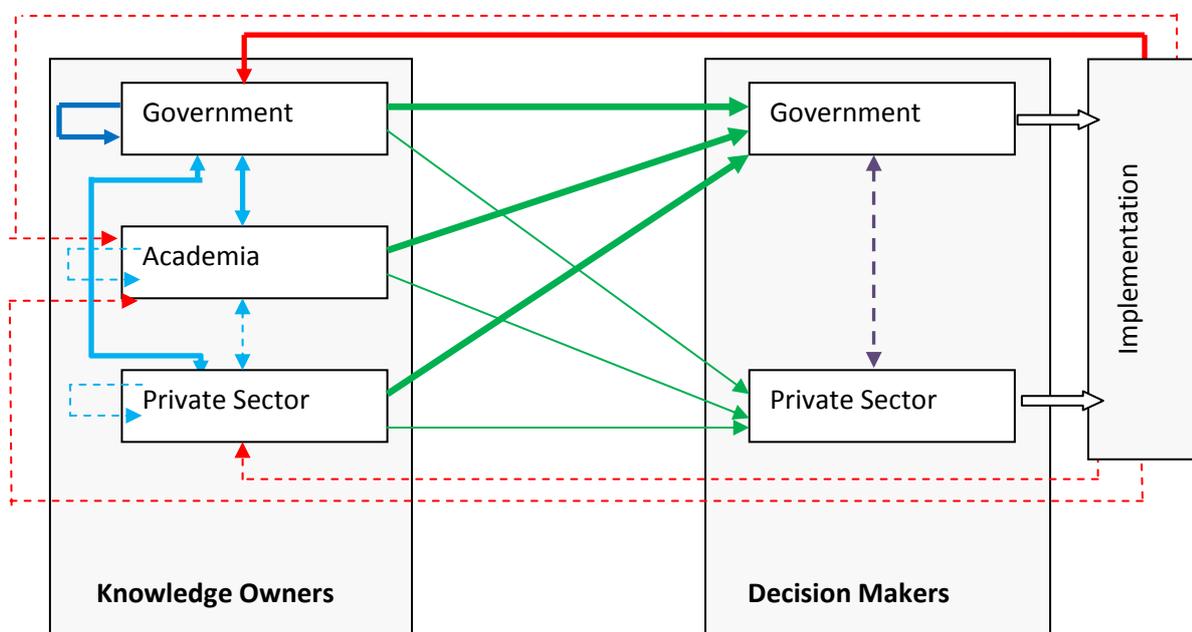


Figure 5. The NRM Knowledge Economy. (Arrows indicate information flows)

5.1 Key Stakeholders

There are many stakeholders in the NRM knowledge Economy. To simplify the analysis of transactions, they are summarised into 3 groups: Government, academia and the private sector (Figure 6). There is considerable diversity within each of these groups.

⁸ The term “knowledge economy” was popularised by Drucker, P. (1969). *The Age of Discontinuity; Guidelines to Our Changing Society*. Harper and Row, New York.

5.1.1 Government

“Government” includes the following Victorian stakeholders:

- Victorian Government departments and agencies responsible for NRM policy development, regulation and research (including DSE, DPI, DPCD, EPA and Department of Business and Innovation);
- Victorian Department of Treasury and Finance and the Victorian Auditor General’s Office;
- Statutory authorities (including Catchment Management Authorities, Regional Coastal Boards, Gippsland Lakes Task Force, Water Authorities, Parks Victoria, Museum of Victoria, National Herbarium of Victoria, and Committees of Management);
- Local government authorities.

It also includes the Commonwealth government, including:

- Commonwealth government departments, agencies and statutory authorities that have interests in NRM (including the Bureau of Meteorology, Department of Sustainability, Environment, Water, Population and Communities and the Murray Darling Basin Authority); and
- The Australian National Audit Office, which reviews the efficiency of Commonwealth government spending.

5.1.2 Academia

Academia includes researchers, universities and research institutions (e.g. CSIRO).

5.1.3 Private Sector

The private sector includes:

- Landholders and farmers;
- Volunteers and community groups;
- NRM sector organisations;
- Industry;
- Consultants; and
- Traditional owner groups and other indigenous people.

5.2 Transactions

Figure 5 shows four major types of “transactions” (transfers of knowledge) in the NRM Knowledge Economy:

- Sharing of knowledge amongst knowledge owners (dark blue and light blue);
- Transfer of knowledge from knowledge owners to decision-makers (green);
- Sharing of knowledge amongst decision-makers (purple); and
- Learnings from the actions of decision-makers (red).

Solid lines on Figure 5 indicate those transactions that are considered to be most relevant to this Strategic Framework, namely:

- Government decision-making, using knowledge from all three groups of stakeholders (green/bold);

- Private sector/individuals decision-making, using knowledge from all three providers (**green/fine**);
- The sharing of knowledge within Government, including amongst Government, agencies and statutory authorities (**dark blue-bold**);
- The sharing of knowledge between Government and other providers, with an emphasis on Government sharing with all agencies, academics and private sector/individuals (light blue – bold); and
- Government learning from the actions of Government decision-makers (**red – bold**).

5.3 Supply and Demand

To continue the analogy of the knowledge economy, the knowledge owners can be characterised as the “supply side” of the economy, whilst the decision makers characterise the “demand side”. Section 6 examines the “demand side” while Sections 7 – 10 discuss the “supply side” of the Victorian NRM knowledge economy. In particular, Section 7 discusses the management and use of existing knowledge held by Government and government authorities. Section 8 discusses issues arising from the role of Government in generating new knowledge through monitoring and evaluation, and research and development. Section 9 discusses the sharing of knowledge between Government and other parties. Section 10 examines the conversion of information to knowledge for decision-making.

6 Knowledge and Decisions

Given that decisions are the “end point” of knowledge management, a logical starting point for evaluating knowledge management is to examine the use of knowledge in the decision-making process.

A decision-based approach may appear to be more relevant to government, which is required to be fully accountable for decisions, than to the private sector. However, there is some scope to work around this, for example, by using simulated “typical” private sector queries to test knowledge management systems.

6.1 Scale

NRM decisions are made at a variety of scales. From the viewpoint of the Victorian Government, three important scales can be identified:

- Property-scale;
- Subregional⁹ to Regional scale; and
- State-wide.

6.1.1 Property-scale

Decision-makers at the property scale include:

- Landholders working on their own properties;
- Land managers (e.g. Committees of Management);
- Traditional Owners and other indigenous groups; and
- Site-based operators (e.g. CMA works at a site on a river, EPA investigating a site-specific incident, DPI farm services, PV on-ground management works).

6.1.2 Subregional to Regional scale

Decision-makers at the subregional to regional scale include:

- Landcare groups and networks;
- CMAs (e.g. regional and subregional strategies and projects);
- Regional Coastal Boards (e.g. Coastal Action Plans);
- Parks Victoria;
- Government agencies operating at subregional to regional scales.

6.1.3 State-wide

Decision-making at the state-wide scale is primarily the domain of state government policy-makers (e.g. DSE, DPI and DPCD) and regulators (e.g. EPA).

⁹ Including sub-catchment to catchment scale.

6.2 Gap Analysis

“Gap analysis” can be used at any of the scales outlined above to compare the knowledge used in the decision-making process with the knowledge required to make a good decision (Figure 6).

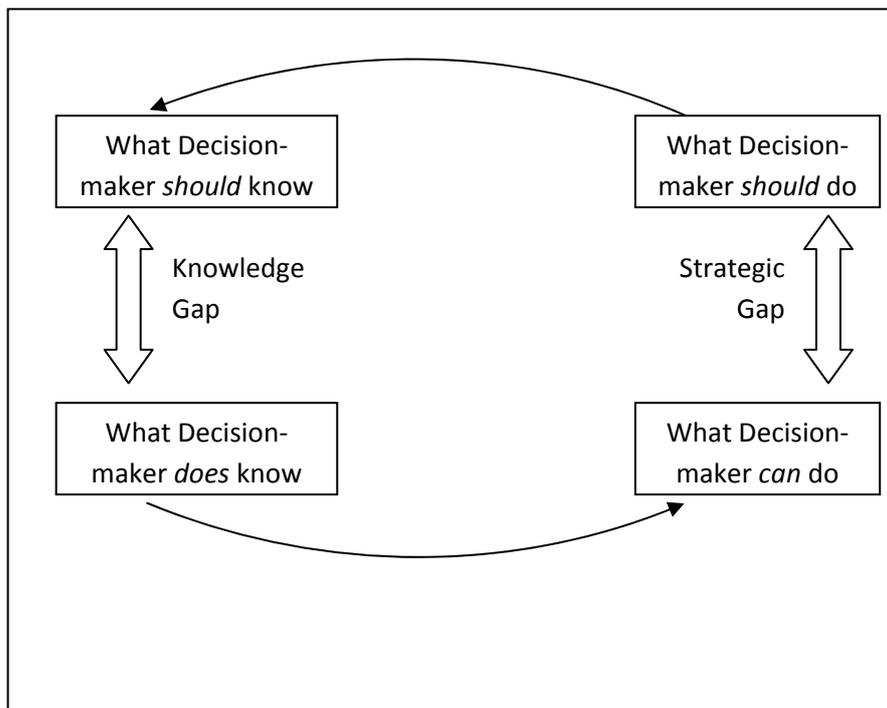


Figure 6. Gap analysis of knowledge management in relation to decision-making¹⁰

Many NRM decisions fall into one of two broad groups:

- Decisions that are intended to improve ecological condition or function in some way; and
- Decisions that permit or limit the degradation of ecological condition or function.

For both of these types of decisions, it is necessary to predict for specific circumstances the consequences of taking the intended action vs. doing nothing. Decisions may be made with adequate knowledge, or with minimal knowledge, outdated knowledge, or wrong knowledge.

“Standards of evidence” provide a basis for determining the adequacy of knowledge in regard to decision-making. These standards may be specific or general, e.g. “best available information” or “best available science”.

¹⁰ After Zack 1999, Figure 3.

Evaluation of knowledge management based on assessment of the NRM decision-making process using a “gap analysis” approach has several limitations:

- The knowledge gap can be widened or narrowed by raising or lowering the standards of evidence required to support decision-making. (It may be appropriate to vary the standards of evidence depending on the level of risk or the consequences of being wrong).
- The standards of evidence are not necessarily clearly defined.
- The standards of evidence may require an understanding of the extent and quality of knowledge that is available (e.g. “best available information”).

Hence, a robust evaluation of NRM knowledge management also requires consideration of the knowledge management system, as discussed in Sections 7 – 10.

6.3 Evidence-based Decision-Making Culture

The extent to which knowledge is incorporated into the decision-making process is influenced by the organisational culture as well as formal standards. In NRM, which is a broad, diverse and rapidly-developing field, and where few formal standards exist (e.g. compared to engineering), cultural norms are of high significance.

7 Existing Government Knowledge

Whilst achievement of the White Paper vision requires improvements in an NRM Knowledge Economy that extends beyond Government, Government has much greater control over its own internal knowledge management systems than those external to it. This section discusses existing knowledge, and establishes principles for housing and retaining knowledge (Section 7.1), finding knowledge (Section 7.2), sharing knowledge within organisations (Section 7.3) and sharing knowledge between organisations (Section 7.4). Section 8 discusses new knowledge. A key element for success in all of these areas is strong organisational commitment so that success or failure is not dependent on an individual or small group of staff members.

Knowledge relevant to NRM is held by the Victorian government, statutory authorities and local government authorities, as well as by the Commonwealth Government (as outlined previously in Section 5.1.1). Sections 7.1 to 7.3 are directed primarily to the Victorian government and Victorian authorities, although the general principles it establishes have broader relevance. Section 7.4 discusses information sharing between government organisations, including within Victoria and between Victoria and the Commonwealth.

7.1 Housing and Retaining Knowledge

Formal and tacit knowledge require very different approaches to knowledge retention.

7.1.1 Formal Knowledge

All existing NRM data and information should be stored in an accessible form in a safe location, with an identified single point-of-truth and appropriate backups.

- This is cost-effective, as it is much cheaper to use existing knowledge than generate new knowledge.
- Duplication of data or information is a waste of resources.
- Historical data is irreplaceable, particularly in situations where there has been significant change.
- Information about data collection methodologies and quality constraints needs to be available in conjunction with the data.

Any prioritisation of knowledge for retention should consider current and future priorities. If based on current priorities only, there is a risk that knowledge relevant to future priorities will be lost. However, even if current and future priorities are considered, there is a significant risk that future priorities will not be foreseen, particularly in the long-term (e.g. the major shift in water management from an engineering paradigm to an ecological paradigm). Hence, whilst prioritisation of knowledge may be necessary in the short term to enable staged establishment of effective archival systems, in the longer-term all existing NRM knowledge, information and data should be retained.

7.1.2 Tacit knowledge

A significant current challenge is to identify, capture and preserve the existing tacit knowledge of individuals and groups, despite staff churn and organisational change. This is important, as much NRM knowledge is tacit rather than formal. There have been sporadic attempts to capture such knowledge, but these have failed, usually due to the burn-out or moving on of a committed staff member, without adequate handover.

Options for retaining tacit knowledge may include the following:

- Identifying and eliciting tacit knowledge;
- Increasing staff retention;
- Succession planning and management, including knowledge transfer;
- Training; and
- Systems and incentives to encourage staff to record and document their tacit knowledge.

Databases that provide support for “knowledge brokers” can also provide a means of capturing tacit information. An example is the system/interface for entering and retrieving property-specific information for DPI extension.

7.2 Finding Knowledge

To effectively use existing knowledge in decision-making, it is necessary for that knowledge to be found.

7.2.1 Formal Knowledge

Data, information and knowledge needs to be indexed so that it can be found. A good example of an in-house indexing and knowledge retrieval system within the Victorian government is the “Victorian Resources Online” website¹¹ hosted by DPI. This is widely used within Government and by external parties. Such a system enabling ready access and retrieval is to be commended and potentially expanded.

Because NRM is multidisciplinary, a variety of sources of data and information are relevant. Currently Victorian government NRM knowledge is stored across a variety of different systems.

It is neither desirable nor feasible at this point in time to establish a single database that contains all Victorian government NRM knowledge, information and data.

There are several reasons:

- Industry standards vary across the various disciplines that form part of NRM – e.g. for water data, Hydstra is the industry-standard data storage and

¹¹ <http://new.dpi.vic.gov.au/vro>

maintenance system, but this system is not set up for use across the entire NRM field.

- Many different systems have already become established across the various parts of the Victorian government with responsibilities for different aspects of NRM. Many of these systems work well and it would be a waste of time and effort to replace these with a single unified system simply for the purposes of streamlining.

To enable more efficient and effective knowledge retrieval, there would be considerable benefit in establishing an effective overarching system that enables a decision-maker to search for knowledge, data and information across all relevant databases. Such a system should be open and interoperable, and support the concept of Government 2.0. Recent advances in the area of eResearch are providing the foundations necessary to develop platforms for collaboration and knowledge sharing within and between knowledge domains. See for example the DPI and Victorian eResearch Strategic Initiative co-funded Ecoinformatics Climate Change Demonstrator ¹². The system could include “blocks” or modules of data which could be used multiple times across various databases, for a variety of outcomes.

Not all NRM knowledge is equally valid. Tools are required for helping to evaluate knowledge and determine the extent to which a particular piece of data / information / knowledge can be trusted. In some instances, such tools already exist – e.g. quality codes for hydrologic data in Hydstra.

Knowledge brokers, who are familiar with the NRM knowledge held across all Government systems, could play a role in enabling decision-makers to find all relevant government knowledge. They could also play a role in filtering knowledge and determining reliability.

VCMC undertook a project called the Catchment Knowledge Exchange, in which a knowledge broker for the area of soil health was established for a trial period of one year. Monitoring and evaluation of the trial led to the conclusion that brokers are the critical human connection between people and knowledge, with the dedicated job of keeping networks or communities of interest alive and active¹³.

7.2.2 Tacit knowledge

A variety of approaches, ranging from informal to formal, can be used to find tacit knowledge, including:

¹²<https://www.versi.edu.au/VeRSI%20Projects/Ecoinformatics%20Climate%20Change%20Demonstrator>

¹³ Catchment Condition Report 2007, p59.

- Internal directories listing staff/group expertise;
- knowledge brokers; and
- informal networks.

New online collaboration tools, such as social networks (e.g. Facebook and Twitter), may assist by fostering such interactions. The recent advances in data clouds and interoperable data schemas are providing new ways to manage and share data and information.

7.3 Sharing Within Government Organisations

Knowledge sharing within Government organisations needs to work in conjunction with established and appropriate information security measures. These information security protocols need to ensure that while knowledge that is in the process of being created may require some level of protection to ensure appropriate confidentiality, professionalism and reputation, the supply/demand aspects of knowledge sharing are encouraged and enabled.

Systems that enable staff to efficiently find and access knowledge held by their organisation, as discussed in Section 7.2, will contribute to improved NRM information sharing within Government organisations. Other measures relevant to information sharing may include:

- Training – as a means of knowledge sharing
- Technological tools that promote knowledge sharing – such as the development of internal “wikis”.

An important limitation on knowledge sharing is that many individuals and groups within Government organisations currently perceive that they will derive greater benefits from hoarding knowledge than from sharing it. This is an important barrier to the effective flow of knowledge into decision-making processes.

To address this issue, it is necessary to take measures that promote sharing rather than withholding of knowledge by people and groups within government organisations. This can be difficult to achieve because of hoarding and competition.

Appropriate measures may include:

- Change the organisational culture –from a culture of knowledge hoarding to a culture of knowledge sharing;
- Personal incentives for knowledge sharing;
- Provision of time and resources for knowledge sharing;
- Inclusion of knowledge sharing in organisational and individual performance plans and evaluation; and
- Establishment of knowledge management systems that promote and facilitate knowledge sharing (including, for example, knowledge brokers, databases, intranets and email groups as appropriate).

7.4 Sharing Between Government Organisations

Barriers to knowledge sharing between government organisations currently exist. Efforts should be made to eliminate or minimise these barriers to enable effective “whole of government” action in NRM.

8 Generating Government Knowledge

This section discusses monitoring and evaluation (Section 8.1) and research and development (Section 8.2).

8.1 Monitoring and Evaluation

Monitoring and evaluation are integral to the adaptive management cycle

Monitoring and evaluation are integral to the adaptive management cycle advocated by the White Paper. Good project management requires a cycle of planning, policy, investment and delivery, monitoring and reporting, evaluation, research and development and continuous improvement.

“Headline indicators” are identified in the White Paper as providing a focus for NRM monitoring and evaluation. Environmental accounting is developing as an alternative approach to synthesising NRM information¹⁴. Sections 8.1.1 to 8.1.3 discuss matters relating to formal monitoring programs. Section 8.1.4 discusses “complementary” monitoring.

VCMC has a special interest in improved, long-term monitoring and evaluation across the State because of our role in delivering periodic catchment condition reports.

8.1.1 Monitoring Program Design

Monitoring program design is crucial to the success or failure of a monitoring program. There is extensive information in the scientific literature regarding monitoring program design. This Strategic Framework does not set out to address this issue comprehensively. However, some key factors that need to be considered in relation to the monitoring requirements established in the White Paper (see Section 3.3) are set out here.

A critical step in monitoring program design is the definition of the question(s) to be addressed. Questions need to be well-framed in order to provide a sound basis for program design.

All monitoring programs need to be underpinned by a sound understanding of the variable(s) of interest, including:

- Scale (e.g. site specific vs. landscape-scale), including extrapolation issues (e.g. use of site-scale observations to assess reach-scale condition);
- Natural spatial variability;
- Timeframe (short-, medium- or long-term monitoring);

¹⁴ Key examples include the Wentworth Group’s “Accounting for the Future” and recent work on environmental accounting being undertaken by the Victorian Department of Treasury and Finance in conjunction with the Australian Bureau of Statistics.

- Natural temporal variability (e.g. seasonal, inter-annual or inter-decadal variability);
- Indicator sensitivity – can the indicator be expected to show meaningful change over the monitoring period in response to management intervention and/or environmental change?

Rigorous methodologies should be employed in quantitative and qualitative data collection. For complex variables, quantitative measurements may not be feasible and a qualitative approach may need to be used. Observational data can be well structured and provide strong and robust information when undertaken by suitably qualified and trained staff. For quantitative data collection, objective measurements are preferable to subjective estimates (for example, LiDAR surveys vs. estimated channel dimensions).

For monitoring programs that are intended to evaluate the performance of government (e.g. impacts of management intervention), further issues need to be considered including:

- A conceptual understanding of the expected response to management intervention, to generate hypotheses for testing;
- Scientific design – e.g. BACI or alternative approach;
- How the impact of “noise” (e.g. natural temporal variability and other confounding factors) will be accounted for;
- Scale in relation to management intervention – e.g. can localised management effort (e.g. 1% of catchment) be expected to alter resource condition at the landscape scale?
- Indicator sensitivity in relation to the scale of management intervention – e.g. can a 1% increase in flow be expected to alter stream condition on a 5-point scale?

8.1.2 Data Collection

Data collection should follow best practice to ensure that useful and reproducible data are collected. Key considerations include the following:

- Clearly defined data collection protocols and processes should be well documented and consistently applied for each indicator;
- People collecting data should have appropriate expertise – this is particularly important for qualitative indicators, which require expert judgement;
- Quality control measures.

8.1.3 Data Capture, Storage and Management

Processes for acquiring, storing and managing data need to be established that provide for:

- Timely capture of data;
- Inclusion of information regarding the data collection methodology as an integral part of the data set;

- Evaluation and recording of data reliability; and
- Retention of raw data to allow for future re-processing and re-analysis (e.g. for streamflow data, it is usual to preserve data on stage height and ratings as well as the streamflows derived from this information; for ISC assessment being made using LIDAR, the LIDAR data files should be preserved, not just the measurements made from them).
- In the case of indicators based on high-level data synthesis (e.g. headline indicators), providing the capacity to “drill down” into the underlying information and data.

8.1.4 Complementary Monitoring

“Complementary” monitoring consists of community monitoring and informal monitoring that fills gaps left by formal monitoring programs, including spatial and temporal gaps as well as gaps in the variables covered. It includes:

- Formal community data collection programs(e.g. Waterwatch);
- Informal monitoring, including photographic records and anecdotal reports of change.

Complementary monitoring is important for providing early warning of threats or trends, particularly in regard to issues and/or in areas where formal monitoring programs do not exist. Important threats or trends, once identified, should prompt rigorous investigation of issues/factors/impacts that may not have initially been envisaged in monitoring program design.

8.2 Research and Development

The White Paper emphasises the need for a strategic approach to Government investment in research and development.

There are other White Paper Actions that deal specifically with research and development (i.e. Actions 3.4.7 and 3.4.8) so this topic is not further investigated in this paper.

9 Government – Sharing with Others

Knowledge sharing between government and external parties (i.e. academia and the private sector) includes the provision of government knowledge to others and the use of knowledge of others by Government, as discussed in Section 5 (NRM Knowledge Economy).

Community engagement is important for developing well-informed NRM decision making by the Government and the private-sector (Section 9.1).

Published information in scientific books and journals provides an additional resource of NRM knowledge (Section 9.2).

“Contractual” issues in knowledge sharing are discussed in Section 9.3.

9.1 Community Engagement

Community engagement is important for developing well-informed NRM decision making by the Government and by the private-sector.

This is a huge topic in itself and is outside the scope of this paper.

9.2 Published Information

Published information provides a significant knowledge resource for NRM decision-makers

Third –party publications such as scientific books and journals contain information relevant to NRM in Victoria. They are indexed in widely-available bibliographic databases such as Scopus.

9.3 “Contractual” Issues

“Contractual” barriers need to be addressed to expedite greater knowledge sharing

A number of specific “contractual” issues arise in knowledge sharing between external parties, including:

- Intellectual property (Section 9.2.1);
- Moral rights (Section 9.2.2);
- Data quality and suitability for purpose (Section 9.2.3); and
- Cost recovery (Section 9.2.4).

These concerns should be addressed in data use agreements, which may be formal or informal, depending on circumstances.

9.3.1 Intellectual Property

Sharing of knowledge between external parties raises questions regarding intellectual property rights. Unpublished knowledge is particularly sensitive. Published knowledge is already in the public domain; however, the underlying data and

information may not necessarily be publicly available and sharing of such information may also be sensitive. Intellectual property issues should be clarified prior to sharing information between external parties. Where public data and knowledge are generated using public monies, they should be freely available and accessible to any user.

9.3.2 Moral Rights

The moral rights of an author include¹⁵:

- the right of attribution of authorship;
- the right against false attribution; and
- the right of integrity of authorship (i.e. the right to object to any material alteration or distortion of their work that is prejudicial to their reputation).

Application of these principles to knowledge sharing would contribute to fostering confidence amongst parties.

9.3.3 Data Quality and Suitability for Purpose

Sharing of data between external parties raises questions of potential liability if problems with the data lead to a poor decision being made. For example, third parties often use data for a different purpose than that for which it was intended, and it may not necessarily be fit for purpose in regard to its new use. A significant barrier to data sharing could be removed by agreeing to waive liability.

9.3.4 Cost Recovery

Significant costs may be incurred to collect data and produce knowledge. No-one has the right to demand that knowledge or data be provided to them at no cost by a third party, simply on the grounds that the knowledge already exists.

In any knowledge sharing transaction between external parties, costs and benefits for each party should be considered and an agreement made that meets the needs of both parties. For example, Government may choose to provide knowledge and information at no cost to the public to enable people such as landholders and farmers to make better NRM decisions, which would provide intangible benefits to the Government in terms of progress towards the White Paper vision. However, a researcher who has undertaken a self-funded project (e.g. a curiosity-driven post-graduate research project) has no vested interest in providing the data or knowledge to a third party at no cost.

In the case of Government-sponsored research projects, the provision of funding provides the Government with rights regarding access to the data and knowledge generated by the project. The funding agreement would normally clarify such rights in this instance.

¹⁵ Part IX of the *Copyright Act 1968 (Cth)*.

10 Converting Information to Knowledge for Decision-making

There will be no value in a knowledge management system that is not used

The following two examples illustrate the need for a human interface in knowledge management:

- Example 1 – A landholder accessing Victorian government vegetation mapping data (e.g. EVC mapping) finds that the scale is too coarse. The services of an Extension Officer or Consultant are required to translate the vegetation mapping data to the property scale.
- Example 2 – Patchy data-sets leading to the problem of seeing the “Big Picture” at a regional level or state level (e.g. for policy development and review). Some of these problems can be addressed (e.g. by consistent and long-term state-wide monitoring). However, human expertise in compiling and interpreting data is often required.

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