Secure and Safe Water Supplies in Remote Australian and Rural Sri Lankan Regions: Common Issues and Emerging Responses

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Abstract

Most urban dwelling Australians take secure and safe water supplies for granted. That is, they have an adequate quantity of water at a quality that can be used by people without harm from human and animal wastes, salinity and hardness or pollutants from agriculture and manufacturing industries. Australia wide urban and peri-urban dwellers use safe water for all domestic as well as industrial purposes. However, this is not the situation remote regions in Australia where availability and poor quality water can be a development constraint. Nor is it the case in Sri Lanka where people in rural regions are struggling to obtain a secure supply of water, irrespective of it being safe because of the impact of faecal and other contaminants.

The purposes of this paper are to overview: the population and environmental health challenges arising from the lack of safe water in rural and remote communities; response pathways to address water quality issues; and the status of and need for integrated catchment management (ICM) in selected remote regions of Australia and vulnerable and lagging rural regions in Sri Lanka. Conclusions are drawn that focus on the opportunity for inter-regional collaborations between Australia and Sri Lanka for the delivery of safe water through ICM.

Key words: secure and safe water, sustainability, appropriate technologies, integrated catchment management, collaborations

Introduction

It is estimated that by 2030, nearly half of the world's population will be living in areas of high water stress which calls for more sophisticated planning that successfully addresses the linkages of water across all economic sectors, and manage water similar to a portfolio of investments; identify those water assets with economic potential and those that are liabilities in need of careful management (World Bank, 2012).

Purpose and approach

The purposes of this paper are to twofold. The first is to provide a context and overview the population and environmental health challenges arising from the lack of safe water in rural and remote communities. The second is to 'snap-shot' the status of and the need for ICM in selected remote regions of Australia and vulnerable and lagging rural regions in Sri Lanka. Conclusions are drawn that focus on the opportunity for inter-regional collaborations between Australia and Sri Lanka for the delivery of safe water through ICM.

The purposes of this paper are pursued through three tasks. The first is to provide an overarching context for the provision of secure safe water by briefly examining the global population and environmental health challenges that are arising from the lack of water security in rural and remote communities. The second is to reflect comparatively on the health challenges using case material from remote regions in Australia and vulnerable and lagging rural regions in Sri Lanka. The third task is to provide a reality check by summarising the status of water resources management in selected remote regions of Australia and in vulnerable and lagging rural regions in Sri Lanka; and exploring the implications of this situation with respect to population health risks. To this end, common issues are identified, policy settings are reviewed and practical measures suited to the geographic and governance realities are identified. Case material is provided on an example of the type of sustainability technology responses needed to provide secure safe water in remote regions and rural areas in both countries.

Conclusions are drawn that focus on the opportunity for inter-regional collaborations between Australia and Sri Lanka for the delivery of safe water and sanitation services through ICM. To that end, a possible pathway is indicated for: sharing ICM policy and practice; exchanging experience based knowledge; and mobilising expertise from comparable Australian case regions. Such collaboration is aimed at helping to ensure that secure safe water supply and sanitation services in vulnerable and lagging rural regions in Sri Lanka are ethically sustainable.

Dimensioning the population and environmental health challenge

Establishing a Context for Providing Secure and Safe Water

Most Australian's take 'secure and safe water' for granted. That is, they have an adequate quantity of drinking water at a quality that can be used without fear of harm from human and animal wastes or salinity and hardness or chemical contaminants such as agricultural fertilisers, insecticides and weedicides or discharges of heavy metals and other toxic materials from manufacturing industries. Water treatment facilities servicing Australian cities and towns provide drinkable water (ie safe water). Urban and peri-urban dwelling Australians in metropolitan regions and country towns use safe water for all domestic purposes. As well, safe water is used in industry for materials processing, cooling and cleaning.

This is not the case in some rural and remote regional environments in Australia where poor water quality has with implications for present and future socio-economic development. Nor is it the case in Sri Lanka where people in rural regions are struggling to obtain a secure supply of water, irrespective of it being safe (ALAF, 2013). And this situation must be rectified in both countries.

Prior to the 'Millennium Drought' Ironmonger (1988) reported that "a typical Australian household consumed an average 900 litres of drinkable water per day". According to the Australian Bureau of Statistics (ABS 2013) during 2004-05 (at the height of the drought) the Australian average per capita domestic consumption was 103 kilolitres (equivalent to 282 litres per day). At the end of drought per-capita household consumptions had reduced to 650 litres per day (ABS 2013). However, the pattern of consumption was not uniform. For example, SEQWater (2013) reported that the per-capita daily household water consumption in Queensland had declined impressively to as low as 140 litres in Central SEQ and to 184 litres in both the Gold Coast and Sunshine Coast. These data demonstrate how the pressures of reduced supply have been effectively addressed by 'demand management' strategies and that this has been carried into post-drought consumption behaviour.

Ironmonger (1988) reported that on average, the major in-house uses were 14 percent toilet flushing, 13 percent showers 12 percent laundry, 7 percent baths and 6 percent dishwashing. That is 51 percent of the domestic usage produced sewage ('black water') and sullage ('grey water'). Only 3 percent was used for drinking and cooking. The remaining 46 percent of the household's 'safe water' was applied to lawns, gardens, vehicle washing and hosing paths and driveways. PIA (2003) noted that for the metropolitan Melbourne situation: "60% of residential water is used in bath rooms, toilets and laundries, which produce 'grey and black water'; 5% is used in the kitchen; while a massive 35% goes on home gardens".

Arguably, the patterns of water consumption by Australian households needs to be critically examined to determine how to optimise saving in resources and costs by moving to 'fit-for-use' supplies rather than meeting all uses with 'safe water. Although not a new idea, as argued by Tang (2000), WSAA (2005) and Tang et al (2007) a split between potable and non-potable uses in households can result in major savings and anchor the ethical sustainability of secure and safe water services; especially in remote regions in Australia and rural regions in Sri Lanka.

UNICEF and WHO (2011) have reported that globally, poor sanitation is considered to be the greatest threat to the supply of safe drinking water. Faecal contamination increases health risks from water borne diseases and the sustainable provision of secure safe water and adequate sanitation is a challenge in rural and remote regions in developed and developing nations alike. For example, the lack of adequate sanitation was viewed in the immediate past by Commonwealth of Australia (2000) as a major risk to water quality and public health in some remote Aboriginal communities in northern and central Australia and this situation has largely been rectified by governmental and community actions. Unfortunately, basic sanitation is still a major challenge in rural areas in vulnerable and lagging regions in northern, eastern, Sabaragamuwa and central Sri Lanka and is major contributor to poor water quality (ALAF 2013).

Australians living in urbanised areas be they cities or towns or small settlements have the luxury of adequate centralised or decentralised sanitation (sewage treatment) services. Remote settlements such as mining camps and many Aboriginal communities treat sewage and sullage using (for example) either decentralised 'package' treatment plants or septic tank systems. Again, this is not the case in Sri Lanka where sanitation in urbanised and rural areas alike is viewed as being inadequate and imposes a considerable threat to environmental and human health through the contamination of surface and ground water supplies. This situation raises the question: What are the global dimensions of the health threat due to poor water quality in general and Australian and Sri Lanka in particular?

Global population and environmental health

The 2003 UNESCO–WWAP report *Water for People, Water for Life* states that: "water-related diseases are among the most common causes of illness and death, affecting mainly the poor in developing countries. They go on to state that: "The majority of those affected by water-related mortality and morbidity are children under five. The tragedy is that this disease burden is largely preventable". Unfortunately this situation is to be found in some rural and remote areas of developed and developing countries alike. Examples are to be found in remote communities in northern and central Australia and rural areas in Sri Lanka. Remedial measures are required in both situations as a matter of urgency and emerging practical responses are discussed below.

Societal health is usually measured by three main indicators: the infant mortality rate, the childhood mortality rate and the life expectancy. Lack of clean water and adequate sanitation are two of the most important factors responsible for the poor health conditions in developing countries. **Table 1** illustrates the difference in health status between some developed and developing countries and compares the life expectancy of these countries at the start of the Millennium and eight year later.

Table 1. Comparison of Population Health Status in Selected Countries

Country	Infant Mortality per 1000 live births 1998*	Child Mortality per 1000 live births (under 5 years)		Healthy Life Expectancy (WHO)	
		Male (1998)	Female (1998)	1999 (DALE)	2007** (HALE)
Australia	6	8	6	73.2	74
Bangladesh	79	106	116	49.9	56
Fiji	20	28	18	59.4	62
India	72	82	97	53.2	56
Indonesia	48	69	56	59.7	60
Japan	4	6	5	74.5	76
New Zealand	7	9	8	69.2	73
Papua New Guinea	61	79	88	47.0	56
Sierra Leona	170	277	248	25.9	35
Solomon Islands	23	32	22	54.9	59
Sri Lanka	18	22	20	62.8	63
UK	7	9	8	71.7	72
USA	7	10	8	70.0	70
Vanuatu	39	54	42	52.8	61
Zambia	82	149	144	30.3	40

**http://data.un.org/Data.aspx?q=life&d=WHO&f=MEASURE_CODE%3AWHOSIS_000002 (* WHO)

HALE (previously DALE:WHO) estimates the number of healthy years an individual is expected to live at birth by subtracting the years of ill health – weighted according to severity – from overall life expectancy. From the data in **Table 1** it is evident that some progress has been made to improve life expectancy in many poorer countries between 1999 and 2007 possibly a result of the UN-MDGs and actions to provide access to water and sanitation. Japan, UK and Australia have the highest in the list and Papua New Guinea, the nearest neighbour to Australia, has 18 years shorter life expectancy.

Also, it has been reported (Commonwealth of Australia, 2012) that within Australia, the gap in life expectancy at birth between Aboriginal and Torres Strait Islander peoples and other Australians for 2005–07 was estimated at 11.5 years for males and 9.7 years for females. In 2008, the Aboriginal and Torres Strait Islander child mortality rate was 213 per 100,000 people compared to 101 per 100,000 people for non-Indigenous children.

Causal factors and UN concerns

Factors such as lack of access to primary health care and treatment, poverty and overcrowded housing conditions, inadequate access to water and sanitation are considered responsible for infectious diseases in Aboriginal and Torres Strait Island communities. Trachoma, an eye infection, if untreated can lead to blindness is well known to be a 'water-washed disease (lack of clean water for washing)" and Australia is the only developed country where trachoma is still endemic and it is found almost exclusively in remote Aboriginal and Torres Strait Islander populations.

In 2003 the UN recognised that adequate quantity of 'safe water' is necessary to: prevent death from dehydration; reduce the risk of water-related disease; and provide water for drinking, cooking and hygiene requirements. REF(date) reported that following many years of discussion, debate and negotiation, in 2010 the UN Human Rights Council adopted a binding resolution recognizing that the human right to water and sanitation are a part of the right to an adequate standard of living. Waterman et al (in prep) argue that this resolution sets the moral imperative for the ethically sustainable provision of secure safe water and sanitation services in communities at risk from inadequate and poor quality water supplies.

Water Supply in Remote Communities in Australia: a selective 'snap shot'

"Water and its availability and quality will be the main pressures on, and issues for, societies and the environment under climate change." (IPCC 2007)

Aboriginal and Torres Strait Islander Communities

Demographic perspective

ABS (2012) and AIHINet (2013) report that in 2011 Australia's Indigenous people made up three percent of the total population. Out of this, 90 percent of Indigenous people identified as Aboriginal, six percent identified as Torres Strait Islanders, and four percent identified as both Aboriginal and Torres Strait Islander. However, in 2011, only around one-third of Indigenous people lived in major cities and the rest are assumed to be living in remote and rural areas of Australia. Within these regions, the majority of lands occupied by Indigenous Australians are primarily as a response to the 'Homelands Movement' that was initiated in the 1970s. This movement was aimed at returning people to traditional country in order to look after the land and its sites of cultural significance. This was to be coupled with (as some of the objectives of the Homelands movement) healthier lifestyle, better food and opportunities for hunting.

However, the tragedy of this initiative, as Wright (2002) points out, is the fact that it does not necessarily mean that all Indigenous people were given back the rights to their land. Nor did it mean that they are responsible for natural resources management (NRM) in general and water resources in particular. Most of the land occupied by Indigenous people is in the centre and tropical north of Australia. Specifically, in desert and monsoonal regions offering very little economic benefits to non-Indigenous people, particularly in relation to agriculture and grazing.

Water supplies in the majority of these areas are drawn from groundwater aquifers. With growing industry demands and population growth the demands on groundwater sources poses questions about sustainability of this resource in some remote regions. Currently, there are no integrated approaches taken to the management of water resources at a catchment scale irrespective of it being in the wet-dry tropics of the Northern Territory or the arid Eastern and Northern Goldfields regions of Western Australia. Nor do easily identifiable Indigenous catchment management groups do not appear to operate in either tropical or Savannah regions of Far North Queensland.

Wright (2002) also points out that in order to understand the sustainability of water in communities; one must first understand the cultural and social issues that induce how water is used and how water is being managed. Water conservation and sanitation strategies and projects cannot simply be taken from urban communities and placed into remote communities. For example, Wright, 2002) makes the point that water efficient shower heads and aerated taps would be problematic in remote communities where, in extreme cases, Total Dissolved Solids (TDS) in the source water reach as high as 50 000 milligrams per litre. This simple example illustrates the ‘truism’ that water efficient technologies and sanitation systems need to be designed to suit the local conditions and capacity for operation and maintenance.

Guerin and Guerin (2010) conducted field work in two remote sites in South Australia primarily with Aboriginal populations and they suggested that “the local community members are probably the best ones to be running things since they know the changes, differences and flexibilities better than anyone else”. At the same time they noted that “remote and arid living also has consequences for relationships since many family members are as far away as are those who control the services”. The authors go on to point out some less obvious factors which have implications for policy decisions that affect the sustainability of small, remote communities in Australia. At the end of their research, Guerin and Guerin (2010) concluded that “government laws and policy are typically formulated as general or abstract propositions designed to be run in the same way over a very diverse group of contexts and situations”. In contrast, Waterman et al (in prep) argue that ‘an ethically sustainable policy system is more appropriate because allows for locally created, managed and implemented policies to ensure rapid and context-driven adaptations to whatever contingencies occur’.

Mining regions in Western Australia

The Northern and Eastern Goldfields are major nickel and gold producing regions with over 20 operating mines that are dependent on groundwater for ore processing. The desert towns of Leonora and Laverton in the south to Wiluna in the north, including the town of Leinster lie within the region. To provide an example of the conditions being faced, the Leinster town supply is obtained from a groundwater scheme operated by BHP Billiton. The licensed allocation for the mining industry is about 90 gigalitres per year and this has been provided wholly from local groundwater with salinity ranging from fresh to brackish (1 000-3 000 milligrams per litre) and hyper saline of up to 200 000 milligrams per litre (Johnson et al, 1999). Groundwater is also used throughout Leonora, Laverton and Wiluna for town water supplies, pastoral purposes, and for irrigated horticulture and citrus at Wiluna.

The public drinking water supply for Laverton is obtained from the Beasley Creek bore and the Wedge Pit bore field which are located about 12 kilometres north-west of the town. Nitrate in all the town water supplies, at levels exceeding the 45 milligrams per litre (as-Nitrate) standard for drinking water and generally exceeds 30 milligrams per litre, with a maximum concentration of 130 milligrams per litre. The treated water is dosed with Calgon to mitigate hardness levels, and then chlorinated before being supplied to the town via the storage tanks. However, the water treatment plant process is currently modified to reduce the naturally occurring nitrate levels in the drinking water to achieve the levels outlined in the Australian Drinking Water Guidelines (Department of Water, 2007). Although absolutely essential to meet human needs, such approaches are questioned in light of other sustainability technologies that are available.

During the period January 2001 to January 2007, positive E. coli counts were recorded in 14 per cent of raw water samples collected from the Beasly Creek borefield. Approximately 11 per cent of these samples had E. coli counts greater than 20 colony forming units per 100 millilitres. A detection of E. coli in raw water abstracted from a groundwater source may indicate possible contamination of faecal material through ingress in the bore, or recharge through to the aquifer (depending on aquifer type). E. coli counts greater than 20 colony forming units per 100 ml can seriously impact on the ability to ensure a safe drinking water supply through disinfection alone. This raises questions as to the source of the contamination including the discharges of sewage and sullage within the Beasly Creek catchment context; especially in relation to the groundwater recharge zones.

Department of Water (2007) considered that there are opportunities to significantly reduce risks to water quality by carefully considering design and management practices. The adoption of best management practices for land uses will continue to be encouraged to help protection of water quality. Also, education and awareness (eg signage and information material) as a key mechanism for water quality protection, especially for those people visiting the area who are unfamiliar with the area. Arguably, for this to be effective it need to done within an ICM framework.

Overviewing the Sri Lanka situation

Historical background

The history and cultural heritage of Sri Lanka extends back over 5000 years. Impounding water in reservoirs during rainy periods and diverting through long canals through irrigation networks into paddy fields during dry periods were special features of ancient Sri Lankan civilizations. Some 3000 years ago ten ancient administrative divisions encompassed the headwaters of the largest rivers in the country (Dharmasena 2012). The boundaries of these divisions align well with the present watershed map of Sri Lanka and it could be argued that ancient kingdoms evolved at that time to administer one or more watersheds.

Dharmasena (2012) provides a chronology that tracks the emergence of irrigated systems and the diversion and sharing of water between catchments and rivers using major canals and storage in systems of ‘tanks’ (impoundments). Extensive hydraulic works serve to exemplify Sri Lanka’s classical age which roughly parallels the rise and fall of Anuradhapura from 437BC to 1040AD. As an example, the long canal Yoda Ela, with a very low gradient, carried water from Lake Kalawewa to an impounding reservoir (Thisawewa) at the city of Anuradhapura; a distance of 87 kilometres. The first 27 kilometres of this canal has a gradient of less than ten centimetres per kilometre and while effectively being maintained as a natural stream feed numerous tank systems. To reduce the risks from natural disasters a ‘tank-village community system’ was established throughout the dry zones (Dharmasena, 2012).

Colonisation of Sri Lanka by the Portuguese in 1505; the Dutch in 1656 and the British in 1798 saw a further strengthening of the hydraulic system by an interconnected network of storages over the dry lowland rural regions. These ‘tank clusters’ are referred to by Dharmasena (2012) as ‘the cascade system’ and form the foundation of the surface water resource system that is still in use for the nation. The maintenance of tracts of forests along with the construction of ponds, reservoirs and irrigation schemes that characterises the Sri Lankan landscape accords with Buddhist principles for food and water security (Dharmasena, 2012).

Water resources management: Scoping the issues

Following independence in 1948, the Sri Lankan Governments approach to water resources management has focused mainly on the constructing large reservoirs for irrigated agriculture and hydro-electric power. In the 1960’s a Water Resource Board (WRB) was established to advise the Government on water resource management. However, the WRB failed to develop any policy guidelines for water resource management. In 1975 the National Water Supply and Drainage Board (NWSDB) was established as a statutory body to provide domestic water and sanitation services in urban and rural areas (NWSDB 2013).

Dharmasena (2012) reports that the dam construction phase of 1980s was replaced in the 1990s with initiatives that emphasised: “improving sector management through policy reform and greater financial control”. This move was largely catalysed by the failure of many irrigation projects and this situation led water professionals and donor organisations to seek institutional reforms in the irrigation sector. The kind of changes which were widely proposed included new water resources management policies, new legislation, and the establishment of basin-wide organisations.

The success of the some of the proposed changes was evaluated by Ariyabandu (2008) who discussed the Asian Development Bank (ADB) supported Comprehensive Water Resources Management Project (CWRM) and Water Resources Management Project (WRMP). These technical assistance

(TA) initiatives were commenced in 1992 and 2001 respectively with the purpose of "streamline policies and institutional arrangements to achieve more efficient and holistic water resources management (WRM)". New national water policy and institutional arrangements were agreed by the Cabinet of Ministers in 2000 and an Act was drafted that would have established the National Water Resource Authority (NWRA) and other water related institutions. Nothing eventuated and as reported by Ariyabandu (2008:1) both projects failed "because of poor project design and a lack of awareness of the Sri Lankan context, in particular the cultural and political nature of water". The author also argues that the legacy of this failure is "of critical concern for water resources management in Sri Lanka" in terms of: "learning lessons, and implementing these lessons". With over 50 percent of people reliant on paddy cultivation water plays an even more powerful social, cultural and political role in Sri Lanka; especially with respect to the equitable allocation of water for domestic and agricultural use.

Ariyabandu (2008:1) also noted that: "Whilst water scarcity is not an immediate challenge, since early 1990s demand has been increasing because of rapid urbanisation and industrial development". Currently, the critical challenges being faced by the Sri Lankan water sector, as reported by ALAF (2013), include, for example: ministerial responsibility for water resources management being spread over several portfolios with a resultant duplication of institutions and legislation; the absence of a national policy for the development and allocation of water resources between competing uses (domestic and irrigated agriculture); and national policies on drinking water and sanitation need to be updated. In short, water resources management remains extremely vexed and policy and practical measures are urgently required to ensure safe secure supplies of drinking water and improved sanitation services.

Furthermore, ALAF (2013) highlighted the need to consider the impacts of changing climatic conditions in rural regions on: the quantity and quality of water that is available for domestic use; food security and poverty levels; and public and environmental health. Climatic induced changes are recognised (Eriyagama et al, 2010; Ministry for Environment 2011) and the water safety and security dimensions need to be addressed through drinking water and sanitation policies. However, the ability of water sector practitioners to address climate change impacts is exacerbated by: the limited availability of meteorological and stream gauging measurements for most of the country; and a lack of coordination in sharing available data with Water Board and other resources managers in the regions.

Water Sector Policies

Sri Lanka does not have an overarching National Water Resources Policy but it does, however, have two sets of policies that relate specifically to drinking water and two that encompass sanitation. They are: the 2001 National Policy for Rural Water Supply and Sanitation (NPRWS&S); the 2002 National Policy for Drinking Water and Sanitation (NPDW&S); the 2005 National Rainwater Policy and Strategies (NRWP&S); and the 2010 National Drinking Water Policy (NDWP). All are directly applicable for meeting the challenge of providing secure safe water in vulnerable and lagging regions. The NRWP&S is administered by the Ministry for Urban Development and Water Supply and the other policy instruments by the NWSDB. This apparent intra-governmental confusion in the policy setting need to resolved if integrated approaches to catchment management are to be implemented in Sri Lanka (ALAF 2013).

The 2001 NPRWS&SS recognises the economic value of water and acknowledges the need for actions such as: cooperative institutional arrangements for the efficient management of resources and facilities; governmental and commercial collaboration in funding the provision of safe piped water and sanitation services; and stakeholder engagement and community participation in service planning and provision. However, the 2001 NPRWS&SS makes no mention of changing climatic conditions and adaptation to climate and related environment changes such as reduction in vegetative cover, soil degradation and stresses on aquatic ecosystems. Nor does it mention integrated catchment management (ICM) as a tool to help to: improve the harvesting and quality of surface and ground water resources; ensure water and food security and enhance food and fibre production; and protect public and environmental health.

Additionally the policy is silent on the essential mechanisms to accurately measure and monitor the quality of domestic water to confirm that it is safe. Specifically, the provision of water analysis equipment in regional areas that is capable of determining a full suite of metal ion and other contaminants that could be detrimental pubic and environmental health. This situation is viewed as a serious deficiency and ALAF (2013) recommend that it be rectified as soon as practical.

The NDWP breaks the water sector into an urban water sub-sector and a rural water sub-sector. The NPRWS&SS is acknowledged in the NDWP as the rural sub-sector. With respect to the Rural Water Supply Sub Sector, the NDWP states:

> "A rural water supply policy document has been approved by the Cabinet in year 2001 with the main focus on the rural water supply & sanitation sub sector. The rural water supply & sanitation policy comprehensively addresses the rural water supply aspects coming under the purview of mainly the Provincial Councils, Local Authorities and Community Based Organizations (CBOs). The service provision for this sub sector is by way of dug wells, tube wells, rain water harvesting and small scale rural piped water supply items".

ALAF (2013) interpreted this statement to mean that the 2001 NPRWS&SS is still in force and guides the actions of the Water Board in rural regions.

The 2002 National Policy on Drinking Water and Sanitation (NPDW&S) has been separated into two Policies; one for 'Water' and one for 'Sanitation': they are the 2010 National 'Drinking Water' Policy (NDWP) and a 'to date work in progress' of a National 'Sanitation' Policy (NSP). Although a draft NSP has been in preparation for some years its date of release is unknown. ALAF (2013) recommended that this deficiency be rectified as soon as possible. In the interim, the Fellows took the position that the sanitation components of the 2002 NPDW&S are still in force.

Institutional setting and emerging arrangements

Currently, there are no institutional arrangements in Sri Lanka for the delivery of IWRM at either the basin or catchment scales. Likewise, there are no formalised ICM arrangements or activities for program or project implementation. Officers at NWSDB, operating at the regional scale, have identified the need for IWRM and ICM and are working informally to introduce these approaches water sector planning. Specifically, embedding drought management plans for meeting drinking water requirements.

Creating new structures and changing roles and responsibilities to meet the goals of integrated water resources management is not easy. Evidence from other countries confronting similar water security and safety challenges indicates that the introduction of new river basin organizations does not always run smoothly (Bandaragoda, 2006). In addition, there is widespread uncertainty in Sri Lanka about the role and functions of river basin organisations when it comes to the implementation of IWRM based approaches to water resources management as illustrated by Bandaragoda (2006) and Ariyabandu (2008).

A 'national forum' for water resources management has been established as the product of consultations at ministry, department, provincial and district levels. This initiative aims to establish an 'institutional framework' for the implementation of IWRM through 'Catchment Protection and Management Plans'. These plans will operate from national to village scales.

As well, a range of ongoing programs, projects and promotional schemes that are compatible with the objectives of catchment management plans are being implemented by different public and community sector organisations. For example, there is a subsidy scheme for diversification of coconut plantation and adoption of soil and water conservation measures. This is being implemented by Citizens Development Business (CDB) Finance Propriety limited company for organic farming funded by Department of Export Agriculture (DOEA). Additionally, there is the 'Green Village' concept implemented by the Hadabina Authority (HA), a community focused organisation. With proactive negotiation and communications it should be possible to incorporate such activities into emerging IWRM-ICM initiatives in rural regions across the nation.

Changing land uses and fostering improvements

Land use in the catchment area is one of the factors that can be changed to improve water supply with minimum annual variation in the quality and quantity of the resource by: increasing the rainwater infiltration and storage capacity; lowering evapo-transpiration rates; and reducing existing inefficient water uses by improving the socio-economic conditions of the resident communities. This can be achieved through measures such as those listed in **Table 2**.

Table 2. **Examples of proposed improvements in land uses in sensitive catchments**

Category of land use	Proposed improvement
Natural forest	☐ Minimize forest disturbances (human/ fire). ☐ Help natural regeneration and forest succession by planting suitable plant species. ☐ Build protected fences around natural forests.
Vacant lands belonging to Government.	☐ Help natural regeneration. ☐ Plant suitable tree species. ☐ Develop mixed cropping systems with soil and water conservation practices.
Privately owned vacant land.	☐ Introduce multiple cropping systems. ☐ Develop forest gardens. ☐ Introduce soil and water conservation methods.
Home gardens.	☐ Develop multi-storey cropping systems. ☐ Introduce soil and water conservation methods.
Perennial crops.	☐ Adopt inter-cropping with other species (diversification) ☐ Improve soil and water conservation, ☐ Fill plant vacancies.
Short-term crop cultivation.	☐ Introduce soil and water conservation methods. ☐ Introduce organic and conservation farming methods.
Paddy cultivation	☐ Introduce efficient water management practices ☐ Adjust the cultivation season according to the rainfall pattern

Many private enterprises conduct business activities that are compatible with the objectives of catchment managements plans. For example: the promotion of organic farming for export of organic products; fostering the cultivation of *Gliricidia sepium* trees for dendro-power (electricity from sustainably grown biomass such as fuel wood) and the collection of aquatic plants for compost preparations. The sustainability of these entrepreneurial activities can be best assured by incorporation of these private sector activities into catchment management plans.

Basin scale integrated water resources management (IWRM): an emerging case example

As indicated above, Sri Lanka has no national water resources policy and water sector management is spread across five portfolio areas within the government. Basically, there is a division in governance between water for hydro-electric power, agriculture and domestic purposes (urban development and rural). Water sector managers, irrespective of their being in the government or private sectors, have to make difficult decisions on allocating water to competing uses. Increasingly, they have to apportion diminishing supplies between ever-increasing demands for irrigation and domestic purposes. Eriyagama et al (2010) report that drivers such as demographic and climatic changes further increase the stress on diminishing water resources.

Faced with these challenges, officers of the NWSDB agreed that the traditional fragmented approach to water resources management was no longer viable and a more holistic catchment based approach was required to meet domestic demands in urban cities and towns as well as for irrigated agriculture in rural areas. To this end, an integrated water resources management (IWRM) initiative has been launched in the basin area encompassed by the catchments of the Badulu Oya, Umaoya and Manik rivers, as delineated in **Figure 2**. The focus of the case example is on the catchment of the Menik Ganga (River).

The Menik Ganga (River) ***catchment***

The Menik Ganga rises in uplands of some 1600 metres elevation and from there it flows approximately 80 kilometres to the sea. The total area of the catchment area is 1272 square kilometres. Average annual rainfall varies enormously from over 2500 millimetres in the headwaters to less than 1000 millimetres at the coast. Throughout the catchment groundwater occurs in a basement complex of weathered gneissic rock. The resultant low yielding aquifers generally produce poor quality water. In the headwaters tea plantations dominate the land use with paddy and sugar cane the dominant cultivation the central section. These production landscapes are in sharp contrast the lower third of the catchment which forms part of the Yala National Park. The total population of the catchment is in the order of 271 000.

Liyanage and Fernando (2002) found that the estimated volume of water discharged annually by the Menik Ganga at the coast is some 298 million cubic metres. However, this discharge is not evenly distributed throughout the year and during the months of June, July and August the flow is dramatically reduced. In recent years flow has ceased completely for several weeks at a time in this dry period, which has extend into September and October, a trend attributed to changing climatic conditions (Eriyagama 2010). Unfortunately, this is precisely the time when the water demands of the rural farming population are at their peak and temperatures are at their highest.

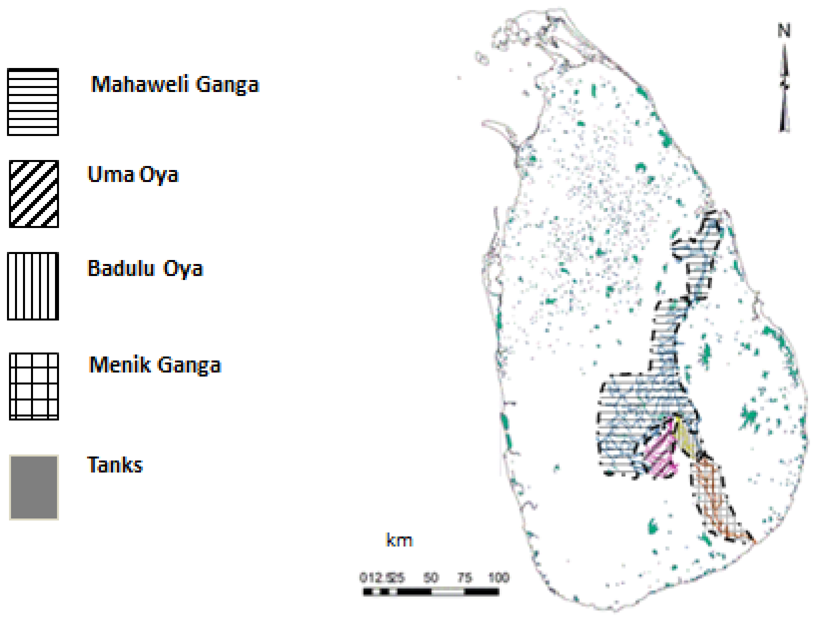

Figure 2. IWRM-ICM Case example catchment systems in Sri Lanka

Currently large-scale abstractions from the river are either via diversion channels (anicuts) to the paddy fields or by pumps to the sugar cane nurseries and town water supply systems. These abstractions are neither intra-governmentally coordinated nor controlled on a catchment wide basis. The inevitable result has been conflict between the major users (farmers) and those minor users who also depend on the river during these dry months. Under these conditions it is not surprising that it is the downstream users, notably the Kataragama domestic supply and the Yala National Park, that have suffered most from the misallocation processes.

Additionally, there are a number of water quality issues to be resolved. Foremost among these is the threat to the quality of the river water itself. Kodikara (1981) argued that tea cultivation which takes place mainly in the headwaters poses a double threat to the quality of the riverine waters. Firstly, in the form of pesticides used on the crop being washed into the river; and secondly, by tea estate workers settling along water channels and having no access to proper sanitation. Faecal pollution has resulted from this situation and is a major health risk to people dependent on river water for drinking, bathing and cooking.

Further downstream the sugar factory and distillery have been accused of either deliberately or inadvertently discharging polluted water into the main channel, causing problems for paddy farmers and domestic water supplies. To compound the situation, much of the groundwater present in the catchment also suffers from severe quality problems. Excessive hardness and high iron content is widespread, while locally fluoride levels are well in excess of permitted WHO limits. Shallow supplies tend to be of better quality, but crucially most dug wells tend to fail in the dry season and the population need to turn to the deeper tube wells, which unfortunately produce poorer quality water.

An emerging approach to integrated management

Liyanage and Fernando (2002) argue that the water resources in the Menik Ganga catchment are not being managed in an effective, equitable, efficient and sustainable manner. In this context, the challenge is to convert what is a chaotic and *ad hoc* method of allocation and distribution of water resources into a fully integrated water management system. Successful achievement of this long-term goal will require the adoption of some basic guiding principles, as articulated by Bromely (2005).

Firstly to proactively involve local communities and obtain stakeholder buy-in to the planning and management processes. Secondly, undertake fundamental institutional restructuring to enable administrative arrangements and functions to be delivered on the basis of a hydrological unit, the catchment. The current system of administrative areas as arbitrarily bounded spatial entities that have no physical relationship with water resources makes integrated responses difficult to deliver in terms of the flows of water and contaminants across the landscape. Thirdly, accurately quantify the resource using a comprehensive hydrological monitoring network including meteorological stations, surface and groundwater monitoring points and flow gauging stations. Laboratory facilities are required to confirm the chemical and biochemical conditions of domestic water supplies and that it is safe for human consumption. Fourthly, a sound decision making support system is required that encompasses not only hydrological factors but social, economic and cultural effects and the linkages between them.

The core mechanism for initiating the Menik Ganga ICM Project is the strategic plan that is to be developed and implemented in two tiers. The first is a total catchment plan to incorporate a broad spectrum of IWRM policies and the second tier encompasses processes and sub-catchment plans for sensitive areas and will be broadly implemented under ICM-IWCM principles. The aim is to deliver secure sustainable water supply to meet the human demands (domestic and agriculture) and environmental flow requirements.

Total catchment planning provides for a sound governance basis that is inclusive of provincial and local governments and the requirement to see hydrological yield on a system wide basis. Sub-catchment plans focus on: water resources conservation; abatement and management of pollution load, water demand and conservation; improvement of the environmental/ecological status in the area; and proactive sectoral participation and stakeholder involvements in the integrated management processes. This is viewed as a long-term venture.

Not with standing, the Sri Lankan Government has recognised that to ensure the sustainability of secure and safe water resources in future dry seasons participatory integrated management at the basin scale offers the best way forward. The delivery of the Menik Ganga IWRM-ICM Project seeks to demonstrate: governmental, private sector and community confidence in the veracity of the approach; and commitment to its successful implementation.

Towards appropriate technology for secure safe water in developing regions: a practical example

Slow Sand Filters (SSF)

For the treatment of drinking water in tropical areas, particularly for rural or decentralized village supply, the WHO recommends the use of Slow Sand Filters (SSF) as an appropriate and sustainable technology. Their simple design makes it easy to use local materials and skills in their construction, operation and maintenance. No chemicals are used, yet very effective in pathogen removal. The slow sand filtered water usually contains no *E.coli* in a 100 mL sample, thus satisfying the most important bacteriological drinking water quality requirement. However, chlorination can be used as an additional safeguard. The cost of operation lies mostly in the cleaning of filters, which may be carried out manually, in smaller units.

One of the major problems in the water industry (or any industry for that matter) is convincing decision makers to use simple and cheap technologies. There is always the misconception among decision makers that simple and cheap technologies are either unreliable or do not produce ‘a good image for the organization’. One way forward to overcome such barriers is through positive information to refute the misconceptions. For example, although very reliable in removing E.coli, slow sand filters are considered by some decision makers in developing countries to be inferior technology. As a result, water authorities are very reluctant to adopt these technologies for new treatment plants. Fortunately, such perceptions are slowly changing in the light of the rising demand for higher drinking water quality standards. Consequently, in recent years, there has been a renaissance of interest in the potential use of slow sand filtration throughout the world.

The filter can be built entirely above ground, partly above and partly below ground or basically as a hole in the ground. There are many means of construction that can be adopted. They range from the very simple, suitable for developing countries with limited means and expertise, to the highly sophisticated, incorporating all the most modern mechanical devices. Hence, the method has successfully produced potable water in the United States and Britain for more than a century and even today most London's surface derived water is slow sand filtered. So why not use it in remote and rural regions where conditions are suitable.

One of the main drawbacks is that the operation of such filters deteriorates during periods of heavy rains when the sources of supply of raw water become extremely muddy. The silts and clays in muddy water will clog the surface layer of sand and fill the pores between the sand grains with a consequent loss of flow capacity and a rapid rise in headloss (pressure drop) across the filter. This shortens the filter runs requiring frequent cleaning and disrupting the water supply.

Thus, to improve performance, it is vital to protect the SSF from such effects during monsoon or heavy rainfall periods by the use of pre-treatment methods. These pre-treatment methods have to meet the criteria of simplicity for application in rural areas. Specifically, they should not involve treatment with imported chemicals due to: their complexity of handling and dosing; and the demands on foreign currency exchange. Although the construction of reservoirs or large settling basins have been considered, and even accomplished in some tropical locations, these are expensive capital projects. Additionally, they may lead to other problems such as excessive algal or weed growth and breeding of mosquitoes.

Pebble Matrix Filtration (PMF)

A novel pre-treatment method called Pebble Matrix Filtration (PMF) developed at University College London, proved to satisfy these conditions and showed promise in laboratory scale (Rajapakse and Ives, 1990) and subsequently field tested in Papua New Guinea (Rajapakse and Ives 2003), Serbia (Rajapakse et al 2005) and Sri Lanka (Rajapakse et al 2007). The PMF can be described as a crude two-layer filter (**Figure 3**), where a turbid suspension approaching the filter flows downward, first through a layer of pebbles only (L1) and then through a matrix of pebbles and sand (L2). The upper part of pebbles only has some pre-filtering effect, but the improvement in suspension solids concentration is dominated by the pebble-sand mixture.

The PMF and SSF are considered to be an example of ethically sustainable systems suitable for addressing water quality problems in remote and rural settings in Australia and Sri Lanka. Both filters use natural purification processes and can be constructed using local materials, Further, the process does not require costly imported chemicals. Most importantly, their operation and maintenance can be carried out without highly qualified local personnel in rural areas. Schematics of a PMF and a SSF are shown in **Figure. 3** below and photos of operating the system in a village near Lae in Papua New Guinea are shown in **Figure 4**.

The total costs of a system with fittings, flow meters, manometers, underdrains, filter media and labour but excluding storage where filter tanks are made of galvanized culvert rings would be around $ 15 800, 29 000 and 41 000 (2010 prices) for populations of 400, 1000 and 2000 respectively. Other construction materials such as ferrocement or concrete may keep the costs even lower.

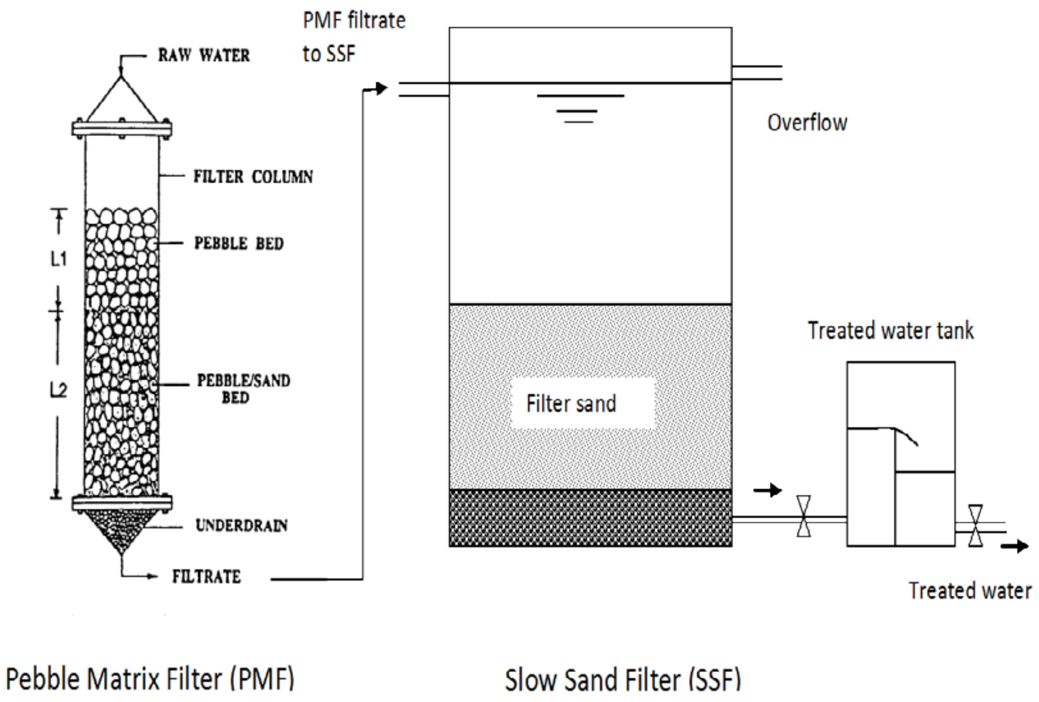

Figure. 3 Schematic of the Simple PMF and SSF systems

(a) PMF

(b) SSF

Figure 4 PMF and SSF Field Trials in a Village near Lae, PNG

Inter-regional collaborations between Australia and Sri Lanka

AusAID Supported Activity

The AusAID funded Australian Leadership Awards Fellowship (ALAF) project titled, *Water security, poverty alleviation and rural development under climate change for Sri Lanka* was undertaken in Australia in July 2013. The project was delivered by the Queensland University of Technology provides a case example of an applied policy research project (ALAF 2013) that is providing on-the-ground outcomes in the water sector. The approach and program for the project was informed by: responses to a needs analysis questionnaire; field visits to lagging regions; and discussions with the

Chairman and senior staff of the NWSDB prior to and end of field visits. Training activities were undertaken in Brisbane and Adelaide. The Return to Work Action Plan (RTWAP) has been accepted by the National Water Supply and Drainage Board (NWSDB) and is being rolled out over a two year timeframe.

The primary focus of the RTWAP is on: establishing appropriate governance arrangements to initiate IWRM as the umbrella for ICM actions; the revision of drinking water and sanitation policies to embed CCA and ICM; building profession and technical capacity in the regions to implement ICM-IWCM; and promoting ‘climate proofing ‘as a collaborative process for engaging stakeholders in new ICM-IWCM initiatives and enterprises. Additionally, the plan establishes a bridge to facilitate knowledge transfer to ensure the ethically sustainable provision of secure safe water and sanitation services (ALAF 2013).

Professional and Technical Linkages

Developing professional technical and socio-economic linkages between Australian and Sri Lankan regions are worth exploring. In the first instance, this could be done by working collaboratively with regionally based Australian catchment management bodies and sharing: knowledge on the benefits and implications of undertaking integrated approaches to water resources management at the catchment scale; practical experiences with appropriate technology for water and waste water treatment and supply; perspectives on public policy with respect to the establishment and governance of regional ICM organisations; and professional development and capacity building expertise.

Such knowledge transfer needs to be aligned with the competencies and capabilities of water sector practitioners in rural regions in Sri Lanka. More importantly, it should build on the momentum of the AusAID ALAF project *Water security, poverty alleviation and rural development under climate change for Sri Lanka* and maximise the opportunities afforded by the institutional commitment and timeline for the roll-out of the RTWAP.

Waterman et al (in prep) report that there is no national or common approach to ICM in Australia and this is advantageous for the Sri Lankan NWSDB. Specifically, the Water Board can learn from the successes and the mistakes of the Australian experience and move to apply administratively effective ‘low cost and low energy’ decentralised 21st Century solutions to the provision of safe secure water and sanitation services. ALAF 12 (2013) indicated that this should enable NSWSDB to be: eclectic in the approach that they adopt for the catchment scale management of water resources; collaborative when optimising public investment in decentralised water supply and waste water treatment facilities; proactive in promoting ‘for-purpose’ quality water supplies; entrepreneurial in linking appropriate sustainably technology with commercial enterprises to deliver ‘on-the-ground’ services; institutionally cooperative in initiating partnerships between government and communities to tackle to pollution abatement, soil degradation and biodiversity conservation measures aimed at improving the quality of surface and ground water resources; and fully cognitive of the moral and ethical dimensions of meeting the human rights imperatives for water supply and sanitation.

That said, the Water Board could be guided by the principles articulated by Ryan et al (2010) and innovative in the ways in which community buy-in is mobilised and transacted. Collectively, such measures should pragmatically support the implementation of ICM that is: tailored to geographic and socio-economic realities; and tuned to institutional and societal capacity to provide ethically sustainable secure safe water and sanitation services.

Observations and Concluding Remarks

To sum up, it has been argued that people in some remote regions in Australia and rural regions in Sri Lanka are facing public health risks due to poor quality water that can be linked to inadequate sanitation. Moreover, as argued by Waterman et al (in prep), the provision of secure safe water and sanitation services, as an integral part of ICM-IWCM, is above all, ethically sustainable. As such, it enables a more structured evaluation of key drivers of changing biophysical and socio-economic environmental conditions and societal needs (Waterman et al in prep).

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