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Management of Water Demand in the Caribbean Region: Current Practices and Future Needs

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Abstract: *This paper assesses the availability, requirements and utilisation of water resources in the Caribbean region. It examines the water scarcity trends in the region and identifies Antigua and Barbuda, The Bahamas and Barbados as countries with the greatest water scarcity in the region. The role of water demand management as a means of optimising the use of water in the Caribbean region is emphasised. It examines the water demand management measures already in place and makes recommendations for the way forward.*

Keywords: Water demand, scarcity, management, Caribbean

1. Introduction

The Caribbean region receives large mean annual rainfall which varies from 1127 mm in Antigua and Barbuda to 4500 mm in Dominica. This is divided roughly between 20% to 25% of water in the dry season, during January to June and 75% to 80% in the wet season, July to December. The major management task for the water authorities in the Caribbean region is to devise methods to manage the surplus of water available in the rainy season to ensure adequate supply during the dry season. Despite the heavy rainfalls and because of their small size, geology, topography, inadequate reservoir storage facilities, scarce financial resources, and the climatic variations mentioned above, the total volume of rainfall captured and stored in groundwater aquifers and surface reservoirs in some Caribbean countries is small and water is mostly used for domestic and industrial uses and not for irrigated crop production (Ekwue et al., 1999) which requires enormous volumes of water.

This means that unlike many countries in other regions of the world like the sub-Saharan Africa and South America, where the largest volume of water from their developed water sources is reserved for irrigation, water in many islands in the Caribbean region is reserved for public water supply geared mainly toward domestic and related uses. For example, in 1980, unlike El-Salvador where 98% of its water was used for agriculture, in St. Lucia, an Island in the Caribbean with a large tourist industry, 96% of its water from the developed sources was reserved for drinking water supply and 4% for industry (United Nations, 1985).

Water Scarcity is a growing problem all over the world. According to The 2030 Water Resources Group (2009) report, by 2030, under an average economic growth scenario and if no efficiency gains are assumed, global water requirements would grow from 4,500 billion m^3 today to 6,900 billion m^3. The report found that if no action is taken, by 2030, projected population and economic growth will lead to global water demand that is 40% in excess of current supply. In addition, this means that one-third of the world's population would have access to only half the water they need, living in water basins with a 50% deficit in supply. The report suggests that a balanced portfolio of demand- and supply-side measures is adopted in each country, all aimed at trying to close the gap between supply and demand of water.

Khroda (1996) reviewed the problem of water stress in Africa and linked it to population growth, urbanisation, increased industry and mining, agriculture, drought and desertification and land use changes, particularly deforestation. He suggested that research and training in water sector related matters, reallocation of water from irrigation to industry, population policy aimed at reducing urbanisation, regional co-operation in the management of river basins, water resources planning, and other water-management issues like water policy, legislation, development of human resources and water demand management. Most of these measures are applicable to the Caribbean region.

Management of water demand is an idea that is now popularly practised in many areas of the world as a way of making more water available for the populace. It is normally a part of the overall integrated water resources management. This paper examines the quantity of water available to the Islands of the Caribbean region and examines whether or not, the practice of demand management is relevant to the Caribbean Region. It goes through the available major water demand management

options and examines the state of practice of these measures in the Caribbean region and recommends the way forward.

2. Assessment of the Water Resources of the Region

The Caribbean region is basically a humid region. Table 1 shows a brief description of the public water supply situation in ten selected Caribbean countries. With the exception of the Island of New Providence, where 67% of the population of The Bahamas resides, all the other Caribbean Islands have adequate water resources (developed and undeveloped) to meet their current water demands for domestic and industrial purposes. However, the smaller countries like Dominica, St. Kitts and Nevis, and St. Lucia do not have enough water resources to provide for irrigation, while the larger countries like Suriname, Jamaica, Guyana and Belize use most of their water resources for irrigation. Plans are made to provide more water for irrigation in Barbados and Trinidad and Tobago.

Table 1. Brief description of the water supply situation of selected countries in the Caribbean

Country	Brief Description of the Water Supply Situation
1. Bahamas	In New Providence Island (with 67% of the population), water supply is from local groundwater and 30% of water barged from Andros Island, 75 km to the West. All water is from groundwater except small supplies from roof catchments and desalination of seawater. New Providence alone has a projected demand of 64,500 m^3/d in 2000 but has only a safe yield of 9100 m^3/d from its water sources, a depressing serious shortage of water. There are no major surface water sources because of the porous nature of the soil and rock. No major irrigation is carried out.
2. Barbados	Public water supply is from groundwater reservoirs. Water from well sources is either pumped directly to transmission and distribution mains or otherwise to 24 service reservoirs varying in capacity from 900 m^3 to 6800m^3. Irrigation water is provided in the public water supply system (23%). Shortage of water is envisaged in the near future, but measures are in place to prevent this.
3. Belize	Public water supply is obtained from 9 rivers, springs and wells. Surface water requires the removal of turbidity, tastes and odours through sedimentation, filtration and chlorination. Department of agriculture drills wells for agricultural use in farming communities, separate from public water system. Enough water is available for the near future for irrigation and other purposes.
4. Dominica	Abundant rainfall, coupled with steep relief and valleys lead to abundant surface water for domestic, industrial and hydro-electricity. Surface water is collected in 5 new reservoirs constructed with welded steel. The capacity of developed water sources estimated at 45,500 m^3/d, greatly exceeds the forecast demand of water up to the year 2005. Not enough water for irrigation.
5. Guyana	Public water supply is obtained from groundwater (84%) and surface water (16%). Quality of groundwater is good except for the relatively high iron content of 1.5 to 2.5 mg/L in sand aquifers. Treatment of surface water is necessary because of the high turbidity, colour, odours and tastes caused by decaying organic matter. Only 40% of produced water is treated. Supply is unreliable. 98% of water is used for irrigation.
6. Jamaica	Public water is from surface (8%) and groundwater (92%) scattered in different Parishes. An estimated 2,542,465 m3/d is withdrawn from developed sources. About 11.2 x 10^6 m^3/d of water is still available for further development. The quality of groundwater is good requiring only chlorination. Surface water is conventionally treated to remove turbidity, tastes, odours and hardness. No problem of water scarcity is envisaged in the near future. 74% of water use is for irrigation.
7. St. Kitts	Both surface water tapped from high elevations and ground aquifers (which occur in formations of volcanic origin) are used. There are 16 distribution reservoirs. Raw water quality of surface and groundwater are good. One third of water supply sources are treated by sedimentation, rapid sand filtration and chlorination. Developed water supply sources with a safe yield of 27,100 m^3/d can meet local needs for the next 10 to 15 years. Not enough water for irrigation.
8. St. Lucia	Water supply is drawn from 33 surface water sources, the most recent being the Roseau River on which a dam and a storage reservoir have been constructed to augment supplies to the Castries area. All supplies are disinfected but some require additional treatment through coagulation, sedimentation and sand filtration. Turbidity levels of water rise because of increased erosion in catchments as a result of removal of forest cover. Present water sources are enough for the forecast future demand, but not for irrigation.
9. Suriname	Public water supply is from groundwater extracted from 10 well fields in three major aquifers. Water is stored in reservoirs. Presence of carbon dioxide, iron, ammonia and chlorides from sand aquifers require treatment. Principal treatment methods are aeration, sand filtration and chlorination. Water is abundant for irrigation and other purposes.
10. Trinidad and Tobago	Water is supplied from surface sources (79%) and groundwater (21%). A total of 97 sources are involved. Caroni-Arena, Navet, Hollis and Oroupouche supply 64% of total production. The first three have earth dams and impounding reservoirs. There are 76 distribution reservoirs ranging in size from 45,500 m^3/d to less than 45 m^3/d. The Desalination Company of Trinidad and Tobago supplies 109,589 m^3/d. The present safe yield of identified water supply sources will take care of the projected water demand. More land could be brought into irrigation if more water can be exploited.

3. Water Stress and Scarcity in the Caribbean Countries

Eberhard and Robinson (2003) defined water stress as the proportion of available water that is already in use. It is a simple ratio, expressed as a percentage of the amount of water drawn from sources divided by the estimated total available water from these sources. Table 2 shows that the water stress in some Caribbean countries ranges from 0.02% in Suriname to 80.5% in Barbados. Apart from Barbados, another country that has major water stress is Antigua and Barbuda. Dominican Republic has abundant water resources but has a water stress of 45%, which could be misleading since most of the water (76%) is used for irrigation. The other countries have low to medium water stress.

Table 2. Population and some water parameters of selected Caribbean countries

Caribbean Country (a)	**Population (x 1,000)** (b)	**Mean Annual Rainfall (mm)** (c)	**Water Availability (m^3/d)** (d)	**Water Withdrawn (m^3/d)** (e)	**Water Stress (%)** (f) = (e/d)	**Water Scarcity (m^3/d/capita)** (g) = (d/b)
Antigua and Barbuda	65	1,127	12,603	7,123	56.5 (High)*	0.2 (Absolute)*
The Bahamas	297	1,434	449,704	105,710	23.5 (Medium)	1.5 (Absolute)
Barbados	277	1,397	232,984	187,627	80.5 (Catastrophic)	0.8 (Absolute)
Belize	266	1,983	59,833,238	263,888	0.4 (Low)	224.9 (None)
Dominican Republic	8,722	1,500	59,906,997	26,958,903	45.0 (High)	6.87 (none)
Guyana	698	1,976	605,613,485	387,000	0.1 (Low)	867.6 (None)
Jamaica	2,576	1,847	11,191,780	2,509,589	22.4 (Medium)	4.30 (Periodic)
St. Kitts and Nevis	50	1,368	56,060	13,600	24.3 (Medium)	1.12 (Absolute)
Suriname	435	2,094	348,674,548	77,775	0.02 (Low)	801.6 (None)
Trinidad and Tobago	1,294	2,054	10,522,170	978,082	9.3 (Low)	8.13 (None)

Sources: FAO Production Yearbook, 2000; UWI Infrastructure Study (1996); Karanjak (2003); Water Resources Institute (2004).
*According to the categorisation of Eberhard and Robinson (2003).

Eberhard and Robinson (2003) defined water scarcity as the amount of water potentially available per person. As showed in Table 2, the water scarcity levels in the Caribbean countries range from 0.2 (absolute scarcity) in Antigua to 867.6 m^3/day/person (no scarcity) in Guyana. Barbados has a value of 0.8 m^3/day/person. Values of the water stress and scarcity indices then show that while countries like Antigua and Barbuda and Barbados have serious water problems, Belize, Suriname and Guyana have abundant water resources. Water scarcity and water stress indicators are just two reasons for countries to implement measures to reduce water demand. However, even in countries that are water rich, these same measures will ensure efficient and equitable use of available resources. Excessive use of water could lead to pollution problems that are abundant in water rich countries like Belize and Guyana. For the countries that have abundant water sources, irrigated agriculture is the major water consumer as shown in Table 3.

Table 3: Water demand by different sectors

Country	**Water Demand by Sectors (m^3/d)**	
Barbados (2000)	Domestic	58,100 (31%)
	Tourism	9,230 (6%)
	Industrial	28,610 (15%)
	Institutional	7,640 (4%)
	Agricultural	48,950 (26%)
	Leakage	32,470 (18%)
Jamaica (2003)	Agricultural	1,857,096 (74%)
	Domestic	463,270 (18%)
	Industry	189,223 (8%)
Dominican Republic (2003)	Agricultural	20,547,945 (76%)
	Domestic	3,972,602 (15%)
	Others	2,438,356 (9%)
Trinidad & Tobago (2003)	Domestic	389,041 (40%)
	Leakage	350,684 (36%)
	Industrial	210,958 (21%)
	Agricultural	27,397 (3%)

Sources: UWI Infrastructure Study (1996); Karanjac (2003)

According to the data provided by Water Resources Institute (2004), the Dominican Republic, Guyana, Haiti and Jamaica utilise 76%, 98%, 89%, and 74%, respectively of their total water extractions for irrigation. Irrigation sector is therefore an important target of integrated water resources management and water demand management in these countries.

There is the need to optimise the water used for irrigation by emphasising irrigation scheduling, minimising irrigation losses by using drip and sprinkler irrigation, rehabilitation of irrigation infrastructure, use of recycled water, encouraging rainwater harvesting, among other measures. With the practice of water demand management, other Caribbean countries which have significant proportions of their people in the agricultural sector like Dominica (27.3%), Grenada (24%) and St. Lucia (21.7%) could provide more water for irrigation than is currently available.

Figure 1 shows that there is a clear positive relationship between per capita water use in Litres per day and per capita income measured by Gross Domestic Product (GDP). The same trend was obtained for the South African countries by the International Union for Conservation of Nature (IUCN, 2004). This means that although Barbados and The Bahamas are water scarce countries, water scarcity does not seem to hold back development, but leads to increases in water consumption. In Barbados and particularly, The Bahamas, the high levels of water consumption are linked to high water levels required by tourists.

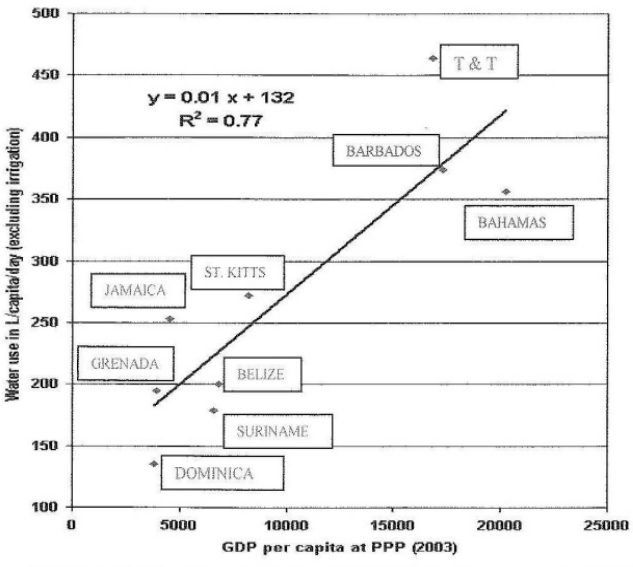

Figure 1. Water use per capita versus GDP per capita (US Dollars, Purchasing Power Parity)

According to the World Bank (2001), tourism contributes to 50% of the GDP in The Bahamas and 75% of the total foreign earnings. It is not, therefore, surprising that the choice of projects for expansion, rehabilitation and construction of new water schemes in The Bahamas, is based on providing water services in those areas selected for expansion of the tourist industry (UWI Infrastructure Study, 1996).

Water resource planners in the Caribbean region need to then realise that economic growth and development are likely to put growing pressure on water resources. The 2030 Water Resources Group (2009) also reported that this would be expected in most countries of the world including India, China and Brazil. Trinidad and Tobago, Barbados and The Bahamas need to focus more on water demand management since they have higher per capita water use than other countries.

4. Water Demand Management in the Caribbean Region

Demand can be defined as the amount of water that would be used by consumers if available, under specific conditions of price, quality, and others (United Nations, 1992). Total demand includes all water, which could be used by a consumer - both internal (private owned) from rain tanks and wells and external (the amount that would be consumed if a pipeline supplied water to the consumer's property).

Because it will not always be possible to supply water to meet all needs, priorities are normally set as to which demands are to be satisfied first. In most Caribbean countries, it is always people first, then industry and then agriculture (irrigation) and the environment.

Water demand management according to IUCN (2000) is a management approach that aims to conserve water by decreasing demand. It involves the application of selective incentives to promote efficient and equitable use of water, leading to increased water availability through more efficient allocation and use. The normal intentions in water demand management are decreasing water demand and increasing supply from non-traditional sources like rain harvesting and desalination of seawater, as well as demand prioritisation and ranking. This is all aimed at closing the supply and demand of water.

The motivating factors for water demand management in the Caribbean will be the water scarcity factors earlier shown and the need to provide more water needed for irrigation and for future economic development needs in the region. Water demand management will also lead to possible savings in operation and maintenance costs and lower costs when compared to the introduction of more expensive new water schemes. According to Falkenmark *et al.*, (2007), it is better to explore all means of decreasing water demand like changing consumption patterns for agricultural production, reducing water losses in water supply systems, before augmenting water supplies by using bigger pumps, higher dams, and larger pipelines.

This is the novelty of using the water demand management approach. These latter water supply measures should be used if the demand reduction measures still do not help to achieve the required balance between water use and availability.

Figure 2 illustrates the major available water demand management measures as enumerated by IUCN (2004). These are technical, financial, policies and legislation and public enlightenment measures. The current practices and the future needs of the management of water demand in the Caribbean region are described below.

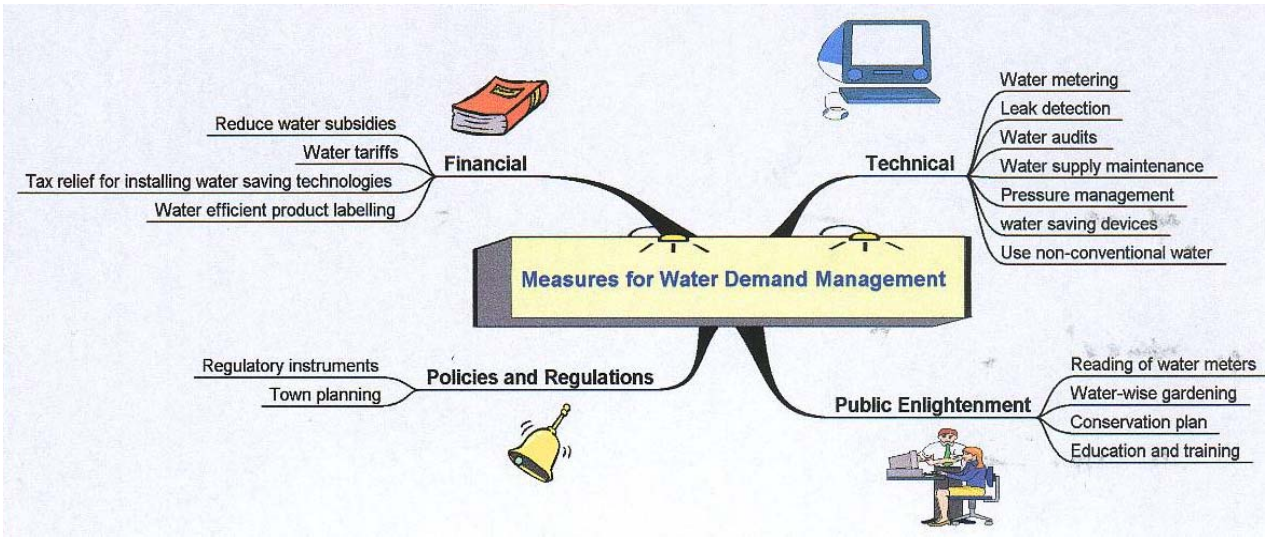

Figure 2. Measures Available for the Water Demand Measures
Source: Adapted from Information Provided by IUCN (2004)

4.1 Technical Measures

In the Caribbean countries, the major technical measures adopted in water demand management include water metering, reduction of water leaks, and the use of non-conventional sources of water. The other technical practices shown in Figure 2 are also practised at varying levels. Many countries in the Caribbean region including Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, St. Kitts and Nevis and St. Lucia have installed water meters for most of its customers. In Trinidad and Tobago, only some water users have installed meters. Metering encourages water consumers to make a wise use of it and reduce their water rates. There is evidence of this in the Caribbean region. The two countries that have a large amount of unaccounted-for water include Trinidad and Tobago with about 36% and Barbados with 18%. The unaccounted-for water in Trinidad and Tobago originates from leakage in the pipes, illegal connections, illegitimate hydrant use, wastes at public standpipes and unregistered use (Karanjac, 2003). Both countries are now making arrangements to reduce the losses in order to reduce their total water demands.

Countries like Antigua and Barbuda, Barbados, Grenada, The Bahamas which have high water scarcity as well as Trinidad and Tobago have all introduced the exploitation of non-conventional sources of water. These include the harvesting of rainwater on roof catchments in Barbados, Grenada and Antigua and Barbuda; and the production of desalinated sea water in Barbados, Antigua and Barbuda, The Bahamas, and Trinidad and Tobago

In Antigua and Barbuda, the average size of rainwater storage is 120 m^3 and with an approximated 30,000 households, rainwater provides a water volume of 3,600,000 m^3, mainly for drinking (Karanjac, 2003). In the same country, desalinated water provides about 7,575 m^3 per day. In Barbados, the production of desalination water is 30,000 m^3/d and is used as drinking water for one-sixth of the Island. The Desalination Company of Trinidad and Tobago supplies about 109,589 m^3/day to industries in Point Lisas Industrial Estate, which represents about 52% of industrial water use in the country (see Table 1). The other uses of non-conventional water are exploration of deep aquifer adopted in Antigua and Barbuda, and wastewater reuse promoted in Barbados. The latter is used for groundwater recharge, irrigation, animal foliage and for industrial cooling.

4.2 Financial Measures

Historically, in the Caribbean region, water has been treated as a public good, whose management and supply is paid for from the government coffers. Prices remain far below supply costs and are subsidised from the general government revenues. According to Mycoo (2005), the practice of price subsidisation in Trinidad

and Tobago is aimed at encouraging industrial growth and meeting basic human needs. The general recommendation is now to treat water as an economic good, so as to decrease water demand by encouraging a wise use of water and discouraging wastage. Two countries that have privatised their major water supply agencies are Dominica and Belize, as a means of strengthening market forces in water prices. Other countries in the region are urged to revisit subsidies by treating water as an economic good. According to IUCN (2004), retaining subsidies could only be justified on social (in the case of those who cannot afford to pay) and on environmental grounds for providing sufficient water for maintaining existing eco-systems like the swamps.

According to IUCN (2004), water tariffs should be based on marginal opportunity costs, which include cost of production, transport, environmental externalities, and predicted benefits of resource depletion. This should be higher than the marginal cost of supply. European Commission (EMWIS, 2010) report on strategies to tackle water scarcity and drought states that greater efforts on establishing an effective water pricing policy, water efficiency, and water saving measures are essential to reverse the over-exploitation of Europe's limited water resources.

One country in the Caribbean region that has tried to make consumers pay prices that come close to economic rates for water is Antigua and Barbuda. The cost of producing surface water and desalinated water in Antigua is US$5 per m^3 while the cost of groundwater is half of this amount. It charges its domestic water users US$ 2.10 per m^3 for use up to 15 m^3 and US$ 5 per m^3, thereafter. It therefore has the highest rate of water tariff in the Caribbean region (see Figure 3), while Trinidad and Tobago (for metered users) has the lowest.

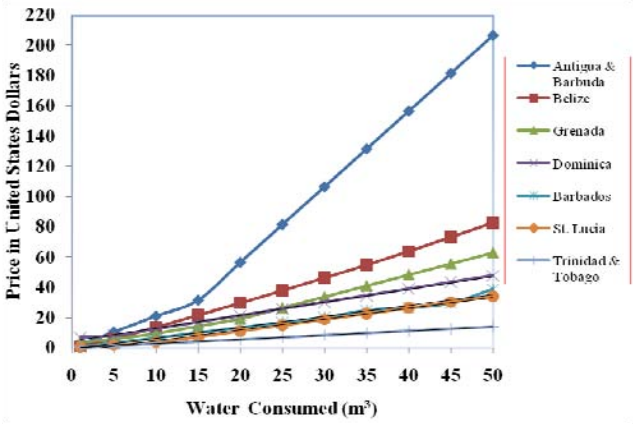

Figure 3. Water in Some Countries of the Caribbean Region (Adapted from Data Provided by Karanjac, 2003)

The block tariff system is used in setting water rates in most countries in the Caribbean. This is the most suitable system from an economic, social and environmental perspective (IUCN, 2004). For instance, in Dominica, domestic water rates are US$ 0.4 per m^3 for the use of first 11 m^3 of water in the month and US$ 0.76 per m^3, for further use of water in the same month. The block system of tariff permits subsidisation from high to low users and offers a financial incentive for effective water use, since high tariff for high water use discourages water usage. Dominica practices the block system, but also has a fixed cost of US $3.70 per month. The block system of tariff can only work with metering and effective meter reading. In Trinidad and Tobago, where water metering is not widely practised, the water tariff for non-metered users is based on a proxy measure (Mycoo, 2005), whereby the value of the property is used as a barometer of income and potential household water consumption. This is based upon a proportion of annual taxable value (ARV) of property within a range of US$17 per quarter to US$48 per quarter year. According to Mycoo (2005), this pricing mechanism based on the ARV does not generate maximum revenue to meet costs of services and is ineffective in rationing consumption patterns.

The findings of the Caribbean countries under study show that the prices of water use for commercial users are higher than those for domestic users and this is desirable. For the other financial measures, only Grenada was found in literature to provide tax incentives for conservation of water resources and other countries are urged to consider this practice. There are no documented tax relief or targeted subsidies for production users that install the latest water demand management technologies. There is no evidence of water efficient product labeling in the Caribbean region, but this should also be considered in order to encourage wise use of water.

4.3 Policies and Regulations

According to IUCN (2004), the regulatory instruments needed in water demand management include by-laws that regulate water use in swimming pools, watering of gardens and control of invasive alien species in water courses; regulation against water wastages; formal certification and regulation of plumbing contractors and pollution by means of effluent changes. There is no documentary evidence of the use of any of these regulatory instruments in the Caribbean, but countries like Antigua and Barbuda and Barbados have made the provision of rainwater collection and storage systems compulsory for new buildings with large floor sizes. In addition, there are ad-hoc regulations on the use of water in times of water scarcity in the dry season like in Trinidad and Tobago.

For town planning purposes, IUCN (2004) suggests that small plots could be allotted to individuals as this reduces water consumption; industries can be directed to areas with cheaper water supply and that the size of a

settlement and the level of services could take into account water scarcity and costs. These practices are in place in most Caribbean countries where approval of new building construction is linked with obtaining evidence of supply of water by agencies. There is need for policies, legislation and regulations in the Caribbean aimed at water demand management in the Caribbean.

4.4. Public Enlightenment and Education

IUCN (2004) suggests that all countries should have public enlightenment and water conservation plans in relation to water demand management. Under public enlightenment, it suggests having posters or leaflets on ways of saving water, education of people on reading of meters, and the use of water wise gardening. Water wise gardening includes providing advice on best watering times, use of drought resistant lawn and plants, proper sprinkler design, duration and frequency of watering, mulching and drip irrigation. These methods are widely practised in the Caribbean region but they should be encouraged for most water users.

For the water conservation plan, IUCN (2004) specifies intensive water communication campaign, education on water audit at schools, water loss management, clearing of evasive plants on catchment areas, water wise gardening (see above), water-wise food production, incentives to save water at home, water regulations, information on billing approach and above all education and training on water demand management. Of all the countries surveyed, only Barbados has a definite water conservation plan which involves reduction of water leakage, efficiency in water metering and pricing, improved agricultural water use efficiency, encouraging reuse and recycling of water by both industries and households and public education and training on procedures for water demand management (Karanjac, 2003). Other countries are encouraged to develop their own water conservation plans as well education and training on the need and procedure of water demand management.

According to the undated report by the United States Environmental Protection Agency, the water conservation plan could be arranged and implemented in three levels. Level one includes universal water metering, water accounting and loss control, costing and pricing and information and education. The Level two measures include water use audits, retrofits of supply system, pressure management and landscape efficiency. The Level three measures are the replacements of parts and promotions, reuse and recycling of water, water use regulations and above all integrated water resource management. These could act as guidelines for implementation of the water demand measures by countries in the Caribbean.

5. Conclusions

Water availability in the Caribbean region has been assessed, together with indices of water scarcity. It has been stated that the countries that have greatest water scarcities in the region are Bahamas, Barbados and Antigua and Barbuda in order. The countries that consume most water are Bahamas, Barbados and Trinidad and Tobago.

While the practice of water demand management described in this paper would be beneficial for most Caribbean countries, it is critical for the water scarce and the high water use countries identified. Of all the countries surveyed, only Barbados, Antigua and Barbuda and to some extent Trinidad and Tobago have developed their plans to conserve water. Other countries in the region are advised to follow suit. It must be emphasised that water scarcity is a global problem and that water demand measures must be seen as one of the overall strategy to manage water in different countries.

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