



**Thematic week:** Water for Life

**Subject matter:** Ecosystem approaches to health and water-resource management

**Paper title:** *Water for life, health and sustainability: An ecosystem approach to reintegrate water resource management with the determinants of health.*

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**Abstract:**

The relationship between water resource management and the ‘upstream’ determinants of health is emerging as a new portfolio of research, policy and practice. This development is informed by growing attention to ecosystem management in the context of catchments (also known as watersheds or river basins) and the potential ‘win-win’ of integrated strategies that improve both health and sustainability within these settings. Sustainable and equitable watershed management can be seen as an upstream driver of the determinants of health – with influences ranging from livelihoods and poverty, to cultural values, food security and lifestyles, as well provision of basic water services and infrastructure. Drawing on an integrated framework and the key concepts of ‘living systems’, ‘livelihoods’, and ‘linkages’ between ecosystems and equity, this paper examines integrated catchment management as the basis for an ecosystem approach that promotes water for life, health and sustainability. These concepts will be examined in the context of a community catchment health project in New Zealand, with cross-reference to initiatives in Hawai’i, Ecuador, Canada and the Philippines. Implications will be discussed in relation to capacity building for governance, research and education that values catchment management as a collaborative, cross-sectoral initiative with interrelated benefits for health, ecosystems and society.

**Key-words:** determinants of health, water resource management, catchment, ecosystems, equity, governance

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## **1. Introduction**

The complex water challenges of the 21<sup>st</sup> century are demanding new and invigorated attention to the converging and overlapping agendas of health and wellbeing, ecosystem sustainability and water resource management. Until recently, health impacts of ecosystem change have tended to be conceived as the result of direct environmental hazards through microbial and chemical contamination of air, soil, water, and food. Yet attention to the widespread health implications of climate change and emerging infectious disease has fuelled recognition of the supporting, provisioning, regulating and cultural role of ecosystems that affect health directly and indirectly (Corvalan *et al.* 2000). The fact that ecologically sustainable development has important implications for the ‘upstream’ determinants of health and well-being is demanding reinvigorated attention to cross-disciplinary, intersectoral and multi-stakeholder governance strategies that harness the common ground between public health, ecosystem management and sustainable development (PHAC 2007, Brown 2007a, von Schirnding 2002, WHO 1997).

While awareness of the socio-ecological context for human health stems from the Ottawa Charter and earlier (Butler 2006, WHO 1986), the critical insight that ecosystem management and human health objectives are fundamentally interwoven was established almost irrefutably by outcomes of the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment Board 2005). Catchments (also known as watersheds or river basins) are a practical geographical unit for the analysis of human activities that affect water and the overlapping socioeconomic and health implications of ecosystem management (Falkenmark and Folke 2002). The relationship between integrated catchment management and the social determinants of health goes beyond the traditional focus of water management on drinking water supply, sanitation and contaminants. Catchments are also the basis for livelihoods, employment, food and service provision, and culture; not only affecting the causes of health inequalities (Marmot 2007) but also providing a setting for intersectoral action to improve health.

Attention to the ‘determinants of health’ has a long history for the fields of population and public health (Evans *et al.* 1994), and has focused attention on health inequities in relation to social gradient, stress, early life, social exclusion, work, unemployment, social support, addiction, food and transport (Wilkinson and Marmot 2003). Of particular importance to this discussion is increased recognition of the links between ecosystem change, social inequities and health that is emerging – fuelled in part by the extensive work of the World Health Organisation’s “Commission on the Social Determinants of Health” (Marmot 2005). In a move to shift attention to the causes of the causes of health inequities Sir Michael Marmot notes that “*Addressing the intersection between social determinants of environmental change and the effect of environmental change on health inequities will benefit sustainable ecological and population health alike.*” (Marmot 2007 p.1156)

The aim of this paper is to examine the interrelationships between water resource management and the determinants of health, focusing on the role of integrated catchment management<sup>1</sup> as a policy and governance process to promote both health and sustainability – through an integrated understanding of “water for life”. The paper will address this aim in three sections. Firstly, an integrated framework is presented to examine different dimensions of “water for life”, including the overlapping objectives of health and sustainability. The framework focuses attention on key concepts of ‘living systems’; ‘livelihoods’ and ‘linkages’ (between ecosystems and equity), and highlights different but complementary views on the relationship between water and health.

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<sup>1</sup> The cross-cutting relevance of catchments as a scale at which to focus ecosystem management is reflected by its use in different languages along with different terminology including: Integrated Catchment Management (ICM) in Australia, New Zealand and parts of Europe; River Basin Management (RBM), in other parts of Europe and Latin America (e.g. Manejo de Cuenca Hidrografica) (Dourojeanni, 2001) and Integrated Watershed Management (IWM) in North America (USEPA, 2005). Each of these approaches exemplifies a specific ecosystem-based approach to Integrated Water Resource Management (IWRM) as per the Global Water Partnership - GWP, 2000.

Secondly, these concepts will be examined in the specific context of a catchment and community health project in New Zealand, noting where similar initiatives have been applied in contexts as varied as Hawai'i, Ecuador, Canada and the Philippines. The third section draws together implications for a portfolio of policy, governance, education and research with a focus on catchment management as a tangible setting to shift the notion of “water for life” into a practical strategy to improve the determinants of health and sustainability.

## **2. Concepts: Living Systems, Livelihoods and Linkages for Health and Sustainability**

The Prism of Health and Sustainability was developed as a heuristic conceptual framework to inform understanding of the relationships between health and sustainability (Parkes *et al.* 2004, Parkes *et al.* 2003). The framework was designed in the context of a catchment and community health project (Parkes 2003) and has particular application in examining different views on the interrelationships between catchment management and the determinants of health (see **Figure 1**).

This section builds on the Prism Framework as a point of reference to differentiate the processes by which catchment management influences the ecological sustainability and social determinants of health. The three-dimensional framework depicts four ‘**views**’ from which to understand the links between water resource management and the determinants of health. These different perspectives are often viewed in isolation but together provide a more integrated understanding of the cross-sectoral potential to promote both health and sustainability in catchment-settings. The Prism Framework also focuses attention on the key concepts of ‘living systems’, ‘livelihoods’, and ‘linkages’ between ecosystem and equity. These concepts are explored as entry points to understanding the relationships between water resource management and the determinants of health. The summary in **Table 1** draws on ideas that are developed in more detail elsewhere (Parkes and Horwitz forthcoming, Parkes *et al.* 2008)

### ***Water, Living systems & Health: Freshwater ecosystems beyond hazard exposure and resource extraction***

Our views on environmental health have predominantly focused on ecosystem disruption as a source of microbial and chemical contamination of air, soil, water. Similar thinking is evident in traditional resource management where water has tended to be seen as a resource to exploit, develop and harness. Together this has fostered a static notion of the water as available for extraction, and as a potential source of hazards. While convenient as a basis for technocratic approaches to hazard and risk assessment and infrastructure development, this notion fails to recognize systemic understanding of water as an integral component of dynamic living-systems of which humans are dependant for life and survival, evocatively described by Falkenmark and Folke as the “*the bloodstream of both the anthropogenic world and the non-human world*” (2002).

Although the interdependence of health, ecosystems and society has been evident in traditional and indigenous cultures for millennia (Stephens *et al.* 2007, Berkes *et al.* 2000), the (re)discovery and (re)engagement of the fundamental links between ecosystem management and human health objectives was established almost irrefutably by outcomes of the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment Board 2005). This comprehensive assessment drew on over 1360 experts to provide important insights into the consequences of ecosystem change for human health and well-being noting that the motivation to protect and conserve ecosystems extends far beyond the prevention of potential hazards to a focus on the provisioning, supporting, regulating and cultural roles. In the specific context of water resources, the findings of the Millennium Ecosystem Assessment reinforced the need to identify appropriate, ecosystem-based scales at which to examine the relationships between watershed management and the determinants of health – adding new weight to a growing portfolio of interest in this theme internationally (Parkes and Panelli 2001, Wagner *et al.* 2002, Falkenmark and Folke 2002, de Groot 2001, Parkes *et al.* 2004).

Water catchments (also known as watersheds or river basins) are a practical geographical unit for the analysis of the links between health, ecosystems and society. Recognition of catchments as a scale at which to focus ecosystem management has led to the field of integrated catchment management (ICM). Falkenmark and Folke (2002) describe the fundamental relevance of catchments as follows “*Water’s flow in the landscape makes the catchment i.e. the area inside a water divide, a useful spatial unit in which ... management also involves the linking of upstream and downstream activities in the catchment*”

The relevance of this scale of water resource and ecosystem management is re-iterated by the applicability across contexts and terminology - integrated catchment management is also known as integrated river basin management (Dourojeanni 2001), and integrated watershed management (USEPA 2006.). The intention here is not to recapitulate the case for these integrated approaches to water resource management but rather to highlight the way a catchment-based view of ecosystem management offers a more nuanced and complex view of water-health relationships that extends well beyond a focus on water-based environmental hazards and water-related disease. Looking ‘upstream’ to the catchment scale shifts attention from specific incidents of water contamination or wastage, to the driving forces of government, development and power that are causing freshwater ecosystem change (see **Figure 1**) and of the interconnections and interrelationships of a living systems across and between ecosystem and social scales. Ecosystem-based catchment management shifts from a view of water as a ‘medium’ whose quality or quantity is harnessed (usually through infrastructure of water supply and sanitation) to water as the basis for life, and catchments as living systems whose structure and function are essential to protect from hazards and also to promote safe and healthy environments. From the point of view of public health, integrated catchment management creates the potential for policy and governance that protects and promotes water quality and quantity as a resource for multiple species, and as a practical mechanism to promote health and sustainability.

### ***Water, Livelihoods and Health: Understanding the role of water in social and health inequities***

Understanding the practical and policy implications of “water for life” requires an understanding of water resources as a fundamental basis for sustainable livelihoods, and – from a health point of view - intimately linked with the social determinants of health. Just as studies of health tend to focus on disease and illness (or a ‘loss’ of health), inter-relationships between water resource management and the social processes influencing health are most dramatically presented through a focus on the deficits associated with a ‘loss’ of access to, or availability of water. Here the focus is not on the ‘direct’ health implications arising from lack of access to safe water and sanitation, since this critical issue is the focus of extensive work elsewhere (Prüss-Üstün and Corvalan 2005, Prüss *et al.* 2002). Rather, the focus here is upstream to the “causes of the causes”, with particular focus on the relationships between water resources, livelihoods and poverty and the links with social determinants of health.

Recognition of the links between water resources and sustainable livelihoods has arisen, in particular, in the context of large-scale changes to freshwater ecosystems in contexts such as dams and drought. The report of the World Commission on Dams enhanced this understanding through analysis of the socio-economic impacts of dam development; the displacement of people and livelihoods and implications for indigenous peoples, downstream livelihoods, gender, cultural heritage, human health and equity (World Commission on Dams 2000). By acknowledging that “*the issue of equity – in terms of pre-existing nutritional and health conditions of the population and the capacity to resist new health problems – is at the root of the adverse health impacts of dams*”, the World Commission on Dams makes important links between the ‘sustainable development’ view and the ‘society & health’ view of the Prism for Health and sustainability. The inequitable impacts of dams on livelihoods, shelter, culture and gender, is a reminder of the many ways in which water-resource management influences the ‘causes of the causes’ of health

inequalities, well beyond the direct impacts of hazardous exposures and water-related disease arising from ecosystem disruption.

The short and long-term impacts of drought also offer valuable insights into the relationships between water resource management and the social determinants of health. In a relatively detailed review of the health consequences of drought in the Canadian Prairies, Smoyer-Tovic and colleagues (2004) make a useful elaboration of the macro and micro factors that both cause drought, and identify direct and indirect effects on health ranging from waterborne disease, respiratory effects from fire and dust, and mental health issues. Yet what is largely missing from this analysis are the longer-term, indirect effects on the social determinants of health. Drought demonstrates the concerning domino effect of a lack of water resources, leading to loss of yield (crops, livestock or virtually any agricultural product), loss of food production, loss of jobs, loss of lifestyles and cultural values, as well as complex challenges to local, regional and global economies. Smoyer-Tovic *et al* do highlight the important – but largely overlooked – impacts of drought on mental health in rural and agricultural communities, and the fact that family and small-scale landholders are especially vulnerable. Yet considered in the light of the determinants of health inequalities (Evans *et al.* 1994, Marmot 2005, Chief Public Health Officer 2008), drought can be seen to have far-reaching implications through impact on income; employment and working conditions; food security; environment and housing. The socioeconomic impact on communities (especially small, remote and rural communities) can also have powerful long-term effects on other determinants of health inequalities such as early childhood development; education and literacy; social support and connectedness; health behaviours; and access to health care.

The examples of dams and drought exemplify potential health impacts of water deficits, showing the range of ‘downstream’ implications for the determinants of health when access to or availability of water is compromised. For the purposes of this discussion, an alternative view is possible when we view sustainable water resource management - including decisions regarding major infrastructure developments such as dams – as a strategic asset, enabling maintenance (or restoration) of ecosystem integrity, as well fostering sustainable livelihoods, equity and engagement. As summarized in **Table 1**, the implications of this approach is that that catchment management – if done well – has the potential to decrease poverty and related drivers of health inequities, and provide an ecosystem-based context within which to improve the social determinants of health. (Parkes and Horwitz forthcoming, Parkes *et al.* 2008)

### ***Linkages between ecosystems and equity: catchment management as a double dividend for health***

This section examines catchment management as an ecosystem approach to health with the potential to create “a double-dividend” for public health by fostering both ecosystem sustainability *and* social equity. Although the linkage between social and ecological dimensions of water management has long been recognised as a central tenant and challenge for IWRM, the ‘added-value’ of the current analysis is the potential to view catchment management as an ‘upstream’ strategy to improve the determinants of health. With **Figure 1** as a point of reference, this section focuses on catchment management as a tangible **linkage** between ecosystems and social systems, providing integration of the different views of sustainable development, ecosystems & health, society & health (**Figure 1**), and as a strategy to link ecosystems and social equity for health.

The links between ecosystems and social processes has been an important feature in the evolution of the field of integrated water resource management (IWRM). In their foundational document on the topic, the Global Water Partnerships notes that “*The challenge ahead for water resources management is to strike a balance between the use of the resources as a basis for the livelihood of the world’s increasing population and the protection and conservation of the resource to sustain its functions and characteristics*” (GWP 2000 , p.12). Linkage between freshwater ecosystems and social processes is also embedded within key documents outlining principles of water management.

This is especially evident in the four Dublin-Rio Principles which were consolidated in 1992 in conjunction with World Summit on Sustainable Development and have since provided the guiding principles underpinning IWRM (World Water Forum 2000) as follows (i) Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment; (ii) Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels; (iii) Women play a central part in the provision, management and safeguarding of water; and (iv) Water has an economic value in all its competing uses and should be recognized as an economic good.

Similar ideas have been echoed in the World Water Forum declaration on water security in a call “to recognize that access to safe and sufficient water and sanitation are basic human needs and are essential to health and well-being, and to empower people, especially women, through a participatory process of water management.” As the implications of these principles and challenges have rolled out there has been growing attention to the characteristics of the participatory and multi-stakeholder processes that are required for integrated catchment and watershed management (Moore and Koontz 2003, Duram and Brown 1999, Kolavalli and Kerr 2002) – and in particular the potential for these social processes to foster social capital, social cohesion, collaborative learning and engagement across and between stakeholders (Hinchcliffe *et al.* 1999, Pretty and Ward 2001, Mullen and Allison 1999).

The important message for those interested in health is the extent of convergence between priorities for (freshwater) ecosystem management and recognized strategies for promoting health and wellbeing. Catchment management appears, for example, to provide a specific ecosystem-based “setting” within which to enable most if not all of the five domains of health promotion action, that is to: build healthy public policy, to create supportive environments, to strengthen community action, to develop personal skills and to re-orient health services (with particular attention to the need for the health sector to “share power with other sectors, other disciplines and most importantly with people themselves”(WHO 1986). Furthermore, part of the growing understanding of social determinants of health is that recognition of the positive health effects enabled from processes that encourage social cohesion and engagement, and enhance different dimensions of social capital (Kawachi and Kennedy 1997, Kawachi 1999).

The concept of *linkage* highlights the potential of integrated catchment management as a collective process that can enable a double-dividend for public health by fostering both ecosystem sustainability (*living systems*) and social equity (including *livelihoods*). These ideas echo the Ottawa Charter’s call for a socioecological approach to health as well as the imperative of reciprocal maintenance – “to take care of each other, our communities and our natural environment” (WHO 1986). The concepts of social-ecological resilience and collective learning have emerged to inform ecosystem approaches to health, both in terms of *why* this kind of linkage is necessary for health and sustainability and *how* to translate this knowledge into actions to promote health and sustainability. These two concepts are briefly introduced here, prior to being examined in more detail in the context of specific case examples.

**Resilience** is a concept that reflects our understanding of ecosystems and social systems as complex adaptive systems and has made an important contribution to ecosystem approaches to health. Informed by complexity science, adaptive management and long-term studies of transformation in human and natural systems (see for example: Gunderson and Holling 2002, Kay *et al.* 1999) the notion of resilience describes the ability of a system to maintain structure and functioning despite changes to their internal and external environment. Such social–ecological systems have been noted to undergo rapid and surprising change, often running through a cycle in which they repeatedly build structure and then collapse, leading to release and reorganization in a manner that demonstrates the capacity for adaptation and innovation (and in the case of human systems, learning) (Parkes *et al.* 2008).

Practical application of the concept of resilience has been exemplified in the development of ecosystem approaches to health and sustainability (Waltner-Toews and Kay 2005, Waltner-Toews 2004, Waltner-Toews *et al.* 2004). In fact ‘resilience’ is increasingly recognized as an integrating concept that bridges health and sustainability concerns across scales from individuals, to communities and ecosystems – including applications spanning individual resilience in rural communities responding to drought, hailstorms and bushfire (Hegney *et al.* 2007), disaster preparedness and recovery (Masten and Obradović 2008) and agro-ecosystem health (Waltner-Toews and Wall 1997). The links between individual and collective (community/social-ecological) resilience in the context of watersheds across different scales is an important emerging research theme (Lebel, 2008; Masten and Obradović 2008; Hegney *et al.* 2007).

In the context of catchment management, promotion of health and resilience converge toward a common goal: to cultivate enduring capacity to respond positively to change and challenges (Parkes and Horwitz forthcoming). If resilience is seen as a goal of catchment management, collective learning represents an integral process to enable our capacity to adapt and respond positively to change and challenges characteristic of health and sustainability issues.

**Collective learning**, thinking and action provide new insights into dynamics of participatory and multistakeholder processes characterise integrated catchment management and arguably, any approach that seeks to link ecosystems and social equity to improve health. At its core, collective learning is based on the need for equitable processes that engage, respect and benefit from different knowledge cultures that inform our understanding of health and sustainability (Brown 2007b, Brown 2007a). The overview in **Table 2** highlights the overlaps between typologies that have emerged in order to encourage socially responsible, equitable and ecosystemic approaches to health and sustainability (Parkes *et al.* 2005, Woollard 2006). The results and benefits of collective learning have, in many ways, been underpinned the emergence of strategies that seek to harness overlapping objectives between sustainable ecosystem management, social equity, promotion of health and prevention of disease – in particular those that have emerged under the banner of ecosystem approaches to health (Waltner-Toews 2004, Lebel 2003, Forget and Lebel 2001). A focus on collective learning among knowledge cultures offers new insights into transdisciplinarity, participation and equity - which have collectively been described as the ‘three pillars’ of ecosystem approaches to health (**Table 2**).

While it is beyond the scope of this paper to recapitulate the many ways in which collective learning can inform the emerging field of ecosystem approaches to health, the important message here is the emphasis on systemic change from hierarchical to synergistic relationships, and from competing interests to collaborative approaches to address the pressing challenges of health and sustainability. These themes are explored further in the following case example of collective learning and an ecosystem approach to health in the Taieri River Catchment of New Zealand.

### **3. Context: Collective learning and resilience in Catchment & Community health projects**

Rural and agriculturally dependant communities – where the sustainability of a water resource is a fundamental requirement for the viability of agricultural livelihoods and communities – are particularly sensitive to the links between freshwater ecosystems and the social determinants of health. Conversely, they also serve to benefit from integrated approaches to promoting *both* health and ecosystem sustainability. An example of the interplay between these multiple objectives is provided by the evolution of multi-stakeholder catchment-based initiatives in the Taieri River catchment of Otago, New Zealand.

#### ***Interwoven priorities: Living systems, Livelihoods & Lifestyles***

The Taieri River is the third longest in New Zealand, draining a catchment area of 5650 km<sup>2</sup> and hosting a population of approximately 18 000 people. It is a notably low volume river reflecting origins in the dry range and basin landscapes of Central Otago in the south-east of New Zealand

and a winding path through three intermontane floodplains. The waterways, fertile alluvial plains, coastal lakes and estuarine flats were an important source of food for Māori in pre-European times (Tipa 1999). In the past 150 years these same ecosystem characteristics provided for rapid development of farming (including dairy, cattle, sheep, deer farming, cropping, and market gardening) and forestry. The Taieri River provides for irrigation, hydroelectricity, mining, recreational uses as well as surface and groundwater contributions to the drinking water supply for the municipality of Dunedin – a city of 100 000 which overlaps with but whose metropolitan hub lies outside the catchment area (Otago Regional Council, 1999). Intensification of agriculture, forestry and peri-urban development (especially in the coastal areas) have placed increasing demands on land and water resources in the Taieri, where diminishing water quality and extremes of water quantity (from drought in the dry uplands, to floods in the increasingly developed coastal plains) have been accompanied by concerns about impacts on the determinants of health (Otago Regional Council 2000, Otago Regional Council 1999).

Following a period of intensive research in the catchment - including long-term ecological studies and assessments of river health (TSRP 1994 -1999, Hamel 1998, Tipa 1999, Townsend *et al.* 2004, Townsend and Riley 1999) - attention turned to the public health implications of changes to the land and water resources in the catchment. Health concerns ranged from the direct health impacts associated with the water-related pathogens, to the indirect health impacts associated with catchment management, rural livelihoods and the social determinants of health.

#### ***From research to collective learning and alliance***

Building on these themes and concerns, the ‘Taieri Catchment & Community Health Project’ was launched in 2000 with aims to: better use existing information on ecosystems and health in the catchment; fill gaps in understanding about catchment and community health issues; and strengthen capacity for integrated, catchment-based approaches to water resource management and related public health issues. While details about this multi-method, participatory study are provided elsewhere (Corvalan *et al.* 2005, Parkes and Panelli 2001, Parkes *et al.* 2003, Parkes *et al.* 2008), the focus here is the study’s emphasis on facilitating collaboration and collective learning among and between different participants. This included an evolving relationship between community reference groups (residents living in different catchment communities) and co-researchers (agencies, researchers, and indigenous organizations involved with science and decision making regarding environment, health, development, and conservation issues in the catchment).

The initial motivation for community engagement in the Taieri project was community knowledge and awareness of the overlapping social, environmental and health benefits of the Taieri River. The level of interest in these issues was identified in a community survey (Parkes 2003) and re-enforced by voluntary participation of community reference groups of catchment residents who recognised the need for learning and exchange between upstream and downstream communities – and thus chose to convene a cross-catchment meeting. Subsequent evolution of the project demonstrates a range of features characteristic of collective learning and decision making (Brown 2007a). Using Browns typology of knowledges (**Table 2**), participation by community reference groups evolved from a cross-catchment community collaboration (mostly representing individual and community knowledge), to a Community-University Partnership in 2000 (linking community and specialist knowledge in particular), to formalisation of an externally funded multi-stakeholder catchment Trust in 2001 (known as the TAIERI Trust – or Taieri Alliance for Information Exchange and River Improvement) (Robinson 2005). By partnering with communities, researchers and local and regional councils, the TAIERI Trust created a process for ongoing learning and exchange between community, specialised and organisational knowledge. While the process was not always focused explicitly on health and wellbeing, the notion of integrated watershed (catchment) management as an investment to improve the determinants of health continued to feature explicitly and implicitly throughout the project as indicated by the ongoing emphasis on “Sustaining Our Lifestyles, Livelihoods and Living Systems” during a multi-stakeholder symposium held in the 4th year of the TAIERI Trust (TAIERI Trust 2004).



***Promoting resilience: An adaptive approach to catchment-based management of health and well-being***

After an unprecedented two rounds of funding from New Zealand's Sustainable Management Fund (2001-2004, and 2004-2006), external funding for the TAIERI Trust and their catchment coordinator came to a close. A notable development was that the TAIERI Trust coordinator becomes the youngest councilor ever elected onto the local Regional Council. In 2007 renewed attention to water quality and quantity (scarcity) issues in the dry-uplands of the Upper Taieri resulted in successful application to the Sustainable Farming Fund for "Effective Community Water Resource Management". This new iteration of a 'Catchment Management Group' is intended to "develop better relationships, improved monitoring, smoother Resource Management Act processes, fairer whole of community outcomes, improved environmental outcomes, and more efficient use of water"(Upper Taieri Water Management Steering Group 2007). In these more recent phases of the Taieri project we see evidence of enduring capacity to respond positively to change and challenges – demonstrating an adaptive and responses approach to viewing the catchment, and suggesting a healthy and resilient response to change and demands that occur at different scales at different times. Arguably the evolution and developments in the Taieri catchment demonstrate the benefits of a collective learning process with ongoing relevance to health and sustainability in this catchment.

Another important element of catchment and health interactions in the Taieri, is the complementary evolution of research and action initiated by the Indigenous people of New Zealand and contributing to understanding of co-management of freshwater resources (Tipa and Welch, 2006). Informed by work undertaken in the Taieri River Catchment, a 'Cultural Health Index for Streams and Waterways' has been developed to recognise and express the values of Maori (the Indigenous people's of New Zealand), as traditional stewards of natural resources and with knowledge that has broad relevance to community health and wellbeing, including participatory approaches to assessment and monitoring (Townsend et al. 2004, Tipa and Teirney 2003). This work was led by members of local iwi (tribes) who are active in research and policy, in partnership with the New Zealand Ministry for the Environment and university researchers, thus incorporating knowledge of indigenous elders, communities, specialized and organizational groups and providing a parallel but complementary contribution to the collective learning process described above.

**4. Implications and Conclusions: Building capacity to link Health, Ecosystems & Society within Catchments**

The previous sections have presented first principles for understanding the relationship between catchment management and the determinants of health, and exemplified these in the context of an ongoing and evolving project in the Taieri River Catchment in New Zealand. While is it beyond the scope of this paper to present other examples in depth, the themes and issues presented above have been found to be relevant in range of contexts including Hawai'i, Ecuador, Canada and the Philippines (**Table 3**). The examples in Table 3 are intended to demonstrate the variety of contexts and scales at which an ecosystem approach to water resource management and the 'upstream' determinants of health can be made. Important emerging themes include that:

- the setting for linking water resources and determinants of health does not always need to be a catchment or watershed - the examples of the community-based irrigation scheme in Ecuador is notable as a proxy for *upstream-downstream dynamics* in a largely anthropogenic context;
- inclusion of diverse knowledges is common across projects but -like the Taieri catchment example- the home-base for multi-stakeholder catchment-based initiatives tends to be initiated 'outside' of existing organizational structures. This creates results in context specific and *variable approaches to governance*;
- catchment-based initiatives demonstrate multiple objectives and multiple outcomes that span environmental, social and health impacts but the need for better *tools to assess and*

*evaluate* these outcomes in an integrated way is consistent across scales and time – i.e. is equally relevant to smaller scale projects in the Philippines as to a longstanding largescale projects in the Fraser River Basin in Canada;

- there is a common need for **capacity building** to equip researchers and professional to engage with the the c-cross-cutting and cross-sectoral approaches to health, ecosystem sustainability and social equity. This takes all involved outside their normal comfort zone.

Informed by a need to systemize these governance, research and education challenges indicated in **Table 3**, the Canadian-based ‘Network for Ecosystem Sustainability and Health’ ([www.nesh.ca](http://www.nesh.ca)) partnered with the International Institute for Sustainable Development ([www.iisd.ca](http://www.iisd.ca)) in 2007, with the explicit intent of advancing research and policy under the umbrella of ‘EcoHealth and Watersheds’. A first step in this initiative was the publication of a scoping document (Parkes *et al.* 2008) to provide a foundation for establishing a Community of Practice in EcoHealth and Watersheds, with particular in the interest for collective learning across and between projects. Of the key areas of recommendation from this initial process three overarching themes are highlighted here:

- **Governance:** A specific theme is what are the most appropriate and effective governance options for enabling adaptive, cross-sectoral, multi-stakeholder processes for health and sustainability. Key questions that are common for those working in population health will be especially important in the catchment context are: Can health funds be ‘diverted’ upstream? And/or “Can upstream activities ‘claim’ health benefit?”
- **Research:** A critical challenge to be able to systematically and appropriately learn from - and between - different examples of catchment management (or a proxy) evidently improving determinants of health & sustainability. An important related research question is deriving a framework or structure for comparing different cases. Practical frameworks for Ecohealth & Watersheds? Examples of strategies for this work will be posted on the websites for the Network for Ecosystem Sustainability and Health and the International Institute for Sustainable Development during 2008 and 2009.
- **Education, Training and Capacity Building:** A critical issue remains building capacity for a new generation of researchers, professionals, practitioners and educators who have the knowledge, attitudes and skills to engage in the innovative ‘boundary crossing’ work that is required to engage with issues that traverse health, ecosystems and society in the manner of catchment management. Initiatives and programs focused on meeting this challenge are starting to emerge, including the International Development Research Center’s Program Initiative in Ecosystem Approaches to Health ([www.idrc.ca/ecohealth](http://www.idrc.ca/ecohealth)); the emergence of the EcoHealth Journal, closely linked with the International Association for Ecology and Health ([www.ecohealth.net](http://www.ecohealth.net)) and, in the Canadian Context a newly formed Canadian Community of Practice in Ecosystem Approaches to Health ([www.copeh-canada.org](http://www.copeh-canada.org)).

The concepts and examples in this paper have provided an introduction to a growing portfolio of ecosystem approaches to linking water resource management and the determinants of health. A key finding is that integrated catchment-based management involves multiple stakeholders in a process focused on equitable and sustainable management of resources (including freshwater ecosystem services) that are the basis for viable livelihoods, communities and economies as well as being critical for the non-human natural world. A positive ‘spin-off’ is that catchment management is reliant on the same social processes required to improve social determinants of health. Thus catchment management – if done well – has the potential to reduce water-related ‘hazards’; reduce inequities; to prioritise sustainable livelihoods as part of water resource management, and to enhance social-ecological assets (through social engagement, trust and/or networks). Such assets rely on interrelationships that are the key to resilience (and health) in coupled human and natural systems. By targeting these assets and relationships, integrated catchment management provides a practical focus for governance and policy and a win-win opportunity to enhance sustainability of social-ecological systems, while actively improving the determinants of health and well-being.

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## **6. Figures and Tables**

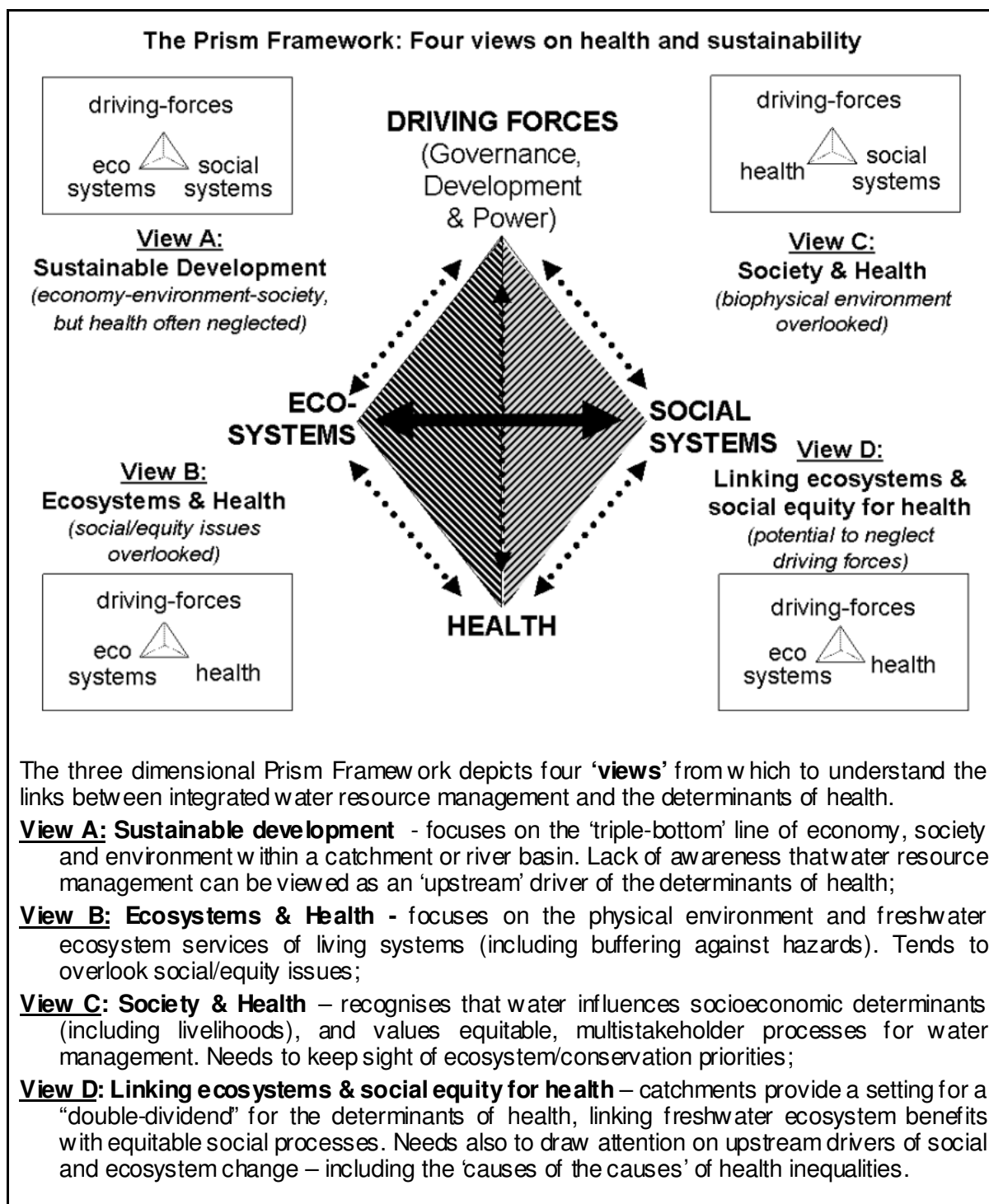
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**Figure 1: The Prism Framework: Four views on water for life, health and sustainability.**  
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**Table 1:** Simple arguments for complex relationships – catchments as settings for health and sustainability \*

<b>Integrated Catchment Management</b>	<b>Connection with determinants of health</b>	<b>Implications for the determinants of health</b>	<b>Enables a view of Catchment management as a means to enable:</b>
<p>Calls for ecosystem-based approaches to integrated water resource management have led to the field of integrated catchment management (ICM).</p>	<p>Our understanding of environmental hazards (microbiological and chemical) is enhanced by understanding of ecosystems attributes (see Table 2).</p>	<p>Catchments provide an ecosystem-based setting to understand and respond to water-based environmental hazards and water-related disease.</p>	<p><b>(a) Living Systems</b> that protect from hazards and promote safe and healthy environments.</p>
<p>ICM is recognised as an important influence on socioeconomic context in rural and urban settings (including poverty, livelihoods, equity of access).</p>	<p>Socioeconomic context is widely recognised as influencing health via the social determinants of health, and in particular in relation to health inequalities.</p>	<p>ICM can be viewed as a strategy to improve the social determinants of health.</p>	<p><b>(b) Sustainable Livelihoods</b>, through equitable management of water (quality and quantity), and a strategy for poverty reduction and social engagement to reduce health inequalities.</p>
<p>ICM is a collective, multi-stakeholder process that involves social learning and collaboration.</p>	<p>Multi-stakeholder processes that involve social learning and collaboration, are characteristic of – and consistent with – both settings approaches to health promotion and ecosystem management.</p>	<p>ICM provides a setting and a process with the capacity to promote both health and sustainability.</p>	<p><b>(c) A tangible setting for linkage</b> between ecosystems and social equity (also between <i>living systems</i> and <i>livelihoods</i>). As a collective, collaborative process ICM has the potential to build social-ecological resilience and improve social and environmental determinants of health.</p>

\*Adapted in part from Parkes and Horwitz (forthcoming, in review)

**Table 2:** Ecosystem Approaches to Health: collective learning across and between knowledges is required to achieve transdisciplinarity, participation and equity\*

<b>Knowledge Cultures</b> (Brown 2007b, Brown 2007a)	<b>Knowledge users &amp; perspectives</b> (see Parkes et al, 2007)	<b>Partnership Pentagram for Social Accountability</b> (see Woollard, 2006)
<b>Individual</b> – grounded in personal experience.	Within/part of any of the below	Within/part of any of the below
<b>Local Community</b> – derived from shared stories, events, traditions.	Community	Communities
<b>Specialised</b> – multiple disciplines and professions each with their own framework.	Practitioners and Fieldworkers Disciplines	Professionals Academic Institutions
<b>Organisational</b> – strategic views from government and industry – includes governance, policy development, legislation, markets	Sectors Units of Governance	Policy Makers Administrators
<b>Holistic</b> – understanding of the emergent whole – includes art, and approaches to complex dynamic systems	Any of the above	Any of the above
* Transdisciplinarity, participation and equity are considered three pillars of ecosystems approaches to health, informed in particular by the Lebel (2003) and the International Development Research Center's Ecohealth Program Initiative ( <a href="http://www.idrc.ca/ecohealth">www.idrc.ca/ecohealth</a> ).		

**Table 3: Emerging capacity to link Health, Ecosystems & Society within Catchments**

Context	Project ( including demonstrative research, policy and capacity- building challenges)	Collective learning between different knowledges
Canada, Fraser River Basin Council	Representation of public health concerns within an extensive <b>monitoring and indicators</b> program focused on the 240,000km <sup>2</sup> river. Tools under consideration including: - refinement of existing indicators to better represent the determinants of health; - inclusion of environmental health impact assessment of development initiatives in the catchment.	The Fraser Basin Council has ongoing relationships with local communities (including First Nations); universities and organizations.
Ecuador (Azuay Province)	An indigenous community in the Canar region was forged through collective building of an irrigation system over 14 years. Informed by concerns about environment and health issues - including upstream-downstream disparities in water quality - and with an interest in <b>building capacity</b> for improved community response to these issues, three community leaders and educators applied and were accepted in a Canadian-funded Masters Program focused on 'an ecosystem approach to health'. Their resulting student community-oriented research projects focus on three different zones of the man-made irrigation 'catchment' including: management of the 'paramo' or upland water source; the health and ecosystem impact of pesticide-use in the mid-range; and evaluation of residual/waste water contamination and options for community response in the lower reaches.	Students bridge individual, community, specialized, organisational and even holistic knowledge – between themselves and others.
Hawaii (Ahupua'a or Mountains to Sea Ecosystems)	Building on a growing appreciation of Hawaii's Mountains-to-sea Ahupua'a systems as a microcosm for sustainability, a real-time monitoring and visualizing system with the capacity for <b>integration of biophysical, social, cultural and health data</b> is under development, in conjunction with the Pacific Island of the U.S. National Ecological Observatory Network (NEON) in partnership with scientists and local communities (Kaneshiro <i>et al.</i> 2005). A key recognition in this initiative is that real benefits from scientific breakthroughs will depend upon peoples capacity to "discover, learn, teach, collaborate, disseminate, access, and preserve place-based knowledge"(Kaneshiro <i>et al.</i> 2005, NCAR and NSF 2003)	NEON's Learning Community seeks to facilitate "collaborative research and learning among scientists, educators, and interest-based communities"
Philippines, Community- based water monitoring for the Panigan- Tamugan Watershed.	A community-based water monitoring project in Davao City was named Bantayo Aweg after a Bagobo term that means water guardians or watchers. While the main objective of the group is monthly monitoring of the watershed using basic parameters of water quality and observation of illegal fishers, the collective learning mandate is also strong. Following their start-up phase, the group reported a <b>range of positive benefits</b> from this social engagement process – including education, empowerment, community confidence, and engagement in social and political processes. These benefits can be viewed as reducing health inequalities through empowering social processes, creating supportive environmental and preventing exposure to environmental contaminants.	The group seeks to share information with community, local schools and government agencies with mandate to protect water resources.