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Interim Report IR-04-008

Integrated Water Resource Management in Trinidad and Tobago

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Abstract

Integrated Water Resource Management (IWRM) promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare (in an equitable manner) without compromising the sustainability of vital ecosystems. This case study focuses on Trinidad and Tobago, a country consisting of two main islands north-east of Venezuela, between 10 and 11.5 degrees north latitude and between 60 and 62 degrees west longitude. It is the most southerly of the Lesser Antilles and experiences a tropical climate with two seasons namely, wet and dry. The major objectives of this project are:

To map water quality information that is, physico-chemical and heavy metal variables for the rivers of Trinidad and Tobago

To look at land use patterns and their effects on the water quality of the rivers of Trinidad and Tobago

To explore how the scientific information can be used to bring about IWRM in Trinidad and Tobago.

The report contains the conclusions of the mapping exercise and an analysis of the stakeholders and their interactions in order to enhance the use of science and technology in finding solutions to sustainable development problems.

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Thank you God for allowing me the opportunity to have worked with such wonderful people in such a wonderful place.

Thanks Mum and Dad for everything….need I say more. You have molded me into the person that I am today and I am very happy with myself and I owe this to you.

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Preface

The Initiative on Science and Technology for Sustainability (ISTS: http://sustainabilityscience.org) is an international, open-ended network with the goal of enhancing the contribution of knowledge to environmentally sustainable human development around the world. The Initiative was founded in late 2000 by an independent group of scholars and development practitioners gathered at the Friibergh Workshop on Sustainability Science. Since that time, it has worked to strengthen cooperation between two communities: practitioners involved in promoting human development and environmental conservation, and researchers involved in advancing science and technology relevant to sustainability.

One of the aims of ISTS is to "foster the next generation" of sustainability scientists. With this goal in mind, ISTS together with the Third World Academy of Sciences (TWAS) and IIASA, invited three young scientists from developing countries to participate in the IIASA Young Scientists Summer Program (YSSP) for three months in the summer of 2003. The competition for fellowships was very strong, with around 100 applicants for the few places that could be funded. The funding was provided from a grant from the Lucille and David Packard Foundation to ISTS.

The aim of this summer initiative was to help the young scientists expand their case studies on environmental issues to consider the issues of sustainable development. This was aided by a protocol developed by David Cash and Vanessa Timmer and others within the ISTS, which raised questions to guide case studies on harnessing science and technology for sustainable development. Obviously, in three short months, it was not possible to answer all of the questions raised in the case study protocol, but it was possible to tackle some of the questions in individual work and group discussions. The three IIASA Interim reports from Sharda Mahabir (Trinidad and Tobago), Juan Moreno Cruz (Colombia) and Riziki Shemdoe (Tanzania) demonstrate very well the progress that was achieved

In addition to presenting the results at the traditional mid-summer YSSP workshop, the ISTS/TWAS scholars also traveled to Trieste and presented and discussed their work at TWAS.

I would like to thank Diego Malpede, ISTS/TWAS Research Fellow, who provided untiring support during the application and selection process and for our visit to TWAS. Thanks also to Leen Hordijk and Joanne Bayer, IIASA, for their support in bring these scholars to IIASA and providing a learning experience for all of us.

Jill Jäger
Vienna, Austria
January 2004

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Sharda Mahabir participated in the 2003 YSSP Young Scientists Summer Program at IIASA. She is a IIASA/TWAS/ISTS Scholar from the The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies.

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List of Acronyms

CAS	Caribbean Academy of Science
CARIRI	Caribbean Industrial Research Institute
CCST	Caribbean Council for Science and Technology
CDCC	Caribbean Development and Cooperation Committee
CEHI	Caribbean Environmental Health Institute
EMA	Environmental Management Authority
GWP TAC	Global Water Partnership Technical Advisory Commission
GIS	Geographical Information Systems
ISTS	Initiative on Science and Technology for Sustainability
IWRM	Integrated Water Resource Management
MEA	Millennium Ecosystem Assessment
SIDS POA	Small Island Developing States Programme of Action
UNCSD	United Nations Commission for Sustainable Development
UNDP	United Nations Development Program
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Program
UWI	The University of the West Indies
WASA	Water and Sewerage Authority
WB GEF	World Bank Global Environmental Facility
WRA	Water Resources Agency

Integrated Water Resource in Trinidad and Tobago

Shanda Mahabir

1. Introduction

Integrated Water Resource Management (IWRM) promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare (in an equitable manner) without compromising the sustainability of vital ecosystems. This process involves the holistic coordination and management of natural systems and human activities, which create the demands for water, determine land use and generate water-borne waste (GWP TAC, 2000).

It follows the four Dublin Principles (Solanes and Gonzalez-Villarreal, 1999), one of which states, "Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment."

Freshwater systems must be properly managed because they represent 0.0001 per cent of the world's water supply and are subject to increasing pressure from competing interests involved in social, economic, political and ecological activities (Gleick, 2000).

Sustainable development requires high water quality in order to balance these demands. However, water quality cannot be managed at an international level owing to the vast differences amongst the physical, chemical and biological characteristics of the many freshwater systems and climates around the world. Hence, freshwater management and Science and Technology (S & T) for sustainable development needs to be "place-based" or "enterprise-based", embedded in the particular characteristics of distinct locations or contexts (Clark *et al*., 2002).

This case study focuses on Trinidad and Tobago, a country consisting of two main islands north-east of Venezuela, between 10 and 11.5 degrees north latitude and between 60 and 62 degrees west longitude. It is the most southerly of the Lesser Antilles and experiences a tropical climate with two seasons namely, wet and dry.

1.1. Background

1.1.1. Water usage and quality in Trinidad and Tobago.

Water Resources Management is a critical development issue for Trinidad and Tobago. Table 1 summarises the water usage for the country and illustrates that most of the demand on water is for domestic use. This demand will almost double in twenty years. Unaccounted water relates to water lost through faulty pipelines and the treatment process.

Table 1. Consuming Water Demand (Million Cubic Metres /Year) 1997 to 2025.

Demand Category	**Year**				
	1997	2000	2005	2015	2025
Domestic	118	120	142	171	203
Industrial, Major	36	51	66	92	112
Industrial, Minor	9	9	11	13	15
Irrigated Agriculture	10	10	10	10	10
Unaccounted water	124	124	128	118	141
Total	297	314	357	404	481

Source: WRA, 2001.

Presently there is an annual 14 per cent deficit in the supply of water and this figure is projected to increase by 27 per cent by 2015. These deficits exist despite an apparent abundance of water in Trinidad and Tobago. The per capita water availability is approximately 2500 m^3/year, which is 2.5 times the international criterion for water scarcity, thus making this country a water abundant country (WRMU, 2002). The unreliability of supply due to low surface water flows during severe dry seasons and high turbidity of surface water results in this deficit on an annual basis.

The quality of water fit for human consumption can be measured via biological, physico-chemical and chemical variables. This report uses the physico-chemical and chemical data on phosphates, pH, Biological Oxygen Demand (BOD) and heavy metals to suggest a protocol for implementing IWRM.

There is no comprehensive assessment of the quality of the water resources of the country but instead a number of independent studies of varying levels of reliability have been carried out (WRA, 2001). Most of the water quality studies in the country have been restricted to the Caroni River Basin because it accounts for 30 per cent of the drinking water for the country. The Caroni River was identified as a major source of pollution for the Gulf of Paria, which is located along the west coast. A survey of this watershed was completed by the Water and Sewerage Authority (WASA) but to date, this information has not become public.

The Caribbean Industrial Research Institute (CARIRI, 1997) also surveyed the water quality of the Caroni River Basin but found no metals present in their water samples. However, the water samples were not pre-concentrated hence the levels may not have been detectable and furthermore sediment was not analysed.

In terms of research done at the University of the West Indies (St. Augustine), there have only been three studies done with regard to metal pollution in rivers. Bernard (1979) identifies possible accumulation of metals in the organisms residing in one river basin in Trinidad. Phillip (1998) conducted a countrywide survey of levels of zinc and copper in water and found that these metals may pose a threat to local fishes. Mahabir (1998) reported levels of metals in sediments collected from two Northern Range Rivers – the Guanapo and Arima Rivers, and found that there was an increase along the course of the river.

The need for monitoring levels of metals in freshwater systems is further emphasised by newspaper reports that attempt to describe the damage done to the freshwater environment locally. For example, an article was headlined "Raw Sewage flowing to Gulf says Watchdogs" (Trinidad Guardian, 1997), and it described a pipeline releasing large amounts of sewage into the Beetham River, north Trinidad. Incidentally, this river is used by residents of the area as a source of water and fish.

1.1.2. Water Resource Management and its Legal Framework

Trinidad and Tobago has a long history of watershed protection. The first forest reserve in the Western Hemisphere, the Main Ridge of Tobago, was created in 1765 "for the protection of the rains" and most of Trinidad and Tobago's existing forest reserves protect critical water resources (WRMU, 2002). Since then, there have been fifteen water protection legislations and numerous others that indirectly protect the water resources of the country.

Nevertheless, there is no clearly articulated land-use policy for Trinidad and Tobago that is presented in a single document, instead there are many laws relating to land and water issues. One of the most important issues contributing to watershed depletion and water pollution has been the lack of enforcement of environmental legislation (WRA, 2001)

1.2. Objectives

The major objectives of this project are:

1. To map water quality information that is, physico-chemical and heavy metal variables for the rivers of Trinidad and Tobago
2. To look at land use patterns and their effects on the water quality of the rivers of Trinidad and Tobago
3. To explore how the scientific information can be used to bring about IWRM in Trinidad and Tobago, following Cash and Timmer (2003) Initiative on Science and Technology for Sustainability Protocol.

2. Methods

Physico-chemical and heavy metal data were collected for surface water and sediments at 64 sites across Trinidad and Tobago for both the wet and dry seasons, from 1998 to 2001. The sites were a subset of 92 sites used for a nationwide water quality and biodiversity survey of fish (Phillip, 1998). They were also chosen according to accessibility, characterized by landmarks such as bridges or mileposts. Three sets of water quality data were collected for the sampled rivers, namely:

1. Physico-chemical data
2. Concentrations of heavy metals in the water
3. Concentrations of heavy metals in the sediments

The physico-chemical data discussed in this paper are pH, phosphates and Biological Oxygen Demand (BOD). The heavy metals, copper (Cu), nickel (Ni), cadmium (Cd), zinc (Zn), chromium (Cr) and lead (Pb), were measured for the water and sediments of all the sampled sites. These results were summarised by site and season and were then compared to appropriate quality criteria. For the physico-chemical variables, values derived for the sites were compared to Phillip (1998). For heavy metals in water, values were compared to the USEPA National Recommended Water Quality Criteria (Corrected) (1999) and for sediments the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (1999) were used.

This information was then plotted using GIS Arc View 3.2 (@ 1992-2000, ESRI) to show the quality of each of the sites according to the three types of data. Land use information collected for the country (Ramlal, 2003) was also overlaid onto the water quality maps to create land use/water quality maps. The original 50 land use categories were summarised to represent the major types of land cover. This information was then overlaid with the surface water quality information to produce land cover/surface water quality maps.

Over 50 maps were generated for all the variables measured. To summarise this information, the sites were categorised as either "meeting (=2)" or "not meeting (=1)" the criteria and a numerical value was awarded for this. The numerical value for each variable was then summed for each site and compared using a scale that corresponded to three categories, namely 'clean', 'perturbed' and 'polluted,' following Phillip (1998). This information was then plotted using the land cover information and watershed information to create two overall water quality maps for the physico-chemical data, heavy metals in water and those in sediments.

Cash and Timmer's (2003) ISTS Protocol was used to examine how the scientific conclusions can then be effectively used in order to encourage sustainable use of water.

2.1. Problems associated with mapping

Land use information for Tobago was not obtained and the map provided did not have the same projection as the data points for water quality. Therefore, attempts to map Tobago's land use and water quality could not be completed. This report thus graphically summarises the information for Trinidad only, with the intention of completing the mapping process for the Tobago later. However, the data for Tobago, summarised in Table 2, are also discussed.

3. Results

The six summary land cover/watershed/water quality maps are presented in Figures 1–3. Table 2 summarises the results for Tobago and Table 3, the number and percentage of sites recognised as clean, perturbed and polluted for the two islands.

3.1. Physico-chemical data

The map of physico-chemical data for Trinidad shows that most sites are 'clean'. Only six per cent of sites were recognised as 'polluted' and these were mostly located in the central region of the island. Referring to the land use map (Figure 1B), sites recognised as having poor water quality were mostly found close to anthropogenic activities, for example, agriculture, commercial/industrial/residential centres, towns and disturbed natural ecosystems.

The watershed map (Figure 1A) indicated that the West Peninsula/Caroni and Central West watersheds are of greatest concern with respect to physico-chemical data. Many of the water intakes or extraction points are located in the former watershed, near to in close proximity to agricultural sites, which has been identified as a source of decreased water quality. Overall, phosphates were found in high concentrations, with only twelve per cent of sites having levels of phosphates that were considered ‘clean’.

The results for Tobago with respect to physico-chemical data showed that two-third of the sites are ‘clean’, one third are ‘perturbed’ and none are ‘polluted’.

3.2. Heavy metals in water

Most sites in Trinidad were categorised as ‘perturbed’ with only 15 per cent recognised as ‘clean’. These were scattered across north and central Trinidad. With respect to land use, agriculture and disturbed natural ecosystems were the major land use activities at the sites considered ‘polluted’. This correlates well with the land use information for the physico-chemical data. Further similarities can be seen between the physico-chemical and metals in water data in the South Oropouche and Cedros Peninsula watersheds, which were recognised in both data sets as ‘perturbed’. However, many of the clean sites for the physico-chemical data were re-categorised as perturbed in this dataset of metals in water. Some polluted sites with respect to metals in water were located close to major roads; this was not seen in the maps for the physico-chemical data. The important metals in water, in order of importance were lead, zinc and copper.

Table 2. Water Quality of Tobago Rivers

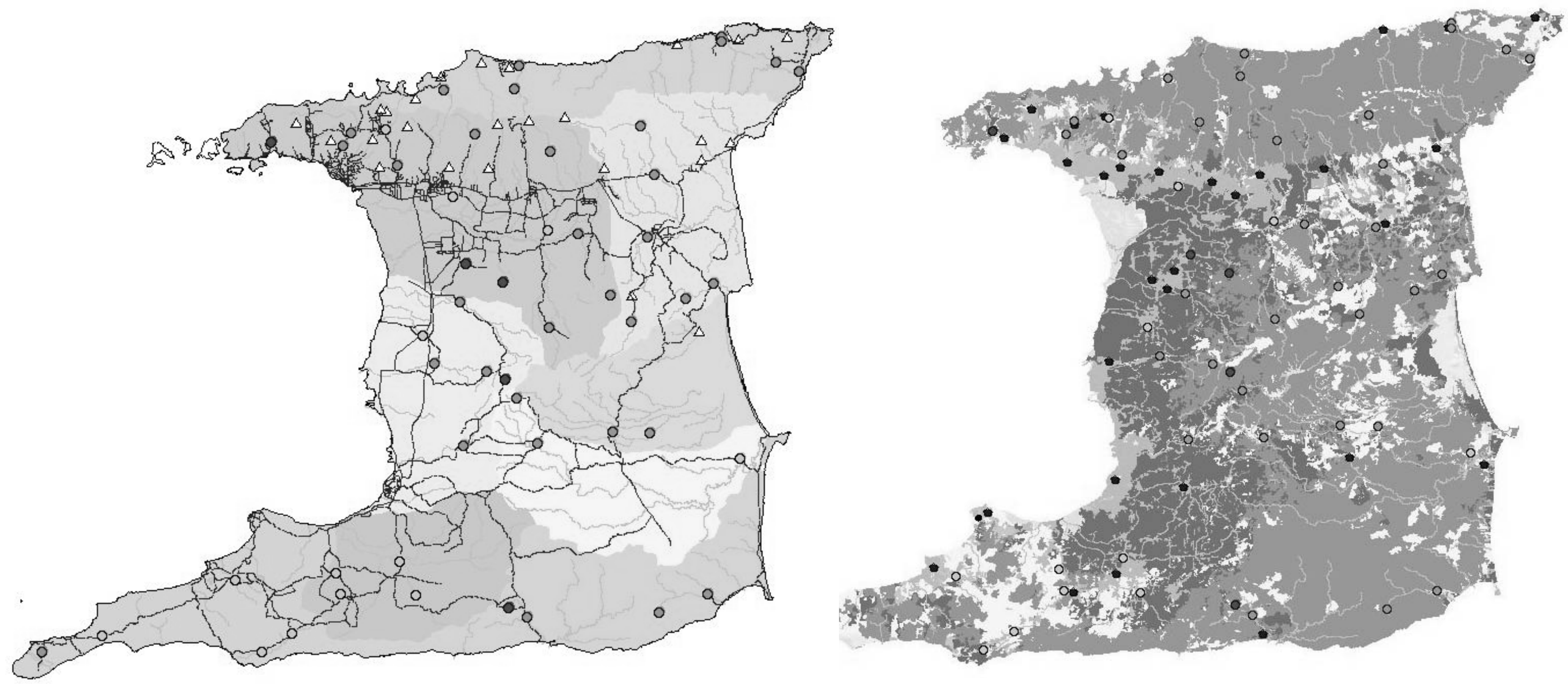
	Site	Upper/Lower	Physico	Sedi	Water
1	Bloody Bay		perturbed	polluted	clean
2	Courland	upper	clean	perturbed	perturbed
3	Courland	lower	clean	perturbed	perturbed
4	Hillsborough West	lower	n/a	polluted	perturbed
5	Lambeau	lower	perturbed	polluted	perturbed
6	Louis D'or	lower	clean	polluted	clean
7	Louis D'or	upper	clean	polluted	clean
8	Speyside	upper	clean	polluted	polluted
9	Speyside	lower	clean	polluted	perturbed

PHYSICO- PHYSICO-CHEMICAL DATA
SEDI – CONCENTRATIONS OF HEAVY METALS IN SEDIMENTS
WATER – CONCENTRATIONS OF HEAVY METALS IN WATER
N/A – NOT APPLICABLE

Table 3. Water quality of Trinidad Rivers

	Clean		Perturbed		Polluted	
Trinidad	Number of sites	%	Number of sites	%	Number of sites	%
Physico-chemical	33	60.0	13	23.6	6	10.9
Metals in water	8	14.5	30	54.5	10	18.2
Metals in sediments	0	0.0	41	74.5	14	25.5
Tobago						
Physical-chemical	6	66.7	2	22.2	0	0.0
Metals in water	3	33.3	5	55.6	1	11.1
Metals in sediments	0	0.0	2	22.2	7	77.8

Figure 1. Physico-chemical Surface Water Quality.



a. Watersheds and Intakes

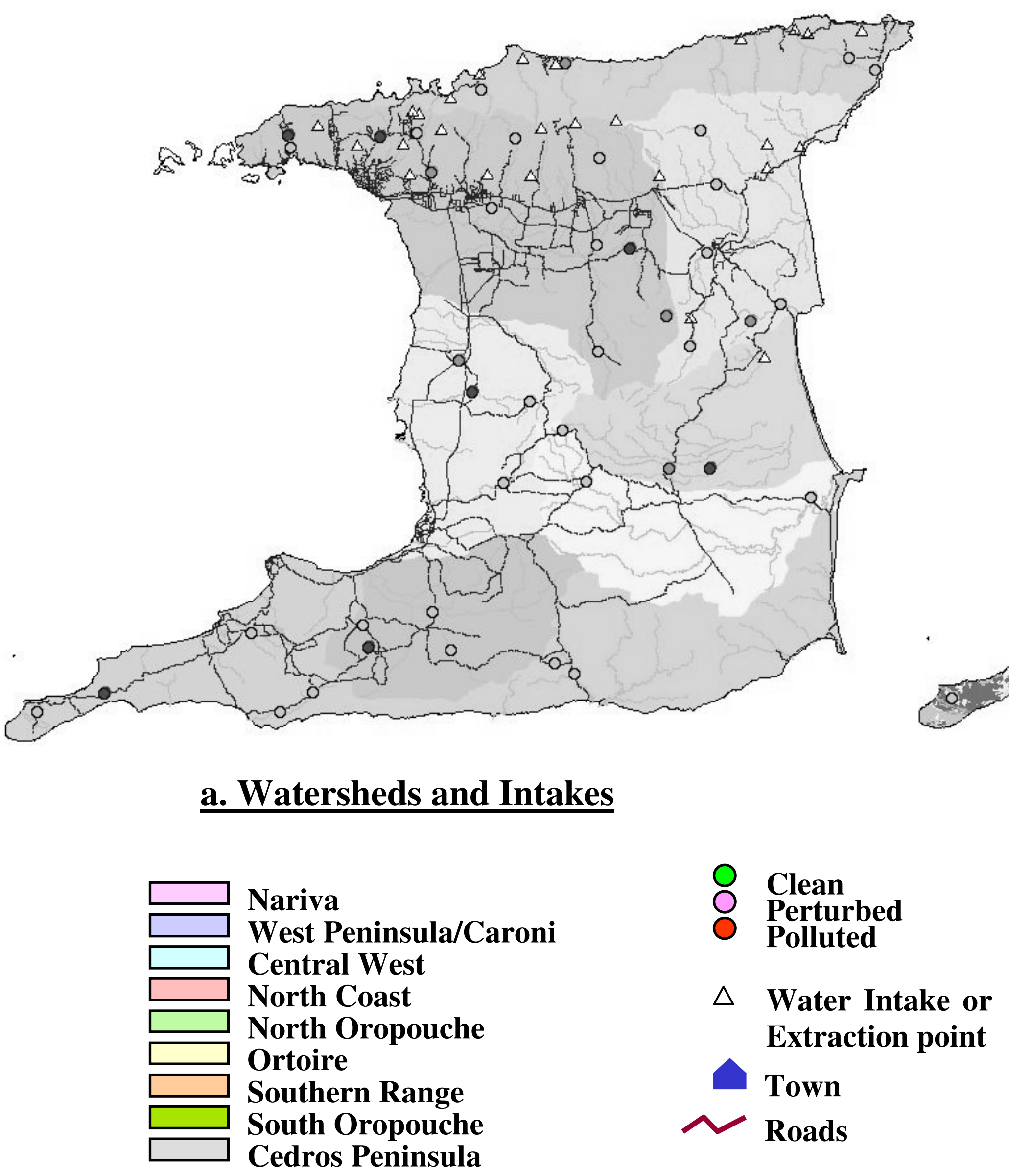
- Nariva
- West Peninsula/Caroni
- Central West
- North Coast
- North Oropouche
- Ortoire
- Southern Range
- South Oropouche
- Cedros Peninsula

- Clean
- Perturbed
- Polluted
- Water Intake or Extraction point
- Town
- Roads

b. Land Use

- Agriculture
- Commercial/Industrial/Residential
- Swamp/Reservoirs
- Grassland
- Forest
- Disturbed natural ecosystem
- Pitch Lake

Figure 2. Heavy Metals in the Surface Waters of Rivers of Trinidad and Tobago.



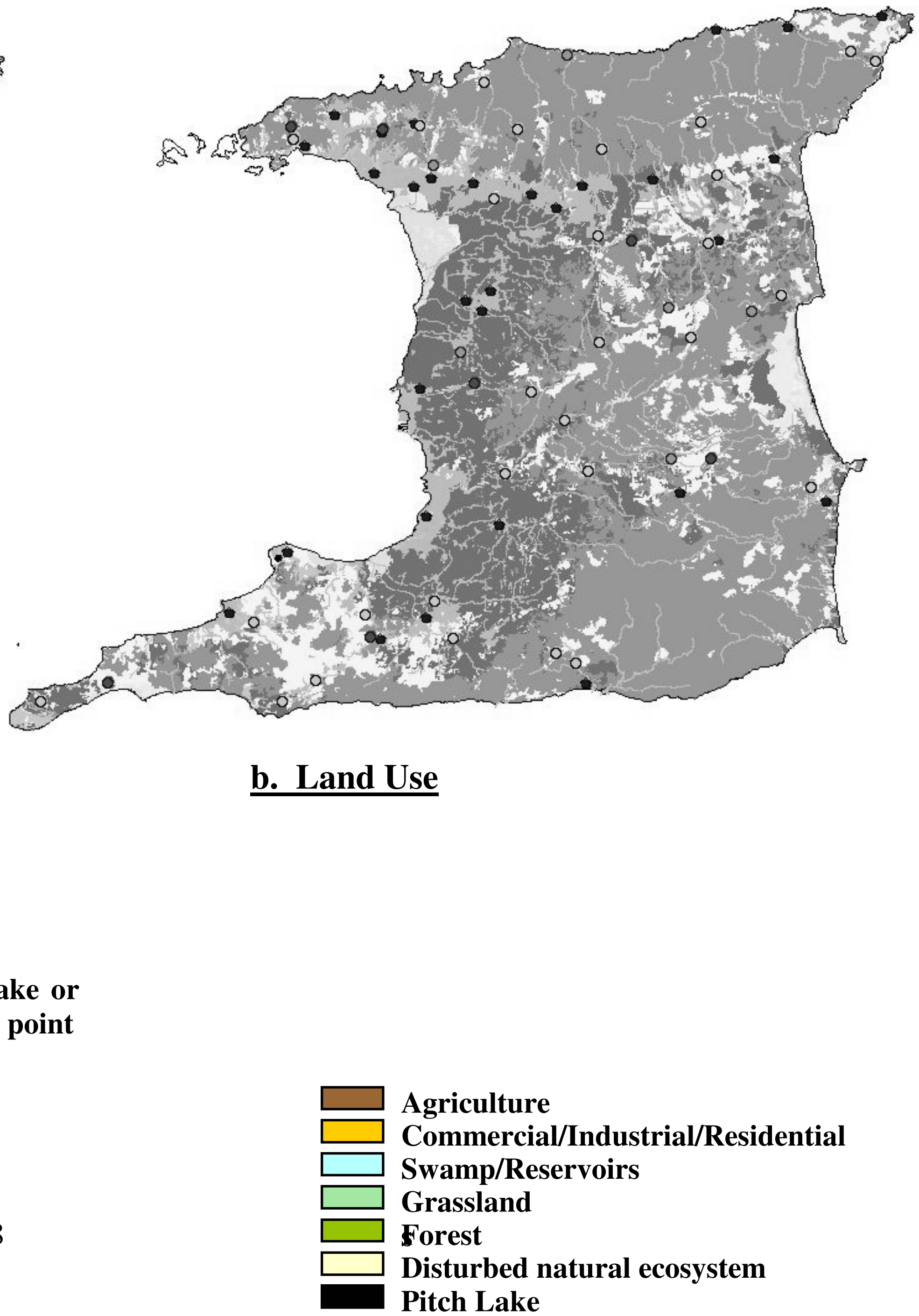
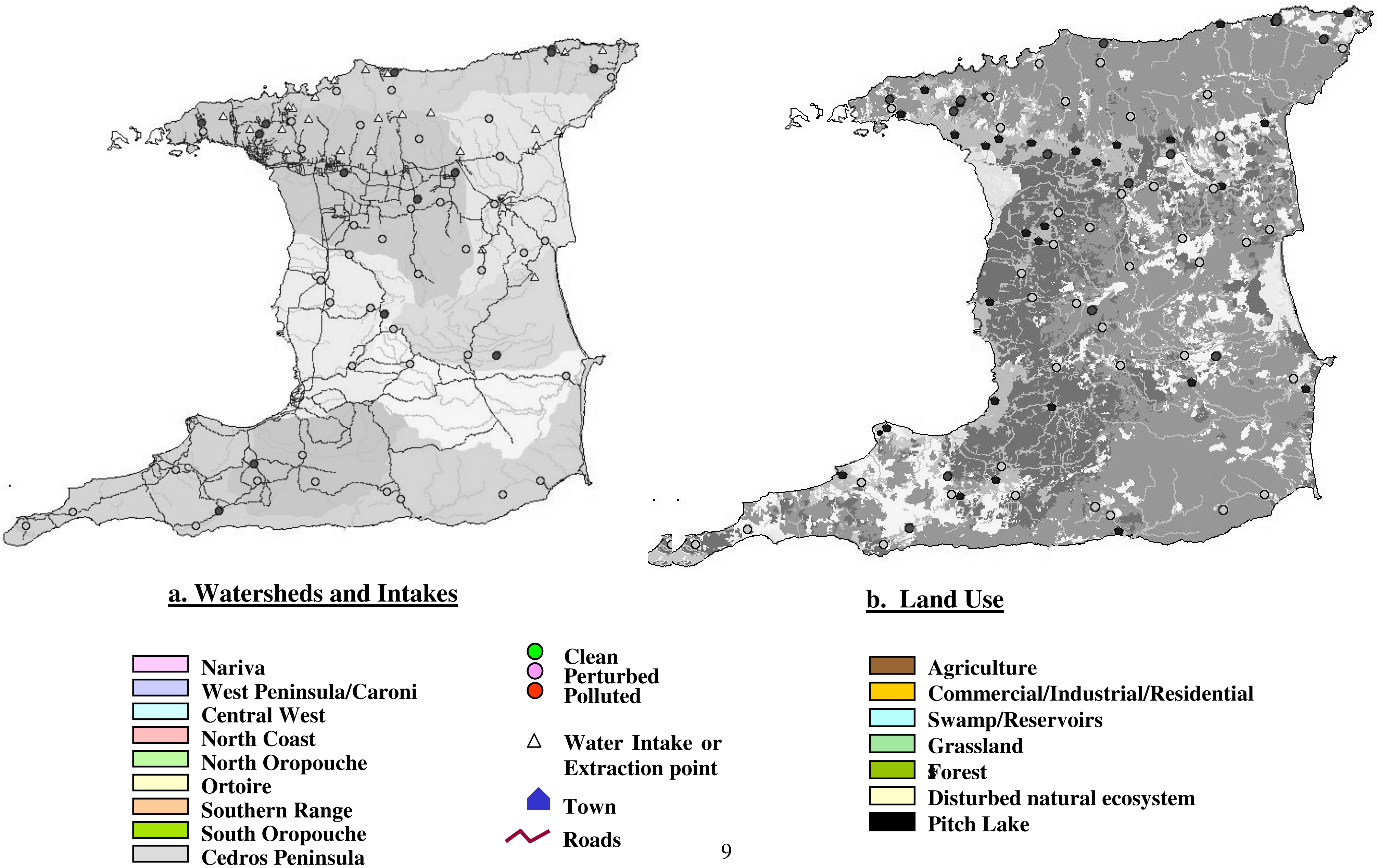


Figure 3. Heavy Metals in the Sediments of Rivers of Trinidad and Tobago.



3.3. Heavy metals in sediments

For both Trinidad and Tobago no site was assessed as 'clean', almost all were assessed as 'perturbed'. The majority of sites assessed as 'polluted' in Trinidad are in the north, where agriculture and commercial/industrial/residential activities have impacted greatly on surface water quality. Further, most of these sites are in the West Peninsula/Caroni watershed, where most of the drinking water extraction is carried out.

The metals of concern for sediments were the same as those recognised for metals in water. Of the three metals, lead was measured in the highest concentrations and was the most prominent in the sediments. Most of the perturbed and polluted sites were close to roads (Figure 3A) therefore it could be concluded that roads have an impact on sediment water quality. Lead emissions originate from the use of local, leaded petrol in vehicles.

3.4. Comparison of criteria

Of the three water quality criteria, the physico-chemical seems to be the least stringent whereas those for the sediment are the most stringent. Hence, the physico-chemical criterion may not be the best method for assessing water quality for long-term decision-making. Sediment act as a sink or source of metals for water and is a more reliable, long-term indicator of the amounts of heavy metals entering freshwater systems (Shea, 1988).

3.5. Summary of results

Overall, the three surface water quality criteria have led to the identification of four watersheds, West Peninsula/Caroni, Central West, South Oropouche and Cedros Peninsula, as areas of concern. Land use types that have contributed to decreased water quality are agriculture, commercial/industrial/residential areas and disturbed natural ecosystems. Specifically, the first two watersheds have the highest concentration of human settlements and are subject to rapid growth in housing developments, quarrying and agricultural activities (WRA, 2001). The latter two watersheds receive effluents from industry, which includes oil production. With respect to measured concentrations of phosphates, lead, copper and zinc were all identified as major pollutants.

4. Discussion

The results highlight the main water quality issues related to land use that should be considered if an IWRM Strategy is to be implemented for the country. The next step is to outline how this information can be effectively used to make the science more policy relevant for Trinidad and Tobago. To assist this process, the ISTS Case Study Protocol was used to steer the discussion. This protocol included four important questions, which are outlined below:

1. Where did the project originate?
2. Who are the major stakeholders and how do they interact?
3. How do you communicate with them in order to bring about positive change?
4. Multi-disciplinary work – why is it important and what were the problems associated?

4.1. Where did the project originate?

This project originated at the St. Augustine campus of The University of the West Indies. It was the idea of a freshwater biologist who understood the lack of information in the field of surface water quality (M. Alkins-Koo, personal communication). Her involvement with local community organisations prompted the study as many were concerned about the quality of water from rivers that was being used for domestic - including drinking water - purposes. This study's genesis in the interaction between local people and a research and development institute means that these parties would be the ones to involve in the thrust towards IWRM.

4.2. Who are the major stakeholders and how do they interact?

Major stakeholders are outlined in Figure 4. Three scales of stakeholders recognised are international, regional and local. At the international level there are organizations with which Trinidad and Tobago signed agreements for sustainable development, such as the one with the United Nations Commission for Sustainable Development to eliminate lead from gasoline by the year 2000 (Earth Summit Watch, 1999). To date, this has not been implemented and has no doubt contributed to the low surface water and sediment quality for local rivers. With respect to IWRM, the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP) are responsible for implementing a project entitled "Integrating Management of Watersheds and Coastal Areas for Small Island States in the Caribbean" with funding from the World Bank Global Environmental Facility (WB GEF).

Regionally, this country is working closely with the United Nations Economic Commission for Latin America and the Caribbean (UNECLAC) and the Caribbean Development and Cooperation Committee (CDCC), under the Small Island Developing States Programme of Action (SIDS POA), to implement sustainable development in the country. Additionally at the regional level, the Caribbean Environmental Health Institute (CEHI) has been designated the executive body for the Integrated Management of Watersheds Project initiated by the UNDP/UNEP. The Caribbean Council for Science and Technology (CCST) can also be recognised as a stakeholder because of its interest in assisting Trinidad and Tobago to implement IWRM through UNECLAC.

Note the direction of the arrows between local, international and regional organization. There is little feedback from the local arena to these higher scales because of the lack of cooperation between local stakeholders. Politics also interferes at the local stakeholder level and also contributes to the slow progress of many regionally and internationally funded projects (Leech & Fairhead, 2001).

At the local level, there are three levels of stakeholders (Figure 4). These include:

1. Government ministries
2. The Governmental Divisions directly responsible for the resource that is the subsidiaries
3. The Research and Development (R&D) institutions
4. The People or Civil Society

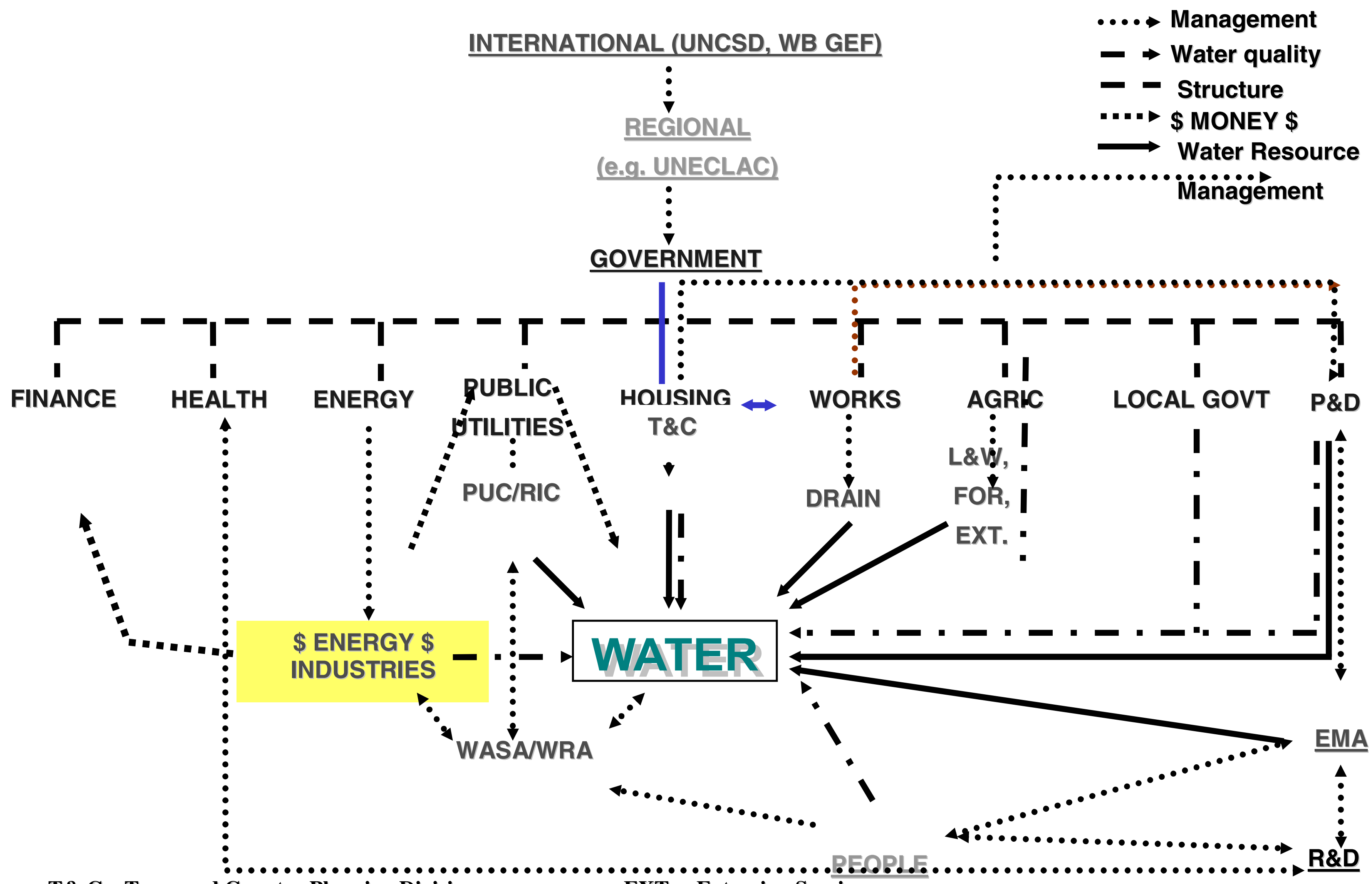
The single dashed line (--) indicates the structure of the Government and the major ministries that exist within it. The dotted lines ( ) indicate administrative interactions amongst levels. Most of the administrative functions exist between the Government ministries and their subsidiaries. Input from the people to the Government has been limited and communication is not effective. The double dashed lines ( ) (Figure 4) indicate direct, adverse effects on water quality directly while the solid lines ( ) show those Governmental divisions responsible for land use, which affect water quality via non-holistic land management. Influx of money or revenue is represented by the stippled lines ( ) (Figure 4).

With respect to surface water extraction, the Water and Sewerage Authority have to provide reliable, quality water and wastewater services for the country. Within this organization, there is the Water Resources Agency, which is responsible for managing the water resources and telemetry of the country (WRA, 2001). These two institutions are solely responsible for water management in the country. The responsibility for administering land use legislation is dispersed among several Governmental entities such as the Town and Country Planning Division, Water and Sewerage Authority, Lands and Surveys Division and the Forestry Division (WRA, 2001). The Environmental Management Authority (EMA) also contributes to the administering of land but this is a recent development. All of these divisions are located within the major ministries of the Government as outlined in Figure 4.

Trinidad and Tobago is a petroleum producing country and significant revenue is derived from the Energy Industries. This revenue has influenced Government into focusing its efforts, over the past forty years, on development of the country via urbanisation through increased housing, industrial estates and increased road works. All of these activities, despite falling under different ministries, are monitored by the Ministry of Planning and Development.

Prior to 1996, there was no ministerial agency responsible for the environment. The Environmental Management Authority was founded to protect, conserve and enhance the natural environment but its activities are governed by the Ministry of Planning and Development. This means that the EMA lacks the clout or power to management the environment sustainably because it is still influenced by Government decision. This is compounded by the fact that the major active ministries and the energy industries contribute significantly towards decreased water quality in local rivers (Figure 4).

Figure 4. ISTS Protocol – Stakeholders and their Interactions.



T& C – Town and Country Planning Division
L&W – Land and Water Division
FOR – Forestry Division
WASA – Water and Sewerage Authority
WRA – Water Resources Agency

EXT. – Extension Services
PUC/RIC – Planning Commission Unit/Regulated Industries Commission
DRAIN – Drainage Division
UNCSD – United Nations Commission for Sustainable Development
WB GEF _ World Bank Global Environment Fund

Adapted from: CEPIS, 2000; WRA, 2001

4.3. How to communicate with stakeholders

The results of research through scientific investigations into water quality have identified pollutants and areas with certain land use activities of concern. There is an urgent need to communicate these findings to the various levels of stakeholders to achieve IWRM. However, the method of communication depends on the level of the stakeholder.

4.3.1. Local community: social issues

The local people are very lax in their attitude towards critical issues in the country and tend not to take a stance or improve conditions until they become serious. This behavior is one that cannot be easily changed. Presently, there is a perception in local communities that an abundance of water can be taken for granted and hence, there is an attitude of wastage (UNDP, 2003). Also, it is believed that rivers are considered the 'cleaners/janitors' of the land, and hence garbage and refuse would be properly treated by dumping them into rivers. There is hope ,however, that the younger members of the society, representing the future of the country, will change this outlook through education. This does not mean that education should only be focused on the young children and youths but adults should be included as well. These groups should be made aware of their own power to dictate the water quality of the country.

This education process has begun with regional and local educational programmes from the Caribbean Council for Science and Technology, WASA, The University of the West Indies and EMA but these programmes emphasise education as the problem. They need to focus on empowerment rather than status or education on rivers. Therefore, extensive community empowerment programmes are needed. Community groups will through solidarity and friendship bring people together. If people know the health risks of low water quality, they will pressure the Government towards coordinated water resource management, as well as assist international bodies to force the Government to implement agreements, such as the case of lead from gasoline.

Rivers and water are of great importance to the local communities for the reasons listed below.

1. Food – local fish 'cascadu' are considered a delicacy
2. Transport
3. Livelihood – fishing, oyster harvesting, tourism
4. Religious significance – Hindus and Spiritual Shouter Baptists
5. Cultural – the 'River Lime' is a meeting of friends, usually males, where food is cooked and eaten on the river banks.

These needs should be emphasised and local stakeholders made aware of the importance of this natural resource. The results from this project can identify in more detail the concerns within watersheds. This can lead to the formation of community empowerment groups to teach people how to manage the health of the rivers in their area. An 'Adopt-a River' programme involving businesses, community groups, secondary schools and primary schools can be proactive in water management. There will be financial and social benefits for such programmes such as reduced cost of water treatment, increased aesthetics and recreation. This will encourage ecotourism and, for private business investors, can lead to tax incentives. It is very important that communication be multi-scaled or multi-levelled at all stages in the water management issue so that trust can be built. This would facilitate faster implementation of a more effective water management strategy.

Media can also play an important role in this process as radio and television are important means of communication locally. There needs to be more local programming dealing with water quality and management issues, especially relating local water usage to water pollution. Summarising, the communication for the local community will consist of the following:

LOCAL COMMUNITY

Community Service – community action and education programmes

Media – television, radio and newspapers

4.3.2. Local government: political issues

Uncoordinated decisions have been made in the past solely by the Government and their subsidiaries. Even within the Government, there is little communication between the water management body (WASA) and the land management divisions identified previously. As a result, land activities have continued unchecked with respect to their effects on water quality such as, quarrying above a drinking water extraction site, as was the case in the Guanapo River, which is located in the West Peninsula/Caroni watershed (TNT Mirror, 2002). Effective communication will be difficult if each ministry or division is addressed individually, however, presenting this surface water quality information via a workshop or seminar to all Governmental agencies would be more effective. This has actually been done (UWI/EMA Symposium, April 2003). The next step would be a series of round-table discussions on water quality issues where each Ministry can assess their needs and look at their synergistic effects. This is especially important with respect to Figures 1-3 where agricultural lands and roads have been identified as land use contributors to the pollution problem. Policies should be drafted and implemented, such as those that reduce the use of chemicals in agriculture and encourage organic methods of farming. Although, this policy-making process however will take some time, it will be encouraged by the local people who, having understood the need for clean water, will pressure the Government to ensure that their activities do not directly or indirectly reduce water quality. Incorporating members of the local community in symposia, conferences and round-table discussions can further facilitate this, as well as enlisting the media as a supporter of the environment and not the Government.

In terms of institutional structure, the Water Resources Agency should be removed from the folds of the Water and Sewerage Authority or, its portfolio handed over to an independent body for better management. This independent body could be the Environmental Management Authority (EMA) only until an autonomous water management body is formed for the sole purpose of managing water resources for the country only. Summarising, the measures of communication for the local Government are:

LOCAL GOVERNMENT

Symposia, Workshops, Conferences, etc.

Round Table Discussions

4.3.3. Local, regional and international

Implementing this sort of discussion and continuous collaboration is easier said than done and hence, the role of the other scales and levels of stakeholders can play an important part. International and regional stakeholders, who include the financial supporters of local water management projects, play important roles in putting pressure on the Government to increase communication and reassess its water management structure. The results here support the need to eliminate lead from gasoline. The UNCSD can now use this information as leverage in their dealings with the Government.

Financial supporters have a stronger 'trump' card over the Government as they can ensure that environment-friendly contracts specifications are met in a timely basis.

LOCAL, REGIONAL AND INTERNATIONAL

Symposia, Workshops, Conferences, etc.

Special Reports and Journal Articles

Internet

4.4. Multi-disciplinary work – Why is it important and what were the associated problems?

IWRM considers the economic, social, political and environmental aspects of water and its use and attempts to balance all these seemingly conflicting activities. For this project, understanding the political and social aspects was vital to understanding the difficulties of implementing IWRM, as well as the importance of communicating amongst scales and levels. This multi-disciplinary project encompassed chemical analyses, GIS mapping and future management strategies using the ISTS Protocol.

The major problem with multi-disciplinary work is the ability to communicate amongst disciplines and the people in them. It requires the worker to understand all aspects of different scales, levels and disciplines in order to properly analyze and disseminate the information.

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