*Pacific Economic
Cooperation Council
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Guidelines on Water Management in islands, coastal and isolated areas

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The Pacific Economic Cooperation Council (PECC) is an independent , multi-stakeholder organization committed to the promotion of cooperation and dialogue in the Asia-Pacific. Founded in 1980, PECC is a network of member committees composed of individuals and institutions dedicated to this mission. The Council is one of the three official observers of the APEC process.

Currently, PECC has a total of 26 member committees representing the economies of Australia, Brunei Darussalam, Canada, Chile, China, Colombia, Ecuador, Hong Kong, Indonesia, Japan, Korea, Malaysia, Mexico, Mongolia, New Zealand, Pacific Islands Forum, Peru, The Philippines, Singapore, Chinese Taipei, Thailand, the United States, Viet Nam, France Pacific Territories and institutional members: the Pacific Trade and Development Conference (PAFTAD) and the Pacific Basin Economic council (PBEC)

PECC provides a forum through which its members and broader stakeholders can influence the development of policies affecting the Asia Pacific region.

These Guidelines are the outcome of a two year process convened by PECC which brought together governments officials, private operators, multilateral institutions and academics to discuss issues related to better management of water in islands, coastal and isolated areas.

While efforts are made to ensure that views of the PECC membership are taken into account, the opinions and facts contained in this Report are the sole responsibility of the authors and editorial committee and do not necessarily reflect those of members committees of the PECC nor their individual members.

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INTRODUCTION AND BACKGROUND

At its April 2007 session in Sydney, the PECC Standing Committee, upon a proposal by France and its Pacific Territories, agreed to launch a **PECC International Project** on "*issues related to water management in Island territories, coastal regions and isolated communities*". This project seconded by the **World Water Council** has immediately received a large support by PECC member economies many of them having extended coastal territories and being confronted at different levels with issues related to water management, water quality or water scarcity.

In a letter dated July 2007 to FPTPECC Chair, former French Prime Minister Michel Rocard, Loïc Fauchon, Chair of the World Water Council said: *"I want to congratulate you upon this project dedicated to the management of water resource in islands, coastal and isolated areas. It is an issue that has not been addressed sufficiently to date. PECC work dedicated to water management in the PECC economies of the Asia Pacific is fully part of the preparatory work for the World Water Forum to be held in Istanbul in March of 2009 where all the stakeholders in charge of water management worldwide will gather".*

Furthermore, Pierre Victoria, alternate Governor of the world Water Council, mentioned *"Island territories, coastal regions and isolated communities were almost forgotten during the Mexico forum"*. In contrast, "*the World Water Forum has acknowledged the vulnerability and particular needs of small islands countries".*

Although the islands and coastal territories share a number of difficulties with all countries in the world, the PECC has pointed out the many ways in which they differ from others. The ability of the islands (such as Solomon Islands, Fiji, Vanuatu, Kiribati, French Polynesia, …) to tackle water scarcity is constrained by their size, their vulnerability to climate change and natural disasters, but also sometimes by the cultural tradition of their population.

Large coastal countries (eg. Japan, Korea, China, Chile, United States, Canada,…) usually benefit from the support of large back-yard territories for supplying water to their coastal population. These coastal areas are often less isolated and better connected to transportation networks than islands. Thus the maintenance of installations, chemical and materials procurement for water treatment, and the human resource management of water services are superior to smaller island nations. . On the other hand, coastal areas of these larger countries may suffer from heavier charge of pollutants discharged upstream.

Both islands and large coastal countries, have to deal their close proximity to the ocean which can be an asset or a scourge. The ocean is the ultimate water resource, and at the same time, it may pollute coastal aquifers by saline intrusion when over-exploited.

It was made clear during the two years of PECC work that we had to refer to the whole water cycle and not only to fresh water. In particular, we had to consider islands that are surrounded by lagoons. It was also made obvious that environmental issues are overwhelming: how to prevent, rather than cure, pollution; how to make better and more efficient use of fresh water; and, how to combine in the best way possible environmental preservation and tourism development.

At the global level, several questions arise from the combined effects of severe draught periods associated with climate change, uneven availability worldwide of water resources often associated with a downgrading of the quality of the resource. Water availability relies not only on the quantity of resource available but also on its quality to best fit the demand for human consumption. The current situation is critical in selected regions of the world, because the resource available cannot meet the needs both in quantity and/or quality.

The growing demand for water has become one of the most poignant environmental issues in the PECC economies today. While climate change may be a major factor in limiting access to natural sources of water, water related crises demand attention. These issues may create conflicts within local populations and between neighbouring economies, raising questions about rights of access to water, its appropriate cost, and priorities for its use.

This international PECC project is ambitious given the technical, environmental, political and financial aspects of the management of water in the Asia Pacific region. Three aspects may even appear more present than others:

- the growing need for water;
- the protection of the water resource;
- a priority access to water and sanitation for those who cannot benefit from these essential services.

I - A growing population associated with better living conditions have strongly increased the demand for water. Over the last forty years the demand for water has more than doubled.

Urban growth is exacerbating the water crisis. The crisis is not, of course, limited to coastal cities, but urbanization has serious consequences on water management. It is estimated that 10 % of the global population live less than 10 km of a coast. With regards to drinking water supply, urban growth accentuates the pressure on dwindling water resources. To meet the need for drinking water, coastal cities have been withdrawing more and more groundwater, often faster than it can be replenished. Many coastal cities, some with large supplies of raw water, are now facing shortages. As the number of consumers and the amount of water needed per inhabitant go up, many municipal water works have a hard time reaching satisfactory volume and service levels.

Each month, worldwide, the urban population increases by the size of a city like Hanoi. Cities of Asia and Latin America are at the forefront of this urban growth. Consequently, the demand for essential services will dramatically grow in the next coming years.

Even though water resource was for a long time considered plentiful, it has become increasingly scarce even in countries benefiting from an abundant resource. For example, in Asia (Bangkok for instance) in less than three decades, a large share of its groundwater resource has been depleted. It means that the noted water shortage is less the result of diminishing water resources than the overuse of a resource that does not expand.

Nevertheless, an increase in demand associated with perceived extended uses of water clearly means that water becomes increasingly scarce and that careful use of water should prevail. The era of plentiful water has come to an end as should the era of bad water management. Most economies worldwide benefit from enough water to meet the human and agricultural demand, but the main issue is related to bad water management in several of them. For example, water distribution networks in many economies are in very poor conditions: water leakage is over 50% in cities such as New Delhi, Colombo or New Orleans. This means that only one cubic meter reaches the consumer when two cubic meters of clean, drinkable water (after treatment) are put into the network.

II - The second challenge is to keep the resource at an acceptable level to meet demand. Protecting the resource, firstly means to collect used water and efficiently treat it. 2008 was the year of sanitation. Sadly to say, sanitation is not always included, as a necessary practice, to the water management process: urbanization translates into a higher concentration of household and industrial pollutants to be treated and a risk of exceeding more rapidly the capacity of aquatic environments to eliminate effluent discharged into them. Sanitation crises occur precisely where human densities are greatest. Chronic and accidental pollution leads to dwindling and poorer quality resources. Several countries of the Pacific Rim are not free from criticism. In the Solomon Islands and in Micronesia, just to name a few of them, less than 30% of the local population have access to sanitation. In Mexico, less than 20% of used water are treated before being discharged into rivers and the ocean.

Protecting the water resource means also being more careful about its use, taking steps leading to an accepted water conservation policy, especially regarding agricultural water. Agriculture is worldwide the largest consumer of clean water and the first waster. Agricultural use is over 75% of total water consumption worldwide, a lot of it being lost in leakages and spill overs. In the irrigation process, more than

60% of water is lost in spill over. In Majorca, which attracts more than 9 million tourist people each year, more than 80% of the fresh water is used by agriculture.

If no regulatory system applies to agriculture it is mainly because agricultural policies worldwide are based on a low water price and ready access to water. These policies are nothing less than disguised subsidies which create an over use of clean water, increasing water scarcity and do not encourage farmers to use water in a more efficient way. In this context, for the years to come, farm production will be made possible only through a reduction of consumption of agricultural water and at a price of water which better reflects water resource scarcity.

Protecting the resource means also developing alternative resources: water scarcity calls for a new water resource, used water is becoming a new additional resource. In many islands and coastal areas suffering from severe drought, water is far too more precious to be used only once. Water recycling is becoming a more and more developed technology to compensate for water scarcity both at industrial, agricultural and even domestic use. Water recycling and reuse allows for a better use of water and extends the water cycle.

Used water is a resource that can increase with the economic growth. Thus recycling and reuse capacities worldwide should triple in the next 10 coming years. The State of South Australia has decided to face the water shortage derived from a low level of rain water and an increase in demand to mobilize non conventional water resources. In the long term the state is expecting to reuse 50% of its wastewater. In Adelaide, the Bolivar recycling plant retreats 43,000 cubic meters per day that is used in 200 plant farms, as street cleaning water, for garden watering for residential areas and to replenish underground water and make it available for summer use.

Sea water is another alternate source of fresh water with unlimited access. It is an abundant water resource representing 97.5% of water resource. However, only 1% of drinking water comes from desalination and this technology will be used extensively in the coming years. More and more plants will pump sea water to satisfy human needs. Several Pacific islands would not have access to drinking water without desalination.

The United States is currently contemplating the possibility of launching several large scale desalination projects around the country. After seven years of severe drought, Australia is strengthening the productive capacity of its desalination plants. Even the United Kingdom, a country with ample water capacity is contemplating the possibility to develop this technology locally.

In that regard, the case of Bora- Bora may be seen as the state of the art in the management of water in a small remote island: where a large quantity of water coming from desalination is used to fit the need of tourism and local population, efficient sewage treatment, reuse of wastewater for gardening, lagoon preservation, and use of renewable energy from the ocean.

At a time when nations tend to be less dependent from outside sources of energy to satisfy their national needs, many also tend to be less dependent on rainfall for their water needs: desalination, recycling of used water, are likely to strengthen the country autonomy in water and also reduce or avoid the import of water from neighbouring countries which is often associated with a political risk.

These newly available technologies may limit international tensions raised from water scarcity. They give access to a secure supply of water, domestically available, not affected by climate change and free of potential international conflicts arising from claims over water rights. Singapore, a territory with limited access to fresh water, has developed an extensive programme of desalination to satisfy its needs and limit its water import from Malaysia.

III - The third challenge to face is to provide an equal access to water and sanitation. Worldwide, 1 billion people do not have access to drinkable water, and 2.6 billion do not benefit from sanitation. To cut this number by two before 2015 is one of the 8 priorities of the Millenium Development Goals set by the UN.

The mid-term review by the UNDP in 2006 shows that the objective set for access to drinkable water should be met, mainly due to the progress made by China and India. By the end of 2005 in China, 300 million urban citizens and 200 million rural people had access to clean water.

But, sanitation is far behind in most countries. 74 countries are off-track. To meet the Millenium goals, East Asian and Pacific economies should bring drinking water to 24 millions people each year and sanitation to 37 million people.

Given the existing scarcity of water resources and the dramatic increase in water demand, all users (private, industrial, agricultural...) have to move towards better use of the resource; they may have to change their habits to move towards more efficient and more secured water consumption. It is necessary to protect the resource and to look forward maintaining it at a sufficient level by developing and making new technologies acceptable to users, such as the reuse of water for agricultural and even domestic use; strengthening the use of existing, but insufficiently developed technologies, such as rainwater harvesting, desalination; and, developing sound environmental practices.

EXECUTIVE SUMMARY:

THE PECC INITIATIVE TO FACE CHALLENGES OF WATER MANAGEMENT IN ISLANDS, COASTAL AREAS AND ISOLATED COMMUNITIES

The present Report and Guidelines, an added value to the ongoing multilateral initiatives in water management, is transmitted as a PECC contribution to the work of the Fifth world Water Forum in Istanbul, Turkey, 16-22 March 2009.

Several international and regional organizations have cooperated to this International PECC project to prepare this set of recommendations transmitted to the World Water Council: SOPAC, UNDP, in liaison with regional and institutional lenders such as the ADB and the AFD (Agence Française de Développement), along with Research Centres and representative from business and academic sectors. For all these partners, an appropriate management of water in islands and coastal regions, interactions between fresh and salt water, preservation of water quality… are issues that are considered as more and more important.

The purpose of this PECC International Project was threefold:

1) Firstly, the sharing of information about the best management of clean water in island territories, coastal regions and isolated communities. Water shortage associated with the potentially negative planned effects of climate change, and its bearing on the management of the resource: identify best practices to reduce water consumption at the individual and at the industry/agriculture level, and make best use of the cubic meter of water distributed, particularly in water stressed or water scarce regions. A large number of territories in the Asia/Pacific region already suffer from a severe water shortage; similarly, in many countries worldwide the present pace of water consumption does not permit a satisfactory timely refill of the groundwater reserve.

   Islands and Pacific islands countries are not so different from other economies in that clean water is essential to human activities and a major requirement in agriculture and industry; but the ability of these islands is constrained by their small size, fragility, vulnerability, and often limited human and financial resource base. At the same time, the Pacific region is impacted by climate change and potential natural disasters that may have the most severe effects on small isolated communities.

2) Second, the acknowledgement that water is a scarce resource and that efforts have to be made in the field of research and development leading to new technologies such as:
   - wastewater recycling associated with an increase in the reuse of water;
   - the examination of competing desalination practices;
   - a more extensive use of rainwater harvesting and fog harvesting, associated with the development of efficient storage facilities at both the private and public level;
   - the development of sound and sustainable technologies at a reasonable cost that can be met by local users with limited maintenance efforts in islands territories and isolated areas;
   - the use of renewable energies such as wind, solar, wave, bio fuels when developing new water treatment plants.

3) Third, the identification of ways and means of developing new governance arrangements in the use of water; water crisis is a deficiency of water governance. Water management deserves bringing together our forces to give an adapted response to water shortage and water quality. There are rights and interests linked to cultural and traditional community structures. True partnership by all stakeholders must

prevail. There is a need for institutional perameters of solidarity: geographical, social, economic, and it is most necessary to combine them when necessary.

Competition between users is increasing in intensity, conflicts may arise between operators and users, between public entities and private operators, between geographical, economic or social category of users.

Water is a source of interdependence, it is a shared resource serving multiple constituencies (agriculture, industry, households), accordingly there is a need for increased consultation between stakeholders before a decision in the field of water management is taken, with a view to building capacity among stakeholders.

A good water policy cannot be effective without determining the sharing of responsibilities between public authorities, service operators, and financing organisations. Good governance requires formalising the rights and duties between the stakeholders. For that purpose it is necessary to:

- Make best efforts to develop a body of common practices to guarantee the availability of the resource and its quality both for domestic and industry/agriculture use.
- Avoid potential conflict that could arise within local populations or between economies, raising questions about rights of access to water, its appropriate cost and priorities for its use (both from an economic and legal point of view).
- Implement a pricing policy, balancing the fact that drinking water is not a free service, but also an absolute human need.
- Establish efficient governance, based on a legal framework, in order to protect the resource and its distribution and set up a differentiation strategy between human, agricultural and industrial uses.

Five main issues with regard to water management in isolated and island territories have emerged from the seminars discussion; they have led to this proposed set of *Five PECC voluntary Guidelines and recommendations on water management in islands, coastal and isolated areas:*

Voluntary Guideline 1 - A need for best practices in the management of water services

Recommendations for optimization and performance improvement of water and sanitation services

• *To public authorities/governments at all levels*	• *To operators of water and wastewater services*	• *To public at large*
– Look for a more integrated approach with a view to optimizing water services at all levels: technical, human, organizational, financial, environmental. – Define the water policy, the water and wastewater service objectives and the performance levels to be reached. – Give itself the means of checking and assessing regularly the services performances, measure the level of satisfaction of the end-consumers and continually drive the operator to make progress, to prevent it from being content with mediocre results; – Respect the several functions of a tariff policy which is at the same time: ✓ an instrument to ensure the financial sustainability of the service in the long run, and then its quality; ✓ an instrument for social solidarity, to make sure that low-income households have access to this basic service; ✓ an educational instrument for inducing water savings behaviour; – Anticipate the balance between supply-demand, in particular in isolated communities which cannot be connected to neighbor networks in case of water shortage, and, more generally, implement an overall policy to achieving sustainability in water and taking the impacts of climate changes into account; – Consider the expertise of the private sector that has come as a result of public private partnerships. Through the private sector can come the knowledge and experience gleaned from other communities that have success and results to share.	– Save water resources. Water savings in urban networks are often the resource that is immediately available in the largest quantity. In practice, a good operator of water services is both a "*water saver*" and a new resource creator; – Regularly maintain and renew the existing infrastructure and optimize it so that it is possible to serve more people with the same means; – Adapt, at all times, the skills of service employees to activities and resources that are becoming increasingly complex to manage; anticipate future needs by training employees to use new technologies ; mobilize staff at all levels in order to reach the water services objectives fixed by public authorities; – Develop a customer oriented culture to better know and satisfy clients' expectations. Delivering a continuous service 24 hours per day/,7 days a week, and drinking water respecting public health standard is a prerequisite before looking for satisfying upper clients' expectations; – Control systematically all operation and capital costs, in order to control tariff and release recurring cash flows. This will allow to improve the quality of the service and to fund new infrastructures. A specific attention should be given to procurement, maintenance and renewal, energy efficiency and costs, and labour costs. – Move toward a water supply culture and toward a culture of water demand management. The challenge is to involve consumers so that they act as manager of their consumption and protector of the environment. Therefore, the operator should give the population the means of managing its consumption (by generalizing installation of individual meters, remote meter reading, SMS information systems,…).	– To farmers: save water to irrigate crops by using techniques such as drip irrigation. Agricultural production cannot continue to increase at the rate necessary to feed the world's people unless water is used less extravagantly.

<table>
<tr><th colspan="3">Recommendations with regards to sanitation in coastal areas in general</th></tr>
<tr><td>• To public authorities/governments at all levels</td><td>• To operators of wastewater services</td><td>• To public at large</td></tr>
<tr><td>– Manage in a coherent way the coast and the sea, plan sanitation coherently with urban development and economic activities and take into account the impact of climate change on sanitation systems;
– Bridge the gap of universal access to sanitation which is the priority before upgrading existing systems, but don't restrict sanitation to toilets;
– In tourist destination:
✓ Implement at the same time the two policies, tourism development and environmental infrastructure construction. Sanitation should be managed in pace with tourism policy, in order to contribute to the well-being of residents and visitors alike.
✓ Check regularly and quickly the quality of bathing water, in order to decide whether to open or close beaches to swimmers. Bathing water should be placed under close surveillance.
– Present the wastewater service as a driver of development for all stakeholders and give to sanitation policy a high degree of priority among public policies.</td><td>– Collect and treat all the sources of pollution of aquatic environments (domestic wastewater, industrial wastewater, stormwater). None should be left out. If just one of the causes of pollution is neglected, the benefits of efforts made to deal with the other sources could be reduced.
– Ensure a thorough and constant level of treatment, in order to minimize pollution discharged into the environment;
– Manage actively the wastewater system during rainy events to limit direct discharge of untreated wastewater into the sea. The sea has to be protected under all circumstances. Wastewater infrastructure is easily managed during dry weather, but the performance of these systems can be compromised during wet weather;
– Select space-saving technologies for high density territories;</td><td>– To industry: treat industrial and toxic effluents at the source.
– To industry and agriculture: consider ecological sanitation alternatives such as recycling wastewater.</td></tr>
</table>

Recommendations with regard to sanitation in small islands		
• *To governments at all levels for a better sanitation*	• *To service operators*	• *To public at large*
– Make use of high-level discussion platforms to mobilize political support for strategic actions required to achieve the MDG sanitation and drinking-water target in the island countries; – Develop a sound sanitation and drinking water monitoring and evaluation system for the island countries, capable of collecting, analyzing and disseminating population-based information on access to sanitation and drinking water. With a view to providing recurrent information on the following: access to sanitation and drinking water services; drinking water quality; hygiene behaviours; water-related diseases. – Promote and support the inclusion of national drinking water safety plans into the national development planning process for the island countries as a crucial measure to improve drinking-water quality generated by the existing and future islands water supply systems; – Promote the establishment of national sanitation, hygiene and drinking-water assessments within the perspective of a sustainable integrated water resources management.	– Encourage technical innovation to facilitate technology transfer allowing for adaptation of designs to local circumstances. – Avoid conflicting and contradictory messages and programmes and encourage open debate so that communities can make informed choices on the eco-sanitation approaches and technologies. – Develop adequately prepared training to introduce eco-sanitation and best practice ecologically sustainable technologies with appropriate follow-up and support using a flexible approach to ensure that local priorities, beliefs and taboos are being addressed.	– Implement practical hands-on training. It is an effective way to promote a sanitation system and convey the principles behind the approach. People are empowered by learning technical skills and knowing that they can make well-informed choices, and that they can construct and maintain the systems themselves. In the Pacific region there are limited opportunities for such training and wider use of this demonstration facility will ensure that affordable and acceptable technologies get replicated in other areas. – Encourage trainees to present what they have learnt to their community. It is an effective method to reinforce and clarify the message, but it is also important that the trainee has the confidence and ability to explain the information in a public setting. – Encourage active involvement of women in the practical training, discussion and decision-making, in order to promote overall participation and understanding in a community. It may be necessary to ensure that women are not prevented from attending the workshop because of their domestic responsibilities. – Beyond practical training on sustainable on-site sanitation, facilitate a further understanding of the complexity of each specific context to allow for further replication of appropriate on-site sanitation technologies.

Voluntary Guideline 2 - A need for best practices in mining industry and agriculture to compensate water shortage and pollution

Recommendations for mining

- *A responsible management for human and environmental issues calls for*

  – An early, permanent and open dialogue.
  – Transparency in the development of the project to reach a high level of trust and respect between the local communities and the mining operator.
  – Implementation plan involving the community.
  – Long term commitment of the mining companies and guarantees by the local government.
  – Internationally recognized environment and water regulation.
  – Responsible and comprehensive mining rehabilitation scheme, including large scale revegetation planning and implementation.
  – Development of new projects in harmony with local economic, technical and social rules and regulations.

- *Sharing the water resource*

  – Extensive preliminary studies to identify all potential water resources.
  – Adequate evaluation of present and long term needs of the population and of mining requirements for water.
  – Audits by external governmental or non governmental organization of these studies to insure objectivity of the results.
  – Show genuine respect to the population by organizing explanation of the projects to the different users of the community.
  – Ensure total comprehension and adhesion to the project by the local communal authorities through frequent formal and informal meetings.
  – Regularly inform the general public of the progress of the project and of the final conclusions through local media.

- *Protect the water resource and the environment for a sustainable development*

  – Manage rain water on roads and pits to avoid pollution of downstream areas by engineered collecting systems and treatment prior to rejection into natural creeks and rivers.
  – Promote best practices by all means including penalties when required.
  – Implement revegetation of mining sites with endemic plants everywhere possible. Involve local population in this activity to create jobs and bring sustainable wealth to their Community.
  – Monitor consumption at all times to avoid spillage and waste. Training can be organized to make operators more conscious of situations where spillage and waste can be avoided. Monitoring consumption can also help because it can give a measurable value to the water used.
  – Generalize use of modern on site autonomous water treatment systems to prevent rejection of untreated used water.
  – Optimize industrial processes to minimize water needs.

- *Promote close partnership between industry and research.*

  – Successful sustainable development requires front end scientific research work closely associated with terrain practises.
  – Private and Public Partnership: Water should to be considered as scarce and precious enough to motivate industrial operators to engage themselves into private and public partnership to develop their technologies in order to minimise water requirements, protect water resources, avoid pollution whenever and wherever possible and reduce it to the smallest possible expression when not possible, reduce costs of revegetation.

<table>
<tr><td colspan="3">• Define with the mining operator and the Community a legal framework that takes into account the specificity of each project and the Community</td></tr>
<tr><td colspan="3">– Make sure to include water as one of the important elements in legal agreements concluded between the mining operator and the community.
– In the legal framework, take into account the specific context of each project and each community. The technical considerations which are specific to the project, the short term and the long term needs of the population and the local rules and regulations must be examined thoroughly in order to secure a balanced implementation scheme.</td></tr>
<tr><td colspan="3">Recommendations for agriculture</td></tr>
<tr><td colspan="3">• General recommendations:</td></tr>
<tr><td colspan="3">– Develop and provide to farmers simple and inexpensive measurement tools to enable them to make good tactical decisions about the need for irrigation and agrichemical applications.
– Develop modelling tools and use them as Decision Support Tools to guide both policy initiatives to regulate water consumption and agrichemical use, and so that these can be translated into simple tools for farmers to manage sustainably their lands through best practices.
– Develop participatory learning and action protocols so that policy agencies (both agricultural and environmental), farmers, exporters, scientists, and the local communities can develop a better understanding of the productive capacity of their lands, the natural capital value of their islands, and the human well-being that flows from the ecosystem services of islands, coastal and isolated areas.</td></tr>
<tr><td>• To public authorities & governments</td><td>• To operators of water services</td><td>• To public and water users</td></tr>
<tr><td>– Stop policy-induced scarcity. Water provides a vehicle for transferring environmental costs, distorting economic signals. Perverse subsidies are visible in many stressed environments. The under pricing of irrigation water creates disincentives for conservation. It should come to an end.
– Develop water allocation guidelines for consents, using Decision Support Tools, for sustainable water takes according to crop type, soils, weather, and land-use practice.
– Monitor the quantity and quality of water resources and report these annually.
– Estimate, or better still meter, the consented takes of water for agriculture, and report these totals annually. Metering devices are now quite inexpensive.
– Report annually the ratio of consented water takes in relation to the volume of the available water resource;</td><td>– Use Decision Support Tools as guidelines to determine what are the sustainable needs for water by various agricultural crops and land uses.
– Engage with farmers and water users to develop a ‘community of practice’ around the sustainable use of water for agriculture, and the negative consequences of poor watering practices.
– Expand this ‘community of practice’ across the islands of the Pacific, and Indian Oceans, to enable collective learning about the special aspects and unique solutions for water management on low and tall islands.</td><td>– Increase the general understanding of the size of the ‘water footprint’ of agriculture.
– Highlight the economic and environmental costs and benefits of the use of water in agriculture, and demonstrate the imperative of shrinking the size of agriculture’s water footprint.
– Use Decision Support Tools and simple measurement devices to minimise the use of water in agriculture and report the continuous improvement in water practices.
– Increase water productivity in agriculture. Living in a world with limited resources means that we have a moral obligation to use in the most efficient way each cubic meter and each dollar directed to water sector.
– When water is scarce, promote drip irrigation technology with allow to save large volumes of water compared to classical irrigation methods.</td></tr>
</table>

Voluntary Guidelines 3 - A need for developing alternative water resources to face water scarcity		
• *To public authorities, governments at all levels*	• *To operators producing water from alternative water resources*	• *To public at large*
– When developing alternative water resources, always involve stakeholders and large public since the early beginning of projects. – Consider both wastewater reuse and desalination as a viable alternative water resource in coastal and tourist area and adapt their implementation to local conditions and specific needs. – Balance the advantage and limitations of each kind alternative resources, according to the need of water users. Wastewater reuse is less energy intensive and more environmentally friendly than desalination, but desalination is the most straightforward option to produce additional freshwater. – Adapt water reuse projects to water quality requirements of end–users. They can be politically more complex, as they require to involve many stakeholders, take into account health standards and public perception.	– Select proven treatment technologies that can be easily adapted to the given local conditions. – With regards to desalination, consider membrane treatment as a preferred option compared to thermal desalination in Pacific region: (1) Reverse osmosis for desalination with energy recovery and (2) membrane bioreactors or tertiary membrane filtration as space saving technologies enabling to produce high quality water for various reuse purposes in tourist and urban areas. – Consider natural wastewater treatment technologies for rural areas and at small scale, while wastewater reuse for irrigation is the main potential reuse application. – Ensure rigorous maintenance of treatment plants to guarantee public health and water security, and to increase life-time of equipment and reliability of operation. Existing reuse projects worldwide demonstrate that water reuse is safe practice without any health risk when wastewater is properly treated and good practices are applied. – Implement best management and operation practices to reduce energy requirements and operation costs maintaining strict compliance with water quality standards.	– Support the mobilisation of alternative water resources as essential elements for integrated water management and sustainable development.

Voluntary Guideline 4 - Controlling the cost of water provision and wastewater services		
Recommendations to optimising the cost of water services		
• *To public authorities/governments at all levels*	• *To water services operators*	• *To public at large*
– Set up regulatory mechanisms to optimize operating and infrastructure costs. One of the main tasks of the organizing authority is to continually drive the operator (public or private) to make progress, to prevent it from being content with mediocre results, with high costs and low performance. There can be no efficient and cost-effective operator without a strong organizing authority. – Implement an operational structure that generate economies of scale. The larger is the scope of activities of the operator, the more it can optimize costs; – Organize competition to better control costs while improving water and sanitation services. Calling for tenders can bring discounts compared to the cost of a public management project or provide a a reference cost for the public operator in place if it keeps on running the service; – In case of Public Private Partnership, select a contractual arrangement that optimizes the whole cost structure of the service, not only one part of them, and that allow the municipality and the population to benefit from all the savings a professional operator can bring.	– Optimize the service as a whole, OPEX and CAPEX, in order to improve the quality of the service provided and release recurring cash flow to fund new infrastructure. – Extend cost control to all kind of costs, with a specific attention to procurement, maintenance, infrastructure renewal and labor cost. – Look for technical and economical optimum while selecting materials and process. – Manage existing infrastructures to the best of their ability in order to reduce the costs of new investments.	– Recognize that water and wastewater services have a cost which should be covered by users and/or taxpayers.

Recommendations with regard to the energy issue in water sanitation		
• *To public authorities/governments at all levels*	• *To water services operators*	• *To public at large*
– Encourage energy savings in water and wastewater services through performance objectives and incentive mechanisms. The most eco-friendly kWh is the one we don't consume. What is saved is saved every year. – Select water sources and processes taking into account energy consumption and green house gas emissions. – Promote research programs that aims at reducing energy consumption of alternative water resource process including desalination and wastewater recycling.	– Optimize energy in conventional water production plants and give specific attention to pumping energy consumption and leakage reduction. – Anticipate the renewal of equipments if it is appropriate to reduce energy consumption and save money. – Implement state of the art energy recovery system to reduce the electricity consumption of membrane process. – Consider sludge as a source of energy, in order to increase the energy independence of wastewater treatment plant. – Minimize the energy consumption all along the life span of the plants through life-cycle assessment approach. – Use the large areas covered by drinking water production plants or wastewater treatment plants to produce solar energy. Roof solar power station can equip drinking water plant or waste water treatment plants and cover part of the electricity needs.	– Implement optimization programs in order to save energy.

Voluntary Guideline 5 - A need for a better governance in the management of the water cycle, water services and sanitation services

Recommendation with regard to trust and partnerships

• *To public authorities/governments at all levels*	• *To operators of water services*	• *To public at large*
– Set up a clear governance system where the respective role of each stakeholder is clearly defined and contain no overlap between different actors. – Provide reliable and sound information for all stakeholders, including the civil society and media, so that debates and arguments are based on facts rather than emotive reactions. – Organize the evaluation of water policy and service performances with external experts. These evaluations also produce factors for comparison and reflection with stakeholders. – Arrange a regular quality dialogue with all stakeholders to lay the basis of a trusting long-term relationship with them and organize extensive public consultation before major projects or changes in the water policy.	– Put consumers at the heart of services management, to boost quality service and customer satisfaction and implement projects that generate immediate and visible results, in particular in destitute. – Issue concrete commitments to subscribers and promote transparency through performance evaluation criteria and regular reporting on ongoing activities, since it facilitates the establishment of trust with consumers. – In coordination with public authority, develop external communications aimed at the general public to keep him informed of the performance of the public service and to respond to any requests. – Gain quality assurance certification since it provides an extra guarantee of the reliability of activities.	

Recommendation with regard to the pricing of water resource

• *To public authorities/governments at all levels*

– Recognize water also as an economic good. The total economic value of water includes both commercial and non-commercial values. Water resource management institutions should be designed with the aim of generating information and creating incentives that guide decisions in the direction of maximising total economic value.

– Organize institutional design so that it can balance market demand with maintaining environmental quality. Managing this interface is a particular challenge because markets generate information on water value whereas prices are not associated with non-market services.

– Where water use can be metered, promote the adoption, by water services providers, of price strategies that recover the full cost of supply and recognise the scarcity value of water. Uniform block tariffs can be used by municipalities to balance revenue with the cost of supply. However, in cases where water is scarce then municipal supply authorities should adopt increasing block pricing strategies. Pricing structures should be fashioned so as to recover capital and operating costs, the value of water in its next best alternative use, and give due consideration to in situ values of water;

– Define high quality water rights if water is to gravitate to uses that enhance productivity and value. In agriculture, where equity is not a concern, tradable rights have been shown to economise on water use and increase productivity. Where rural poverty is of concern the welfare of low income users can be protected and enhanced by the appropriate design of water rights;

Recommendations with regard to the set up of a legal framework:		
• *To public authorities and decision makers*	• *To operators of water services*	• *To public at large*
– Organize a common corpus of rules, to federate global agreements. – Create a Pacific Island Coastal and Isolated Areas Committee for water, to establish the basis of a global governance. – Favor circulation of water data between stakeholders. – Define a water policy and articulate it with closely related policies and sector based policies (urbanism agriculture, industry, tourism, biodiversity) in the concerned areas. – Settle new rules with incentives and financial penalties. – Establish the frame of an ecological damage or disaster and ecological responsibility. – Define scheme for "*water pollution allowance trading*". – Define the good levels of local governance, and eventually create local water agencies or committees with a subsidiary power. – Reinforce the strength of the contract when regulation is weak, for example through Public Private Partnership and favour firms' innovations and their diffusion. – Create a new entity and alternative procedure of conflicts resolution.	– Contribute to create trust through contractual links, and local links with the populations complying with their social and cultural specificities. – Be respectful of aims of quality of water. – Participate to the regulation through their offers and prices policy. – Become aware of their environmental liability, and to avoid pollution.	– Recognize areas of solidarity and respect community specificities. – Adopt responsible behaviour. – Participate to all type of dialogue. – Accept, in case of conflicts to appeal to alternative dispute resolution.

CHAPTER 1 - A NEED FOR BEST PRACTICES IN THE MANAGEMENT OF WATER SERVICES

1 - Pacific Islands water challenges

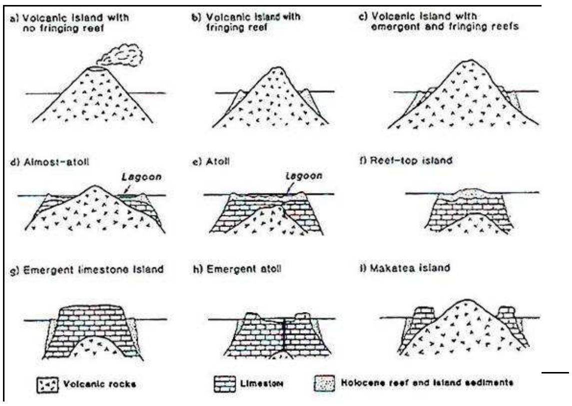
In the Pacific region there are 14 island countries and several island territories which together consist of only 550,000 km^2 of land with approximately 7 million inhabitants, speaking in the order of 1,000 different languages, spread across 180 million km^2 of ocean or about 36% of the world's surface. Pacific island countries and territories (PICTs) are no different to any other in that freshwater is essential to human existence and the sustainable development of small economies. However, the ability of the island countries to effectively manage the water sector is constrained by their unique characteristics of small size, fragility, natural vulnerability, and limited human and financial resource base, to mention but a few.

Most of the islands can be considered as "small", i.e. islands with areas less than 2,000 km^2 or widths less than 10 km (UNESCO, 1991) and most of these fit into the category of "very small islands", which are less than 100 km^2 or have a maximum width of 3 km. Many of the populated islands in the Pacific are less than 10 km^2 while some, especially those on atolls, are less than 1 km^2.

Over 30,000 small islands are in the Pacific (UNESCO, 1992) and they vary greatly in their physical characteristics including high volcanic islands, low lying atoll islands and uplifted limestone islands. The high islands are large, consisting mainly of volcanic rock and are generally forested with fertile soil and usually an ample availability of freshwater. The low islands are usually small with limited freshwater resources and poor soil. In very small islands, surface and groundwater resources are generally limited to the supply of water to island communities.

Of the 18 Pacific Island Countries and Territories five are in Melanesia, seven are in Polynesia and six are in Micronesia. The Melanesian countries (Fiji, New Caledonia, Papua New Guinea, Solomon Islands and Vanuatu) are extensions or parts of undersea mountain ranges. The Polynesian and Micronesian islands are made up of small island groups consisting of a mixture of larger volcanic islands and small coral atoll islands (American Samoa, Cook Islands, Federated Sates of Micronesia, French Polynesia, Guam, Palau, Samoa and Tonga) or consist only of atolls (Kiribati, Marshall Islands and Tuvalu) or small uplifted limestone islands which are the only non-archipelagic countries in the Pacific (Nauru, Niue). Variations of volcanic, limestone and coral atoll type islands in the Pacific are shown in the figure below.

Main types of mid-oceanic islands in the Pacific. (Woodroffe, 1989)



Increased urbanisation and economic development in Pacific coastal areas are putting pressures on already fragile and limited surface water and groundwater resources. Unsustainable practices such as the overexploitation of aquifers leading to saltwater intrusion; surface water and groundwater chemical pollution from industries; inadequate wastewater disposal; overuse of pesticides and fertilizers in agriculture; high freshwater consumption; unacceptable levels of unaccounted for water through leakage; high sediment levels in rivers due to soil erosion and unsustainable agricultural practices; etc. will ultimately all result in a scarcity of freshwater in the region.

It will be good to note that this scarcity is not only a matter of quantity but it is intrinsically linked to the quality of water. As the most prominent use of water in Pacific island countries and territories is domestic water supply, the safety of freshwater is essential as is the potability of the water related to its salinity.

Beyond these anthropogenic influences the increasingly variable rainfall, cyclones, accelerating storm water runoff, floods, droughts, decreasing water quality and increasing demand for water are so significant in many small island countries and territories, that they threaten the economic development and the health of their peoples.

The Intergovernmental Panel on Climate Change (IPCC) continues to report that expected climatic changes over the region will stimulate an increase in extreme weather events that include higher maximum temperatures, increased number of hot days, more intense rainfall over some areas, increased droughts in others, and an increased frequency and severity of tropical cyclones. Although the contribution of small island countries to greenhouse gas emissions is globally insignificant and rank amongst the lowest in the world, the islands face arguably the heaviest and most immediate burden of climate change.

1.1 - Challenges and Constraints

The challenges and constraints of sustainable water resources management in Pacific island countries and territories were categorized into **three broad thematic areas at the regional consultation on Water in Small Island Countries held in preparation of the 3rd World Water Forum in Kyoto 2003.** These are:

1) **Pacific island countries and territories have uniquely fragile water resources due to their small size, lack of natural storage and competing land use, vulnerability to natural and anthropogenic hazards, including drought, cyclones and urban pollution. This requires detailed water resources monitoring and management and improving collaboration with meteorological forecasting services.**

2) **Water service providers face challenging constraints to sustaining water and wastewater provision due to the lack of both human and financial resource bases, which restrict the availability of experienced staff and investment, and effectiveness of cost-recovery. Future action is required in human resources development, water demand management and improving cost-recovery.**

3) **Water governance is highly complex due to the specific socio-political and cultural structures relating to traditional community, tribal and inter-island practices, rights and interests. These are all interwoven with past colonial and 'modern' practices and instruments. These require programmes to develop awareness, advocacy, and political will, at all levels to create a framework for integrated water resources management.**

1.2 - Coping and adaptation to Climate Change and Anthropogenic Influences

Through an analysis of vulnerability and adaptation assessments undertaken under the United Nations Framework Convention on Climate Change (UNFCC), it was found that climate variability, development and social changes and the rapid population growth being experienced by most Pacific island countries and territories are already placing pressure on sensitive environmental and human systems and these impacts would be exacerbated if the anticipated changes in climate and sea level (including extreme events) did materialise.[1]

This finding is particularly significant since it implies that in most parts of the Pacific region present problems resulting from increasing demand for water and increasing pollution of water may be much more significant that the affects of climate change. Therefore, addressing the challenges we currently face in water management will become increasingly important because there is general agreement that the supply of and demand for freshwater resources will be substantially affected by climate change over the longer term.

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[1] *Hay, 2000*

The Global Water Partnership states in their latest Policy Brief that the best approach to manage the impact of climate change on water is that guided by the philosophy and methodology of Integrated Water Resources Management (GWP, 2007). It also states that the best way for countries to build the capacity to adapt to climate change will be to improve their ability to cope with today's climate variability.

For small islands, climate change is just one of many serious challenges with which they are confronted. Adaptation to climate change impacts certainly requires integration of appropriate risk reduction strategies within other sectoral policy initiatives such as in water resources management.[2]

In the Pacific region, the concentration on the potential impacts of climate change on small island communities has even deflected attention and resources away from the immediate and serious day-to-day problems faced by small island nations, particularly in water resources.[3] The above obviously does not preclude the application of coping strategies and adaptation measures to climate variability and change, which on the contrary, is essential for the sustainable management of water resources in Pacific island countries and territories.

"*Island Vulnerability*" and the Pacific Regional Action Plan on Sustainable Water Management

Regarding the vulnerability of Pacific island countries and territories to climate variability and change as well as anthropogenic influences, the required coping and adaptation strategies have been articulated under a specific theme of "*Island Vulnerability*" in the Pacific Regional Action Plan on Sustainable Water Management (Pacific RAP) as follows:

- *Key Message 1:* Strengthen the capacity of small island countries to conduct water resources assessment and monitoring as a key component of sustainable water resources management.
- *Key Message 2:* There is a need for capacity development to enhance the application of climate information to cope with climate variability and change.
- *Key Message 3:* Change the paradigm for dealing with Island vulnerability from disaster response to hazard assessment and risk management, particularly in Integrated Water Resource Management (IWRM) and Drinking Water Safety Planning.

1.3 - Future Outlook

It is generally recognised that improving the way we use and manage our water today will make it easier to address the challenges of tomorrow.

A recent WHO/SOPAC report revealed that the annual incidence of diarrhoeal diseases in the Pacific, still nearly matches the numbers of its inhabitants with 6.7 million cases of acute diarrhoea each year, responsible for the annual death of 2,800 people, most of them, children less than 5 years old. Country statistics on access to improved sanitation and improved drinking-water indicate that on average, approximately only half of the total population of the Pacific island countries are served with any form of improved sanitation or drinking-water.[4]

It is clear that increased efforts are required to achieve the Millenium Development Goals targets of halving the proportion of people without access to safe drinking water and basic sanitation by 2015 as well as the target of developing national Integrated Water Resources Management and Water Use Efficiency plans.

1.4 - Recommendations for action

Following the above key messages some actions are recommended as priority for Pacific island countries and territories:

- *Water resources monitoring and assessment*

There is a need to invest in adequate water resources monitoring and assessments in order

[2] *Emma L. Tompkins et al., 2005*
[3] *White I. et al, 2007*

[4] *WHO/SOPAC, 2008*

to cope with climatic extremes, both droughts (often related to ENSO events) and flooding (often linked to the occurrence of cyclones).

Insufficient understanding and knowledge on how rivers respond to extreme rainfall or how resilient aquifers are in prolonged periods of drought, will compromise the provision of freshwater supplies. This requires the increased capacity of National Hydrological Services in flood and drought forecasting as well as a stronger collaboration between them, water resources managers and water utilities.

Awareness of the effects of floods and droughts on drinking water quality needs to be increased through closer engagement between water users and water suppliers. Increased health surveillance and water quality monitoring should be encouraged especially in times of disasters.

- *Using climate information*

There is a need to make use of climate forecasts to support decision makers in the water sector. Research into the interaction of the ocean and atmospheric over the last two decades has resulted in an impressive ability to observe and account for many of the factors governing climatic variability at the seasonal and inter-annual time scale.

National Meteorological Services are being strengthened in their capacity to develop techniques that are able to produce climate forecasts of modest skill but this information is not easily accessible and available for interpretation by water resources and water supply managers. Strategies for especially the rainfall dependent low lying atoll islands to cope with extended periods of drought, will largely depend on their ability to make interpretations of 3-monthly rainfall forecasts.

Strategic storage of rainwater and the introduction of water saving or water conservation measures adopted by both the utility and the general public, will enhance the ability of Pacific island countries and territories to overcome droughts and maintain sufficient standards of drinking water quality.

- *Mainstream risk management into water supply and water resources management*

There is a need to mainstream risk management into water supply and water resources management, building on the integrated approaches adopted by Pacific island countries and territories such as Drinking Water Safety Planning and Integrated Water Resources Management. The concept and the approaches IWRM embodies - namely, the need to take a holistic approach to ensure the socio-cultural, technical, economic and environmental factors are taken into account in the development and management of water resources - has been practised at a traditional level for centuries in the Pacific Islands.

For Pacific island countries and territories these IWRM plans would need to include drought and disaster preparedness plans. Pollution on land from inadequate wastewater disposal, increased sediment erosion and industrial discharges, are impacting upon coastal water quality and fisheries stock which sustain entire island populations. This requires Pacific island countries and territories to look at managing water resources not only within the watershed but also the receiving coastal waters.

Drinking Water Safety Planning is defined as "*a comprehensive risk assessment and risk management approach that encompasses all steps in the water supply from' catchment to consumer' to consistently ensure the safety of water supplies*".[5] It addresses all aspects in drinking water supply through an integrated approach with a focus on the control of abstraction, treatment and delivery of drinking water in combination with attention for awareness and behaviour change.

This requires close collaboration between the water supplier, the water quality and health regulator and the water resources managers in conjunction with a strong participation of communities living in catchments of high volcanic islands or on top of water reserves on low lying atolls or raised limestone islands. Improved hygiene behavior and awareness of the linkages between drinking water and health are essential and participatory approaches and

[5] *WHO, 2004*

community based monitoring are needed for urban as well as rural communities.

- *Demand Management*

Pacific Island nations have some of the highest per capita demands for water in the world. As an example, the Koror / Airai water supply system in Palau produces, on average, 900 litres per person per day to meet the demand for piped water in the Koror / Airai urban area. The high demands result from high per capita consumption of water, in conjunction with substantial leakage and other physical losses from the water supply networks. With population growth and increasing consumption at the individual consumer level, many water supply operators in Pacific Island nations are unable to provide secure, reliable and sustainable water supply services to customers and require substantial capital works to meet the demand.

Demand management, or resource conservation, provide water supply operators with the opportunity to increase the efficiency of water supply systems at relatively low cost and the potential to defer costly water supply capital works programs.

Demand management measures available include:

– reducing system losses through leak detection and repair programs, reducing supply pressures, and optimizing peak demand balancing capacity;

– encouraging consumer conservation through community awareness and public education campaigns to use water wisely;

– implementing appropriate tariff structures and charges that reflect the true cost of treating and distributing water to consumers;

– promoting the use of other sources of water at the local such as household rainwater tanks and the reuse of greywater; and,

– encouraging the use of waterless sanitation.

2 – Water service optimization and performance improvement

2.1 - Water and wastewater service performances and environmental protection

Many services, whether they are located in islands or coastal territories of large countries, are trapped in a vicious circle of poor performance such as: high water losses, excessive energy consumption, low level of service (eg, water supplied to residents 2 hours a day on alternating days), overstaffed utilities, inability to attract capable human resources, over-extraction of water resources and low cost recovery. In most cases, this is due to bad governance and to the fact that water service improvement has not been selected as a priority by public authorities.

Another aspect of this issue is the general under-pricing of water by water utilities. As a consequence, funds are not provided for replacement of capital; maintenance budgets are reduced; the service quality itself declines and systems are not expanded to the unconnected. In fact, many utilities have been locked in a cycle of underfinancing, undermaintenance and underexpansion.

Furthermore, grossly underpriced water perpetuates the illusion that it is plentiful and nothing is lost when it is wasted. Water may be available in finite quantities—but it has been treated as an environmental resource with no scarcity value. In a context of growing scarcity, a key target of pricing policies should be to give a price to nature and a cost to pollution.

The coast is a source of pride for many communities and the sea is a common asset that should be preserved. Without improvement of water and wastewater service performances, it will be impossible for coastal cities to break the link between urban growth and pollution of aquatic environments; to protect better the sea while satisfying the domestic, industrial and agricultural demand for water; to absorb tourism and manage its impact.

2.2 - Toward an overall optimization of water services

It is fundamental to optimize "*everything that can be optimized,*" and to improve the water service at all levels: technical, human, organizational, financial, environmental, etc. This overall optimization makes it possible to improve the quality of the service provided and to generate recurring cash flow to finance new infrastructure. Without operational effectiveness of water and wastewater services, environmental protection and public health are not secured and economic development is limited.

In this context, one of the main tasks of the organizing authority is to continually drive the operator (public or private) to make progress, to prevent it from being content with mediocre results: there can be no efficient operator without a strong organizing authority.

In the case of Public Private Partnership, only contracts covering complete missions can turn around an entire service. In counterpart, this highlights one of the main limitations of Build-Operate-Transfer contracts (BOT), as they deal with a single issue within the management of a service: for example, the construction and then the operation of a water treatment plant.

- *Maintaining infrastructure*

The most "*up-to-date*" public infrastructures prove to be disappointing when their management and maintenance are not funded in the initially approved amounts. Faced with growing demand, it is necessary to create new installations. However, economic history highlights the importance of properly managing existing infrastructures to get the most out of them. The quality of service depends on works maintenance and discipline in their daily management.

- *Optimizing existing infrastructures*

By exploiting existing infrastructure better, it is possible to supply more people with water using the same resources and reduce or delay the need for certain investments. This is—or should be—the prime role of a professional water services operator. Emerging countries are going through an intensive period of infrastructure building: in such periods, there is a tendency to focus on the construction of new infrastructure rather than improve the operation of what already exists. These two approaches are, however, complementary.

In the distribution networks in many cities, losses can be as much as 50%. Out of 2 cubic meters of water treated, 1 cubic meter is lost during its transport to the end consumer! Reducing these losses can improve water supply pressure and continuity to outlying areas: the volume saved can be redirected to areas that are under-supplied with water and which are also the poorest. Many measures can be taken to deal with this issue: adaptation of equipment usage instructions, sectorization of water distribution network stages, revision of preventive maintenance, etc. Similar improvements can been undertaken for sanitation system in order to optimize their management (functioning of storm overflows, sediment buckets, rainwater holding ponds, etc.).

- *Improving the continuity of essential services*

Because they are essential utilities, water and sanitation services must be offered continuously. For many drinking waters services the challenge of moving from an intermittent to a continuous service is a momentous one. Each service should be managed so that the water network would function 24 hours a day and seven days a week: public health and environmental protection has to be guaranteed permanently.

- *Modernizing customer management*

Focusing services on customers is an essential aspect of a good governance policy. In a context of increasing expectations of the general public with regard to information and customer relations, water services should increase their efforts to strengthen customer culture. They have to put in place tools to offer its clientele responsive, high-quality service in order to meet customers' requirements as effectively as possible. It is all the more necessary since customers are comparing the performances of various utilities (mobile phone, electricity,…). Improved customer management relies on the principles of proximity, availability and effectiveness and the implementation of modern communication tools such as Call Service Center.

- *Instilling dynamic management of human resources*

Highly committed and motivated people are the key to success in all service activities. This is also the case for water and wastewater. Men and women are the core of water service professions: they are the source of all improvements. Enhancing skills is a prerequisite to maintaining individual and collective performance over the long term. Among various steadfast values, human resource management should be founded on accountability and mobilization of all.

In overstaffed utilities, driving down operating expenses is a necessity in order to free up financial resources for investing in new infrastructure and improving the quality of services. Many experiences show that it is feasible to gradually achieve such an objective while respecting public service status, maintaining employment safeguards and without resorting to dismissals.

- *Promoting training and technology transfer*

Training is a priority for Asian and American emerging countries and a catalyst for development. Moving toward modern forms of economy, they expect a lot from technology transfers. Improving water services will not be achieved without boosting local skills. This is one of the most prominent duties of operators to foster training, skills development and the transfer of adapted and efficient technologies.

- *Controlling quality/cost ratios for service operation and new infrastructures*

Optimizing the cost of service delivery enables prices to be controlled and provides the financial resources for regular maintenance, renewal and new investment. Cost control should be extended to all kind of costs, but a specific attention has to be given to procurement, maintenance, infrastructure renewal, human resources. This issue will be analyzed in the Chapter 4 of these guidelines.

A similar attention should be given to control and reduce energy consumption, because of costs and because of greenhouse gas emissions. Usually, energy costs represent a large part of direct operating expenditures. Furthermore, it is necessary to reduce the energy dependence of the services (in particular in isolated areas) and move toward a less carbon-based economy. Various options must be systematically explored, such as optimizing the energy consumption of treatment process in drinking water production plants, reducing leakage in the networks to avoid wasting energy, increasing the energy self-sufficiency rate of wastewater treatment plants.

Cost control should also focus on new infrastructure, in order to guarantee the quality of any new installation built, optimize investment programs and spread them as evenly as possible over time. In fact, all operators are responsible for managing existing infrastructures to the best of their ability, controlling operating costs and spending and using funding obtained as efficiently as possible.

- *Dealing with risk, vulnerability and uncertainty*

In many Pacific areas, the impact of climate change is already being felt, with more extreme weather events, more droughts and floods and saline intrusion of coastal aquifers. Many arid regions and islands are the hostages of hydrology. But if we can't control the weather, we can manage the water. With a more unpredictable hydrological cycle, increasing water security becomes a priority for water services and public authorities. Investments in water infrastructure play a crucial role to mitigate risk and vulnerability.

2.3 - Recommendations:

- *To public authorities/governments at all levels*

– Look for a more integrated approach with a view to managing the wate cycle and to optimizing water and sanitation services at all levels: technical, human, organizational, financial, and environmental.

- Define the water policy, the water and wastewater service objectives and the performance levels to be reached.

- Give itself the means of checking and assessing regularly the services performances, measure the level of satisfaction of the end-consumers and continually drive the operator to make progress, to prevent it from being content with mediocre results.

- Recognize the several functions of a tariff policy as:
  - ✓ an instrument to ensure the financial sustainability of the service in the long run, and then its quality;
  - ✓ an instrument for social solidarity, to make sure that low-income households have access to this basic service;
  - ✓ an educational instrument for inducing water saving behaviour.

- Anticipate the couple supply-demand, in particular in isolated communities which cannot be connected to neighbor networks in case of water shortage, and, more generally, implement an overall policy to achieving sustainability in water and taking the impacts of climate changes into account.

- Consider the expertise of the private sector that has come as a result of public private partnerships. Through the private sector can come the knowledge and experience gleaned from other communities that have success and results to share.

- *To operators of water and wastewater services*

- Save water resources. Water savings in urban networks are often the resource that is immediately available in the largest quantity. In practice, a good operator of water services is both a "*water saver*" and a new resource creator.

- Regularly maintain and renew the existing infrastructure and optimize it so that it is possible to serve more people with the same means.

- Adapt, at all times, the skills of service employees to activities and resources that are becoming increasingly complex to manage; anticipate future needs by training employees to use new technologies ; mobilize staff at all levels in order to reach the water services objectives fixed by public authorities.

- Develop a customer oriented culture to better know and satisfy clients' expectations. Delivering a continuous service 24 hours a day, 7 days a week, and drinking water respecting public health standard is a prerequisite before looking for satisfying upper clients' expectations.

- Control systematically all operation costs and capital costs, in order to control tariff and release recurring cash flows. This will allow to improve the quality of the service and to fund new infrastructures. A specific attention should be given to procurement, maintenance and renewal, energy efficiency and costs, and labour costs;

- Move toward a water supply culture and toward a culture of water demand management. The challenge is to involve consumers so that they act as manager of their consumption and protector of the environment. Therefore, the operator should give the population the means of managing its consumption (by generalizing installation of individual meters, remote meter reading, SMS information systems, …).

- *To public at large*

- To farmers: save water to irrigate crops by using tehcnics such as drip irrigation. Agricultural production cannot continue to increase at the rate necessary to feed the world's people unless water is used less extravagantly.

3 - The issue of sanitation

Managing wastewater services will always be a major challenge for seaside communities. This challenge has taken on more importance as standards have tightened, coastal populations have grown, and the expectations of residents and tourists have increased.

3.1 - Overview of the issue of sanitation in islands, coastal areas and isolated communities

- *Sanitation is one of the great omissions of water policies*

2008 was the year of sanitation, but the situation has not enough improved. Sanitation is too often relegated to the back room of public action.

There is a large deficit in access to sanitation and then a large deficit in health. Coverage rates are extremely low: only 1 in 3 people in East Asia has access to sanitation facilities; in Jakarta, only 1 in 10. In Solomon islands and in Micronesia, less than 1 in 3. According to UNDP [6], East Asia and the Pacific will have to provide sanitation facilities to 330 million inhabitants and Latin America to 60 million in order to respect the Millennium Development Goals. Sanitation is among the most powerful drivers for human development. Then, why so large a deficit? Because sanitation suffers from a combination of institutional fragmentation, weak national planning and low political status.

However, closing the vast deficit in sanitation is feasible. Thailand recently achieved 100% coverage in sanitation on the national level. In Colombia, the coverage rate – about 86% – is far higher than its national income would predict.

Beyond the issue of access to basic sanitation for all, there is a lack of efficient collection and treatment systems. Many coastal cities have achieved a minimal level of sanitation service at household. But in most cases, these investments have not been followed by the development of public infrastructure, such as feeder and trunk sewerage systems, to convey wastewater away from the community for safe disposal. Other cities have feeder and trunk sewerage systems, but no or very limited treatment capacity. According to UNDP, in Latin America and the Caribbean, 85 % of wastewater discharged into the rivers and seas are not treated. This rate amounts to 80 % in South-East Pacific and 90 % in East Asia.

In the huge urban sprawls with their teeming population, urban inflation generates pollution at unbearable levels. The destructive potential of wastewater that is neither collected nor treated is truly explosive. These "*sanitary bombs*" – as expressed by M. Loïc Fauchon, Chairman of the World Water Council – are ready to explode, one after the other. They threaten not only the cities that have produced them, but also the regions downstream to which the rivers will carry them.

The Pacific Ocean is the primary source of water but also the final destination for garbage. To date, the warnings were somewhat invisible, due to the size of Pacific Ocean. The Ocean suffers from the illusion of its immensity. But it has not an infinite power to regenerate. If we do not protect the Pacific Ocean, we not only endanger our ecological heritage but also the professions that earn their living from tourism and fishing.

The Pacific leaders at the 2007 Asia Pacific Water Summit in Beppu, reiterated their commitment to effective sanitation and safe drinking water for 36 countries of the region (see box at the end of chapter).

- *A multi-pronged strategy is needed to manage wastewater and preserve environment*

There are many different sources of marine pollution which should be treated, in particular:

- Direct discharges of uncollected wastewater into the natural environment.
- Discharges from wastewater collection systems. The capacity of wastewater collection systems can be overpassed by urban growth, car parks connected to the system, seasonal tourism, etc.

[6] *"Beyond scarcity: Power, poverty and the global water crisis", Human Development Report 2006, UNDP*

- Discharges from wastewater treatment plants when operation deteriorates. Pollution peaks are more pronounced when they occur in an initially healthy environment. Therefore, the shock effect is bigger.
- Discharges into the environment from stormwater collection systems, during wet weather.

To ensure conservation of water quality and the sea's many gifts, it is vital to work simultaneously on all the sources of pollution of aquatic environments. None of them can be left out. If just one of the causes of pollution is neglected, the benefits from dealing with the other sources could be reduced to nothing.

The quality of rivers and seawater is always a true measure of the wastewater policy because they cumulate the effects of pollution. In the end, coastal waters are the ultimate judges of the overall effort made by public authorities to deal with the issue of wastewater.

Bridging the gap of universal access to sanitation is the priority, before upgrading existing systems. But sanitation should not be restricted to toilets. It incorporates many other components. Managing a wastewater system means to:

- Collect wastewater. Removing wastewater from the vicinity of houses guarantees health protection for the local community.
- Ensure the absence of leaks in pipe systems to limit the infiltration of aquifers.
- Ensure a thorough and constant level of treatment, in order to minimize pollution discharged.
- Manage actively the wastewater system during rainy events to limit direct discharges of untreated wastewater into the rivers and sea. The sea has to be protected under all circumstances. Wastewater infrastructure is easily managed during dry weather, but the performance of these systems can be compromised during wet weather.
- Treat industrial and toxic effluents.
- Treat the waste produced by the wastewater system, such as sludge and reduce noxious odours, which is particularly important for tourist destination;
- Consider ecological sanitation alternatives. New approaches focus on closing locally the water cycles by reusing wastewater and the storm water.

It is necessary to manage in a coherent approach the coast and the sea. To "*drive pollution away*" from the coast and conserve the quality of seawater, public authorities must work upstream of the problem: sustainable management of the sea first requires sustainable management of the land. There can be no efficient management of bathing and fishing waters without efficient management of wastewater and storm water on land.

Public authorities should plan sanitation coherently with urban development and economic activities. It is necessary to plan ahead in order to anticipate the impact of the city's development on the sewerage system and to safeguard natural assets. Many wastewater collection systems have reached saturation point and can no longer collect or treat wastewater. Restoring the quality of coastal waters is a good thing. Conserving its quality in the first place is even better.

Furthermore, public authorities should present wastewater service as a driver of development. Wastewater services restore or reinforce the attractiveness of territories. Wastewater services contribute to consolidating the whole local economy. It is an illusion to hope to boost economic development and to maintain the uses that depend on the sea if sanitation facilities are not built and managed properly. This is particularly true for tourist destinations. The quality of tourism infrastructure, but also the one of environmental protection infrastructure, play a key role to make some destinations more successful in tourism.

Wastewater management should be adapted to specificities of territories:

- High density territories, like Singapore which has a population density of 7,500 inhabitants per km², require space-saving technologies (e.g. wastewater treatment plants build underground).
- At tourist destinations:

- ✓ Public authorities and their partners should implement two policies at the same time. Tourism development and environmental infrastructure construction are usually not implemented at the time. Sanitation should be managed in pace with tourism policy, in order to contribute to the well-being of residents and visitors alike.
- ✓ Checking regularly and quickly the quality of bathing water is of the utmost importance, in order to decide whether to open or close beaches to swimmers. Bathing water should be placed under close surveillance.
- ✓ Tourism cannot succeed in an environment that fails, in an environment that is polluted. If a local authority positions itself at the top-of-the-line of tourism market, sanitation infrastructure should also be positioned at the top-of-the-line of environmental protection.

Infrastructure planners, designers and wastewater service operators should take into account the impact of climate changes on sanitation systems. More frequent droughts will increase suspended solids deposits into the network and odors problems which are very inconvenient for tourism development. And more frequent heavy rains will lead to discharge more untreated storm water and then pollutants into the sea, except if storage basin of storm water are built or if the capacity of wastewater treatment plants is extended.

- *Recommendations:*

<u>To public authorities/governments at all levels</u>

- Manage in a coherent way the coast and the sea, plan sanitation coherently with urban development and economic activities and take into account the impact of climate change on sanitation systems.

- Bridge the gap of universal access to sanitation which is the priority before upgrading existing systems, but don't restrict sanitation to toilets.

- At tourist destinations:
  - ✓ Implement tourism development and environmental infrastructure construction policies at the same time. Sanitation should be managed in pace with tourism policy, in order to contribute to the well-being of residents and visitors alike.
  - ✓ Check regularly and quickly the quality of bathing water, in order to decide whether to open or close beaches to swimmers. Bathing water should be placed under close surveillance.

- Present the wastewater service as a driver of development for all stakeholders and give to sanitation policy a high degree of priority among public policies.

<u>To operators of wastewater services</u>

- Collect and treat all the sources of pollution of aquatic environments (domestic wastewater, industrial wastewater, storm water). None should be left out. If just one of the causes of pollution is neglected, the benefits of efforts made to deal with the other sources could be reduced to nothing.

- Ensure a thorough and constant level of treatment, in order to minimize pollution discharged into the environment.

- Manage actively the wastewater system during rainy events to limit direct discharge of untreated wastewater into the sea. The sea has to be protected under all circumstances. Wastewater infrastructure is easily managed during dry weather, but the performance of these systems can be compromised during wet weather.

- Select space-saving technologies for high density territories.

<u>To public at large:</u>

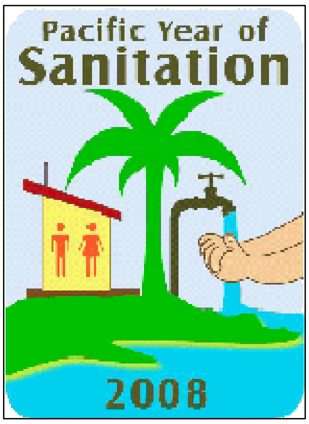
- To industry: treat industrial and toxic effluents at the source.

- To industry and agriculture: consider ecological sanitation alternatives such as recycling wastewater to produce water for factories or irrigation.

3.2 - The specific case of sanitation in small islands/isolated areas: a need for robust, low cost, low maintenance technologies.

- *Introduction*

The 2008 International Year of Sanitation has marked a period of increased support for, and intervention in the region's water and sanitation sector. This unprecedented support has been guided largely by a number of strategies developed by the region over the last eight years, through a broad series of coordinated and comprehensive consultations. This includes the Pacific Wastewater Policy and Wastewater Framework for Action (2001); the Pacific Regional Action Plan on Sustainable Water Management (2002) and the Pacific Framework for Action on Drinking Water Quality and Health (2005).



A recent WHO / SOPAC report on sanitation, hygiene and drinking water in Pacific Island Countries revealed that the annual incidence of diarrhoeal diseases in the Pacific, still nearly matches the numbers of its inhabitants with 6.7 million cases of acute diarrhoea each year, responsible for the annual death of 2,800 people, most of them, children less than 5 years old. Country statistics on access to improved sanitation and improved drinking-water indicate that on average, approximately only half of the total population of the Pacific island countries are served with any form of improved sanitation or drinking-water.[7]

It is clear that increased efforts are required to achieve the Millennium Development Goals targets of halving the proportion of people without access to safe drinking water and basic sanitation by 2015. According to the UN Millennium Project Task Force on Water and Sanitation (2005), basic sanitation is the lowest-cost option for securing sustainable access to safe, hygienic, and convenient facilities and services for wastewater disposal that provide privacy and dignity while ensuring a clean and healthful living environment both at home and in the neighbourhood of users.

Improved and unimproved sanitation types of facilities

Improved sanitation facilities*	Unimproved sanitation facilities
Flush or pour-flush to: – piped sewer system – septic tank – pit latrine Ventilated improved pit latrine (VIP) Pit latrine with slab Composting toilet	Flush or pour-flush to elsewhere** Pit latrine without slab or open pit Bucket latrine Hanging toilet or hanging latrine No facilities or bush or field (open defecation)

** Only facilities which are not shared or public are considered improved.*
*** Excreta are flushed to the street, yard or plot, open sewer, a ditch and a drainage way.*

Monitoring access to basic sanitation according to this definition is currently not possible provided the limited level of information available at country level or internationally. The WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation works with the concept of access to "*improved*" sanitation facilities and uses this indicator as a proxy to measure progress towards the achievement of the Millennium Development Goals sanitation and drinking-water targets throughout the world. Improved and unimproved technologies as defined by the JMP are provided in the table above mentioned.[8]

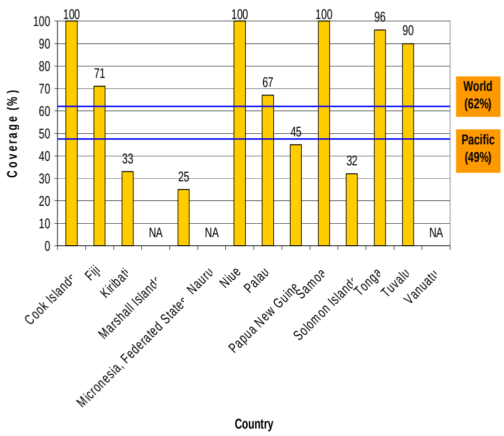
- *Sanitation coverage and need for on-site improvements*

The sanitation coverage in the Pacific island countries (48%) in 2006 was far below the world average of 62%. As can be seen from the figures below there is a huge disparity in access to improved sanitation services among the Pacific island countries but also between the urban and rural population with the rural coverage of improved sanitation being on average only 56% of the urban coverage.

[7] *WHO/SOPAC, 2008*

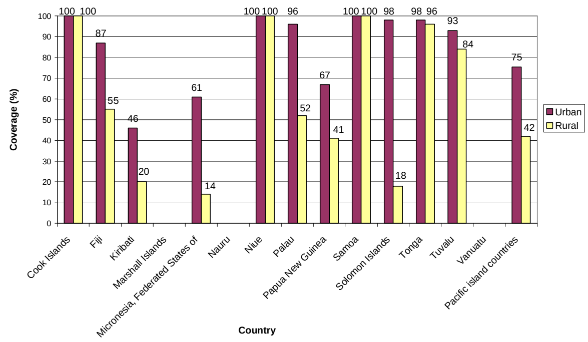
[8] *WHO/UNICEF, 2006*

Sanitation coverage in Pacific islands



Source: primary country coverage data from UNICEF, WHO (2008)

Urban and rural disparities in sanitation for Pacific island countries



Source: primary country coverage data from WHO, UNICEF (2008)

In Pacific island countries and territories, government bodies and the public give little attention to sanitation issues in contrast to freshwater issues. This complacency and subsequent lack of investment has led to inadequate development of the sanitation sector. The lack of awareness on appropriate excreta disposal leads to little or no maintenance of existing sanitation facilities, thus resulting in a poor standard of environmental sanitation.

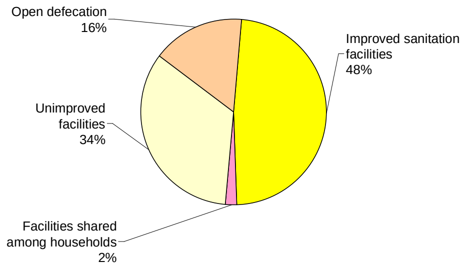
As a result, faecal borne diseases are prevalent in most rural communities and squatter settlements, where poverty is rife. Ultimately the marine environment, water resources and sub-soil suffer due to dangerously high levels of faecal contamination and small island communities with sensitive ecosystems are especially at risk.

Despite the production of numerous reference books throughout the world on appropriate technologies for on-site sanitation, there has only been limited success in the sustainable use of these technologies. The main reasons for this are a lack of community involvement in all phases of project development and a lack of recognition and experience by local government that community participation is an essential component to achieve success. Additionally the issue of gender sensitivity in on-site sanitation and the different and complex roles played by men and women within the communities has often not been fully recognized, and as a result has been considered to contribute to project failures in the past.

- *Best practices*

As can be seen in the figure below the introduction of improved sanitation has not been very successful in the region and open defecation is still a widespread practice in some islands with over 16% of the total Pacific population defecating in the open.

Type of sanitation in the Pacific region



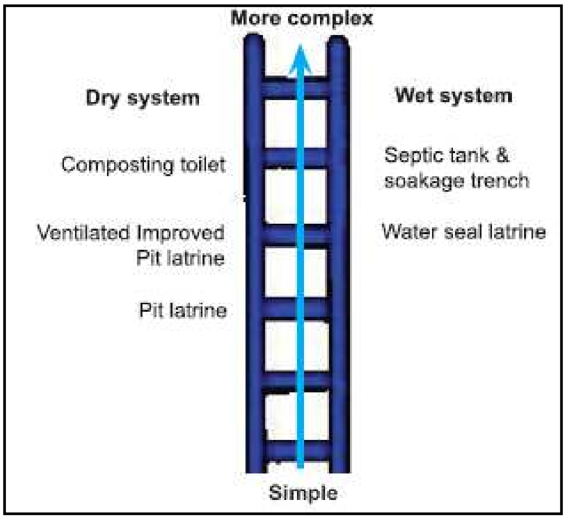
Source: primary country coverage data from WHO, UNICEF (2008)

A good example of the promotion of best practices for on-site sanitation is provided by the Sanitation Park located at the Fiji School of Medicine (FSMed) in Suva. The Park provides a range of selected affordable wastewater technologies to be used for demonstration purposes.[9]

Involved were the World Health Organization (WHO), the Fiji Ministry of Health (MoH),

[9] *Bower, R., Crennan L. and Navatoga, A., 2005. The Sanitation Park Project: A regional initiative to increase participatory approaches in the sanitation sector. SOPAC Technical Report 386*

FSMed and the Pacific Islands Applied Geoscience Commission (SOPAC) who worked together to implement the Sanitation Park Project with funding provided by the New Zealand Agency for International Development (NZAID).



The "Sanitation Park"

The "*Sanitation Park*" contains a range of demonstration systems, beginning with low technology facilities to progressively higher-level treatment systems, in a "sanitation ladder" of available treatment and disposal options. The "Park" provides an opportunity for interested community members, students, leaders and community health workers to examine how the different wastewater treatment systems work to treat excreta and protect human health. Each system is accompanied by informative signage illustrating the system design and do's and don'ts of location and usage. Additionally the systems serve as a technical training tool for use by FSMed in their School of Public Health and Primary Care teaching programme.

The available systems in the Park include the following:

– A sanitary well;
– A water seal (or pour flush) latrine;
– A septic tank and soakage trench;
– A waterless or Composting toilet.

- *Eco-Sanitation Training*

Although a technology based approach has been introduced in several villages in Fiji and to future health and sanitation workers through the Fiji School of Medicine through the Sanitation Park, there is little information available on successful adoption and replication throughout the Pacific region.

Large scale introduction of appropriate technologies such as composting toilets have been known to fail due to the lack of consultation, participation and ownership by recipients. Capacity building within government departments and communities have been undertaken in the region to enhance the understanding of applying new technologies.

For example eco-sanitation training was carried out in order to protect fragile water reserves on low-lying atoll islands such as Tuvalu and Kiribati followed by implementation of demonstrations. A composting toilet trial was linked to a groundwater pollution study in Tonga and eco-sanitation workshop in Vanuatu introduced ecologically sustainable sanitation as part of a watershed protection programme.

- *Recommendations*

To governments at all levels for a better sanitation:

– Make use of high-level discussion platforms to mobilize political support for strategic actions required to achieve the Millennium Development Goals sanitation and drinking-water target in the island countries.

– Develop a sound sanitation and drinking water monitoring and evaluation system for the island countries, capable of collecting, analyzing and disseminating population-based information on access to sanitation and drinking water. With a view to provide recurrent information on the following: access to sanitation and drinking water services; drinking water quality; hygiene behaviours; water-related diseases.

- Promote and support the inclusion of national drinking water safety plans into the national development planning process for the island countries as a crucial measure to improve drinking-water quality generated by the existing and future islands water supply systems.

- Promote the establishment of national sanitation, hygiene and drinking-water assessments within the perspective of a sustainable integrated water resources management.

<u>To service operators:</u>

- Technical innovation should be encouraged to facilitate technology transfer allowing for adaptation of designs to local circumstances.

- Conflicting and contradictory messages and programmes should be avoided and open debate should be encouraged so that communities can make informed choices on the eco-sanitation approaches and technologies.

- There is a need for adequately prepared training to introduce eco-sanitation and best practices ecologically sustainable technologies with appropriate follow-up and support using a flexible approach to ensure that local priorities, beliefs and taboos are being addressed.

<u>To public at large:</u>

- Implement practical hands-on training. It is an effective way to promote a sanitation system and convey the principles behind the approach. People are empowered by learning technical skills and knowing that they can make well-informed choices, and that they can construct and maintain the systems themselves. In the Pacific region there are limited opportunities for such training and wider use of this demonstration facility will ensure that affordable and acceptable technologies get replicated in other areas.

- Encourage trainees to present what they have learnt to their community. It is an effective method to reinforce and clarify the message, but it is also important that the trainee has the confidence and ability to explain the information in a public setting.

- Encourage active involvement of women in the practical training, discussion and decision-making, in order to promote overall participation and understanding in a community. It may be necessary to ensure that women are not prevented from attending the workshop because of their domestic responsibilities.

- Beyond practical training on sustainable on-site sanitation, facilitate a further understanding of the complexity of each specific context to allow for further replication of appropriate on-site sanitation technologies.

Box 8 Message from Beppu

The Pacific Leaders attending the First Asia-Pacific Water Summit organized from 3 to 4 December 2007 in Beppu City, Japan reiterated their commitment to effective sanitation and safe drinking water. Ten heads of state, 31 ministers, and representatives from 36 countries committed to the following:

We, the leaders of the Asia-Pacific, coming from all sectors of our societies and countries, meeting at the historic inaugural Asia Pacific Water Summit, in the beautiful city of Beppu, in the hospitable Oita Prefecture of Japan, do hereby agree to:

- Recognise the people's right to safe drinking water and basic sanitation as a basic human right and a fundamental aspect of human security;
- Reduce by half the number of people who do not have access to safe drinking water by 2015 and aim to reduce that number to zero by 2025;
- Reduce by half number of people who do not have access to basic sanitation in our region by 2015 and aim to reduce that number to zero by 2025, through the adoption of new and innovative sanitation systems that are not as water reliant as current methods;
- Accord the highest priority to water and sanitation in our economic and development plans and agendas and to increase substantially our allocation of resources to the water and sanitation sectors,
- Improve governance, efficiency, transparency and equity in all aspects related to the management of water, particularly as it impacts on poor communities. We recognise that while women are particularly vulnerable, they are also resilient and entrepreneurial, hence, should be empowered in all water-related activities.
- Take urgent and effective action to prevent and reduce the risks of flood, drought and other water-related disasters and to bring timely relief and assistance to their victims;
- Support the region's vulnerable small island states in their efforts to protect lives and livelihoods from the impacts of climate change;
- Exhort the Bali Conference to take into account the relationship between water and climate change, such as the melting of snowcaps and glaciers in the Himalayas and rising sea levels, which are already having an impact on some countries in the region;
- Establish concrete goals for the 2008 Toyako G8 Summit to:
    - commit to support the developing countries to achieve their MDG targets on water and sanitation; and
    - take immediate action to support adaptation to climate change by developing countries;
- Empower a high-level coordinating mechanism in our cabinets and where possible, appoint a minister in charge of water to ensure that all issues related to water and sanitation would be dealt with in a holistic manner;
- Respect and strengthen the region's rich history of water-centered community development, including the rehabilitation of urban waterways and protecting the environmental integrity of rural watersheds;
- Work together with other like-minded institutions, entities and individuals in order to achieve our collective vision of water security in the Asia Pacific region.

We will support the Policy Brief as prepared by the Asia Pacific Water Forum family.

We encourage all governments to make all efforts to implement its recommendations.

We have the will and courage to realise our vision.

Source: APWF (2007)

4 - Storm water management

Storm water management is fully part of a good water sanitation. In urban environments, rain waters, and especially in the Pacific region strong storm waters, are generally sources of major issues such as erosion, flooding, disturbances of the wastewater system (sewers and treatment plants), pollutions of rivers and beaches.

Addressing properly these issues is more and more important as a large part of economic and social activity may be disturbed in our increasingly urbanized world.

Managing storm water has often been taken as a simple engineering problem: finding the right size for the right pipe that will evacuate storm water as quick and as far as possible from the city. Unfortunately, this has sometimes resulted in "*Pharaonic*" civil works creating more new issues downstream that it was solving upstream.

Therefore, during the last decades, new trends of storm water management have surfaced, with the development of the so-called Urban Hydrology, conducting to a more integrated approach of water management in the cities.

Some of the main streams of modern storm water management are the following:

- ***Risk approach is crucial****:* according to the Pareto Principle, trying to solve 100% of the stormwater issues is generally not cost effective. In other words, it is better to admit that a system will, from time to time, result in some limited flooding or pollution events rather that to try to avoid any issue.

- ***Technology vs. civil works:*** with the development of sensors, modeling, telemetry… technology is now available to managed storm water events proactively. These solutions known as "Real Time management systems" are now applied in great cities in Europe or the US (see Paris, Barcelona and Bordeaux case studies) but may be applied in the future in smaller systems.

- ***Operation vs. capital investment:*** a storm water event is by nature very changing. Therefore, its proper management requires well prepared teams able to react efficiently to mitigate the effects of storm. Moreover, a constant monitoring of the system is necessary to avoid illicit discharges in the system. The Honolulu experience described below shows the importance of having a great professional team for storm water management.

- ***Think upstream solutions:*** if the effect of storm water is visible downstream, we have to look for the more efficient solution upstream. Avoiding runoff and erosion by maintaining forests or green coverage in the upper watersheds, alternative solutions (such as permeable pavements.) to facilitate local infiltration rather than waterproof soil and runoff. In Pacific region, this "ridge-to-reef" approach is part of the traditional culture;

- ***Population involvement is essential****:* whether it is for cleaning an urban river of debris after a storm water event or to protect their house from flooding during the storm, population contribution is always a very good solution. It not only reduces costs of operations but also works to give the community a sense of responsibility regarding natural phenomena. The importance of this social approach is well treated in Honolulu case study (Public Participation & Outreach), and through the Barcelona experience (real time warning system for bathing waters quality).

- ***"Rediscover" water:*** in modern cities, open urban streams have often disappeared, buried into underground pipes. Pipes were synonyms of progress and modernity. But a new trend consists of maintaining or even re-opening urban streams. This not only facilitates the hydrological management of stormwater, but also re creates a link between water and the urban populations. In this field, the experience of many cities in China is remarkable, as shown in the Yangzhou case study, which places City waters in their historical perspective.

In conclusion, storm water management is certainly a very complex area requesting an integrated approach involving different public authorities, specialized firms and the population. But its correct management, instead of generating critical situations, may bring value to the cities by highlighting and reminding the importance of waters in urban development.

Protection Honolulu Oahu's waters and storm water management

As an island State, Hawaii residents enjoy various activities in and around water like paddling, surfing, fishing, and swimming. The reefs and various forms of marine life also thrive in waters. Warm waters and beaches on Oahu welcome approximately 4.6 million visitors annually. Clearly the health of island waters is vital to the economy and the way of life

On Oahu, rainfall in urban areas is drained from the surface through the City's Municipal Separate Storm Water Sewer System (MS4). Runoff enters the MS4 at various points such as catch basins along our streets, inlets and connections from private properties then travels through a network of pipes that lead out to the ocean and streams. A common misconception is that both wastewater and storm water go to combined sewers and wastewater treatment plants but in Honolulu the systems are separate. Storm water is normally not treated.

As a large municipality, the City of Honolulu is required to obtain a permit to operate the (MS4). The City is subject to conditions of this permit which consists of required elements that make up the City's "Storm Water Management Program". As quoted from permit: *"The discharge of pollutants from the Permittee's MS4 shall be reduced to the Maximum Extent Practicable (MEP). This permit, and the provisions herein, are intended to develop, achieve, and implement a timely, comprehensive, cost effective storm water pollution control program to reduce the discharge of pollutants to the MEP from the City's MS4 to waters of the State"*.

Best Management Practices (BMP) are the principal pollution reduction measures that have been incorporated into the City's storm water management plan

The City's Storm Water Management Program is grouped into these required elements:

- public participation & outreach
- pollution prevention & Good housekeeping
- illicit discharge and elimination
- construction site runoff control
- post construction storm water management
- industrial & commercial discharge

The Storm Water Management Program activities are continuously monitored and reports are developed to document progress and effectiveness.

Public Participation & Outreach

The City's public education and outreach program is comprehensive. The goals of the public education and outreach program are to raise awareness on pollution prevention and effect behavior change. Throughout the year various events, involving private business, schools, other agencies and the general public, are organized to create awareness and provide education on storm water pollution prevention.

Such methods to reach out and work with the public have included

- developing educational brochures
- conducting workshops to industry such as construction, automotive, landscapers, Fire Sprinkler Testers, and Refuse Collectors
- organizing community adopt-a-block & adopt-a-stream clean ups

Pollution prevention & Good housekeeping

Surely an effective storm water management program should start at home. For the City, it means that all of the City's municipal facilities should have an exemplary pollution prevention program that would include best management practices to minimize to the maximum extent practicable the amounts of pollutants generated by municipal operation and maintenance activities.

City staff as well as contractors are trained annually on:

- field Operations BMPs
- chemical Applications BMPs
- construction Site Erosion control BMPs
- integrated Pest Management
- identifying & eliminating Illicit Discharges, Illegal Connections and Spills

City Facilities are inspected annually to ensure BMPs are in place and effective maintenance is taking place. City Baseyards and industrial sites have Storm Water Pollution Control Plans which direct activities and ensure pollution control.

Illicit Discharge and Elimination

Illicit discharges contribute to high levels of pollutants that enter the storm drain system and degrade receiving waters. Pollutants threaten aquatic wildlife and human health. Illicit discharges may be found throughout the storm water system including residential, industrial, municipal and institutional facilities.
Therefore, the implementation and enforcement of an illicit discharge detection and elimination program is essential to detecting, eliminating and preventing illicit discharges and reducing unauthorized and illegal discharge to its MS4.

The City continues to implement various activities in detection and elimination including

- field screening of industrial and commercial areas
- training for City inspectors
- licensing program for private drain connections
- disposal programs for used oil and toxic materials

And in enforcement and response, the City's procedures involve Informational Letter of Warnings which escalate to a Letter of Warning then a Notice of Violation as well as associated fines. Stop work orders are also issued when necessary.

Response plans are also in place and includes coordination with various agencies such as the fire department, department of health, civil defense and coast guard.

Construction Site Runoff Control

Sediment is one of the leading causes of water quality impairment nationwide. Construction activities such as clearing, excavating and grading significantly disturb the land. The disturbed soil, if not managed properly, can easily be washed off the construction site during storms and enter streams, lakes, and coastal waters. Storm water discharges from construction activities can cause an array of physical, chemical and biological impacts.

The construction site runoff control program covers the planning permitting and construction stages of development. The City promulgates and enforces rules regarding the design of erosion control practices during construction and for permanent installation after construction. Appropriate plans and designs must be submitted for a project to receive permits. Inspections must be conducted to ensure compliance with the plans and adequate maintenance of the BMPs. A training program is in place to educate inspectors, designers, and contractors, both government and private.

Post construction Storm water Management

The post construction storm water management program has been developed to ensure that developed/redeveloped sites continue to minimize polluted discharge. This include sites that result in a land disturbance of one acre or more and smaller projects that have the potential to discharge pollutants to the City MS4. They are required to implement post construction or permanent controls must prevent or minimize water quality impacts to the MEP storm water management BMPs. This Program covers initial project planning through design, construction and completion, including requirements for long-term maintenance of permanent BMPs. Industrial and Commercial businesses must participate in the reduction of pollutants generated by their facilities to minimize discharge into the City's MS4.

Industrial & Commercial Discharge

It is estimated that there are approximately 300 private industrial facilities and approximately 5,400 private commercial facilities that may potentially contribute pollutants to the City's MS4. Inventory and mapping of industrial and commercial facilities that discharge into the City's MS4 is being developed. Industrial and commercial establishments are regularly inspected to ensure compliance. The inspection program is coordinated with outreach and training in order to ensure that these facility owners understand the requirements and make permanent change.

Monitoring

The City has developed programs to track and report results from monitoring and pollution prevention activities which include: debris Control Program, Erosion Control Program, BMP Installation, community involvement and outreach, water quality monitoring.

The City prepares implementation and monitoring plans for watersheds where DOH has established Waste Load Allocations (WLA) and Total Maximum Daily Loads (TMDL) and identifies the City as a source. The monitoring plans specify the activities necessary to reduce pollutants in specific watersheds. The City submits Annual Monitoring Plans and Reports to DOH for review and approval. The City's Department of Environmental Services is directly responsible for storm water.

At the very top of the management framework is Revised Ordinance of Honolulu Sec. 14-12.23, which states: *"It shall be unlawful for any person to discharge or cause to be discharged any pollutant into any drainage facility which causes a pollution problem in state waters, or causes a violation of any provision of the city NPDES permit or the water quality standards of the State of Hawaii."* The City implements this mandate through a comprehensive program of regulations, education and outreach, effective maintenance, inspections, and enforcement.

Storm water management in real time: 3 European experiences

Bordeaux : real time control to avoid floods

The Urban Community of Bordeaux (0.7 M inhabitants) entrusts the management of its sewage system to Lyonnaise des Eaux. Since the center of the city lies beneath the highest level of the Garonne river that flows through the community, there have been recurrent problem floods due to storms until 1981. Since then, the sewerage system (3600 km of pipe, 5 Waste Water Treatment Plants, 121 pumping stations) has been fully equipped to cope with these floods (43 retention tanks totalizing 1 745 000 m^3, 10 pumping stations from 1 to 12 m^3/s and 53 power supply generating groups).

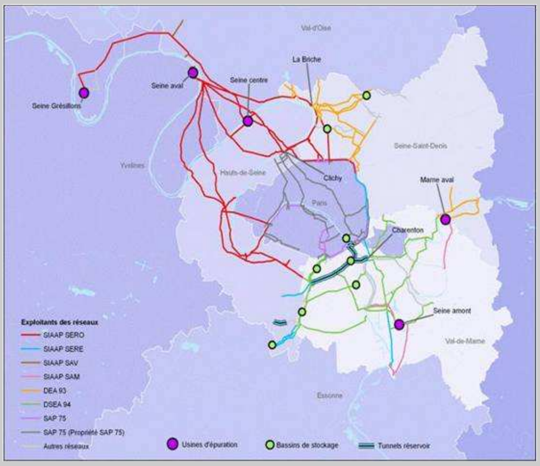
Radar weather forecasts are currently used as raw information by the controllers, giving them simple indications about when the rain will occur and how much rainwater will fall to the ground. Shortly, the radar data will be incorporated in a new system (called the Dynamic Management system) that will compute the rainwater entering the sewerage system and through some predictive modelization, deduce all the consequences of these inputs for the behaviour of the control works (valves, pumps, treatment plants) for the next 6 hours, turning the existing system into a global (concerning all the perimeter of the drainage system), predictive and optimized (minimizing quantities of water spilled to the river) real-time controlled system.

Paris: optimisation of storm water management

Increasing waterproofing of surfaces in urban areas is causing overload of combined sewerage systems and stormwater systems, leading to spills into the natural environment (or flooding of surface infrastructures) with serious environmental, social and economic consequences.

The *Syndicat Interdépartemental pour l'Assainissement de l'Agglomération Parisienne* (SIAAP − Greater Paris interdepartmental syndicate for the management of the sewerage system), responsible for the daily transportation and treatment of wastewaters from the Greater Paris area, is highly concerned by this issue. On average, the SIAAP treats some 3 Mm^3 of wastewater each day, used by the 8.6 million inhabitants of the Ile de France region. During rainy periods, flow rates reach 90 m^3/s for long hours.

As a further step towards protecting the natural environment, and towards addressing the environmental and economic issues relating to this large-scale sewerage system more effectively, the SIAAP commissioned the Modèle d'Aide à la Gestion des Effluents du SIAAP (MAGES − Management Aid Model for SIAAP Effluents) from a consortium led by Suez Environnement. The project perimeter is the Greater Paris area.



SIAAP system

The targets of the MAGES project are mainly two-fold:

- real time, for rainy weather, it will minimise spills into the natural environment, without increasing the risk of overflow, by optimising the use of the capacities of the treatment plants and the use of the storage capacities of basins, as well as the sewerage network itself;
- off-line, it will be used for post-analysis of the sewerage system during any given event, as well as for analysing the response of the sewerage system under various hypothesis like the unavailability of some existing works or the existence of some projected parts of the sewerage system.

Real-time use of the MAGES software is intended for SIAAP regulators who ensure permanent operational management of the network 24/7. The three main general functions can be described as:

- an overview of the sewerage network configuration (valve positions, etc.) and of the water situation (water levels, flow rates);
- Anticipation of flow rates and water levels at the 400 key points in the network, calculated using a detailed predictive model that includes the exact configuration of the network and weather forecasts at every time-step;
- management instructions computed for the fifty or so main control devices (valves, pumping units) that are dynamic optimum and comprehensive. These instructions are calculated using a simplified predictive model associated with an optimisation module.

All this information is refreshed every 15 minutes to get real-time adjustment of the MAGES system to the changes of the system configuration that arise from possible incidents or operational requirements (diminished capacity of the treatment plant, incidents in the network, etc.). The many inter-connections that exist between the mains pipes and the high number of the control devices affecting the distribution of the flows (around 700 valves, weirs, pumps and tanks are modelized) make the management of such a large-scale sewerage network complex task, and numerical optimisation methods are well suited for such a complexity.

Barcelona: monitoring Bathing waters

Suez Environment, through the CLABSA Company, is in charge of the planning, operations and control of the urban drainage system of Barcelona (3.5 M inhabitants). Lying between a steep mountain and the Mediterranean sea-shore, Barcelona puts a strong demand on this urban drainage for better effectiveness against floods through the city itself, as well as river and coastal pollution.

In this respect, CLABSA ended recently the

COWAMA project, which purpose is two-fold:

- develop an integrated planning and management system for bathing water quality,
- develop a real time warning system for bathing waters quality, exploiting all the available forecast tools currently accessible, not only weather forecasts for winds as well as rain, but also sea currents and sun-lighting of the sea-surface.

Real time Internet info on beaches water quality

The COWAMA solution makes use of all these forecasts to compute the successive states of all the drainage system for the next 24 hours, allowing local authorities not only to anticipate adequately the closing of its popular beaches, but also to confidently authorize the reopening of these same beaches when their sanitary situation has returned to normal. The EC Bathing Waters Directive makes it mandatory for the local authorities to inform the citizens about the sanitary situation of the beaches in a near future, and CLABSA provides with COWAMA a valuable tool that will make it possible to comply to this new requirement: a web site, as well as electronic panels on the beaches, display these information in real time.

Improving the water environment and saving the cultural heritage: the renovation of Yangzhou water environment.

Yangzhou City, in the middle of Jiangsu Province, is located between the Yangtze river and the Huaihe river. The Yangzhou City has a population of 720,000 over 72 km^2. In recent years, the city government has undertaken the control of water pollution, improvement of water environment.

Built at the the confluence of the Yangtze river and the Beijing-Hangzhou Grand Canal, Yangzhou was during the Tang Dynasty the most prosperous city of China, an important port of the Silk Sea Road, the centre of salt transport and water transport in Qing Dynasty, and was one of the 10 cities in the world with more than 500,000 inhabitants. Since the 1980 the rapid economic development of the city, the growth of population, several Yangzhou rivers, including the Ancient Canal, the most prominent feature in Yangzhou, have been polluted to various extents.

To fight pollution,Yangzhou has drawn up a new Five Year Plan relevant to environmental protection, such as the Environmental Protection and Ecological Construction Planning of Yangzhou, the Drainage Planning of Yangzhou, the Renovation of Urban Water Environment Planning of Yangzhou, the Water Conservation Planning of Yangzhou, the Water Resource Planning of Yangzhou. These plans provide guidelines for ecological reconstruction of Yangzhou’s water environment.

In recent years more than 2 billion RMB has been invested in improving urban water environment. Several projects have been carried out to intercept sewage from rivers, such as a part of Ancient Canal in the urban areas, Caohe river, Erdao river, Hangou river. The intercepted sewage is transported to treatment plants via pipelines amounting to about 40 km. At present, the total length of sewage pipeline has reached more than 350 km and with more than 30 sewage pumping stations. The pipeline network coverage is about 70%.

As the result of significant improvement of urban water environment, the city has earned a series of awards "*China's excellent tourist cities*", "*National Health City*" and "*National Environmental Protection Model City*" and "*National Garden City*", "*China Human Inhabitancy Award*" and "*UN-Habitat Award* ".

CHAPTER 2 - A NEED FOR BEST PRACTICES IN MINING INDUSTRY AND AGRICULTURE TO COMPENSATE WATER SHORTAGE AND POLLUTION

1 - Impact of mining on human communities and environment

1.1 - Water Issues Related to Mining

The relationship between water and the mining industry is both simple and complex – mining and mineral processing requires substantive amounts of water but it can also have a major impact on the quality and quantity of water resources. The ongoing journey of sustainability requires a close attention to this fundamental relationship, especially in the context of potential future climate change impacts across the Pacific further affecting the relationship between water and mining.

The mining industry is a major field of economic development for several countries of the Pacific Ocean and a fast developing activity in a world context of strong raw material demand. It's therefore a huge challenge to develop a major mining industry in fragile environments such as Islands when the land and of the lagoons are host of an outstanding biodiversity.

The technologies and references in drinking water, waste water and industrial water treatments have proved successful and it highlights the possibility to develop safely, on those issues, a mining industry in a highly sensitive environment.

Mining companies need to have access to the mineral resources. Local communities want to benefit equitably from mining activities in terms of employment, social welfare, revenues and protection of their living environment including:

- the access to water resources in sufficient quality and quantity for their day to day needs;
- the protection of the natural water resources is vital;
- the availability of water for the long term at no extra cost to them because of the mining activity.

On certain mining sites, water resources are scarce and this can lead to pumping and utilization of water from the coastal areas where there are local communities who have been living there well before the arrival of mining companies.

Mining also means building roads and therefore sometimes huge earthmoving works which bring large scale transformation of the natural physical environment. Rain water on the roads and mining pits need to be carefully managed to avoid pollution of downstream creeks and rivers where water is used by the population.

The hydrologic cycle involves the distribution, movement and cycling between the various sectors of the environment – from rainfall to soils, surface runoff, dams, streams and groundwater. A mining project often involves the development of large scale changes to the local topography, through open cut mining, processing plants and tailings and waste rock storage facilities. A mining project can also give rise to the need for a hydroelectric dam for electric power generation (and/or water supply), or alternately a major extraction of surface water and/or groundwater.

There are multiple aspects to consider when beginning to develop an understanding of the link between water and mining, including [10]:

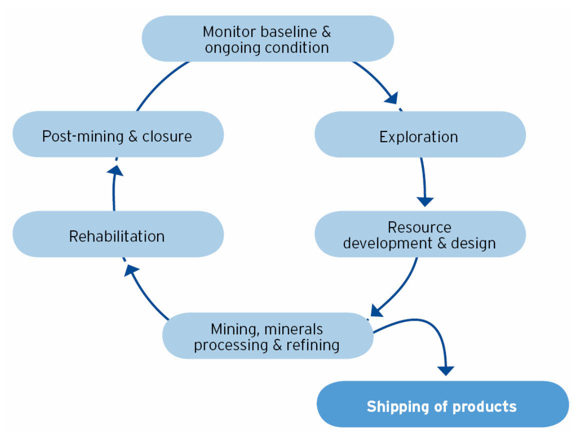
- the type of mine, such as an underground or open cut mine, as this influences the surface area affected;
- the commodity being extracted, as some commodities require more water for processing (such as bauxite compared to iron ore);
- the type and scale of ore processing, such as a conventional mill or heap leach facility;
- local climatic conditions, especially the difference between tropical, temperate or arid environments;

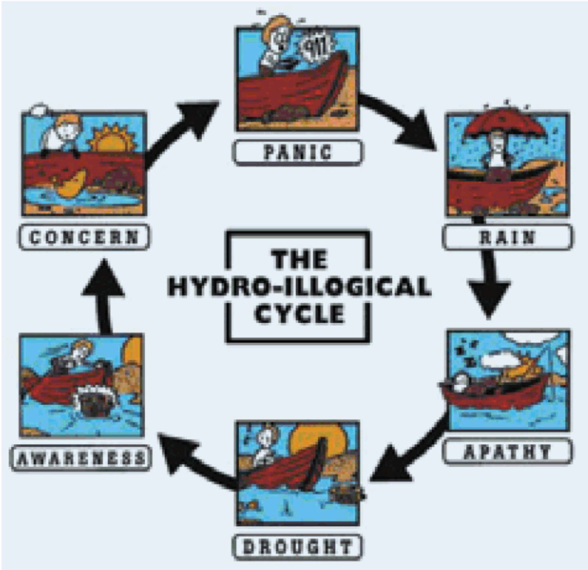
[10] *IIED & WBCSD 2002; DRET & MCA, 2008; Mudd, 2008*

- major water resources being affected, such as surface and/or groundwaters;
- the nature of the mineral deposit being mined, especially issues such as any sulphidic minerals present in ore/tailings and waste rock which can lead to acid mine drainage (‘*AMD*’, also known as acid and metalliferous drainage; DITR & MCA, 2007);
- the quality of water consumed, and the potential for recycling (most mines already do this to a significant degree);
- the extent of environmental monitoring and management measures undertaken during exploration, construction and operations; and
- the design and long-term effectiveness of post-mining rehabilitation and closure measures.

The overall cycle of mining is shown in the figure below, illustrating the main stages where water issues must be considered and continually evaluated. Often, sustaining efforts on pro-active water management is difficult – perhaps explained by the concept of the “*hydro-illogical cycle*” also included in the next figure. During periods of normal or strong rains, no concerns prevail as water is abundant. After a sustained period of below average rain, a drought ensues and action is progressively taken in proportion to the severity of the prevailing shortage – until the drought breaks and a typical rainfal regime perhaps returns.

The mining cycle and associated ‘hydro-illogical cycle’ (DRET & MCA, 2008)





In many tropical regions there is often an excess of water reaching a mine site, and this requires well designed infrastructure, pro-active management and sufficient water treatment capacity to ensure sound water management at mining projects. At some sites, government have permitted the discharge of minesite-derived waters into adjacent ecosystems under specific regulatory conditions (such as pollutant concentrations and loads, monitoring and dilution ratios).

A key dilemma in considering all of the above issues is that there are often significant time lags between these aspects, the spatial and temporal extent of information and process information is often less than perfect, and there are widely different cultural values associated with water across the world – especially so in the Pacific.[11] Climate change is looming as a pivotal issue with respect to water and mining, as it could exacerbate many of these problems in tropical, temperate or arid regions.[12]

In summary, it is critically important for a mining operation to carefully consider its potential and actual impacts on water resources in both quantity and quality terms as well as the perceived impacts (eg. cultural values). This requires a pro-active approach and careful engineering design combined with a thorough environmental monitoring and management regime specifically for water management.

[11] *Mudd, 2008*
[12] *DRET & MCA, 2008*

1.2 - Best practices: a brief review of water and mining

The concept of best practice is generally unique and highly site-specific – however, some key themes are important across all mining and mineral processing projects. For example, sound water management invariably saves financial resources, improves operational reliability, reduces environmental and social impacts and helps a company to maintain their reputation and '*social licence to operate'*.[13]

In recent years a number of key references have been published on water and mining:

- *Minesite Water Management Handbook*, Minerals Council of Australia (MCA 1997);
- *Best Practice Environmental Management in Mining* – Water Management Booklet (EA 1999);
- *Mining, Minerals and Sustainable Development* ('MMSD') Study and Report (IIED & WBCSD, 2002);
- *Mine Water Hydrogeology and Geochemistry* (Younger & Robins, 2002);
- *Mine Water: Hydrology, Pollution, Remediation* (Younger, Banwart & Hedin 2002);
- *Leading Practice Sustainable Development Program for the Mining Industry* – Water Management Handbook (DRET & MCA 2008).

All of these references provide extensive details concerning mining and water, as well as numerous case studies highlighting practical examples of different minesites and water technologies.

Overall, to understand the relationship between a given mining project and water resources, the following key aspects require specific attention[14] :

- ***Hydrologic Cycle*** – climate, surface water, groundwater, quantity and quality, ecosystems, biodiversity and cultural values;
- ***Principles and Planning*** – investigations, regulatory requirements, community consultation and requirements, historic monitoring and information gaps, data management and reporting needs;
- ***Mining Cycle*** – life-of-mine planning, water management system, major components (underground/open cut mines, tailings dams, waste rock dumps, heap leach piles, water retention ponds and other infrastructure such as transport, camps, etc.).

At its simplest, the concept of '*best practice'* or '*leading practice'* requires that a given mining project contributes to sustainable development.[15] Although this can be viewed as a somewhat subjective concept, it is expected by many communities that environmental pollution legacies or permanent changes to water resources and natural hydrologic regimes will not be left behind by former mining projects.[16]

Some examples of good technology for water monitoring and management at existing mining projects includes:

- ***Zero-Release Water Management Regime*** – the former Nabarlek uranium project in the tropical Arnhem Land region of the north-eastern Northern Territory, Australia, designed and operated a water management system which achieved no direct releases of contaminated minesite waters to adjacent streams [17] ;
- ***Wetlands for Water Treatment*** – the Ranger uranium project, surrounded by the world-heritage listed Kakadu National Park in the north-eastern Northern Territory, Australia, has used wetlands for active treatment of contaminated minesite runoff waters since 1995, and is a critical feature of their zero-release water management system[18];
- ***Water Recycling*** – the Weipa bauxite project, on the western side of Cape York in tropical northern Queensland, Australia, has been pro-active in incorporating water recycling from its tailings dams [19];

[13] *DRET & MCA, 2008*
[14] *Adapted from MCA, 1997; EA & MCA, 1999; DRET & MCA, 2008*
[15] *Eg. DRET & MCA, 2008*
[16] *Mudd, 2008*
[17] *Eg. Waggitt & Woods, 1998*
[18] *Eg. Rogers & Mudd, 2008*
[19] Eg. RTA, 2008

- ***Seawater Cooling Tower Infrastructure*** – during construction of the new Yarwun alumina plant near Gladstone, on the central Queensland coast, Australia, the cooling towers were built to be compatible with fresh or seawater to allow for future switching if drought conditions prevailed and fresh water was unavailable.[20]

Water treatment on mining sites: the example of Goro Nickel in New Caledonia

Activated sludge with membrane ultrafiltration (0.03 µm) provides a '*zero water discharge*' solution for a '*zero tolerance environment*'. This technology is available on skid mounted units making it easy to set up with outstanding cost and environmental benefits.

A successful implementation of this technology can be found on the mining camp of GORO Nickel (VALE Group) in New Caledonia.

Different types of processes have been used for the domestic waste water temporary camp treatment plant, hosting construction teams. They are mainly granular beds, trickling filters, rotating biological discs. But for the permanent camp site treatment plant, high levels of treatment have been required by the authorities to limit the impact of discharged water on the environment (creek, lagoon).

The membrane activated sludge bioreactor, selected solution, consists in:

- Activated sludge with membrane ultrafiltration (0.03 µm) for the water treatment.
- Reed beds, using phragmit australis, for the sludge treatment.

Several issues have driven this choice:

- Ultrafiltration provides a very high level of treatment compatible with European standards for bathing water, watering and fishing activities; making treated water compatible with any environmental requirement and therefore providing a wide range of solutions for the industrial to comply with regulation.
- Ultrafiltered water can therefore be safely reused for:
  - ✓ watering mining tracks, camp site gardens,
  - ✓ the industrial process, hence reducing environmental withdrawal in streams and lakes.
- Reed beds for sludge treatment:
  - ✓ it is a cost effective solution compared to filter press or centrifugation.
  - ✓ it enables to convert the sludge in compost that can be used for mine revegetation with endemic species using waste water sludges.

Ultimately this is a '*zero water discharge'* and '*zero waste'* solution for a '*zero tolerance environment*'. The civil work is restricted to a concrete slab for the membrane skid and a concrete tank for the activated sludge process.

An increasing requirement for mining projects, big and small, is the need for accurate water accounting, including the quantity of water consumed, impacts on adjacent water resources and water quality monitoring. A major mechanism for this work to be reported, apart from statutory environmental management reports to government authorities, is through sustainability reporting protocols. The most popular protocol used by numerous mining companies around the world is the Global Reporting Initiative 'GRI' (GRI, 2006).

Although the GRI is a voluntary framework, auspiced through the United Nations in conjunction with government, industry and civic society groups, it covers a range of environmental, social, economic and human rights indicators which allow an assessment of the sustainability performance for a given mine (or company). The relevant water indicators in the GRI include:

- EN8 - total water withdrawal by source (core);
- EN9 - water resources significantly affected (voluntary);
- EN10 - percentage and total volume of water recycled and re-used (voluntary).

[20] DRET & MCA, 2008

The lack of all indicators being core or compulsory (plus the GRI itself being voluntary) has led to major problems in ensuring that all reported data is of equivalent quality and accuracy.[21]

However, when done thoroughly, it should be possible to develop an annual water account for a given mine site, thereby allowing the investigation of changes over time and improvements (or declines) in water management performance. An example of a water account is given in the table below.

Overall, a range of technologies exist to facilitate sustainable management of water and mining. The final choice will be site-specific, but there is a clear need to think strategically and laterally – especially in the face of climate change leading to potential major impacts on water resources across the Pacific in coming decades.

An example of a minesite water account (DRET & MCA, 2008)

Mine X Copper 2006

WATER SOURCE ACCOUNT

	VOLUME MEGALITRES PER YEAR				
	input	diversion	tasks	output	Δ store
Surface	780	0	300	200	280
Ground	15 000	13 800	460	100	640
Marine	0	0	0	0	0
Site stores	0	0	550	175	-725
Third-party	275	0	245	20	10
TOTAL	16 055	13 800	1555	495	205

WATER STATE ACCOUNT

	VOLUME MEGALITRES PER YEAR				
Raw fresh	15 000	13 800	460	100	640
Raw non-fresh	780	0	300	200	280
Worked	0	0	450	175	-725
Treated	275	0	345	20	10
TOTAL	16 055	13 800	1555	495	205

EFFICIENCY %	
Reuse	35
Recycle	22

	MEGALITRES
store capacity	12 000
inventory	7850

OPERATIONAL RISKS	CURRENT	WET	DRY
time to fill (year)	20.2	8	49
time to empty (year)	-	-	2.5

1.3 - Recommendations

The key to successful mining projects is to take into account their impact of the physical environment and local and indigenous community, and their expectations especially with water availability and the correct management of running water to avoid pollution of their natural resources. That means:

- *A responsible management for human and environmental issues calls for:*

  – An early, permanent and open dialogue

  Nowadays, local communities are much more aware not only of their rights but also of the benefits of economic development to their population. However they are also keen to defend proper and sustainable development in order to insure long term benefits to their children.

  Environmental issues are often under very close scrutiny. Internet facilitates exchanges and communications with national and international non governmental environmental group. Links are easily created and expert help can therefore be quickly obtained from worldwide "friends". Advice from these organizations can sometimes be radical and therefore cause communication break-down with the industrial partner.

  Today, no major mining project can be developed without a very early dialogue with the local communities.

  Sometimes, it can be rather difficult to properly identify the most appropriate representatives. Indeed, in certain regions, land ownership and therefore of the mining sites is not always known through conventional documents and the only way to do so is to organize talks with different tribal authorities.

  The early approach is not sufficient though. Permanent and open dialogue with local communities is required in order to explain again and again the different impact and outcomes of the project.

  – Transparency in the development of the project.

[21] *As discussed by Mudd (2008)*

– Thanks to global communications and worldwide networking, economic and scientific knowledge is not any more reserved to a few privileged organizations.

  Technical and scientific data put forward by industrial organisations to promote their business and project are now systematically being challenged by local communities.

  Transparency in the development of the project is essential to reach a high level of trust and respect between the local communities and the mining operator.

– Implementation plan involving the community: usually the development of a major mining project means huge capital expenditures. How much of these benefits flow directly or indirectly to the local communities is generally a major issue. The right approach is to build the implementation plan with as much contribution of the local communities as possible.

– <u>Long term commitment of the mining companies and guarantees by the local government.</u>

  Local communities tend to be suspicious of major industrial operators which have their main office overseas. The general belief is that these companies only come to extract the wealth of the land for their exclusive benefit. Guarantees by the local government are usually required to address this issue.

– <u>Internationally recognized environment and water regulation.</u>

  In this century where scientific knowledge is accessible to most people who demonstrate a strong desire for it, local environment and water regulations are not any more a sufficient reference. There is a strong call for internationally recognized regulations.

  European regulations and standards are probably the most in demand. There is a general belief that rules which have been defined for large countries must and can be implemented advantageously in small countries.

– <u>Responsible and comprehensive mining rehabilitation scheme.</u>

  No major mining project today can be accepted without defining in advance a responsible and comprehensive rehabilitation scheme. Most major modern industrialised countries require industrial operators to carry out impact studies of their projects on the environment at large (human, social, physical).

  Describing the state of the physical environment at time zero is now a standard exercise any responsible mining operator is required to establish and present to local authorities. This knowledge is then very useful to set up the rehabilitation scheme including large scale revegetation planning and implementation.

– <u>Development of new projects in harmony with local economic, technical and social rules and regulations.</u>

  Local rules and regulations even if they are sometimes incomplete or insufficient to fully address an issue must be taken into account. They must be integrated in the project through constructive dialogue even if some modifications are sometimes necessary.

• *Sharing the water resource:*

– <u>Extensive preliminary studies to identify all potential water resources.</u>

  All efforts must be carried out to make sure that the extent of the potential resource is correctly identified. In order not only to evaluate the capacity of the different areas but also to design appropriate protective measures for each one on the short and long term.

– <u>Adequate evaluation of present and long term needs of the population and of mining requirements for water:</u>

Long term planning of the needs of the population and the mining operation is without any doubt a must. The needs must be largely matched by the natural resources. In case of a perceived short supply the mining operator must make financial provision for an adequately designed water treatment plant to complement the natural resources.

Skid mounted equipments (SME) of water clarification consisting in: coagulation, flocculation, lamellar decantation and sand pressure filtration have proved to be efficient and cost effective.

These units have been used to address different type of water treatment issues in islands as in New Caledonia, to:

- Provide drinking water for the camp site with water from creeks, streams getting high levels of turbidity, above 500 NTU, when it is raining.
- Treat, before returning them to the environment, the power plant :
  - ✓ coal yard water,
  - ✓ process and industrial areas waters,
  - ✓ storm water.

These units have given full satisfaction in terms of:

- Performance:
  - ✓ Enabling the power plant to recycle the treated water hence providing a '*zero liquid discharge*' process and reducing environmental withdrawal in streams and lakes.
  - ✓ Providing drinking water all year long whatever the weather.
- Implementation on site. Mining sites are usually in remote places where setting up equipment is difficult. Skid mounted equipment has met all their requirements. They have been fully checked and tested in factories. They require little on site civil work, only a concrete slab, and are quickly set up.
- Cost effectiveness: being skid mounted, highly compact, requiring very limited little civil work.
- Operation & Maintenance: they have proved highly reliable and easy to operate and maintain by local teams.

Sludges treatments on drying beds have proved effective, reliable and low cost.

SME units are well suited to drinking water treatment for small cities and villages getting their water from turbid creeks, streams and lakes.

The successful implementation and the performance of these skid mounted units make a sound reference in the mining industry. From this reference, other units are implemented on the main island to supply drinking water for villages. Their cost effectiveness and O&M advantages make them attractive and enable a reliable treatment of stream water to get safe drinking water.

- <u>Audits by external governmental or non governmental organization of these studies to insure objectivity of the results.</u>

  Industrial operators need to have the results of the studies certified by scientific and engineering teams which do not belong to their organization to guarantee the total objectivity of the results.

- <u>Show genuine respect to the population by organizing explanation of the projects to the different users of the community:</u>

  People generally are striving for respect and consideration and want to be part of the decision making that affects their daily lives. They want to be part of what is happening and be sure that their needs are taken into account for the short and long term. Regular explanations of the progress of the project are a sure way to show respect to them and obtain their support in return.

- <u>Ensure total comprehension and adhesion to the project by the local communal authorities through frequent formal and informal meetings.</u>

The most formal political representation of the local population are the people who are designated by them through local elections. In that sense the communal authorities are supposed to defend their interests.

It is therefore indispensable that the communal authorities be regularly informed of the progress of the project so that they can bring their remarks to the developer well before final decisions are made. That is one of the conditions required for their support.

– Regularly inform the general public of the progress of the project and of the final conclusions through local media.

  Frequent communications to the general public are also essential. Well informed people tend to be more tolerant and constructive than those who are poorly informed. The latter tend to listen to rumours and rumours are generally negative.

- *Protect the water resource and the environment for a sustainable development:*

– Manage rain water on roads and pits to avoid pollution of downstream areas by engineered collecting systems and treatment prior to rejection into natural creeks and rivers.

  Uncontrolled rain water can be disastrous for downstream rivers, creeks and beaches. Heavy rain water tends to erode all loose fine mineral and carry them from the mountains to the valley polluting everything on its way. The only solution to avoid this situation is to collect the different streams and direct them towards filter dams made of large stones in which fine mineral can have time to settle. Clear water can then be rejected downstream by overflow and through natural filtering.

– Promote best practices by all means including penalties when required.

  Best practices when known must become part of formal rules and regulations. Local authorities are required to promote these best practices by all means including application of penalties when necessary.

– Implement revegetation.

  Plan extensive revegetation of mining sites with endemic plants everywhere possible. Involve local population in this activity to create jobs and bring sustainable wealth to their community. This also means creations of a dedicated endemic plants nursery well before the commencement of mining operations.

– Monitor consumption at all times to avoid spillage and waste.

  Water tends to be used in many applications even when an alternative requiring less or no water at all can be used (for example in the cleaning of conveyor belts).

  Training can be organized to make operators more conscious of situations where spillage and waste can be avoided.

  Monitoring consumption can also help because it can give a measurable value to the water used.

– Generalize use of modern on site autonomous water treatment systems to prevent rejection of untreated used water.

  Nowadays, modern on site autonomous water treatment systems exist. Their use should be encouraged in order to avoid rejection of untreated used water in nature.

– Optimize industrial processes to minimize water needs.

  Industrial processes are designed to produce at a nominal rate and cost. Water, when required, sometimes represents only a small part of the production cost and is often not optimised. . More attention should be given to this issue not only during design but also during operation.

- *Promote close partnership between industry and research*

  – <u>Successful sustainable development requires front end scientific research work closely associated with terrain practises.</u>

  Sustainable development cannot be achieved without extensive scientific work. Engineering systems are best designed when sound scientific data and concepts are used but they need to be closely relevant with terrain practices.

  – <u>Private and Public Partnership:</u>

  Water should to be considered as scarce and precious enough to motivate industrial operators to engage themselves into private and public partnership to develop their technologies in order to:
  ✓ minimise water requirements,
  ✓ protect water resources,
  ✓ avoid pollution whenever and wherever possible and reduce it to the smallest possible expression when not possible,
  ✓ reduce costs of revegetation.

- *Define with the mining operator and the Community a legal framework that takes into account the specificity of each project and the Community.*

  – Make sure to include water as one of the important elements in legal agreements concluded between the mining operator and the community.

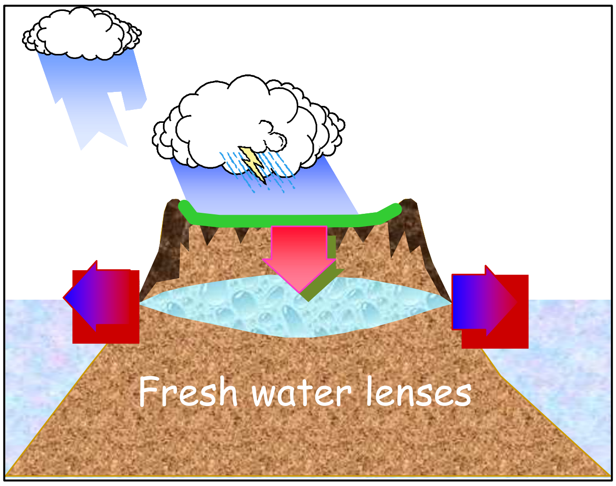
  – In the legal framework, take into account the specific context of each project and each community. The technical considerations which are specific to the project, the short term and the long term needs of the population and the local rules and regulations must be examined thoroughly in order to secure a balanced implementation scheme.

2 – The issue of water and agriculture in coastal areas, islands and isolated communities

The soil-plant-sea-atmosphere ecosystems of islands are critical, and through their ecosystem services they sustain human well-being [22]. Understanding and managing the soil-plant-sea-atmosphere system is crucial, not only for the economic futures of islands, coastal and isolated areas, but also for the health of their environments, and the wealth of their social systems. This is especially so for the fragile and resource-constrained environments of the islands, coastal and isolated areas across the Pacific.

Many islands, coastal and isolated areas across the Pacific are vulnerable due to their small size in both biophysical and socio-economic senses. They are increasingly confronted with the environmental consequences through utilisation of their fragile natural resources for economic development. The impact of the management of their soils and landscapes for agricultural, mining and urban development, plus the natural estate, is transmitted through the soil to the fresh water lenses and groundwaters underneath, and then frequently by interface reconnection to estuaries and fringing coral reefs. In these fragile island and coastal environments, land management determines groundwater quality and quantity, as well as the integrity of the lagoons and coastal zones. Land management involving irrigation, agriculture, mining, urban development and waste application, vegetation management, plus pesticide and nutrient usage determines the state of the fresh water lenses, groundwaters, and coastal waters on low islands. For tall islands, the issues can be similar, yet exacerbated through soil erosion and sediment runoff into estuaries and the fringing coastal zones. Agrichemicals are frequently adsorbed to the soil particles that are in the turbid run-off waters that end up in the lagoon.

[22] *Millennium Ecosystem Assessment, 2005*



The intimate connection between agricultural land management and the fresh water lenses, groundwaters, and coastal waters of islands, coastal and isolated areas, especially under the high rainfall conditions of the Pacific, and the permeable soils of these islands and their coastal regions.

Costanza *et al*. (1997) have estimated the natural capital value of 17 terrestrial ecosystem services, all involving the soil-plant-atmosphere-groundwater system, to be globally worth US$5.74 trillion. On a larger island, New Zealand, its former Parliamentary Commissioner for the Environment commented in 2004 that New Zealanders "*… are highly dependent on our natural capital – our waters, soils and biodiversity – for sustaining wealth-generating capabilities, [yet] our farming systems are financially and environmentally brittle, [and] fundamental redesign of farming systems is required*". The *Guardian Weekly* noted in 2002 that "*water is now known as 'blue gold' … and 'blue gold' is this century's most urgent environmental issue*" (Vidal, 2002). Barlow & Clarke (2002) have outlined the risks associated with our rush for blue gold. Through the use, and abuse of water by agriculture on islands and in coastal and isolated areas it is necessary to ensure that natural capital is not degraded, and that the value of these islands' ecosystem services is not diminished.

Agricultural land management determines both the quality and quantity of groundwaters and coastal waters for islands, coastal and isolated areas. Worldwide, the productive outcome from agriculture is, however, having negative impacts on ground and surface waters, for as the American lawyer Robert Glennon commented "*… the legal rules governing groundwater use reward rational economic individuals by assuring them that the biggest pump wins*". Sound policies and sustainable practices are needed to avoid such an outcome. Land management, surface waters, groundwaters and coastal waters are connected, yet as Glennon (2002) lamented, in the US "*… a complete misunderstanding of hydrology has been memorialized, where groundwater and surface water (plus coastal water) are legally unrelated things*". In dealing with non-point source pollution from agriculture, it is imperative that these are connected, for contaminants leaking from the rootzone will end up eventually degrading receiving waters, for they are linked hydrologically. Modelling can be used to make this connection so that land-management policy and best practices on farms can be developed to protect freshwater lenses, groundwater and coastal water.

There is increasing urgency to manage agriculture sustainably so that the gold mine of water, both its quantity and quality, is protected and enhanced. Agricultural intensification of land-use can return economic benefit to small island developing states. However, through intensification we can, "*… temporarily exceed the carrying capacity of the earth, but put our natural capital into decline […] Put another way, the ability to accelerate a car that is low on gasoline does not prove the tank is full*".[23] It is imperative for our productive and ecological futures that we sustainably manage our lands to protect the natural capital of our groundwaters.

For one small island state, since 1987 Tonga has exported squash pumpkin solely to Japan.[24] Up until very recently, over the last 10 years, these exports have accounted for more then 40% of total export earnings, and represent 60 to 70% of GDP derived from agricultural export. This increase in exports is matched by an abrupt increase in the import and usage of agricultural chemicals. The island's freshwater lenses are increasingly under pressure from agricultural intensification. In the economic

[23] *Hawken et al. (1999)*
[24] *Van der Velde et al.(2007)*

decision process, environmental impacts are often not taken into account. This is partly because of overlapping institutional responsibilities of water management, and opaque institutional structures. The environmental consequences experienced by small islands in terms of primary production stresses the need for taking ecological and natural capital into account when the benefits from international trade are evaluated. At the same time pollution will result in irrecoverable losses in terms of tourist potential. Improved agricultural practices have to be implemented through educational tools to ensure continuing economic prosperity derived from agricultural exports. Economic development of islands, coastal and isolated areas should also focus on the maintenance of kin relationships overseas, securing rent incomes and regional cooperative development efforts.

We need to understand better how land-management practices control groundwater quantity and quality.[25] Here, is discussed how smart measurement technologies and integrated modelling schemes could be used in the Pacific to provide new knowledge and improved tools for better managing water and chemical use by agriculture on islands and in coastal and isolated regions, and also developing regulatory policies to protect freshwater lenses, groundwater and coastal waters, without compromising production, natural capital value, and ecosystem services. Quantitative biophysical modelling is a valuable means by which it is possible to organise our knowledge so that it can be applied to manage better agriculture, and so that it is possible to develop policies and implement actions to protect the natural capital of islands, coastal and isolated areas.

2.1 - The issue of water wastage in agriculture

Agriculture is the world's biggest consumer of water and also wastes the most: it accounts for almost two thirds of water usage. Too often, the regulation of water stops at the city boundary. Why? Because agricultural policies, like the Green Revolution that enabled India to achieve food self-sufficiency, have often been based on more productive varieties, and on plentiful water available at a ridiculously low price. In the long term, however, such hidden subsidies create shortages because they encourage waste.

The issue of water is inseparable from that of food safety, a constant concern in many Asian countries. Drink or eat, will people have to choose? The necessary increase in agricultural production will not be able to continue without less extravagant use of "*the water in fields*."

How can agriculture be made less water-greedy? Two key points should be emphasized:

- it will not be possible to build a coherent strategy without first getting rid of the existing incoherencies, and without first abandoning policies that reward waste, i.e., the perverse subsidies that encourage overuse of groundwater;
- at the same time, there should be an increase in the use of trickle or drip irrigation. Drip irrigation can reduce water consumption up to two thirds. But worldwide, this technique is used for only 1% of irrigated land.

The issue of virtual water

Virtual water is the quantity of water used to produce a good or a service. It takes 400,000 liters of water to manufacture a car or 1,300 liters for mobile phones. China produces twice as much rice per hectare as India with the same amount of water. On the other hand, for each unit of GNP produced, China consumes 6 times as much water as South Korea and 10 times more than Japan. Whatever uncertainties about these figures and even if the structure of economies goes some of the way to explaining these differences, that leaves a huge margin for improvement. There's a lot of talk about dematerializing economic growth. But it is also necessary to dehydrate it.

Living in a world of scarce resources means that all stakeholders have a moral obligation to use each cubic meter of water as efficiently as possible. Recycling wastewater is one way to increase water productivity. By unlinking uses from withdrawals, it maximizes the number of uses of a given quantity of initial

[25] *Clothier, 1997*

resource. Similarly, recharging aquifers makes them more productive: it boosts their natural potential.

Unlike oil, it is not economical to transport huge quantities of water over long distances. As a result, world trade in water is not a solution that can be applied across the board to offset local imbalances. The overabundance of water in Canada can unfortunately not relieve the dry regions of Chile. However, purchases of finished products made in countries with excess water can, indirectly, relieve hydric shortfalls. For example, when countries import grain, they also import the water contained in those agricultural

2.2 - Measurement technologies

Thanks to electronic developments and new information technologies, it is now possible to collect, quite cheaply, long records of biophysical data about the state and fate of water and chemicals in agricultural fields with fine temporal and spatial resolution. Furthermore, thanks to new (and cheap) technologies this can be done at remote locations on islands, coastal regions and isolated areas. So it is now easier and quite inexpensive to monitor and predict the need of irrigation, plus fertiliser and pesticide use in agriculture. So we can now more easily obtain information about the state of and pressure on the water resources of islands, coastal and isolated areas.

2.3 - Modelling and Policy Formulation

Armed with such measurements of water consumption and leakage of chemicals, it is possible through modelling to use long historical records of meteorological data to generate risk assessments of the need for, and consequences of, irrigation and agrichemical use. Parsimonious water use is the goal of sustainable irrigation and agrichemical use for two reasons. First, minimising the application of water will reduce wastage of irrigation through the drainage which compromises the quality of the underlying water; and secondly, since groundwater is a prime source of irrigation water, minimising abstraction will maintain groundwater quantity. Likewise, reducing the use of agrichemicals on islands will reduce the contaminant loading on the connected freshwater lenses, groundwaters, and coastal waters.

Decision Support Tools are available to predict what the minimum amount of irrigation needed is, and to prescribe best practices for agrichemical use on islands, coastal and isolated areas. These are in use in other areas of the world [26], and incipient initiatives have been attempted in the Pacific. Not only can these tools be used to guide the development of sustainable policies, they can also be used, possibly in modified forms, by farmers to ensure that their on-farm practices are sustainable.

To manage agriculture sustainably to protect the quality and quantity of water on islands and in coastal and isolated areas will require the combined scientific powers of new measurement technologies and comprehensive modelling schemes. This knowledge, transmitted through Decision Support Tools, will be usable by farmers to implement sustainable agricultural practices on the soils which overlie yet are hydro logically linked to freshwater lenses, groundwater and coastal waters. Armed with understanding of the connectedness of the soil to these waters, and on the impact of agriculture on the quality of these waters, policy agencies will be able to draft and implement policies to protect the blue gold upon the future wealth of these islands depend, whether that be through agriculture itself, or via aquaculture and tourism.

2.4 - Drip irrigation

Drip irrigation is a highly water-efficient irrigation system by which water is delivered to the crops in small amounts, directly to the stems and roots of the plants. It is possibly one of the most significant innovations in irrigation in the 20th century. This method consists typically of a net of pressurized irrigation pipelines, which deliver water in small quantities (drops) though small holes at the desired places. The pipeline network can be at the surface or be covered underground. Drip irrigation is substantially more efficient than flood irrigation or other irrigation methods

[26] Green *et al*. 2006

because it reduces significantly the water loss due to evaporation, and the "*loss*" of water delivered away from the crops´ roots or in more supply than the roots can absolve. This system can also make a more efficient use of nutrients, as they can be added directly to the water and delivered in limited quantities directly to the crops´ roots. Another advantage of drip irrigation is the possibility of employing recycled (residual and grey waters) in safe conditions, as water is controlled in its distribution, and makes contact with the environment only at ground level and only where the plants are located.

Drip irrigation has been widely and successfully employed in a large variety of crops in arid or semi arid conditions, for example in vines, berries and tomatoes and other crops in Australia, Israel and northern Chile, among many other examples. Accordingly, this method can allow expanding irrigation to areas otherwise regarded to wastelands or non-arable lands, while relying on a limited supply of water, and even employing recycled waters. Even steep and rocky terrains can be converted to agriculture using this method. Despite the significant economic and water efficiency-related benefits of drip irrigation, the establishment and maintenance (to avoid the clogging, for example) of the pipeline network for large extensions requires a significant investment that can be hard to finance and implement on small farms, especially in developing countries. Hence, this suggests a role for public policies (credits, financial and technical assistance policies) in supporting the adoption of drip irrigation.

2.5 - Recommendations for agriculture

- *General recommendations:*

– Develop and provide to farmers simple and inexpensive measurement tools to enable them to make good tactical decisions about the need for irrigation and agrichemical applications.

– Develop modelling tools and use them as Decision Support Tools to guide both policy initiatives to regulate water consumption and agrichemical use, and so that these can be translated into simple tools for farmers to manage sustainably their lands through best practices.

– Develop participatory learning and action protocols so that policy agencies (both agricultural and environmental), farmers, exporters, scientists, and the local communities can develop a better understanding of the productive capacity of their lands, the natural capital value of their islands, and the human well-being that flows from the ecosystem services of islands, coastal and isolated areas.

- *Sector-specific recommendations to:*

<u>To public authorities & government</u>

– Stop policy-induced scarcity. Water provides a vehicle for transferring environmental costs, distorting economic signals. Perverse subsidies are visible in many stressed environments. The under pricing of irrigation water creates disincentives for conservation. It should come to an end.

– Develop water allocation guidelines for consents, using Decision Support Tools, for sustainable water takes according to crop type, soils, weather, and land-use practice.

– Monitor the quantity and quality of water resources and report these annually.

– Estimate, or better still meter, the consented takes of water for agriculture, and report these totals annually. Metering devices are now quite inexpensive.

– Report annually the ratio of consented water takes in relation to the volume of the available water resource.

<u>To operators of water services</u>

– Use the Decision Support Tools as guidelines to determine what are the sustainable needs for water by various agricultural crops and land uses.

– Engage with farmers and water users to develop a *'community of practice'* around the sustainable use of water for agriculture, and the negative consequences of poor watering practices.

- Expand this *‘community of practice’* across the islands of the Pacific, and Indian Oceans, to enable collective learning about the special aspects and unique solutions for water management on low and tall islands.

<u>To public and Water Users</u>

- Increase the general understanding of the size of the ‘*water footprint’* of agriculture.

- Highlight the economic and environmental costs and benefits of the use of water in agriculture, and demonstrate the imperative of shrinking the size of agriculture’s water footprint.

- Use Decision Support Tools and simple measurement devices to minimise the use of water in agriculture and report the continuous improvement in water practices.

- Increase water productivity in agriculture. Living in a world with limited resources means that we have a moral obligation to use in the most efficient way each cubic meter and each dollar directed to water sector.

- When water is scarce, promote drip irrigation technology with allow to save large volumes of water compared to classical irrigation methods.

CHAPTER 3 - A NEED FOR DEVELOPING ALTERNATIVE RESOURCES TO FACE WATER SCARCITY

1 - Introduction and background

The problem of water scarcity has become increasingly important in many parts of the world, and there seems to be a trend in that direction. This resource has become scarcer, at its short supply must be allocated among various, competing uses, including human consumption, agriculture and irrigation, mining, industrial uses, among others, and of course, the use of it by nature and the environment. These conflicts have been exacerbated by the fact that, unlike other goods, water is essential for life and human development and well-being, which requires water allocation not only to be economically efficient, but also fair and universally guaranteed.

Blue gold and black gold

Water is sometimes described as blue gold in a simplistic analogy with black gold. There is no comparison: water is not oil. Oil is a fossil resource that is mined, whereas water is a renewable resource. According to the calculations of Global Water Intelligence, the average global price of water billed to the customer is 75 cents per cubic meter in areas covered by a distributor. Compare that with 320 dollars per cubic meter for oil! This implies radically different economic systems: on one hand, we have a product so expensive that it is worth transporting from one end of the world to the other, while on the other, we have a heavy and low-priced product that requires local service. For oil, there is a single, globalized market; for water, the market is fragmented. Oil prices are unstable, subject to the ups-and-downs of international relations and the law of supply and demand; water prices are governed by hundreds of thousands of local services regulated by a public authority.

Another related problem has been that of inadequate treatment of wastewaters, which has led to health and pollution problems around the world. In addition, many opportunities of dealing properly with water scarcity have been missed, and with it, the opportunities of win-win solutions dealing simultaneously with the two water problems mentioned above.

1.1 - Water scarcity and water allocation

- *Economic scarcity and ownership*

Economic theory suggests that clear, well-defined ownership or property rights over a resource promotes its efficient allocation, whereas undefined or unclear property rights often lead to its misuse or misallocation. In this context, defining property rights over water and water rights seems one aspect that would contribute towards dealing with water problems in general. Of course, defining property rights does not necessarily mean *private* property. It is possible, for example, to have water sources being owned by the State, or local communities, but sold, or transferred for private use.
However, in many countries, raw water resources are public property. For example, this is the case in China, Vietnam, Polynesia or New Caledonia, where water resources are officially part of the *"nation's common heritage."* In the United States, Chile and Australia, certain water resources have become private property. But being the owner of a resource does not mean that one has the right to use it as one pleases.

Of course, there are circumstances where the social costs of defining and enforcing property rights may offset its social benefits, for example in situations where water is abundant relative to its consumption or demand. But this would be unlikely to happen in contexts of water scarcity, where water issues are pressing.

- *Scarcity and Pricing*

A concept related to that of property is *pricing*. Prices play many roles. First, it signals, to consumers the scarcity value of the resource. Second, it provides incentives to use the resource up to the point where its private benefit equals its price. As a consequence, prices coordinate efficiently the allocation of water among its alternative private uses. Third, prices imply that the provision of water is financed by its direct beneficiaries (consumers), and not by public funds, which often have other alternative uses that are socially valuable, including the onerous but necessary combat of poverty in developing countries.

In PECC economies, water prices are governed by hundreds of thousands of local or regional services regulated by a public authority. In case a private operator is entrusted with the management of the water service (like in Chile, China, Australia, New Zealand, Mexico,…), the price is always defined by the public body.

- *Prices and incentives for ownership*

Prices and ownership interact. In fact, it is ownership which provides meaning to the price as the driver of efficient allocation. On the other hand, price provides the value of ownership. This in turn, creates an incentive to find and explore water sources, and make them available to the various alternative uses. Similarly, price creates incentives to treat wastewater and make it available for some uses. Prices provide a similar incentive to preserve water, for example investing in reducing leaks, or to invest in desalination technologies, or fog/mist harvesting, among other examples. These examples illustrate that total water supply is, therefore, to some (although limited) extent, endogenous to its price or scarcity value.

All the above indicates, as a corollary, that the massive, generalized underpricing of water that is observed in many parts of the world, including developing countries, is partly responsible of the mismanagement and misuse of water.

- *The limits of pricing and ownership*

There are, however, some limitations to this approach, which we address below. First, the normative problem of poor families being excluded from water markets and consumption if prices are too high relative to their income. Second, the use of water in non-market activities, for example the use of water by nature and the environment, a use that is neither represented, nor valued in the market for water. This implies that market forces alone are unlikely to allocate water efficiently in contexts of scarcity from a social perspective, issue that we address next.

– "*Ecological flow*" and sustainability

Water is also important for the protection of the environment and the natural life it sustains. These uses of water are unlikely to be represented in water markets. As a consequence, surface and underground waters and aquifers can be used beyond their sustainable level. This problem justifies limiting water rights and the use and extraction of water for market uses to a point compatible with two principles: i) long run water sustainability, and ii) preserving an "*ecological flow*" that sustains at least part of the natural life that depends on it.

If, as a consequence, water supply is limited due to these constraints, then water prices would ideally reflect the new scarcity value of water, considering the non-market uses of water.

– Prices, fairness and basic water needs.

If water is priced according to its true scarcity value (and not under-priced), this raises the ethical question of how to guarantee the consumption of quality water to the poor, a problem that is more severe in developing countries. The "*canonical*" solution to this problem from an economics perspective, and which does not contradict neither water pricing nor water ownership, is to implement water subsidies to the poor, for example, free or subsidised water up to a point deemed as "*basic*", "*minimum*", "*ethical*" consumption right, and then charge the scarcity value (price) for marginal consumption above this threshold. This still provides the signal of water being scarce anyway, and therefore the incentive to limit its use.

This, of course, requires the implementation of reliable water meters and devices, whose cost in most cases in scarcity situations are low relative to the social benefits they provide.

The successful implementation of schemes like this indicates that there is no contradiction between dealing with the ethical imperative of guaranteeing quality water to the poor, and relying on prices reflecting scarcity to allocate water among its alternative uses.

As an example, Chile employs a scheme combining a two-part system as described above, plus focused, means tested subsidies for the poor. The subsidies range between 25 and 100 per cent of the variable price. The subsidy applies only to the consumption up to 15 m^3 per household per month, after which the standard price applies for the additional consumption. This means that the subsidy applies up to about 120 *l* per person per day for a representative household.

The subsidy represents about 6 per cent of total sales, and it benefits about 17 per cent of the population. This scheme requires a reliable device to means test the population eligible for the subsidies. In such a device does not exist or is insufficiently reliable as a way of establishing a household's socioeconomic status and purchasing power, then this scheme can be severely limited.

If focused subsidies cannot be implemented, other pricing schemes can be good alternatives. For example, a ladder-like pricing system associated with increasing consumption levels can be preferred, on the basis that on average, the poor have significantly lower levels of water consumption than the richer part of the population. Similarly, this cross-subsidization can also happen among different economic sectors. For example, in Bora-Bora in French Polynesia, the touristic sector, typically more affluent than most of the local population, faces a charge per m^3 significantly higher than the charge that applies to local households and businesses.

- *Efficient water management and infrastructure*

Distributing water for human consumption and other uses requires costly infrastructure and investments, as well as a continuous effort in maintaining it. This raises the issue of what incentives can be employed for this to happen. One alternative is to have water utilities being run and operated by the State. Although this has worked reasonably well in many circumstances, it is not led by profit seeking, and relies on the political or otherwise commitment of the authority to provide water in good quantity and quality, at a low cost, and to invest in infrastructure and maintain it. Evidence suggests this commitment cannot be taken for granted in all circumstances. Another alternative is to have water utilities being selected in a (hopefully) competitive public auction process, combined with price regulation and other controls. If such schemes are well designed and well supervised, evidence suggests it can be quite successful. Regulated prices close to marginal cost can be established using "*a model firm*", or external expert opinions. The stability of regulated prices for a long enough span of time would provide incentives for firms to increase operating margins by investing in cost-reducing activities. Development and investment plans can be incorporated in the auction process, as well as water standards and the quality of services to consumers.

Beyond economic theory, it is noticeable that the use of marginal costs is not a at all common way to calculate the price of water. In fact, the marginal approach presents serious shortcomings. In many cases, applying the marginal approach is not a guarantee to collect sufficient revenues to cover either the average full costs or global financial needs of the water services.

If seasonal variations in water availability and water provision costs are significant, prices may vary across seasons to reflect scarcity throughout the year.

Finally, as utilities are often *"natural monopolies"*, pricing water at the marginal cost would lead to economic losses. This shortcoming may be dealt with by means of a two-tariff system, where consumers have a fixed "*connection*" fee, plus a variable fee per unit of water consumption (cubic meters) close to the marginal cost. If set properly, the fixed fee prevents the negative profits problem.

A similar approach can be used to create the incentives for the treatment of wastewater and the required-often expensive-investment, where a *"treatment"* fee can be charged to consumers, which can be an increasing function of their own water consumption, used therefore as a *proxy* of their contribution of the total wastewater to be treated.

1.2 - Wastewater treatment and recycling

Another problem associated with water management is that of wastewater. The unregulated market does not have an incentive to treat wastewater, nor to recycle wastewater up to the socially desirable levels. Although pricing provides some incentives for recycling water as far as acquiring "*fresh*" water is costly, this is unlikely to create incentives for recycling water to socially desirable levels. This requires additional incentives that can arise from adequate wastewater regulations.

First, as mentioned above, utilities can be made responsible for the treatment of wastewater, and the cost can be passed on to water consumers. The recycling of the treated water is a separate matter that must be addressed considering the costs of recycling the treated water *vs* disposing it in the natural environment (rivers, oceans, underground), and using "*fresh*" water from other sources. This assessment obviously varies from place to place. Again, water price would play a central role in this decision, if it adequately reflects the scarcity value of water.

Returning to the point of water treatment, the main incentives must arise from wastewater regulation. Emission regulations are one possibility. If emission standards are set, then firms (agriculture firms, etc) must treat water according to those standards before releasing it into the environment or otherwise risk penalties and fines (good enforcement is a prerequisite). Alternatively, treated water can be privately re-used perhaps with a lower quality standard in its own production process (irrigation, for example), where nature completes the treatment process spontaneously (it can also be sold to another nearby buyer). This would be facilitated if standard for irrigation (compatible with health considerations, however) are lower and cheaper to comply with that standards for treated water to be released into the environment.

Water scarcity and wastewater issues may be solved altogether, particularly under severe water scarcity circumstances.

A problem, however, with emission regulations would arise if one does not take into account the environment's assimilative capacity. Some rivers can be polluted even if firms comply with too low emission regulations.

1.3 - Integrated Basin Management and Environmental Impact Assessments

Given the complexities of water management, and the interactions between ownership and alternative and competing uses, the externalities associated with water, and site specific circumstances, a policy option is to establish an integrated basin management approach, in order to address the various water-related problems jointly. This, however, is quite demanding from the institutional perspective, as it requires a significant deal of cooperation and coordination between various public institutions, representatives of the various water users, and the civil society, to mention a few actors.

A complementary way of achieving some of these purposes is the requirement of Environmental Impact Assessment be undertaken for new projects that may put pressure on water scarcity and/or wastewater problems. Given that water problems tend to be site-specific, this institutional arrangement is a first step towards dealing with water problems on a case-to-case basis.

1.4 - A call for clean water in small islands

The main problem for small volcanic islands is the lack of freshwater resources. Indeed, groundwater resources are usually globally limited and with population growth, industrial or tourist activity accelerating, alternative water resources should be considered as increasing in value..

However, sustainable development can not be achieved without an economic development being respectful to environment and sanitary conditions. Thus, municipalities and water services must find alternative and environmental friendly water resources to answer the growing demand of potable water.

The example of Bora Bora

It is the case in Bora Bora, French Polynesia, where the municipality decided in 1990 to create a private company called Vaitehi. This company after developing the production of potable water from groundwater had to find alternative solutions due to the development of tourism and severe drought. To solve the problem, the chosen strategy was :

- to develop desalination process by reverse osmosis to increase the production of potable water to fit the needs of tourism and the local population;
- to develop water reuse for gardening to save drinking water resources and to limit the need of new reverse osmosis plants.

- *Desalination by reverse osmosis for the production of potable water*

Where fresh water is scarce or not available, water harvesting fails to provide self-sufficiency, and no other alternative solution is available, desalination by reverse osmosis proves to be the best recommendation. It is cost effective and enables economic development.

Reverse osmosis plant must be run by very competent staff and maintenance operations must be rigorously done.

Moreover, the need of chemical products for the process is a main constraint when the plant is located on an isolated island. For instance, Bora Bora's water production capacity by reverse osmosis is about 3 000 m^3/d. The total production of drinking water is about 5 500 m^3/d. Indeed, the delay between the order and the delivery of chemical products is about 4 months. So, the staff who run the plant must cope with these delays and a stock of chemical products has to be made.

The new generation of reverse osmosis plants require less energy. As the energy consumption is the main operating cost, this point must be studied at the beginning of the project.

When it is possible, the process should include two or three filtration stages. It allows getting lower conductivity and salt concentration in the treated water.

As the operating costs of a reverse osmosis plant are quite expensive, it is important to optimize underground water production from drilling. To do so, hydrological studies must be done to get a better understanding of underground water flow. Water table in boreholes must be followed accurately by remote monitoring. In addition, a leakage control strategy must be planned in order to reduce leakage from water supply and distribution networks.

The production of drinking water from seawater increases the cost price of water. As a consequence, prices must adjust. In Bora Bora for example, hotels support a larger part of the costs of water production. Water fees expected to include the costs were modified to be more expensive for large-scale consumers than for the domestic users. The progressive rate is a reminder of the lack of water and the necessity to save the resource. Thus, thanks to the high standard required by tourism in Bora Bora this industry represents 40% of the drinking water consumption and 60% of the total drinking water billing.

Nevertheless, sea water desalination is a well known and efficient process, and a good solution to increasing drinking water production.

In the northern part of Nouméa, resorts were periodically suffering from water shortage. A global solution has been implemented:

- a desalination plant, made of a containerised reverse osmosis unit with a capacity of 100 m^3/day, provides safe drinking water all year long;
- a waste water treatment plant provides water reuse for watering gardens and enables energy consumption optimisation;
- sewage sludge is treated on reed beds and produces compost for gardens.

Such solutions are '*zero water discharge*' and '*zero waste*' and optimise the use of water and energy. Their global investment and energy consumption costs are issues of concern for hotels or municipalities in remote places. They enable the development of tourism with cost effective and environmental friendly solutions.

Small islands like Ouvéa or Ile des Pins have exceptional sightseeing spots and beaches. The lack of available drinking water has for a long time limited the development of high standard hotels.

For that purpose the municipality of Ouvéa has decided to set up desalination plants by reverse osmosis on the island.

- *Wastewater recycling*

In small isolated islands the lack of underground water requires protecting limited drinking water resources by:

- promoting the reuse of wastewater for gardening, car wash, and industrial use;
- developing desalination.

Membrane activated sludge bioreactor solution has proved to be relevant for sensitive environments. It enables water reuse and safe water discharge compatible with bathing and shell fishing.

In the island of Bora Bora, to take into account these requirements, a membrane tertiary treatment was implemented for the production of high quality recycled water. This was possible because the island's raw sewage are collected, transported and treated by a pressure network and two wastewater treatment plants.

The reuse water production is 400 m^3/d by the end of this year. Water reuse allowed saving nearly 10% of the precious water resource.

Before the implementation of the process by a membrane tertiary treatment, water reuse plant already existed. The recycled water was polished effluent by maturation ponds. But its quality was not approved by health authorities for spray irrigation. Only a few hotels, equipped with underground irrigation network were interesting in using it. The recycled water consumption was about 60 m^3/d. With the new plant, the recycled water quality is better which allows a diversification of its water uses. Thus, the demand of recycled water has increased continuously. Supplying good quality of water seems to be a very important factor to succeed in this kind of project.

Moreover, pricing is a crucial tool for the economic viability of water reuse projects. The most appropriate pricing instrument to achieve in delivery costs and to attract the larger water-consumers is the declining rate structure. Declining block rates encourage large users. For example, in Bora Bora, large users such as luxury hotels were the first to recognize the economic benefits of wastewater reuse as the cost of high-quality recycled water is, in fact, 2.5 to 3 times less expensive than potable water.

The municipality of Mont-Dore, in the suburb of Nouméa, treated waste water is discharged into the lagoon where people bath and fish shells, part of it being reused for municipal watering. Similarly, the municipality of Nouméa plans to develop two treatment plants with a capacity of 30,000 inhabitants each with low impact on the environment in terms of odour, noise and water discharge in the harbour and the bay. Water reuse is an important issue with regard to the municipal sustainable development policy and water management program for resource preservation. The recycled water will be used for public garden watering, street cleaning.

The most important consideration that should be taken into account in the choice of best treatment option at small scale for wastewater recycling are as follows:

- For works below 400-500 population-equivalent (p.e.), it is important to favour low operating costs and low energy technologies such as reed beds, trickling filters and RBC. These technologies can be implemented for moderate water quality requirements.
- Extended aeration (package activated sludge, oxidation ditches or SBR) should be considered for works capacity over 400 p.e. and should be preferred for works capacity over 1000 p.e. or stringent water quality requirement are expected, including N removal.
- Natural lagooning is cost effective for small scale projects, because the very high land requirement and associated land costs. Aerated lagoons enable to reduce land

requirement, but are associated to high operating costs, mainly power consumption.

1.5 - Alternative water resources and large coastal cities

Wastewater recycling and seawater desalination provide primary or complementary resources for many large coastal cities or industrial. Furthermore, with a more unpredictable hydrological cycle, increasing water security becomes a priority. Investments in water infrastructure and alternative water resources mobilization play a crucial role to mitigate risk and vulnerability.

Therefore, many coastal cities or islands have implemented technological solutions to mobilize, at a large scale, alternative water resources. "*Security through diversity*" is a way to describe the policy implement by various states of Australia. Their seawater desalination and wastewater recycling program, which was recently extended, aim at organizing a water supply system independent of uncertain and erratic rainfall.

Wastewater recycling : the example of the Western Corridor Recycled Water Project

Queensland is Australia's second largest state in terms of surface area and constitutes an area of strong economic and demographic growth (with a population expected to reach 5.3 million by 2025).

In addition, the State of Queensland suffered from the repeated effects of unprecedented droughts. In July 2007, the water reservoirs guaranteeing nearly all the drinking water supply of the State's South East urban area (1.8 million inhabitants) and that of thermal power plants were only 17% full.

In 2006, in light of this aggravated drought situation, the Queensland government realized the scale of the issue and carried out an active policy designed to save, preserve and diversify water resources, notably by encouraging the development of innovative technical solutions such as the recycling of treated wastewater.

The State of Queensland has launched the Western Corridor Recycled Water Project. It is an important part of the Queensland Government's South East Queensland Water Grid, the largest urban drought response in Australia. The objective of this project is to enhance the security of water supply in South East Queensland.

The Western Corridor Recycled Water Project is a major infrastructure development project aimed at supplying the Swanbank and Tarong power plants with purified recycled water for industrial usage and refilling the Wivenhoe soft water reservoir (the region's main source of water supply) with a view to indirect reuse for the production of drinking water. One of the objectives of the project is also to reduce nitrogen and phosphorus discharge into the natural environment, in particular into Moreton Bay.

This project is the most important recycled water project in the Southern Hemisphere, and the world's third largest. The project cost amounts to €1.2 billion. The infrastructure consists in 200 km of pipeline, 8 storage reservoirs, 9 pumping stations and 3 water treatment plants which capacity production amounts to 232,000 m^3 per day.

The three recycling plants use advanced treatment technologies (microfiltration, reverse osmosis, disinfection, advanced oxidation, etc.). The State of Queensland selected Veolia Water Australia as the Scheme operator.

With regards to desalination, it is noticeable that seawater desalination is becoming a more competitive solution, although its price remains higher than treating poor quality freshwater. Its costs usually range from €0.5 per m^3 to €1.5 per m^3, for large desalination plants. Twenty years ago, desalt water cost 20 times more than producing drinking water from raw freshwater. Thanks to the improvement of membrane performances, economies of scale and energy recovery systems, membrane desalination can be an economically competitive alternative.

2 - Available technologies to use alternative water resources

Increasing water shortage associated with climate change and population growth are the main drivers for development of alternative water resources such as wastewater reuse and desalination. The main objective is to provide a complementary drought-proof water resource ensuring integrated water resource management with better protection of environment and biodiversity.

The reuse of wastewater has been practiced for centuries in a number of countries, but only during the last twenty years is it becoming a global issue. Seawater desalination is a relatively recent practice and it has been in operation for forty years. Technical advances, particularly in the field of membrane treatment, has enabled a significant decrease in capital and operation costs and an increase in the reliability of operation of membrane technologies.

Nowadays, water reuse and desalination contribute 0.2 and 1%, respectively to water supply; although global world water demand remains low. However, the expected growth for the next ten years is very high: + 102% for desalination with the increase of daily production from 30.6 Mm^3/d in 2005 to 61.7 Mm^3/d in 2015 and + 181% for water reuse from 19.4 to 54.5 Mm^3/d for the same period. Desalination already provides drinking water to over 200 million people in coastal areas, while wastewater reuse enable to recycle 5% of the treated wastewater worldwide.

It is important to underline that desalination and wastewater reuse are not substitutable options. Wastewater is available everywhere in urban areas, while saline water is available mostly in costal areas. When high investment is mobilised for desalination, the reuse of treated wastewater remains necessary. In fact, wastewater recycling is mostly practiced for non-potable purposes enabling a reduction in costs. For augmentation of water supply, desalinated water can be directly used as a substitute for "*freshwater*", an aquifer or reservoirs is commonly practiced even after the production of high-quality recycled water using reverse osmosis.

Wastewater recycling for direct potable use

During nearly 40 years, the city of Namibia was the only case of direct water reuse at large scale. Since 1969, this city has been recycling wastewater on a large scale to directly produce drinking water for its inhabitants.

True, Namibia has the unenviable privilege of being the driest country in southern Africa. The permanent river nearest to Windhoek is 600 km away. In 2001, the city built a new wastewater reclamation plant and called in Veolia Water and its partners to manage it. This factory has a capacity of 21,000 cubic meters per day, and supplies water to 250,000 residents. In order to prevent health risks, the process contains multiple pathogen barriers: pre-ozonation, coagulation / flocculation, flotation, rapid sand filtration, ozonization, granular activated carbon filtration, ultra-filtration, chlorination. The Goreangab plant is designed to recycle used purified water, in order to plug chronic water shortages in the capital. Had it not taken this path, its water supply would have been 35% short of meeting demand.

With its NEWater project, Singapore recently started recycling 1% of its wastewater to produce drinking water.

Wastewater reuse is a political and socio-economic challenge for the future development of water supply and sanitation services, in particular in isolated islands and coastal regions. It has, in fact, the major advantage of providing an alternative resource at a lower cost to limit water shortages and to better preserve natural freshwater resources. Recycle properly treated wastewater represents one of the most effective way to reduce water withdrawal, ensuring thus sustainable development of islands with lack of freshwater resources.

The role and relevance of desalination and water reuse for the development of industrial and tourist activities were well demonstrated in numerous islands and coastal cities in the PECC region such as Hawaii, Polynesia (Bora

Bora), Singapore, Adelaide and Sydney, etc. The integration of recycled wastewater into the existing water management master plans is essentially geared towards non-potable uses such as irrigation of agricultural crops, golf courses and landscapes. Industrial and urban uses are also rapidly growing for fire protection, street and vehicle washing, toilet flushing, etc. Recently there has been an increasing interest in the production of high quality recycled wastewater for aquifer or reservoir recharge and industrial uses as cooling or boiler water.

Different wastewater treatment schemes could be used to protect natural water bodies or for water reuse depending on the purpose, scale and constraints. The choice of the optimal solution depends on numerous factors, including water quality requirements, plant capacity, land constraints, climatic and other specific local conditions, as well as capital and operation costs.

In this context, the purpose is to provide a comprehensive decision making tool to local authorities for choosing an adequate treatment process depending on water quality requirement and potential reuse purposes.

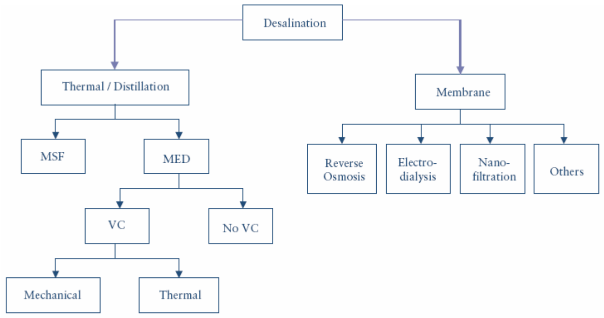
Several technologies are available for desalinating sea water. The choice depends on many factors such as the size of the plant, the source and the local cost of energy, the competencies of local companies and their partners and the quality of the seashore (with regards to seawater intake and concentrate release).

2.1 - Reverse osmosis and thermal desalination

Among the 13,000 desalination plants implemented in more than 140 countries worldwide, the largest commercial installations are developed on the basis of two main technologies:

- thermal desalination using the conventional technology of multi-stage-flash-evaporation (MSF) or the more recent technologies of multi-effect-distillation (MED) and vapour compression (VC).
- reverse osmosis (RO), a membrane technology operated since 1960s.

Classification of desalination technologies



Distillation is typically viable only for plants with large capacity and particularly where a low cost, high quality heat and energy are available. In general RO plants are cheaper than distillation facilities, and are the only financially viable technology for small plants, which is the case for coastal and tourist areas and isolated islands.

Moreover, during the last few years, significant technical improvements have been made in the RO technology, resulting in:

- increased membrane efficiency;
- significant energy reduction and recovery;
- decreased membrane cost and increase membrane life;
- improved reliability of operation and better control membrane fouling.

- *Principle of reverse osmosis*

Reverse osmosis (RO) is a separation process that uses pressure to force a solution through a membrane that retains the solute on one side and allows the pure solvent (water) to pass to the other side. This is the reverse of the normal osmosis process, which is the natural movement of solvent from an area of low solute concentration, through a membrane, to an area of high solute concentration when no external pressure is applied.

The RO membranes are semi-permeable with a dense barrier layer in the polymer matrix where most separation occurs. In most cases the membrane is designed to allow only water to pass through this dense layer while preventing the passage of salt ions. This process requires that a high pressure be exerted on the high concentration side of the membrane, usually 2–17 bar for fresh and brackish water, 8-10 bar for wastewater and 40–70 bar for seawater.

The typical single pass seawater reverse osmosis system consists of the following components: intake; pre-treatment; high-pressure pump; membrane assembly; remineralisation and pH adjustment; and, disinfection.

- *Energy consumption and cost of reverse osmosis*

The minimal cost of RO at optimal conditions and for large scale facilities is about 0.4 and 0.7 US$/m^3, respectively for brackish and sea water. This cost can more to double with a decrease in plant capacity or poor water quality. Currently, the minimum energy consumption for large plants with optimised operation is in the range of 3-5 kWh/m^3 of produced desalinated water. Advanced reverse osmosis systems apply energy recovery or pressure conversion devices lowering energy consumption to about 2 kWh/m^3. A number of research projects and innovative technologies are under development to reduce energy requirements of RO.

2.2 - Water quality requirement for wastewater recycling

Advances in wastewater treatment enable the production of any water quality using a wide range of natural or advanced treatment technologies. The choice of the most adequate treatment depends not only on water quality requirements, but also on plant size, climate conditions, local specificities (infrastructure, geographical, social, political conditions, etc.) and economic factors including financial resources, capital and operating costs.

The first parameter of concern by the primary wastewater treatment is suspended solids, which where present in the effluent and can plug irrigation systems or soils, and shield microorganisms, thus decreasing the disinfection efficiency of most treatments. The second important parameter of wastewater treatment is the secondary treatment for carbon removal. Even if carbon removal is not strictly required for the reuse in irrigation, this process is of great importance for the reduction of the regrowth potential of residual microorganisms in distribution systems. The next parameter of interest is nutrients. Generally recommended for agriculture, their presence in groundwater recharge effluents and most industrial applications is not desirable.

Further treatment includes polishing tertiary treatment for the removal of residual suspended solids and some specific compounds such as organic micropollutants, salts, heavy metals, and most importantly, the final disinfection.

The use of recycled municipal water for indirect potable reuse or in industry requires limitations on dissolved solids, ammonia, disinfection by-products and other specific inorganic and organic constituents. In many countries, the use of recycled wastewater for indirect potable reuse such as direct aquifer recharge or augmentation of drinking water reservoirs requires drinking water quality in respect to inorganic and organic micro pollutants.

The starting point for consideration of wastewater reuse for any specific application is ensuring the biologic and chemical safety of using recycled water by applying appropriate treatment technologies. Consequently, the choice and design of treatment scheme to meet water quality objectives is a critical element of water reuse system.

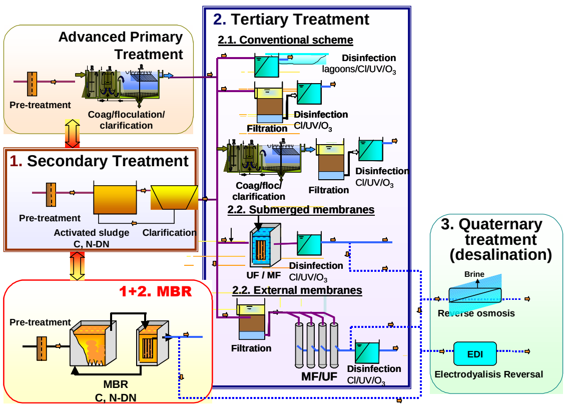
The major objective of wastewater treatment for agricultural irrigation is the removal of microbial pathogens, in particular when spray irrigation is used. The following table illustrates the water quality requirements for the two most common water reuse standards, the WHO guidelines (2006) and the Californian Water Recycling Criteria (2000).

Compared to agricultural irrigation, landscape irrigation and other urban uses require higher water quality because of the greater risk to public health associated with the difficult restriction of public access to irrigated areas and the possibility of direct contact with recycled wastewater or aerosols (cleaning, toilet flushing, fountains, irrigation of parks and gardens).

Advanced treatment processes such as membrane bioreactors or tertiary membrane filtration are highly recommended for urban, industrial and indirect potable reuse purposes because the high recycled water quality, low foot print and high operational reliability. In some cases, where for example partial desalination is needed, additional treatment by reverse osmosis or electro dialysis can be implemented.

The membrane bioreactor (MBR) process is a modification of the conventional activated sludge, where the clarifier is replaced by a membrane unit for the separation of the mixed liquor from treated effluents. The main advantages of this technology are the high-quality effluent, high flexibility, compactness and low sludge production. This technology is a cost competitive solution for tourist islands and coastal areas where land cost is high and high quality recycled water becomes a relevant alternative resource.

Typical treatment schemes for the production of high quality recycled water for landscape irrigation, urban uses, industrial purposes and indirect potable reuse



- *Cost of wastewater reuse technologies*

Though it represents a relatively small part of the costs of most recycling wastewater projects, the attention of practitioners often focuses on the cost of tertiary treatment and disinfection. The distribution of capital and O&M costs of additional treatment and reuse varies from one project to another and depends on the type of the applied treatment processes. These costs are also highly influenced by local constraints: price of the building site, distance between the production site and the consumers, need to install a dual distribution system or retrofitting. The latter two constraints are important as in many projects, the main capital investment concerns the distribution system and can reach 70-200% of the overall costs depending on site-specific conditions. Storage, mainly seasonal storage, also represents a significant part of investments. New systems are less expensive compared with the retrofitting of existing networks.

It is important to stress that the costs reported here are only to illustrate the influence of plant size on treatment costs. The costs' values cannot be extrapolated to other case studies or countries because the unit cost of reclaimed wastewater depends not only on the plant size and the treatment chain, but also on wastewater composition, water quality requirements and other local conditions (energy costs, labour, etc.). Moreover, the main components of recycled water costs are not the same from one plant or country to another.

Operating costs are about 45-50% of total annual costs for the major part of advanced tertiary treatment (chlorination, UV disinfection, ozonation, membrane filtration). As a rule, the major part of operating costs for small works is labour. To decrease this cost, it is recommended to implement an appropriate level of automation and remote monitoring (screen, pumping, mechanical devices).

On the basis of the existing experience [27], the overall life cycle cost for the treatment of raw sewage to produce recycled water suitable for unrestricted irrigation varies from €0.4 to €1.5 per m^3. Capital costs for tertiary filtration and disinfection and for full Title 22 treatment (coagulation/flocculation, filtration and disinfection) did not exceed 30-40% of the investment for secondary treatment. Higher expenses are needed for membrane treatment.

Among the tertiary treatments, polishing pond

[27] Lazarova *et al*. (2006) Evaluation of Economic Viability and Benefits of Urban Water Reuse and its Contribution to Sustainable Development, *Proc. IWA Water Congress*, Beijing.

treatment is the most rustic but has proven to be a competitive, efficient solution for small communities. This technology is the cheapest solution for flows under 3000 m^3/d (15,000 p.e.) with average total annualised cost of about 5 to 7 €cents/m^3. In this range, polishing pond treatment might be a practical and efficient solution for wastewater reuse purposes such as irrigation.

As the project size increases, polishing pond treatment becomes less and less competitive compared to the other solutions, not taking its storage function into account. There are two main reasons for this. First, the capital expenses for polishing pond treatment do not greatly benefit from scale economy. Second, the operational expenses per cubic meter do not decrease, because they are largely dictated by the cost of sludge evacuation and disposal. This cost is typically a fixed cost per cubic meter, as agreed with local farmers. Additional difficulties arise when the project increases. The surface of the ponds may become prohibitive, as well as the sludge evacuation campaign.

For small and medium size treatment facilities (<50,000 p.e.), chlorination and UV irradiation are more competitive than ozonation with average total annualised cost of about 2 to 8 € cents/m^3. The cost difference between UV and ozone decreases with plant size. The competitiveness of ozonation appears clearly for large plants (>100,000 p.e.), where total costs are in the typical range from 1 to 2.5 € cents/m^3. Given that ozone also improves the removal of emerging pollutants and the visual aspect of recycled water, lowering also its odour, this process should be considered as a viable option for large plants.

For project sizes over 7500 m^3/d (50,000 p.e.), the cost for UV or chlorine becomes comparable within the error margin of the cost estimation. As a reminder, the addition of chlorine in treated wastewater has been shown to produce carcinogenous compounds; however, concerns related to potable water might not be extrapolated to all reuse applications. After years of debate, this issue is now a major concern for the regulator and for environmental associations, which makes the future of wastewater chlorine disinfection uncertain.

The cost of membrane filtration (microfiltration and ultrafiltration) are significantly higher compared to the other disinfection processes and typically can reach 20-70 € cents/m^3 for plant capacity of 20,000 to 500,000 p.e. and up to 2.5-3 €/m^3 for small units <2,000 p.e. In all cases, recycled water quality is significantly higher, as well as operational reliability, which is often the decisive criteria for the choice of treatment train for indirect potable reuse, industrial reuse and even some urban applications.

The high cost of membranes is also the main constraint for the widespread application of MBRs, despite all the process advantages. Compared to activated sludge, the overall costs still remain up to 20-50% higher than activated sludge depending on plant size. Reported MBRs costs typically vary from 10 to 30 € cents/m^3 for treatment plant size up to 50,000 p.e.

- *Pricing of wastewater recycling*

The great difficulties in estimating wastewater treatment costs have direct impact on the definition of water reuse costs. In addition to this constraint, water reuse pricing is strongly challenged by the low water prices that are, as a rule, subsidized or do not include all incurrent expanses.

A wide variation in recycled water unit pricing exists depending on the type of reuse, flow rates and local conditions, ranging from 0 to 0.5 €/m^3 depending on recycled water quality and local conditions. Among existing urban water reuse projects, the prices of recycled water range from 25 to 100% of potable water rates. For example, a 25-40% discount for the Title 22 quality recycled water used for landscape irrigation and other urban uses is proposed in the West Basin, California. In Bora Bora, however, the recycled water price is fixed at 20-60% of potable water charge, depending on water consumption in order to encourage water recycling. Declining block rate is applied to encourage large users, with lower charges for small private consumers.

- *Guidance for the choice of best treatment option at small scale*

Adequately designed and managed small wastewater treatment works are a cost-effective and long-term option for meeting public health and water quality goals in isolated islands and coastal areas. Consequently, taking into account the extremely high variation of hydraulic and organic loads, the design of small works becomes a challenging task requiring good professional experience and knowledge of a wide range of treatment processes.

Small works (<2,000 p.e.) represent the majority of the wastewater treatment in isolated islands. However, many existing works are poorly designed with inadequate operation. To comply with the new EU regulations for wastewater discharge, in the next few years a great number of new works will be constructed and the existing ones would need repair and extension.

The requirements for nitrogen removal and disinfection are most critical when choosing the best option.

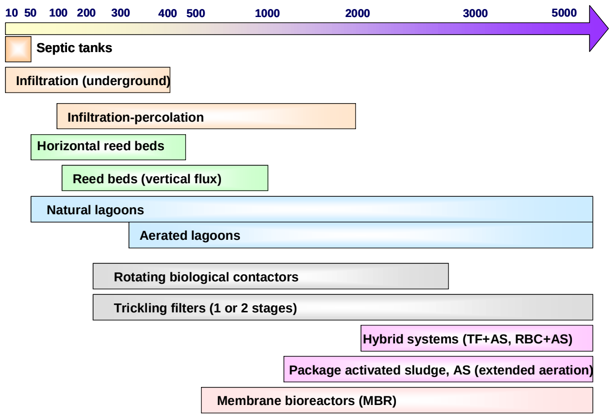
- *Selecting the best option for wastewater recycling*

The selection of the best treatment option is highly influenced by the following critical factors:

- robustness and simplicity of operation;
- low operation costs and minimal maintenance;
- good tolerance of loads variations;
- the possibility of in-side sludge treatment.

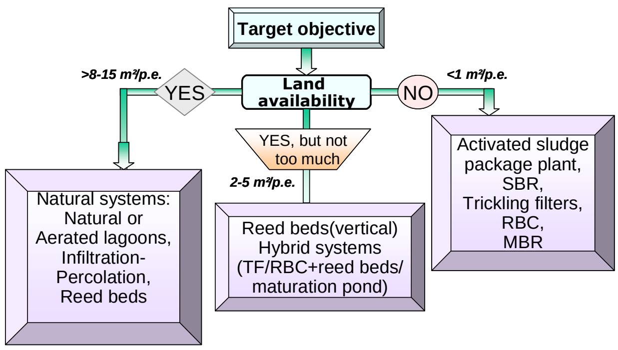
On the basis of the critical analysis of the proven wastewater treatment processes and the feed back of their reliability of operation for urban wastewater treatment, the next figure illustrates the optimal range of plant capacities for the implementation of treatment processes for small communities <2,000 p.e. and plants with intermediate size up to 5,000 p.e.

Optimal range of plant capacity of several proven processes for wastewater treatment at small scale (Suez Environnement)



The following picture presents a simple decision-making flow chart for the choice of best treatment option depending on land availability. Of course, the ability of the given technology to remove different pollutants of concern, operational flexibility and drawbacks, as shown in the next two tables, need to be also taken into account.

Decision making flow chart for the choice of best wastewater treatment option at small scale (<2,000 p.e. (Suez Environnement))



⇧ Increase of water quality	WHO guidelines (2006)	Californian Water Recycling Criteria (2000)	⇩ Decrease of treatment level
	Unrestricted irrigation of leaf crops without additional barriers (cat.E) <10 *E.coli*/100 mL Unrestricted irrigation (cat.A, root crops, with additional barriers of die-off and product washing) $<10^3$ *E.coli*/100 mL, <1 helm.egg/L (arithmetic mean) ↬*Treatment requirements: secondary + filtration + disinfection, stabilization ponds* Drip irrigation (Cat. D and C): $<10^3$ *E.coli*/100 mL, <1 helm.egg/L (low-growing crops plus die-off); $<10^5$ *E.coli*/100 mL, <1 helm.egg/L (high-growing crops plus die-off) Restricted irrigation (Cat. F and G) $<10^4$ *E.coli* /100 mL, <1 helm.egg/L (labour intensive agriculture); $<10^5$ *E.coli* /100 mL, <1 helm.egg/L (highly mechanised agriculture)	Disinfected tertiary effluent 2.2 TC (total coliforms)/100 mL: food crops, open landscape areas, toilet flushing, non-restricted recreational impoundments ↬*Treatment requirements: CT > 450 mgCl-min/L, <2 NTU (<0.2 NTU if membrane treatment), 5 logs MS2 removal* Disinfected secondary effluent 2.2 TC/100 mL: food crops where edible portion is under ground and not contacted by recycled water Disinfected secondary effluent 23 TC/100 mL: pastures, landscape areas, industrial cooling, roads cleaning Undisinfected secondary effluent: orchards, vineyards, fodder crops, processed food crops	

List of the most adequate wastewater treatment technologies at small scale and their ability to remove different target pollutants

Treatment process	COD	BOD	Suspended solids	Nitri-fication	Denitri-fication	P removal	Dis-infection
Septic tank with infiltration	+++	+++	+++	-	-	-	yes
Infiltration-percolation	+++	+++	+++	++	-	-	yes
Reed beds with vertical flux	+++	+++	+++	+	-	(a)+/-	no
Reed beds with horizontal flux	+++	+++	+++	-	+	-	no
Natural lagooning	++	++	+	-	-	-	yes
Aerated lagoons	+++	+++	+	+	-	-	no
Trickling filters	+++	+++	+++	++	-	(a)+/-	no
Rotating biological contactors	+++	+++	+++	++	-	(a)+/-	no
High-rate clarification	++	++	+++	-	-	+++	no
SBR	+++	+++	+++	+++	+++	(a)+/-	no
Activated sludge (package)	+++	+++	+++	+++	++	(a)+/-	no
MBR	+++	+++	+++	+++	+++	+++	+++
Tertiary sand filtration	-	-	++	-	-	+	+
Tertiary membrane filtration	+	+	+++	-	-	+	+++

a) P removal by chemical precipitation

3 – Capture and conservation of rainwater in small islands or isolated communities

3.1 - The case of small and isolated islands

Atolls, protected by a coral reef, are flat sand circles, a few acres wide, with the ocean on one side and the lagoon on the other side. In the early 19th century, the few islanders lived on fishing and taro planted in pits in contact with the fresh water lense. Fresh drinkable water could come either from these pits or from green coconut water. The rainwater could be collected in small coconut shells or in wider turtle shells.

With the arrival of modernity, tin roofs appeared and were used to harvest rain water that was stored in rough concrete tanks covered with roofs. A permanent problem was achieving a fair distribution of water at the only faucet in the village knowing that in dry periods, water was scarce. A constant nightmare was the possible pollution of the tank by dead animals, mainly rats that had fallen in from the roof.

For the last 30 years, economic reasons have been strong enough to encourage inhabitants to stay on their atolls: for example, culture of pearls, copra, and fishing.

The first step was to insure enough fresh water supply. Two main techniques were used to get safe drinking water. Desalination has proved costly and hard to maintain by lack of experienced technicians locally. Most systems are today out of order except for Bora- Bora where 30% of the water produced is consumed by the hotels that pay 70 % of the bill while the inhabitants that consume 70 % of the water pay 30 % of the bill. Elsewhere, rain harvesting has been favoured with a financial subsidy from public authorities. The equipment is rather simple and does not consume energy. Rain is captured on the roofs, then, through gutters and pipes, goes to plastic tanks that are tightly closed to prevent pollution. At the same time, public infrastructure such as airstrips, schools, medical centres and public buildings were established on these small and isolated islands, usually equipped with their own rain harvesting systems. This infrastructure has permitted the local, population to choose to live locally instead of migrating to urban centres in larger islands.

However, many problems are still pending. All families are not yet serviced. The lack of supervision of maintenance creates tension within the populations because the quality of water is uneven and politicians are suspected to favour public subsidies to their supporters. This is more evident when seasonal rainfall deficits occur.

Although the capacity of the storage system is not sufficient yet, rain water capture has proved to be the cheapest method to date; and this is an important factor when financial resources become scarcer because of the crisis in pearl farming and tourism that are the main industries in these islands. In order to insure the long term stability of the system; more public subsidies are needed to complete the water collection system for the families left behind. Local authorities in the islands should provide, through a proper management, practical training to families in order to have proper maintenance and cleaning of the tanks to increase the quality of drinkable water that has to be stored for several weeks in certain seasons.

In conclusion, despite some drawbacks, rain water harvesting in Pacific islands has allowed, for a rather low price, to allow local populations to stay in their native islands.

3.2 – Past answers to produce drinking water: the case of the Tuamotu islands

The archipelago of the Tuamotu islands is composed of more than forty atolls inhabited permanently. These atolls are only a few meters above the ocean. Around 15,500 people live in this archipelago, i.e. 6% of the French Polynesian population. The lack of any mountain explains why rain fall is much lower in the Tuamotu islands than in the volcanic islands.

The capture and distribution of water is therefore a major issue in the Tuamotu islands and requires a very specific solution adapted to small municipalities with very low financial resources.

The capture of rainwater from roofs has always been the oldest and the simplest way of collecting water. This way of capturing rainwater requires reservoirs and large surfaces of roofs to collect enough water. The quality of the water is very dependant upon the cleanness and the maintenance of these reservoirs. At first, public reservoirs were built in concrete, later on they have been progressively replaced by individual and private reservoirs built using plastic.

Due to their geo-morphological composition, some atolls had fresh water lenses. In these atolls, wells were dug to access the water. Over-exploitation of these fresh water lenses has broken the fragile natural equilibrium of these very specific atolls. A high concentration of population and a lack of proper waste water treatment as well as a lack of maintenance forced locals to abandon these wells .

Nevertheless, in only two atolls where the system still works, the quality of the water is very low. In order to face a growing and urgent demand of drinking water from populations with low financial revenues, it appeared that the only solution consisted in installing individual and private reservoirs. This solution seemed very economical, very easy to put into action, and very flexible. Given that the reservoirs were private, consumers were expected to act rationally to moderate their water consumption and to look for water with high quality standards.

In the period going from 1995 to 2005, many programs were heavily subsidized by public authorities to accelerate the equipment of families from the Tuamotu islands with private reservoirs.

The latest program began in 2003 and was completed in 2005. It included more than 2000 private reservoirs of 7,500 litres each. Given the average rainfall in the Tuamotu islands, the average size of the families, and the average estimated surface of the roofs (around 30 square meters), it was necessary to equip each household with the equivalent of 2 reservoirs of 7 500 litres just to give 50 litres of drinking water per day and per capita.

The Tuamotu islands, with 50 litres of drinking water per capita, per day,, is far behind the target of 300 litres that most projects are looking for in the other archipelagos. There is a lack of 1,800 private reservoirs of 7,500 litres, especially among the poorest people.

Private reservoirs are rarely taken care of properly. Only one fourth of the private reservoirs satisfy all the criteria for a proper use, i.e. a separator of the first rainfalls, a sewing tap, proper gutters. Only one third of the families have proper gutters collecting 100% of the rain falling on the roof and 5% of the private reservoirs are never maintained. Only one third of the private reservoirs are regularly maintained, i.e. emptied and cleaned.

Public reservoirs are also in the same situation, only few public reservoirs are still working. Most of the reservoirs had to be stopped very shortly after their installation. Anyway, the lack of proper maintenance is very often the main explanation.

In order to tackle this problem, the local authorities have recently supported some innovative initiatives :

- The "*PAPE ORA*" program has consisted in equipping public reservoirs with a system of low capacity drinking water distribution. Technically, the system is made of 1 pre-filter, 3 successive filters and finally a UV lamp. These reservoirs distribute small quantities of drinking water. The water is free. And the reservoirs are located near city halls, schools or public buildings.
- Reverse osmosis systems have also been tested in 11 different locations in the Tuamotu islands to equip tourist resorts, public high schools or whole municipalities. Out of these 11 different locations, only 3 are still working (and 1 is a private reverse osmosis system). Three other locations could re-activated easily. The others are completely out of order namely because of the lack of capabilities at the local level to ensure effective maintenance and to the high cost of outside maintenance due to isolation. This underlines the parameters to be introduced before introducing very innovative solutions.
- There is also the sole case of the HAO Island which, after the departure of the Nuclear Experiment Center, inherited of 2 army water boilers. These had given drinking water to the hundreds of soldiers living there as well as to the local population. French government subsidies helped to replace these boilers by more recent reverse osmosis systems which can now produce up to 540 cubic meter per day. Now, the drinking water produced in Hao costs around €4 per cubic water and the people only pay for two thirds of this cost.

All these solutions are based upon public reservoirs collecting water from the roofs of public buildings (schools, city halls, and sporting halls) or from reverse osmosis systems. Estimated cost of the program is €14.3 million for 16,000 people, i.e. €900 per capita.

For a proper water management it is essential to teach users good habits for efficient water use and train municipal workers for the maintenance of reservoirs in order to improve public health and the life expectancy of public water equipment.

The most appropriate solution in remote islands surely consists in public reservoirs equipped properly to distribute drinking water to a sole public point. The consumption of water from this public point has to be restrained through a pre-pay system. It seems irrational to plan to equip all islands with public water distribution system, therefore private reservoirs are often the simplest and easiest solution.

4 – Fog harvesting

Fog harvesting is a non-traditional method of collecting water by means of inducing the water droplets contained in fog or mist to precipitate when they encounter a solid obstacle. The small water droplets present in the fog precipitate when they come in contact with objects. The frequent fogs that occur in the arid coastal areas of Chile and Peru are traditionally known as ***camanchacas.*** These fogs have the potential to provide an alternative source of freshwater in this dry region if harvested through the use of simple and low-cost collection systems known as **fog collectors.**

This collection method allows for providing some amounts of safe water in places confronted with a short supply of other water sources such as rain, underground or surface water, but endowed with a large supply of fog or mist throughout the year.

Present research suggests that fog collectors work best in coastal areas where the water can be harvested as the fog moves inland driven by the wind. The technology could also potentially supply water for multiple uses in mountainous areas should the water present in stratocumulus clouds, at altitudes of approximately 400 m to 1,200 m, be harvested.

A well known and well studied area for fog harvesting involve many coastal parts of the Atacama desert in northern Chile and Perú. In these areas, moist air from the Pacific Ocean is driven inland by the wind to the hot and dry lands, creating the spontaneous condensation and precipitation of waters in the coastal mountain range. Other places with similar conditions where fog harvesting has also been used include Oman, Yemen, Gibraltar, Ecuador, Mexico, South Africa, among others.

Currently used in Israel to irrigate the vines plantation, fog harvesting was also used in the ancient Egypt where the dew and fog were collected. Piles of stones were arranged so that private reservoirs are often the simplest and easiest solution. The condensation would drip to the inside of the base of the pile, where they shielded from the sun. A similar technique is used in Gibraltar: a large area on the slope of the rocks has been covered with cement blocks. Fog and rainwater runs downwards and is collected underground. On a smaller scale, rain, fog and dew are collected on enormous granite rocks at Cape Columbine lighthouse, on the West Coast of South Africa. Some Beetles (*Onymacris unguicularis*) in the coast on Namibia desert use their bodies to catch the fog and dew to their mouth, where there isn't access to fresh water.

The standard device of fog harvesting is simple. It consists of a net and some supports to hold it in vertical position against the prevailing winds, and a water collection pipe at the bottom of it. The collected water can be driven by gravity to a storage place. The fog collectors are typically on high ground, where condensation and wind speed is higher, and also to avoid catching salty water. The harvested water sometimes has to be treated due to the contamination of the nets by dust and other materials.

The Fog Catcher consisted of a single 2 m by 24 m panel with a surface area of 48 m^2. Full-scale fog collectors are simple, flat, rectangular nets of nylon supported by a post at either end and arranged perpendicular to the direction of the prevailing wind.

Research into fog harvesting in many sites in the coastal areas of the Atacama Desert in Chile and Perú has yielded 2-8 liters per square meter per day, with an average of about 4 liters per m^2 per day, which is similar to what has been obtained in other sites. Considering, for example, the implementation of 100 collectors of 60 square meters each (as in the El Tofo-Chungungo experience in Northern Chile), which yields 6000 square meters of harvesting net, the average water collection per day would be about 24 cubic meter of water. Considering a small local population of about 450 inhabitants, this would yield about 50 to 60 liters per person per day, which stands as a rather limited amount. Alternatively put, for a supply of about 50 liters per person per day, about 13 square meters of net would be needed for each person in the distribution network.

Regarding costs, the empirical evidence reports a cost per cubic meter of water of about US$2 to 5, depending of the productivity of the fog collector system and the geographical conditions of the site. This value is fairly high in comparison with most alternative water sources. Even though the cost of the fog collection devices and its maintenance is fairly low in absolute terms, cost values per cubic meter are fairly high as a consequence of the limited supply of water that they provide.

In conclusion, fog harvesting can be a fairly cheap, technologically simple method of collecting water in circumstances deprived of other reliable water sources. Yet, evidence suggests that fog collection can at best support the basic water requirements of fairly small communities, at a non-negligible cost per m^3. In addition, the required geographical conditions for fog collection –the existence of a steady supply of fog all year round (ideally without a seasonal pattern), and winds driving the fog to a sufficient speed to allow its collection (about 4-8 meters per second)- are very specific and not commonly found, even less in combination with deprivation of other perhaps cheaper and more reliable water sources.

The system requires a low level of investment and is inexpensive to operate and to maintain due to its flexibility and modularity. Production can be increased incrementally as funding becomes available or as demand grows. It has no significant impact in the environment. Nevertheless, given the benefits that can be derived from this technology, some drawbacks are present: the availability of sites at which to install the fog harvesting system is limited (coastal areas, abundant fog, mountains, etc); the water provided by a fog catcher can only supply small communities; and, traditionally the material used for the construction has a short life time.

While the technology has few environmental impacts, the harvesting structures may be visually intrusive. The technology is very sensitive to changes in climatic conditions i.e.water content and occurrence of fogs. Moreover in some coastal regions (e.g. Paposo, Chile) fog water has failed to meet drinking water quality standards due to the concentrations of chlorine, nitrate and some minerals.

5 - Recommendations on alternatives resources

- *To public authorities, governments at all levels*

– When developing alternative water resources, always involve stakeholders and large public since the early beginning of projects.

– Consider both wastewater reuse and desalination as viable alternative water resources in coastal and tourist area and adapt their implementation to local conditions and specific needs.

– Balance the advantage and limitations of each kind alternative resources, according to the need of water users. Wastewater reuse is less energy intensive and more environmentally friendly than desalination, but desalination is the most straightforward option to produce additional freshwater.

– Adapt wastewater reuse projects to water quality requirements of end–users. They can be politically more complex, as they require to involve many stakeholders, take into account health standards and public perception.

- *To operators producing water from alternative water resources*

– Select proven treatment technologies that can be easily adapted to the given local conditions.

– With regards to desalination, consider membrane treatment as a preferred option compared to thermal desalination in Pacific region: (1) reverse osmosis for desalination with energy recovery and (2) membrane bioreactors or tertiary membrane filtration as space saving technologies enabling to produce high quality water for various reuse purposes in tourist and urban areas.

- Consider natural wastewater treatment technologies for rural areas and at small scale, while wastewater reuse for irrigation is the main potential reuse application.

- Ensure rigorous maintenance of treatment plants to guarantee public health and water security, and to increase life-time of equipment and reliability of operation. Existing reuse projects worldwide demonstrate that wastewater reuse is safe practice without any health risk when wastewater is properly treated and good practices are applied.

- Implement best management and operation practices to reduce energy requirements and operation costs maintaining strict compliance with water quality standards.

• *To public at large*

- Support the mobilisation of alternative water resources as essential elements for integrated water management and sustainable development.

CHAPTER 4 - CONTROLLING THE COST OF WATER PROVISION AND WASTEWATER SERVICES

1 - Selecting technologies for drinking water and wastewater services: a cost theory approach

A number of characteristics of water influence the cost of supplying water services to the community. First, the natural supply of water, whether from rainfall or aquifers, can be variable, both in space and time. Spatial shortages can be overcome by piping water to areas with insufficient supply. Temporal variability can be managed by building reservoirs to store water for use during periods of water shortage. Second, the natural supply of water has a quality dimension that can influence cost. Water treatment costs vary according to the quality of the water as it is taken from the natural environment, and according to its end use. For example, elevated nitrogen levels in groundwater are of greater concern to households than farmers who use the water for irrigation. Third, water is bulky and moving it from the point of extraction to the user necessarily incurs costs. At the lower end of the scale the unit cost of distributing water from an aquifer and to irrigate crops is low relative to the cost of distributing water to a large metropolitan area. Fourth, water has the capacity to assimilate and transport waste which adversely impacts other users and the natural environment.

The cost of supplying water services arises not only from the inherent characteristics of water but also from public policy that sets standards for water quality and sustainable use. Community water supply that does not meet the requirements is faced with either increased treatment costs or finding alternative sources of drinking water. Clearly treatment costs increase if the level of contaminants increases above these maximum acceptable values. Guidelines for aesthetic variables, such as hardness, turbidity and taste, influence cost. Public policy also impacts cost through legislation directed at achieving sustainable water resource use, access to water, and water distribution aimed achieving equity goals.

Given that water supply services are usually provided at the local level and user charges can be levied, an argument can be made that the cost of service provision should be recovered from the beneficiaries. Within the context of the European Water Framework Directive water services are defined as all services relating to abstraction, impoundment, distribution and treatment of surface water or groundwater, including the provision of drinking water and waste water treatment. The Directive established a framework for community action in the field of water policy and called for full cost recovery. [28] In 1994 the South African government called for the recovery of at least recurrent – operation and maintenance – costs of water charges through direct user charges.[29] The policy was motivated by the idea that cost recovery would free up financial resources for capital expenditure aimed at improving the supply of water to households.

Cost recovery is achieved through prices that are paid for water services. Full cost recovery implies that all production costs, treatment and distribution costs are covered, including pollution costs and scarcity costs. This paper identifies and describes components of the cost of water supply services. The first section provides an overview of the principles for valuing the cost of service delivery. The second section provides an economic framework for selecting technology on the basis of cost.

1.1 – Cost valuation principles

Charging for water serves two purposes. First, it is a financial mechanism for recovering investment, operation and maintenance costs associated with a water system; second, it is an economic mechanism used to signal scarcity value and the opportunity costs associated with the supply of water services across existing and potential users. While the content of the mechanisms will overlap it is worthwhile highlighting the important differences between accounting and economic costs. Accounting costs are explicit costs that have occurred and

[28] *Unnerstall, 2007*
[29] *Alence, 2002*

typically follow the requirements of tax laws, laws regarding disclosure, and so on. Economic costs include both explicit and implicit costs. The cost of electricity used to run a water treatment facility is an explicit cost. The adverse impacts associated with excessive depletion of an aquifer is an implicit cost. Both are opportunity costs.

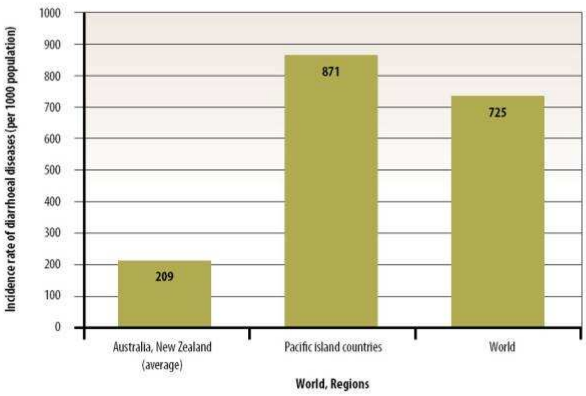
Determining the opportunity cost of capital deserves special attention because capital invested in water supply is a durable good that provides a flow of services over time. Two problems must be addressed when attempting to recover the cost of capital. First, the cost of capital has to be allocated over time. In principle the opportunity cost of a water supply and treatment system is the amount that the service provider could charge others to rent the system. This, of course, is problematical because capital is quite specific to water treatment and supply. Second, recognition should be made of the fact that the value of capital can change over time through use and technological obsolescence. These two issues are incorporated into the principle of capital charging which is becoming common practice in public sector management. Capital charging covers both the depreciation of assets and a return on assets explicitly through interest or dividends or implicitly through retained earnings. The two main components of a capital charge are: the extent to which capital is "*consumed*" over the period; and, the cost of capital which is the opportunity cost of not investing elsewhere in the economy. Valuing the change in capital value can be estimated using the optimized deprival valuation method which values the assets at a level at which they can be commercially sustained in the long term. The resulting value should be equal to the loss to the service provider if they were deprived of the assets and then took action to minimize their loss. Capital charging can be based on the interest that could be earned in the next best alternative investment with similar exposure to risk.

By definition the variable costs of water services supply change with output. Measuring variable costs is relatively straightforward. Provided the economy is reasonably competitive variable costs are simply the annual expenditure on inputs such as labor, energy, and maintenance. Finally a complete accounting of economic costs should include external and resource scarcity costs. For example, according to Easter and Liu (2005) irrigators in South Australia are responsible for the costs associated with all-post 1998 irrigation environmental externalities.

When infrastructure has to be renovated or built to reduce externalities fixed costs can be recovered in the fixed portion of the two-price tariff and the quantity related external costs can be included in the volumetric portion of the tariff. The concept of marginal user cost applies to situations where current use increases the cost of obtaining future water supplies because the cheaper water is used up first. This cost is especially relevant to aquifers and excluding marginal user costs can result in overuse of the resource.

It is imperative that the external costs associated with poor water quality are not overlooked in project evaluation. The figure below illustrates the incidence of diarrhoeal diseases in Pacific Island nations relative to Australia, New Zealand and the rest of the world. Improving water sanitation in these small Pacific Island nations can reduce the incidence of disease (an externality) which, in the context of project evaluation, is a benefit.

External costs associated with low water quality

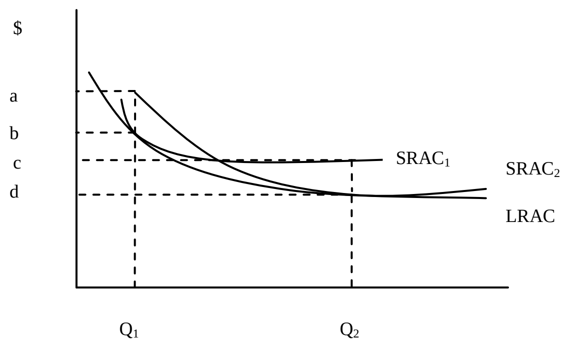


1.2 - Cost and technology

The production of water supply and distribution services is typically characterized by decreasing cost in the long run. Decreasing costs arise out of economies of scale. This implies that the average cost falls as the quantity of treated water supplied increases to a level referred to as the minimum efficient scale. The figure below illustrates the average cost of water supply from two plants labeled 1 and 2. For the smaller plant, the supply agency's short run cost curve is $SRAC_1$. Clearly, if the agency knows that it will only ever produce Q_1 units of water then it minimizes its average costs by using the smaller plant. However if it expects to produce Q_2 units of water then average costs are minimized using the larger plant.

The best a small community can do to supply Q_1 units of water is to invest in plant 1. The average cost of producing Q_1 units of water is \$b. If instead the agency used the next largest plant, its cost of producing Q_1 units of water would be \$a > \$b. If the population is expected to grow and Q_2 units will be needed in the future then the smaller plant could meet this output but at an average cost of \$c. The larger plant could produce Q_2 units of water at an average cost of \$d < \$c. Empirical studies find evidence of economies of scale.[30]

Long run average costs
as an envelope of short run average costs



It should also be pointed out that the marginal cost of supply is relatively constant beyond the minimum efficient scale. Marginal cost pricing is unlikely to cover total costs. One approach around this problem is to use a two-part tariff that is designed on efficient prices and covers total costs. The simplest version of such a tariff scheme involves charging consumers a constant price per unit purchased equal to the short run marginal cost and a fixed annual access charge. The total cost of the water supply system is recovered by a lump sum access charge – a connection charge – on the users of the service, who then face the marginal cost of production. A two-part tariff may however be imperfect because the fixed charge may cause some consumers to drop out of the market. The fixed charge is a regressive household charge which may conflict with the distributional policy of government.

Investing in water supply systems shares many of the challenges associated with other infrastructure projects, such as road and electricity networks. Lumpy investment which occurs early on in a project's life raises the issue of scale.

Economies of scale deliver falling average costs but plant size determines the extent to which low average cost can be attained. For example, suppose the community currently faces Q_1 and invests in plant 1 and at some stage in the future growth is expected to grow to Q_2. Clearly plant 2 will supply Q_2 at lower average cost. At some point given the lower costs of plant 2 it will become economic to invest in the larger plant. Economies of scale can also be gained from network expansion. If, for example, plant costs and separable from distribution costs – such as piping – then expansion of the network can lower the overall average cost of supply.

If an investment in a water supply project yields a positive net present value this does not mean that net present value is maximized. In other words, the dynamic aspect of investment should be considered especially in situations where demand is changing over time. The mere fact that a project has a positive net present value if constructed now does not mean that it should be constructed at that time, for the net present value might be greater if constructed at another point in time. On the supply side, technological change may offer an opportunity to achieve lower costs. Considering both expected future demand and possible cost scenarios makes for more complex analysis of the optimal timing of investment [31].

As noted above, the cost of producing potable water depends on the source of the water, location and the plant economies of scale. Advances in technology have reduced the cost

[30] Asian development Bank, 2004; Shih, et al. 2004

[31] Marglin, 1963

of desalination over the past 25 years from around US$5.30 m^3 to US$1.05 m^3 (according to Yuhas and Daniels, 2006). In contrast, surface water costs range from US$0.22 m^3 to US$0.33 m^3 while groundwater costs vary from US$0.08 m^3 to US$0.21 m^3. Surface water is relatively more expensive because of large capital expenditures such as dam construction and water filtration systems.

Integrating full cost recovery with pricing is achieved as follows:

$$\sum_{t=1}^{T} \frac{Q_t * P_t - (K_t + OM_t + E_t + U_t + A_t)}{(1+r)^t} = 0$$

Where

$Q_t * P_t =$ revenue in year t

$K_t + OM_t + E_t + U_t + A_t =$ sum of capital, operating and maintenance, externality, user and administration costs in year t

r = discount rate

Collapsing the above equation into a static model greatly simplifies the exposition of full cost recovery and the role that both cost and price play in the design of an efficient water system:

$$Q * P - (K + OM + E + U + A) = 0.$$

If price is set so that the above condition holds then it is possible to formulate a cost minimization problem where the objective is to the minimize cost of producing water from different sources - surface or ground water, non-conventional sources such as re-claimed water and desalinated water - subject to: supply meeting demand across uses, the availability of natural water, delivery losses, satisfying quality and environmental constraints. This type of analysis would also reveal the user cost, if any, of water.

Basic needs for water and full cost recovery

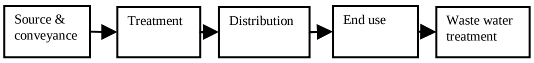
In most societies water is viewed as a basic necessity and concerns about equity will most certainly enter the public debate about water supply. These concerns can be directly factored into cost minimization. Regardless of whether full cost recovery occurs or not recognizing and accounting for the full costs should be an integral part of the analysis. Even if a government prefers to directly invest in water supply and not recover costs the full costs should be made transparent.

1.3 - Cost and energy

Energy embodied in a water supply system finds expression in both fixed and variable costs. Clearly the fixed costs of a desalination plant (energy intensive) are greater than the fixed associated water drawn from a reservoir. Although variable costs, which vary with the quantity of water produced, are typically relatively small energy savings can be significant. In a cross section study of water supply authorities in the US Shih et al. (2004) found that the average cost of energy ranked fourth, behind labour, materials and capital costs; and the elasticity of energy was estimated at -0.12, indicating that energy use associated with a 10% increase in production would decrease by 12%.

A water supply-use chain, as illustrated in the next figure, provides a framework for identifying the use of energy. The benefits of associated with energy saving strategies can be estimated once consumption at each point in the supply chain is identified. The cost of energy used in water supply can account for up to 60% of the operating and maintenance costs in small Pacific Island nations. High energy costs arise from these nations having to import fuel. According to Choen and Nelson (2004), the State Water Project in California is a net energy consumer and electricity costs account for around US$300m annually. Efficiency measures include: projecting water demand buying energy early; optimising pumping scheduling; and reducing water loss during conveyance. Energy conservation at the treatment stage can be effected by reducing peak demand and water conservation. Distribution typically accounts for most of the energy used in municipal water systems. Cohen and Nelson (2004) report that the City of Fresno (California) saved US$725,000 a year by monitoring energy use at well sites, selecting wells according to the time-of-day electricity prices, and reducing leakage. Energy consumption at "*end use*" clearly depends on water use. For example, electricity use will be high in areas where water is pumped for intensive irrigation. Eliminating subsides to agriculture can result in water and energy conservation. Finally, wastewater treatment accounts for a large amount of electricity and conserving water can generate energy savings.

Water supply chain



Both pricing and cost must be considered simultaneously when planning for future investment in water supply services. Price balances demand with the supply of water services and should, in principle, incorporate full cost recovery into the supply price of water services.

Full costing of water supply services includes operating and maintenance costs, annual capital costs, external costs, and, user cost. Annual capital costs are not simply annual capital expenditure; rather these costs are based on the principle of opportunity cost and changes in the value of capital invested. Costs arising from externalities – such as water pollution – and resource scarcity – user costs – should also be included in the process of selecting water supply technology.

Scale economies are typical in water supply systems. Once output is at the minimum efficient scale the average cost of production tends to be relatively constant. But of course demand and technology will change over time making dynamic analysis an integral part of investment in planning water supply systems.

The average cost of energy in water supply systems are typically less than capital and labour. Furthermore, the unit cost of electricity consumption per unit of water produced decline with scale. Considerable opportunities exist for energy conservation at each point along the water-use supply chain. However, sight should not be lost of the connection between energy use and other policy variables, such as water and agricultural policy.

2 – Optimizing the costs of water and wastewater services

2.1 - Overview of cost structure of service and drivers for optimization

Optimizing the cost of services enables prices to be controlled and provides the financial resources for regular maintenance, renewal and new investment. Cost control should encompass all kind of costs, but specific attention has to be given to procurement, maintenance, infrastructure renewal, human resources and energy. All operators, whatever their status, are responsible for controlling operating costs and spending and using funding obtained as efficiently as possible.

Cost structure of water and sanitation service

	% of total costs	**Variations depend on**
Staff (operational)	30 % to 40 %	Equipment sophistication, network length, training level, management, …
Direct operational costs	20 % to 30 %	Raw water resources, treatment process, procurement, energy consumption, operational management, …
Maintenance	10 % to 20 %	Maintenance budget permanence all along the past years, age and nature of plans and networks, procurement, management, …
Capex: amorti-zation and debt service	10 % to 25 %	Financing structure, accounting principals, …
General administration	15 % to 25 %	General policy management, organization,...
Taxes		

Labor costs represent up to 40 % of total costs. In most services, it is the highest expense. Therefore it is a key issue to control them.

Many water services are characterized by over-staffing and under-productivity. With adapted approaches, it is feasible to gradually reduce payroll costs, while maintaining employment safeguards and public status of the staff. Over-staffing reduction can be gradually achieved, based solely on natural and voluntary attrition and a shift to part-time work

Leakage reduction in drinking water network is another major issue to control the costs of water services. In many Asian and American cities, losses can reach up to 50 %. In a 2008 study, the World Bank conservatively estimated non revenue water in the order of 50 billion m^3 per year in low and middle income countries. The total cost to water utilities caused by higher production costs and lost revenues was estimated at $ 15 billion per year! Small leaks for a long time are responsible for the biggest volume of water lost. Big bursts that come to the surface are normally repaired quickly and the volume of water lost is therefore small. The objective of service operators should be to reduce current real loss to the technico-economic level loss. Adapted pressure management, improved speed and quality of repairs, an active leakage control and better infrastructure management, can work to reduce losses.

Maintenance is another key budget line to be optimized. For East-Asia, investments and maintenance needs in electricity, roads, telecoms, water and sanitation, rails, were estimated for 2008-2010, to be $165 million.[32] Approximately 60 % is needed for investment and 40 % for maintenance. The interesting point about these estimates is that the reverse holds for water and sanitation: maintenance needs are higher than investment. The reduction of maintenance costs can be achieved through various means such as:

- optimization of maintenance program based on long-term experience, accurate information on infrastructure and asset management procedure;
- new methods to schedule maintenance operations, such as joined operations, daily checking of critical factors (e.g. noise), anti-corrosion program, …;
- looking for technical and economical optimum while selecting materials. For instance, the price of nickel (included into steel) was increased by a factor of 5 between 2003 and 2007;
- new rehabilitation methods. Implementing trenchless pipe rehabilitation techniques allow to rehabilitate more of a pipeline with the same budget;
- insourcing services, such as maintenance, repairs and meter-reading, previously handled by subcontractors, allow to resorb water service offer-staffing, increase productivity and introduce better maintenance methods ;
- ergonomics and automate jobs, which make maintenance easier and less expensive.

Cost control should also focus on new infrastructure, in order to guarantee the quality of any new installation built. According to the Environmental Protection Agency, USA will need €189.3 billion over the next 15 years to replace drinking water infrastructure. With such amounts, the issue of CAPEX costs control is of the utmost importance.

It is necessary to optimize the total cost of projects (capital expenditures and operation expenditures), over the whole lifespan of infrastructure. The objective is to avoid savings made on construction translating into extra operating costs. The definition of the optimal renewal rate, maintenance and rehabilitation policy depends on multiple parameters: age of infrastructure, materials used, quality of construction, location, renewal policy of public authority (eg: 0.5 % or 1 %), services objectives, …

As noticed in the PECC Guidelines for Effective Public Private Partnerships, the first role of a professional operator (public or private) is to optimize the use of existing infrastructure so that it can serve more people. This approach can postpone or reduce new investment necessary to increase production capacity. But if investment is needed, the water service operator has to play a pivotal role:

[32] Source: Yepes (2004) cited in ADB, JBIC, World Bank, « Connecting East Asia: a new framework for infrastructure »

- to help the public authority optimize the investment program and lower the total cost of investments;

- to spread the investments over several years so that their impact on total costs and thus on the price of water will only be felt gradually.

2.2 - Toward an overall optimization of costs

It is crucial to optimize the service as a whole, in technical, human, organisational, financial and environmental terms. This "*wholesale*" optimization improves the quality of the service provided and releases recurring cash flow to fund new infrastructures. In that respect, the juxtaposition of limited scope operators in the same city prevents an overall optimization of costs and economies of scale. The larger the scope of operator activities the more it is possible to optimize costs.

That is the reason why, the BOT formula (Build – Operate – Transfer contract), however interesting, has several limits. Several of them are related to costs issues:

- the BOT formula deals with a specific investment. It does not address other issue like networks leakages, Human Resource management of the whole water and wastewater service, customer management, etc. Cost optimization is limited to a small part of the water cycle;

- not having one part of investments funded by existing cash-flows at the beginning of the project, increase the financial cost of the project, especially in a period of generalized credit crunch;

- the sophistication of project financing generates high legal fees which represent a non negligible percentage of the total project cost.

Therefore, in case of Public Private Partnership:

- the contractual arrangement should address this issue. Lease or concession contracts usually aim at optimizing the whole cost structure of a service. But it is not the case of BOT schemes. The BOT formula addresses only one issue: to build, finance and operate efficiently a specific infrastructure. By being limited to just one problem, BOT contracts deprive the municipality and the population of the savings they could derive from the service's overall optimization;

- contracts must cover a sufficient period to allow for complete optimisation of the service and to generate substantial productivity gains for consumers. Short contracts restrict the role of the operator to considering only certain variable costs and prevent the complete of the full cost structure.

With regards to private sector involvement, it is noticeable that:

- Usually, private operators are more experienced in cost control than public ones. They have also more incentives to achieve cost reductions than public ones. Outsourcing water management to professional private companies results in cost reduction through enhanced efficiency.

- Controlling operating expenses is an essential task for a private operator to ensure that it will have financial resources to invest in new infrastructure and improve the quality of the service. It also allows price moderation.

- Competition is a way to control better costs while improving water and sanitation services.

2.3 - Cost control and pricing policy

Costs control is one of the main issue of water services management. A symetrical issue is the generalized "*water underpricing observed in water utilities*" (Angel Gurria, OECD, 2007). For instance, most Indian cities charge an average tariff that is equivalent to only one-tenth of the operation and maintenance cost. As a result, no Indian city is capable to provide water service 24 hours a day. Funds are not provided for replacement of capital; maintenance budgets are reduced; the service quality itself declines and systems are not expanded to the unconnected. A lot of utilities have been locked in a cycle of underfinancing, undermaintenance and underexpansion.

For many services, cost optimization won't be sufficient to compensate the unwillingness of public authority to increase the price of water. "*People have a willingness to pay but governments don't have a willingness to charge*".

Operating charges reduction: the example of Adelaide (Australia)

The public private partnership encompasses operation and maintenance, asset management planning, project management of capital works. The main drivers for outsourcing these functions in Adelaide (1.1 million inhabitants) were to improve the quality and level of service provided, and generate economic growth in South Australia by developing an export orientated private sector water industry.

Engaging a reputable major water company allowed for an improvement in technical performance and greater overall efficiency in operations and maintenance practices.

The contract pricing structure encourages cost reduction and performance improvement. The operator receives a lump sum to cover general operations, management functions, overheads and profit. Maintenance activities are reimbursed as follows: previous 3 year average as annual target, and a 50/50 share of overs and unders. There are also scheduled or negotiated fees for project management of capital works and larger projects can have incentive arrangements linked to performance.

The contracts has delivered an average 20 percent annual saving in maintenance and operation costs, compared to historical data.

The quality of drinking water and wastewater treatment performance have also been significantly improved.

2.4 - Recommendations

- *To public authorities/governments at all levels*

– Set up regulatory mechanisms to optimize operating and infrastructure costs. One of the main tasks of the organizing authority is to continually drive the operator (public or private) to make progress and to prevent it from being content with mediocre results, with high costs and low performance. There can be no efficient and cost-effective operator without a strong organizing authority.

– Implement an operational structure that generate economies of scale. The larger is the scope of activities of the operator, the more it can optimize costs.

– Organize competition to better control costs while improving water and sanitation services. Calling for tenders can bring discounts compared to the cost of a public management project and provide a reference cost for the public operator in place if it keeps on running the service;

– In case of Public Private Partnership, select a contractual arrangement that optimize the whole costs' structure of a service, not only one part of them, and that allow the municipality and the population to benefit from all the savings a professional operator can bring.

- *To water services operators*

– Optimize the service as a whole, OPEX and CAPEX, in order to improve the quality of the service provided and release recurring cash flow to fund new infrastructures.

– Extend cost control to all kind of costs, with a specific attention to procurement, maintenance, infrastructure renewal and labor costs.

– Look for technical and economical optimum while selecting materials and process.

– Manage existing infrastructures to the best of their ability in order to reduce the costs of new investments.

- *To public at large*

– Recognize that water and wastewater services have a cost which should be covered by users and/or taxpayers.

3 - The issue of energy in water and sanitation services

In all public services, it is crucial to control energy use and greenhouse gas emissions. With energy sources running out and rising prices, it is vital to halt wasteful behavior and a consumerist relationship with nature. All the more so as energy is a big item in the procurement budgets of water and sanitation services.

A lot of energy is expended on producing and distributing water, treating and recycling wastewater. In United States, 5 % of the electricity produced is used for the water and wastewater infrastructure (including pumping). In this country, wastewater treatment alone represents 1.5% of the national electricity consumption.[33]

On the one hand, the total electricity consumption of the water and wastewater sectors will grow globally by a predicted 33 % in the next 20 years.[34] On the other hand, the 21rst century will end without oil. The most reactive countries and cities will get greater chances to face successfully this challenge. Therefore, saving energy and moving towards low carbon sources of energy are a key challenge for all public services.

3.1 - Optimizing energy in conventional water production plants

With regards to drinking water production from freshwater resources, it is of the utmost importance to monitor and to optimize pump consumptions as this function frequently uses more than 80 % of the sites' electricity bills. This is clearly where effort should be focused. According to the potential gain in terms of energy consumption and savings, it is sometimes worthwhile to anticipate pump renewal. The energy consumption generated by the presence of ozonizers in a drinking water production plant is also far from negligible. It can be up to 10 % to 15 % of major plants.

The example of Hohhot (China)

In 2004, Veolia Water was awarded the 30 year contract for managing the wells' field and drinking water production plant of Hohhot, a Chinese city of 2.5 million inhabitants. The production capacity of water installations amounts to 515,000 m^3 per day. In 2008, Veolia Water made a study to renew 14 boosting pumps and 15 deep-well pumps.

By carefully selecting energy efficient pumps and properly adapting the pumps to specific needs and conditions, the project could save 7.2 million kWh per year. This is equivalent to 3,700 tons of coal and to US $400,000 savings on the annual electricity bill (2.9 million Yuan). The total investment amounts to US $250,000 (1.8 million Yuan). The payback will be shorter than 1 year.

This investment project is going to be implemented.

One part of drinking water production needs may be covered by recovering potential energy with turbine. At some plants, there is often an inevitable water drop which may be equipped with a turbine to convert the water mechanical energy into electricity. Water drop should be higher than 5 m, to reach a reasonable yield. This situation is not so common. For example, the Illawara drinking water production plants (one of the plants of Sydney) produces electricity thanks to 250 m difference in level between the water resource. In 2007, the hydro-electricity produced at Illawara amounted to 12,556 MWh. It covered 75 % of the electricity needs of 2 conventional drinking water production plants: the one of Illawara (210,000 m^3/day) and the one of Woronora (160,000 m^3/day).

[33] *Source: H2E Centre, Penn State University*
[34] *Source: Business in the World of Water – "the H2O Scenarios" - Joppe Cramwinckel*

3.2 - Seawater and brackish water desalination

As expressed in the under mentioned table, seawater desalination consumes at least 20 times more electricity than conventional treatment of freshwater: 3,000 Wh per m^3 versus 50 to 150 Wh per m^3. However, advanced treatment of bad quality freshwater, such as surface water, can require up to 700 Wh per m^3.

With regards to water purification, reverse osmosis is the most powerful of membrane technologies. But the smaller the pore membranes the higher is the energy required to push water through membranes: 3,000 to 5,000 Wh are needed to produced one cubic meter of potable water by membrane desalination of seawater (with an energy recovery system). In case there is no energy recovery system, electricity consumption ranges from 5,500 to 8,000 Wh per m^3. In reverse osmosis plant, over 50 % of operating costs are due to electricity.

Thermal desalination consumes much more energy than membrane desalination of seawater. Thermal desalination consumes at least over 6,000 Wh per m^3 produced and, on average, 3 times more energy than membrane desalination

Brackish water is easier to treat than seawater. It has good bacteriological quality and there are few suspended solids. This means a simplified and less energy consuming pre-treatment. Furthermore, the lower salt concentration of seawater implies lower energy consumption. As a result, brackish water desalination requires only 600 to 1,500 Wh per m^3.

Membrane technologies open the way to alternative water resources (seawater desalination or wastewater recycling). But such technologies require a lot of energy. Nations and cities could find themselves faced with a dilemma: whether to increase their water independence at the cost of reducing their energy independence. To help them deal with this situation, it is necessary to carry on researches in order to reduce the energy consumption of membrane technologies.

Electricity consumption of various process according to the provenance of raw water

Raw water resources	**Drinking water production process**	**Electricticy consumption in Wh /m^3**
Fresh water	Conventional treatment	50 - 150
	Membrane treatment (*ultrafiltration / microfiltration)*	100 - 200
	Advanced membrane treatment	250 - 700
Brackish water	Brackish water desalination *(nanofiltration or reverse osmosis)*	600 - 1500
Sea water	Seawater desalination with energy recovery system *(reverse osmosis)*	3000 - 5000
	Seawater desalination without energy recovery system *(reverse osmosis)*	5500 - 8000
	Thermal desalination (distillation) *	> 6000
Wastewater	Wastewater recycling	25 - 1500

** Electricity + heat converted into electricity equivalent*
Source: TSM n° 9 - 2007

Energy consumption of desalination has been reduced by a factor of 4 over the past 20 years. In the 1980's, in reverse osmosis plants, the yield of recovery energy system was limited to 75 %. Today, it is 96 %. However, further gains in energy efficiency, and hence in cost reduction, will be increasingly difficult. Thermal desalination is a more mature technology and less progress is hoped with regards to energy reduction than with reverse osmosis.

3.3 - Wastewater treatment and recycling

On the wastewater treatment plants, energy is usually the 3rd budget line. Treatment plant aeration is generally the largest electricity consumer, followed by the air treatment (if there is one) and the sludge treatment (when there are centrifuges). Pumping generally represents the remaining electricity consumption.

In plants with activated sludge tanks, the most energy-intensive function is aeration (60 % to 85 % of the total electricity consumption). However, energy consumption linked to aeration is rarely optimized. Optimization goes through various measures such as adapting the biomass quantity in activated sludge tanks; cleaning or replacing air diffusers and improving aerator control.

Sludge should always be seen as a source of energy:

- sludge digestion is an anaerobic process which produces biogas that can be used to produce heat and/or electricity.
- sludge incineration reduces the volume of sludge to its dry mineral part and recycles its energy content. Most of the heat produced in hot gas is recovered by exchangers.

Usually, ernergetical valorization of sludge (sludge digestion + biogas production) offers an opportunity to cover 60 % of energy needs of wastewater treatment plants. Energy independence of a wastewater treatment plant is a realistic middle-term objective through the reduction of energy consumption by a better management of process and further progress in energy recovery.

The electricity consumption of wastewater recycling varies heavily, from 25 to 1,500 Wh par m^3, according to the quality of recycled water produced. On average, wastewater recycling consumes 1,000 Wh per m^3. Wastewater recycling saves the energy consumed by pumping and water transportation since this alternative resource is usually located where it is needed (e.g. for industrial reuse). Wastewater recycling is a less-energy consuming solution compared with seawater desalination, brackish water desalination or water imports over more than 60 km.

3.4 - Other initiative towards low carbon economy and *"low carbon water"*

The end of cheap energy forces public authorities and operators to look for alternative and more environmental-friendly energy sources. One of the options is to mobilize solar energy. This technology requires large areas. There is an undervalorized potential on water treatment and wastewater treatment plants, since these plants are usually *"space consumers"*. Part of the electricity needed can be produced by a roof solar power station that supplies drinking water plant or wastewater treatment plant. Solar powered reverse osmosis desalination plants are being tested in several parts of the world.

Major water and wastewater infrastructure represents by far the largest part of energy consumed. It should be the priority. However, attention should also be given to complementary measures such as replacing existing fleet of vehicles with less polluting vehicles. Using natural gas in light-duty cars leads to a significant reduction in GHG emissions compared with gasoline (15% to 20% emission reduction). Many solutions are available: for example, electric vehicles, electric hybrid vehicles and natural gas for vehicles (NGV). Service agents equipped with electrical scooters or electrical bicycles (such as in Changzhou, in the coastal province of Jiangsu) can reduce GHG and air pollution.

3.5 - Cost of water processing in Pacific Island countries (PICs)

Costs to process water vary widely in Pacific Island countries due to a number of factors including the scale of processing, the technology adopted, isolation, and topography. Energy costs associated with processing water in Pacific island countries typically represents more than 60% of total O&M costs. Most urban water supply and sewerage schemes rely on electricity supplied from local power grid systems.

3 cases studies in Pacific Island countries

- ***Drinking water treatment in Suva, Fiji Islands***

Treated water distributed to the residents of the Suva/Nausori Region (population 320,000) is supplied from the Waila and Tamavua water treatment plants. Both water treatment plants are conventional chemically assisted sedimentation plants and have a combined average daily production of 150MLD.

Raw water for the water treatment plants is abstracted from surface sources and pumped to the water treatment plants.

In 2007, the average production cost was US$0.107/kL compared with the base rate tariff of $0.067/kL. Electricity costs accounted for approximately 60% (or US$0.065/kL) of the average production plants.

- ***Sewage treatment in Apia (Samoa)***

A sewage treatment plant is currently being constructed to service 130 commercial and Government customers in Samoa's capital Apia.

The sequencing batch reactor plant is designed to treat an average daily inflow of 1MLD and peak daily inflow of 1.5M.

The electricity requirement for the plant is estimated at 561MWh/year. At current electricity tariffs, the annual energy cost will be $US0.16million representing about 53% of estimated annual O&M costs.

For recovery of O&M costs, a tariff of $1.20/kL is required. A Tariff of $1.84/kL is required for full cost recovery.

- ***Drinking water treatment in Koror (Palau)***

Water supplied to the residents of Palau's capital Koror and the adjacent state of Airai is treated at a conventional chemically assisted sedimentation plant located in Airai. The plant has an average daily production of 14.4MLD and services about 16,800 people.

Raw water for the plant is abstracted from surface sources and pumped to the water treatment plant.

Approximately 65% (or $0.95 million) of annual O&M costs is attributed to electricity costs and has an average electricity cost of $0.18/kL of water treated. This compared with the average tariff of $0.13/kL charges to consumers in Koror and Airai.

Unaccounted-for-water (leakage, poor metering, illegal connections, and plant losses) accounts for more than 50% of total daily production.

3.5 - Recommendations:

- *To public authorities/governments at all levels*

– Encourage energy savings in water and wastewater services through performance objectives and incentive mechanisms. The most eco-friendly kWh is the one we don't consume. What is saved is saved every year.

– Select water sources and processes taking into account energy consumption and green house gas emissions.

– Promote research programs that aims at reducing energy consumption of alternative water resource process, desalination and wastewater recycling.

- *To water services operators*

– Optimize energy in conventional water production plants and give a specific attention to pumping energy consumption and leakage reduction.

– Anticipate the renewal of equipments if it is appropriate to reduce energy consumption and save money.

– Implement state of the art energy recovery system to reduce the electricity consumption of membrane process;

– Consider sludge as a source of energy, in order to increase the energy independence of wastewater treatment plant.

- Minimize the energy consumption all along the life span of the plants using the life-cycle assessment approach.

- Use the large areas covered by drinking water production plants or wastewater treatment plants to produce solar energy. Roof solar power station can equip drinking water plant or wastewater treatment plant and cover one part of the electricity needs.

- *To public at large*

- Implement optimization programs in order to save energy.

CHAPTER 5 - A NEED FOR BETTER GOVERNANCE IN THE MANAGEMENT OF THE WATER CYCLE, WATER SERVICES AND SANITATION SERVICES

1 – A prerequisite for governance improvement: education for a better use of water

The concluding chapter of these guidelines is focused on the critical issue of governance. Establishing trust and partnership with all stakeholders is dependent on all parties understanding the goals, objectives and facts surrounding sound water management policy. This can only be achieved through a comprehensive education initiative that begins with very fundamental facts about the global water supply. Only by understanding the whole water cycle and the inherent issues of water supply shortages can sound discussions commence regarding alternative technologies and approaches.

Successful education programs need to include environmental groups, regulatory officials, local officials and the public. End users must have access to facts and answers to their concerns. Educating the public must be extensive and on-going. The most successful water projects that include beneficial reuse and recycling began years before implementation with a communication program. Outreach programs focused on letters of support from community leaders and fact based endorsements from environmental experts, educators and scientists. Resistance results from a lack of credible information that does not overcome the psychological and cultural barriers in existence.

Concrete examples of the value of an education program are evidenced in California where attempts to implement water recycling projects met with very different fates. In the late 1990's a recycling project was halted in San Diego over public outcry, and again in 2001 in Los Angeles a $55 million wastewater recycling project was shelved for similar reasons. By contrast, Orange County, California opened the largest indirect potable water reuse facility in the world in January 2008. Years before, Orange County started a public outreach program that educated the public on the necessity of looking to alternatives for water supply and provided face to face sessions with the public to alleviate safety & health concerns. By the time the system was operational 70% of consumers had a favorable opinion of the project.

Education needs to begin with communication of facts:

- fresh water makes up only 2% of the total water supply on earth;
- water is a commodity not priced for its value;
- population can not achieve water resource sustainability when water is used only once;
- preserving water resources, rationalizing withdrawal and developing alternative resources are needed in order to meet growing supply and demand challenges.

The growing number of successful water reuse projects all over the world needs to be communicated through comprehensive media and public relations programs.

Water policy must combine the right quality for the right application, with the process differences explained to consumers.

Public and private sector companies engaged in research & development of new and innovative water technologies and supply options need to also include an education program aimed at establishing public trust in the safety of alternative solutions.

2 – Trust and partnerships

2.1 - Good governance and trust

Water is an industry which involves many stakeholders. Over the past two decades, the bilateral relation between the public authority and the operator moved to a trilateral one between the public authority, the operator and the consumers. It was further extended with the inclusion of environmental protection associations, solidarity associations and all the civil society.

Water is a field of action where no stakeholder can work alone. In this context, the key word is trust. No partnership can begin or survive without trust. No service improvement project can be undertaken without trust. No finance can be raised without trust. One of the aims of a system of governance is to arrange stable relations focused on action; to create the conditions for mutual trust between all the stakeholders in the water sector: organizing authorities, operators (public or private), investment agencies, NGOs, population, etc., and to direct them.

In fact, a water policy cannot be effective without a clear breakdown of responsibilities between public authorities, service operators and financing organizations. This is a condition of both good governance and long term trust. As good governance, trust requires formalizing the rights and duties between these stakeholders, and clearly separating the roles between regulator and "*regulatee*." A situation where roles are mixed, in which one group carries out the tasks of another or where they are not formally defined, is a source of confusion and failure.

Trust of customers and local population is essential, since the values associated with essential services will require inhabitants to adhere to the decisions made by the public authorities. As an asset that belongs to the community, public services require the support of customers and citizens. As mentioned in the PECC guidelines for efficient Public Private Partnership published in 2006, without the support of local populations about service policies, service levels and price levels, nothing sustainable can be built. But this is true whatever the type of operator (public, private, non governmental).

2.2 - Listening and talking with all stakeholders

All over the PECC economies, authorities have the crucial power to set the public service policy and arrange for citizen involvement. Information is obviously a prerequisite for consumer adhesion and trust. Without having access to information, consumers cannot come to informed opinions and adhere to the policy jointly implemented by the local authority and the private operator.

When the operator of a water service and/or its public authority make concrete commitments to subscribers, when they promote transparency through performance evaluation criteria and regular reporting on ongoing activities, it facilitates the establishment of trust with consumers and the population.

The public authority and the operator should seek to maintain a quality dialogue with all stakeholders and the general public:

- With the media, by regularly organizing press conferences, press updates or media events. These enable the journalists to better understand ongoing projects of water and wastewater services.
- With the general public, regular dialogue should be maintained through agencies or during work, or in specific meetings organized during impact studies with local residents or concerning specific topics such as the organization of plant visits.
- With non-profit organizations by organizing roundtable and common projects in poor wards.

2.3 - Quickly improving the performances of the service to build trust with the customers and the population

The best way to win trust is action. Improvements which generate immediate results on strategic projects increase the support of the population for the project. Good performance and short-term results are an antidote to potential mistrust. For instance: demonstrating to consumers that the initial charges associated with connection of new wards to the public network translate immediately into additional benefits.

2.4 - Certification of water services as a guarantee for government public authorities and customers

Quality assurance provides an extra guarantee of the reliability of activities. It positions or repositions customer satisfaction as the main objective of the service. It shows everyone that all drinking water and environmental protection services are produced and delivered in accordance with stringent quality standards.

2.5 - Promoting trust in destitute areas

In emerging countries where a large part of the population is not yet connected to the public water service, water services operators needs to set up what could be named "*formal-informal partnerships*" with local non-profit organizations. This cooperation with NGOs is just one of the key relationships needed to reach objectives to take up the challenge of developing essential services in destitute areas and of implementing the right to water. In fact, an extended social policy is not possible with restricted partnerships.

When a town grows too quickly and when a service has been neglected for years, not everything can be done at once. In such a situation, while initiating infrastructure construction or rapidly making good a shambolic system, government authorities and operators have to strive to "*manage impatience*" in order to maintain trust. For example, they can resort to temporary solutions such as standpipes before extending networks and servicing of urban neighbourhoods enables individuals to be supplied by a network connection.

2.6 - Recommendations:

- *To public authorities/governments at all levels*

– Set up a clear governance system where the respective role of each stakeholder is clearly defined and contain no overlap between different actors.

– Provide reliable and sound information for all stakeholders, including the civil society and media, so that debates and arguments are based on facts rather than emotive reactions.

– Organize the evaluation of water policy and service performances with external experts. These evaluations also produce factors for comparison and reflection with stakeholders.

– Arrange a regular quality dialogue with all stakeholders to lay the basis of a trusting long-term relationship with them and organize extensive public consultation before major projects or changes in the water policy.

- *To operators of water and wastewater services*

– Put consumers at the heart of services management, to boost quality service and customer satisfaction and implement projects that generate immediate and visible results, in particular in destitute.

– Issue concrete commitments to subscribers and promote transparency through performance evaluation criteria and regular reporting on ongoing activities, since it facilitates the establishment of trust with consumers.

– In coordination with public authority, develop external communications aimed at the general public to keep him informed of the performance of the public service and to respond to any requests.

– Gain quality assurance certification since it provides an extra guarantee of the reliability of activities.

3 - Pricing policy

The water crisis facing many countries is largely a fault of our own making. While it is true that scarcity can arise within the hydrological cycle, access to appropriate technology is often limited, and that countries face financial constraints, the origins of a water crisis can be traced back to governance. Most water crises arise out of failures in water governance *viz.* the way in which water is allocated, used and managed. For example, allocating water on the basis of first-come-first served encourages a race to acquire rights, often using technologies that are wasteful. Combine this approach with a policy of not pricing water and sustainable use levels are soon exceeded. The implications of this policy are twofold. First, investment in technology, being path dependent, soon becomes inappropriate. Second, economic development is compromised because access to water by more efficient users is denied. These outcomes apply to water abstraction from both surface water resources and aquifers. Similar reasoning applies to issues related to water quality.

Water-related decision making typically occurs at many levels, central and local government, irrigation companies, and, of course, users. Economics can assist decision making at most of these levels. Getting the economics right involves underpinning water allocation and water management with an appropriate institutional framework. To state the obvious, market mechanisms – pricing and tradable rights - do not operate in an institutional vacuum. Until market-based instruments are adequately provided for in legislation they have no chance of implementation.

It is assumed that the function of a resource allocation mechanism is to guide decisions that maximise the value of water. If we accept the goal of adding maximum value to a scarce resource then the challenge is to design robust policies and good institutional structures consistent with this goal. Management mechanisms must be capable of generating information on the relative value of water in its alternative uses. In many countries allocation is based on “expert” judgement and politics. For example, the preference of administrators for allocating on a first-come-first-served basis is not maximising value. A recurring problem is that administrators have little, if any, information on the value of water to out-of-stream users and the values that attach to water *in situ*.

The first section provides an overview of water pricing. Coverage is limited to the use of two instruments *viz*. pricing and tradable rights. The second section discusses the issue of governance and the third section provides a brief overview of approaches to water resource management in other countries. A key issue to emerge from the overview is that countries have turned their attention from water resource development to water resource allocation and water quality.

3.1 - Water pricing

Most contemporary approaches to sustainable development call for resource pricing. In order to inject a little realism let us consider access to a river and assume that water can be freely taken from the river for irrigation. Furthermore, assume that rights are granted on a first-come-first-served basis, rights are not transferable, and total abstraction is limited to $\overline{X}$ so that a minimum flow $X_{\min}$ is satisfied. If we let X_i represent water use (we will not complicate matters by considering return flow) use by irrigator *i* and the total allowable abstraction is constraining then

$$\sum_{i=1}^{N} X_i = \overline{X}$$

(1)

- *Total economic value*

Equation 1 tells us that water use, provided use rights are monitored and enforced, stays within the environmental constraint set by water resource managers. The economist would ask two questions: (a) is the allocation across the *N* irrigators value maximising? (b) what is the value of water *in situ* (given $X_{\min}$)? The concept of total economic value (TEV) - the sum of use values (UV) and *in situ* values (IV) – can help us answer these questions.

$$TEV = UV\left(\sum_{i=1}^{N} X_i\right) + IV(X_{\min})$$

(2)

Equation 2 can be used to illustrate the importance of opportunity cost when dealing with resource scarcity. First, there is a trade-off between use and *in situ* values. What is given up in terms of use value when more water is allocated to meet environmental standards? The use value of water is, in principle, relatively easy to quantify. *In situ* value is a measure of the community preferences that attach to the flow of *in situ* services, for example, the maintenance of biodiversity. Young (2005) provides an excellent account of how to estimate the various components of TEV and apply the results to the practical problem of allocating surface water between abstractive uses and the maintenance of *in situ* services. Second, the notion of opportunity cost also applies within use value because it might be possible to increase use value by reallocating existing water use rights.

The challenge frequently facing water resource managers is that they have little information on the relative value of water. In short, there are no mechanisms in place that generate information on opportunity cost. First-come-first-served, non-transferable permits, minimal monitoring, and limited cost-recovery are common. Let's stay with the above irrigation example and describe the outcomes that will be associated with this approach.

- *Water demand*

Irrigators combine water with other factors of production—pumps, pipes, spray equipment, labour, fertiliser, and land—to produce a market-valued output, call it crop A. Looking over the array of factors we immediately see that each input other than water is priced. Consider fertiliser; the irrigator must meet the market price to obtain supply and, in the interests of returning a profit, fertiliser will be used at a rate where its contribution to profit, at the margin, roughly equals its cost. Why would the irrigator spend more on fertiliser than the contribution it makes to profit? Now apply this logic to water. In the above scenario, the price of water is zero and we can expect water to be used up to the point that its contribution to profit is zero. If water is scarce then the distortion created on the input side of production is obvious—too much water is being used. That is, if the opportunity cost of water is positive then water should be used at a level where its contribution to profit approximately equals its opportunity cost (which may be measured against alternative production systems and/or forgone *in situ* values).

- *Race to the pump house*

Allocating water on a first-come-first-served basis does not encourage patterns of efficient investment (Anderson and Hill, 1975). The timing of development will be biased toward acquiring the right. A dry land pastoral farmer, at the head of the queue, might invest in low-cost high-water-using irrigation technology simply to secure a right. Locking water allocation into this technology by not allowing transferability exacerbates the problem.

- *Existing uses unlikely to be efficient*

Even if an environmental standard is being satisfied, the above allocation regime is most unlikely to add maximum value to water. The reason is that water cannot move to its most highly valued use. Let's assume that the cost of supply is invariant with respect to irrigator. If irrigator #1 can generate a net return of $10 from applying a unit of water to crop A and irrigator #5 could produce an additional net return of $30 from applying the same amount of water to crop B, and #1 holds the right, then the economy is forgoing $20 net benefit.

- *Natural-manufactured capital substitution*

Substitution is the process of replacing one factor of production with another factor of production while holding output constant. Let's assume that irrigator #1 can produce 100 units of crop using 10 units of water (irrigation technology Y) or 2 units of water (irrigation technology Z). The cost of Z is greater than Y. If water is not priced which technology will be used? Obviously the relatively high-water-using technology Y because it is relatively cheaper in terms of manufactured capital. In this example (un-priced) natural capital (the flow of water) is substituting for (priced) manufactured capital.

- *Dynamic efficiency*

Technical progress occurs when a higher level of output can be produced from the same quantity of inputs. Or, the same output can be produced using less. Improvement in irrigation technology is an obvious example. Pricing water creates an on-going incentive to find more effective and efficient ways of using a scarce resource. As water becomes increasingly scarce and its price reflects this scarcity, then innovations in production systems, organisational arrangements, value-adding practices, contracting arrangements, and so on, will occur. Market-based instruments, such as tradable rights, unleash a dynamic that results in innovation and economic growth that far exceeds that emanating from command and control systems of water management. Moreover, economic growth can occur while meeting environmental standards.

- *Pricing*

Pricing as a potential tool in water resource management derives from the principle that if demand exceeds supply then price must be too low. As illustrated above, if water is not priced then the productive value of water at the margin is driven to zero. That is, the economic rent (factor payment) accruing to water is zero, an inefficient outcome where water is scarce. If demand does not equal supply then price must be adjusted to bring the water allocation system into balance. Water is underpriced and quantity demanded frequently exceeds supply (Rogers, 2002). The price of water is a statistically strong determinant of demand even when the elasticity of demand is relatively low (Griffen, 2006). Of course the practical issue of restoring and maintaining the demand-supply balance requires greater insights into the water resource and the institutions of a particular country. Fortunately, this paper is able to abstract from these idiosyncrasies and limit the discussion to principles.

Economic efficiency, or net benefit maximisation, is typically described by a balancing of marginal benefits (MB) with marginal costs (MC). Benefits derive from the use (we assume) of water and are represented by demand, thus we need information on MC to get the optimal price. There are two types of scarcity to address through the pricing mechanism. The first scarcity relates to the capital required to capture, contain and deliver water to consumers. The second scarcity involves water itself. Pricing to recover investment costs is relatively straightforward. However, addressing the issue of scarcity also involves including the marginal social value of natural water as suggested by the TEV framework.

Water price is a volumetric price placed on water ($/m^3). In practice water pricing includes two components: a volumetric rate and a fixed rate. The shape of the volumetric rate can be:

– *Uniform*: price is constant over water use, for example $p/m^3;

– *Decreasing block rate: p*rice is a declining block function of water use. Decreasing block rates are common and have been justified on the basis that a natural monopoly provider faces declining average costs. A greater proportion of revenue is derived from initial units of water.

– *Increasing block structures: p*rice is an increasing block function of water use. Increasing block rates are aimed at enhancing water conservation and, possibly, introducing an element of fairness into pricing. Of course, while small users (say households) might consider increasing block structures fair, large industrial users of water will probably consider the structure unfair.

Water pricing in Melbourne

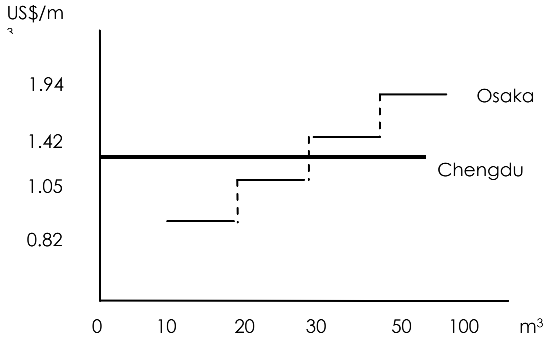
	$A / kilolitre
Residential properties	
Water use	
Up to 440 litres/day	1.0052
440-880 litres/day	1.2206
Over 880 litres/day	1.9745
Quarterly water charge	$14.24
Sewerage	
Volumetric sewerage charge	$1.2565
Quarterly sewerage charge	$48.16
Non-residential properties	
Water use	$1.2206
Quarterly water charge	$14.24
Volumetric sewerage charge	$1.2565
Quarterly sewerage charge	$57.20

Source: http://www.sewl.com.au

The cities of Melbourne Australia and Osaka Japan have approached the problem of water scarcity by adopting an increasing block structure. In contrast, the city of Chengdu China has adopted a uniform pricing structure. The former table illustrates water prices and charges for both residential and non-residential properties in Melbourne, Australia. Properties pay a fixed fee for both water and sewerage connection. Non-residential properties pay a uniform rate whereas residential households face an increasing block structure. A common, uniform, volumetric price is levied on sewerage disposal.

The Osaka Municipal Waterworks Bureau supplies water to the city’s population of 2.6 million. All consumers are metered (Asian Development Bank, 2004). A lump sum payment of US$8.04 covers the first 10m^3 of use, additional consumption is priced according to the increasing block price schedule illustrated below. Sewerage is also priced on a volumetric basis using an increasing block price. Chengdu's Municipal Water Company supplies water to the city's population of 2.8 million (Asian Development Bank, 2004). Almost all connections are metered and domestic consumers pay a uniform tariff of US$0.127/m^3. Sewerage is also priced on a uniform tariff.

Domestic tariff structures Osaka and Chengdu



Why is it that water remains underpriced and demand frequently exceeds supply? Griffen (2006) suggests that this arises out of pricing strategies that seek to satisfy multiple goals; such as:

- Revenue sufficiency: collecting sufficient revenue to cover all costs.
- Economic efficiency: price is set so as to maximise net benefits.
- Equity: price is set to satisfy notions of horizontal and vertical equity.
- Simplicity: prices are easily understood by consumers.
- Legality: legislation provides for the pricing mechanism.

Pursuing multiple goals inevitably involves conflicts and trade-offs. Efficiency might be traded off against equity, resulting in a price structure that is not consistent with marginal cost. In these situations price formation is blended by political, social and economic forces.

In contrast to setting an administered price, price can be discovered in the market through the use of tradable rights. In this case the management agency would specify a limit to the quantity of water that can be abstracted and enable right holders to transfer their rights within this cap. The focus now turns to setting allowable abstraction limits, defining the shape of property rights and providing a framework for trading to occur. Rights based management is discussed below.

3.2 - Governance of water resources

Institutions provide a fundamental link between water policy and public sector organisations, commercial organisations, communities and individuals. At the most fundamental level, institutions can be thought of as rules that apply to the community. These rules can be the product of parliament, regional government, the courts, company-specific rules, water care groups, and so on (Kasper & Streit, 1998).

- *Property rights*

Property rights include the laws, customs and regulations governing the rights and obligations of individuals and firms to have access to and use water resources. Greater insights can be gained by viewing property rights as comprising a bundle of rights that are distributed across administrators, users and the public. The following characteristics give shape to the structure of property rights and in doing so determine their value to water users.

Duration

The length of time a user holds a legal claim against the profit associated with use. Other things being equal, water rights of longer duration are relatively more valuable. Duration is particularly important when asset-specific investments (e.g., irrigation infrastructure and dams) are needed to exploit the full economic potential of water.

Exclusivity

The ability of individual users to appropriate the profits associated with their investment and operational decisions. For example, the incentive facing a water user to invest in water conservation technology would be considerably reduced if other users could free ride on benefits of conservation. Greater exclusivity more directly aligns profits with costs.

<u>Transferability</u>

Rights that are transferable are relatively more valuable. Transferability enables the right to move to its most highly valued use in the market. Moreover, transferability unleashes a dynamic that enables profit-seeking individuals to innovate and develop new and more profitable forms of enterprise.

<u>Quality of title</u>

Rights that are relatively more secure are more valuable.

Reforms of water rights can increase efficiency. In Australia, water policy reform, including higher prices for water and water trading has contributed to a 50% reduction in the amount of irrigated water per hectare, while maintaining agricultural production (OECD, 2008).

3.3 - International practice

A review of water governance shows countries have turned their attention from water resource development to water resource allocation and water quality. The notion of water provision as a public good and welfare enhancing activity is being replaced by the concept of water as an economic good and input in economic activity. This change in emphasis has heralded in new and innovative institutional arrangements. The old "development model" centred on centralised decision-making, administrative regulation, and a new model based on decentralised allocation, economic instruments, and stakeholder participation is replacing bureaucratic allocation.

While water sector reforms differ across countries in terms of their actual coverage and effectiveness, the institutional changes evident are similar in terms of their focus and direction. Commonalities are: shift from development to allocation; emphasis on decentralisation and privatisation; integrated approach to water management; and an emphasis on economic viability and physical sustainability. The figure below summarises the gradient of institutional structures, from administered allocation and limited use of pricing, through market-based approaches centred on tradable rights.

Gradient of institutional structures

Administered **Limited pricing** (Canada, New Zealand)	**Administered** **No rental price** (Israel,New Zealand)	**Market based** **Transferable rights** (USA, Australia Chili)

From the institutional change reported it is possible to conclude that *a priori* expectations—that the net gain of institutional change at least exceeds the cost of change—have been met. Most countries are advancing their earlier reforms by continuing to modernise and strengthen the legal, policy, and administrative arrangements governing the water sector.

Ownership of naturally flowing surface water typically rests with government. Use rights derive from this so-called "public" ownership. Western states within the US have a well-established record of water trading. This tradition is anchored in the prior appropriation doctrine.

Most countries are moving to improve the performance of their urban water sector. Typically this involves privatisation (or at least autonomous and financially independent) of urban water supply agencies, full-cost pricing with protection of poor consumers through demand rather than supply-side subsidy, and the mandatory treatment of urban sewerage to protect water quality. In Israel, water pricing is based on full-cost pricing.

Consistent with the switch to an economic approach to water resource management are policies aimed at fully pricing irrigation development and irrigation water. The co-existence of government and non-government water organisations is a feature of rights-based systems of governance. In general governments are getting out of water resource development and are focussing on management.

Water crises are the product of institutional failure. Command and control approaches to water management have led to excessive water use, dampened innovation and constrained economic growth. What tends to be neglected in most arguments for and against market-based reforms is the fact that all instruments generate effects. The state of water resources and their contribution to the economy is a function of the existing institutional structure and the incentives working at the level of implementation.

Three challenges have to be faced by stakeholders; governance, property rights, and prices.

Good governance can be fashioned around the notion of maximising the total economic value associated with water resource management. This will involve addressing both productive and non-productive uses of water. Recognising and incorporating non-productive values – such as making sure that there is sufficient water *in situ* to sustain eco-system functions – into water management planning is essential for sustainable development. Flexibility will be required in striking this balance because society's demand for the services of water will change over time. In many countries, water use rights are not well defined. Water is often allocated on a first-in-time basis. Poorly defined water use rights result in the economic value attributable to water being dissipated. Allocation on the basis of first-in-time leads to inefficient investment, less efficient technologies, limited inter-sectoral reallocation, and reduced economic benefits. Water users respond to prices and there is growing evidence that water supply authorities are turning to increasing block tariffs to manage scarce water resources. Demand can be revealed through administered prices or tradable rights. The former are being applied in domestic, industrial and commercial settings while the latter are seeing increasing use in the rural sector.

3.4 - Recommendations

- *To public authorities/governments at all levels*

– Water should be recognised as an economic good. The total economic value of water includes both commercial and non-commercial values. Water resource management institutions should be designed with the aim of generating information and creating incentives that guide decisions in the direction of maximising total economic value.

– Institutional design will need the capacity to balance market demand with maintaining environmental quality. Managing this interface is a particular challenge because markets generate information on water value whereas prices are not associated with non-market services.

– Where water use can be metered, providers of water services should adopt price strategies that recover the full cost of supply and recognise the scarcity value of water. Uniform block tariffs can be used by municipalities to balance revenue with the cost of supply. However, in cases where water is scarce then municipal supply authorities should adopt increasing block pricing strategies. Pricing structures should be fashioned so as to recover capital and operating costs, the value of water in its next best alternative use, and give due consideration to in situ values of water.

– High quality water rights are essential if water is to gravitate to uses that enhance productivity and value. In agriculture, where equity is not a concern, tradable rights have been shown to economise on water use and increase productivity. Where rural poverty is of concern the welfare of low income users can be protected and enhanced by the appropriate design of water rights.

4 - Infrastructure, regulation and the natural monopoly problem

The development of the required infrastructure to provide safe drinking water and for the treatment of wastewater is costly. In addition, this infrastructure is such that it creates the condition known as a "*natural monopoly*". A natural monopoly is a situation where the existence of large fixed and investment costs in relation with the size of demand implies that the average cost are decreasing, and marginal costs are below average costs at least around the economically relevant scales of operation. In a natural monopoly, it is socially desirable to have a single supplier, in order to avoid the duplication of the large fixed and investment costs. This desired condition, however, would lead to a monopolistic situation, which requires additional regulation in order to avoid the well known problems associated with monopolistic power and promote social welfare. Next, we present some that the issues and approaches that help promote social welfare in the context of natural monopolies, which applies to the firms that typically provide water, sanitation and treatment services around the world.

4.1 - Price regulation

Unregulated profit-maximizing monopolies typically supply a good or service up to a point where marginal revenue equals marginal cost, which in turn leads to a price above the marginal cost. Accordingly, this pricing criterion leads to too little production, and too high prices. In this context, the canonical solution is that of price regulation, where the desired objective is to charge a price where demand meets marginal cost. This criterion, however, poses two problems in the context of natural monopolies. First, setting a price equal to marginal cost implies that the price would be lower than the average cost (due to the very definition of a natural monopoly). This would imply that a private firm facing this form of price regulation would necessarily have economic losses, and therefore, no profit-maximizing supplier would be interested in engaging in this economic activity. An alternative to marginal cost pricing is that of average cost pricing. Yet, the condition of natural monopoly implies this time that the price would be above marginal cost, which is socially costly, as the optimal pricing rule, in absence of externalities and other considerations, is to set a price equal to marginal cost. In this context, a possibility is to set a price equal to marginal cost, and have the State provide for the economic losses incurred by the operator. Yet, this approach has been criticized on the grounds of the significant opportunity cost of public funds involved, for example, to fight poverty, implement education and health programs, etc., all of which can be all important for developing countries in particular.

4.2 - Two part tariffs

In this context, an option that has been proposed and that is widely implemented is that of two-tariff systems. In these schemes, price regulation sets the price at near marginal cost (a variable charge associated to water consumption), but consumers also face a fixed charge, unrelated to consumption. The amount of the fixed component is set typically such that the sum of all consumers´s fixed costs covers the economic losses incurred by firms when facing marginal cost pricing. This scheme has the benefit of not relying on public funds to cover the economic losses of marginal cost pricing, as well as having the beneficiaries of the service pay for it. Such a scheme has been implemented successfully in many developing countries, for example Chile and Colombia, and has made possible the privately–led development of sanitation and treatment infrastructure. A precondition for this scheme to work, however, is to have a universal or near universal distribution of reliable meters. For example, in Chile where two-part tariffs are widely employed, the cost per m^3 of water is about 1 US$, and the fixed fee is between 1 and 3 US$ per month. Considering a monthly consumption of 20 m^3 of a representative household, about 10 per cent of the monthly bill is associated with the fixed fee.

A similar approach can be used to create the incentives for the treatment of wastewater and the required-often expensive-investment, where a "*treatment*" fee can be charged to consumers, which can be an increasing function of their own water consumption, used therefore as a *proxy* of their contribution of the total wastewater to be treated.

4.3 - The problem of asymmetric information

Price regulation, whether in a two-part tariff or other schemes, is subject to the problem of asymmetric information between the regulated and the regulator regarding the true costs of supplying the service. If the goal is to set a price equals to marginal cost, there is the risk that if the regulator is poorly informed about the true cost of the service, it may well set a price above the true marginal cost. Accordingly, the supply of the resource ends up being lower than the social optimum, and the operator gets economic profits above the standard or expected rate of return. Moreover, it is likely that operators may even try to misinform the regulator with a distorted (higher) cost of providing the service to promote the establishment of a high price. In this context, price regulation can be socially inefficient.

A possible solution to this problem is to admit the asymmetric information condition of the regulator, and set prices above the real marginal cost, and revise them after a number of years. If prices are kept fixed (and guaranteed for some time), this scheme provides incentives for operators to decrease their costs in order to expand the margins and profits. This provides the incentives to invest in effort and activities that lead to the reduction in costs, an incentive that would be eroded if prices were revised too often. On the other hand, if prices are never or rarely revised, then reduction in costs would never be passed on to consumers, which is also socially inefficient. This trade-off can be addressed by setting a reasonable and convenient span of time of fixed, guarantee prices to the operators, a goal to which empirical evidence has contributed significantly in the last years. In the case of Chile, for example, tariffs are revised every 5 years.

In addition, price regulation functions much better if the underlying asymmetric information problem is reduced from the start. A way of doing this is to have a better informed regulator, which can be done by means of a "*model firm*", that is, a hypothetical firm built by a panel of experts that can recreate the approximate true cost of the real operators. If the model firm is reliable enough and sufficiently well designed, the regulator can employ such information to infer and to have a better idea of that is the true cost structure of the operator, and what pricing policies derive from it. An example of this model-firm approach is the Chilean regulation of water utilities.

4.4 - The need of strengthening ex-ante competition

Natural monopolies imply that a single operator must be selected to provide the service in a given region. It is socially desirable that this operator be the most efficient potential operator, that is, the one that can provide a given service at the lowest cost (at the socially desired quality and reliability). This would yield not only a better use of society´s resources, but also the lower prices to consumers. Yet, it is not clear the extent to which the existing operators in practice are indeed the most efficient ones out of all potential operators. In this context, it makes sense to strengthen *ex-ante* competition-or "*competition for the field*"- among potential operators, which can be implemented by means of a public auction, and select the operator that may provide the service at the lowest cost. If the auction is indeed competitive, such a scheme is likely to select the most efficient operators, and the revealed costs are likely to be a good ground to establish a socially efficient pricing regulation. In addition, development and investment plans can be incorporated in the auction process, as well as water standards and the quality of services to consumers.

5 - Towards an optimal legal framework

Mechanisms of market are necessary but not sufficient to allocate scarce resources. Water scarcity has to conduct to new models of regulation and governance of production and sharing out, with a link between the global and the local level.

Better governance in islands, coastal and isolated areas means and needs to establish and to use legal tools to enable, complying with the essential objectives (Millennium Development Objectives) of:

- a sustainable and responsible management of water;
- the preservation of water quality;
- an access to water for all populations victims of exclusion;
- a fair sharing of water.

One of the main stakes of better governance is also to prevent from conflicts between stakeholders: operators and users, public entities and private operators, but also between different types of use of water: domestic, industrial, and agricultural and through them between geographical economic or social categories of users.

The aim of efficient governance is to avoid potential conflict that could arise within local populations or between economies, raising questions about rights of access to water, its appropriate cost and priorities for its use.

As no specific mode of resolution of conflicts over water prevails, the best way to solve potential conflict is to prevent it by the rules, by a strong regulation, and through contractual links.

And, if necessary, better governance has to contribute to solve conflicts where they exist, by offering alternative procedure for conflicts resolution.

What is the purpose for a legal framework in that context? Real governance based on a strong legal framework discussed and endorsed by all stakeholders to the water management process, is necessary to protect the resource, ensure its distribution and to set up a strategy that would allow differentiating amongst users being human, industrial and agricultural:

- legal rules have to settled institutions to support water management;
- legal rules have to determine the rights and the duties of stakeholders, from the peculiar level of the consumer, through the whole entities responsible of access to water and its management, to the most global level that is the one of governments and public authorities;
- legal rules have to organise, when necessary, contractual frameworks to support economic links between stakeholders;
- legal rules can define incentives, penalties, and means of conflicts resolution.

5.1 - Legal rules have to settled institutions to support water management

Firstly, *rules are necessary to identify a good level of governance.*

Island or coastal dedicated level of governance seems to be the most adapted regarding to the rights and interests linked to cultural and traditional community structures.

But, rules could also create a consolidated level of governance around institutional perameters of solidarity: geographical or social, or functional, or economic and to combine them whenever useful and possible.

And, rules could establish a higher global level of governance, through territories and economic activities.

In fact, a political choice has to be made:

- either to create specific entities in charge of water governance;
- or, to leave stakeholders organising themselves through partnerships;
- or, to combine both.

Then, eventually, a legal frame is necessary to determine the status and the missions of these entities in charge of water governance as for example Water Agency or specific Committees.

Such entities would have, in the case at stake, a subsidiary power regarding to legal rules and its essential principles.

Some kind of national water committee should be in charge of research, expertise, evaluation, elaboration of programs, control of the resource, and the financial solidarity between basins.

Other functions of a basin committee include defining strategic orientations and organizing the link between governments, public local authorities, users and associations.

They can also offer technical and scientific assistance to the services of water agencies that may:

- develop solidarity within territories or activities;
- measure water consumption and its quality;
- share water, along its natural life-cycle;
- regulate water access on basis of solidarity including a financial one, with no extra cost for the user.

They could, in the case in point, take into account the specificities of each territory and adapt the management of water and sanitization public services in regard to transparency, solidarity and environmental efficiency.

They could regulate and control water use, and contribute to a good enforcement of a pricing policy.

Thus, a progressive transfer of water management toward the regional or local public entities, trough these kinds of "*water management unities*", can through those systems be organised to assure proper maintenance of the networks and an adequate control of prices and quality,

In an alternative or a complementary way, at the global and/or international level, governments could conceive and sign framework agreements for water management in island territories, or coastal regions and/or isolated communities concerned.

Such agreements are sometimes supporting the creation of guarantee funds (For example in 2002 "La Facilité africaine de l'eau" with the coordination of the African bank of development coordinates between all the countries and the local economic entities) dedicated to:

- strengthen their financial and human capacities;
- reform the general legal and institutional framework;
- valorize and diffuse information;
- define and settle the regulations frameworks;
- develop exploitation and maintenance means.

5.2 - Legal rules have to determine the rights and the duties of stakeholders, and define incentives, penalties

These rules would have to settle essential principles around:

- how to share a common and sustainable vision of the future in water governance?
- how to save and share water resources?
- how to regulate water's waste and water prices policies?

- *At a global level*

A legal framework will have to ensure an efficient, coherent and sustainable water policy. So, it would establish common and essential principles to guarantee access to water.

A "*water directive*" specific and adapted for each coherent territory of solidarity could be conceived for preservation, protection, improvement of environment and of rational use of natural resources.

Such a directive could build in particular a global program and plan of actions well adapted to each local context, elaborate environmental quality standards, and modes of prices adjustments, for example pollution tax.

Such directive already exists (European directive n° 2004-35, 21 April of 2004) that creates a peculiar system of environmental liability with an ability to police for, among others things, damage to water environment when it represents a risk for human health.

A code for the environment that establishes the principle "*the one who pollutes pays*", and creates prevention and reparation obligations (amends for damage, penalties system).

And, in some countries, sometimes legal precedents recognize the existence of ecological damage and responsibility and ability to act to administer with a particular mission or with environmental organisations.

Lastly, Constitutional charter makes environmental liability a principle.

It could also be useful to examine the pertinence and the opportunity of establishing a scheme for water, as the one existing for greenhouse gas emission allowance trading within the European Community.

- *At a local level*

The legal framework will have to determine trans-frontiers rules and procedures within the boundaries of a common hydrographical basin.

Specific rules and rights of property can also be necessary to organize new market areas.

5.3 - Legal rules have to organise, when necessary contractual frames

When regulation is weak, or in any event to reinforce regulation, rule can give more strength to the contract.

Public local authorities in charge of the public service have possibilities to mobilize private operators and investors.

Then, building on the previous PECC work (PECC Guidelines for effective Public Private Partnerships) it could be adapted to retain the Public Private Partnerships approach that enables for public authorities to federate financial means, competences and technologies from private economic operators.

Public Private Partnership is a solution that presents the biggest potential for contractual innovation and adaptation to diverse social and cultural contexts.

Public Private Partnerships have different contractual realities, but are always a tool to:

- mobilize and optimize massive financing with serious guarantees;
- improve forms of governance and efficiency of management of public services;
- establish a clear breakdown and allocation of risks between strong supervising public authorities, service private operators and financial institutions;
- transmit formation of local professionals and education of populations;
- implement sustainable development policies through long term vision and day-to-day management preserving future generation;
- build trust between partners, with the staff retained, with the consumers, with the population;
- organize economic stability and predictability;
- offer access to settlement for disputes resolution.

A specific "*Water Public Private Partnership*" could:

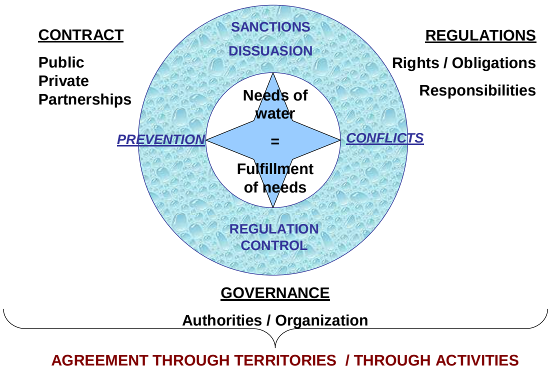
- operate a clear sharing of responsibilities and benefits for an equilibrated relationship;
- settle a governance by contractual means to regulate (by the contract or a third person) and fulfill the political engagement for an equal access to water for all people;
- enable regulation of water prices by public authorities;
- adapt incentive measures such as performance indicators, bonus linked to the achievement of specific objectives (eg. new connections in destitute areas to protect poor populations from discrimination, output based aid for realizing new infrastructures to bring water to isolated places;
- preserve a good balance between financial and social aims, by taking into account populations' capacity of payment;
- use a clause of best efforts and resolution of disputes.

5.4 - Legal rules can means to solve conflicts

Three ways to answer needs and resolve disputes may be used:

- define a (local or regional) area of solidarity,
- at this level of solidarity, recognise or create a supra-local entity to regulate the conflicts about water property and water waste,
- search for solutions through regional dialogue between public entities, users, associations and NGOs.

Virtuous circle of water



SOURCE : DS AVOCATS

It would be also possible to create a specific entity offering a "water dispute resolution service" as it exists for example for domain names with WIPO (World Intellectual Property Organization, Arbitration and Mediation Centre, based in Geneva, Switzerland, established in 1994) or Alternative Dispute Resolution (ADR) options, in particular arbitration and mediation, for the resolution of international disputes between private parties, developed by leading experts in cross-border dispute settlement. The procedures offered could be widely recognized.

Water for life: water sector policy in Samoa

In July 2008, the Cabinet of Samoa endorsed a sector-wide strategic development plan and implementation framework for Samoa's water sector for the period from 2008/09 to 2011/12.

Titled *Water for Life: Sector Plan and Framework for Action*, the strategic development plan articulates the specific policies, program priorities, and budgetary implications to guide the medium-term development of the water sector guided by the over-aching goal of *Ensuring community access to water of suitable quality and appropriate quantities to meet all reasonable health, environmental, and economic development needs*.

Water for Life recognizes the importance of a holistic sector policy approach and notes the cross linkages between infrastructure and non-infrastructure aspects including natural resources and environmental management, health and hygiene promotion, water supply and sanitation infrastructure, and community participation and behaviour.

The guiding principals for the policies and strategies to attain the sector goal as outlined in the strategic development plan are:

- To ensure benefits and opportunities are shared by all sections of the community and across both urban and rural areas.
- To set development within an integrated water resources management framework which addresses institutional, social, economic and environmental aspects.
- To adopt a flexible and phased approach to development which responds to demand and is compatible with the capacity to manage and operate systems.
- To integrate the provision of improved water supplies with appropriate sanitation and wastewater disposal measures to maximize public health and environmental benefits.
- To promote independent and financially viable service provision through appropriate. cost-recovery tariffs and user-pays policies
- To ensure co-ordination of domestic and external financing and resources within the framework of a sector-wide approach.
- To build partnerships across public, private and civil society for effective implementation.

A number of legal and regulatory assessments of water and environmental legislation have been undertaken in Samoa but many recommendations to rectify concerns remain outstanding. In 2001 a comprehensive review of the Water Authority Act and the Water Act was undertaken as part of an Australian Aid-funded Institutional Strengthening Project in the SWA.

An updated Water Authority Bill was subsequently enacted in 2003. A new Water Resources Bill (albeit rather incomplete) was drafted to replace the antiquated Water Act (1965) but has stalled and not received the attention it deserves. A Water Resources Management Strategy was issued in 2007.

Whilst policy development has received relatively high priority the enactment of suitable up-to date legislation is lagging behind. Drafting and preparation of new water-related legislation needs to overcome the current contradictions and deficiencies. While a Water Resources Bill was drafted and enacted in 2008, the main challenge for the first few years of the Sector Plan implementation will be to draft and enact a revised Water Services Bill and to produce Drinking Water Quality Standards.

Source: Samoa Water for Life Water Sector Plan and Framework for Action (2008-2012).

5.5 - Recommendations addressed to:

- *To public authorities and decision makers*

– Organize a common corpus of rules, to federate global agreements.

– Create a Pacific Island Coastal and Isolated Areas Committee for water, to establish the basis of a global governance.

– Favor circulation of water data between stakeholders.

– Define a water policy and articulate it with closely related policies and sector based policies (urbanism agriculture, industry, tourism, biodiversity) in the concerned areas.

– Settle new rules with incentives and financial penalties.

– Establish the frame of an ecological damage or disaster and ecological responsibility.

– Define a scheme for "*water pollution allowance trading*".

– Define the good levels of local governance, and eventually create local water agencies or committees with subsidiary powers.

– Reinforce the strength of the contract when regulation is weak, for example through Public Private Partnership and favour firms' innovations and their diffusion.

– Create a new entity and alternative procedure of conflicts resolution.

- *To operators of water services*

– Contribute to create trust through contractual links, and local links with the populations complying with their social and cultural specificities.

– Be respectful of aims of quality of water.

– Participate to the regulation through their offers and prices policy.

– Become aware of their environmental liability, and to avoid pollution.

- *To public at large*

– Recognize areas of solidarity and to respect community specificities.

– Adopt responsible behaviors.

– Participate to all type of dialogue.

– Accept, in case of conflicts to appeal to alternative dispute resolution.

ISBN

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