Catchment surveillance for water resource management

by Barry J. Lloyd and Teresa Thorpe

As water resources deteriorate and demand increases, should governments even attempt to manage and protect micro-catchments? A project in the eastern Caribbean concludes that they can and should — with a little help from state-of-the-art surveillance techniques, and practical grassroots action.

DESPITE HIGH ANNUAL rainfall levels, many communities in the eastern Caribbean experience major problems in obtaining a continuous supply of any water; even water which routinely fails to meet the most basic WHO drinking-water quality guidelines. In St Lucia, for example, while a few coastal villages benefit from reasonably reliable supplies, the majority suffer chronic discontinuities.

Unofficial estimates put the discontinuities figures at between 50 and 150 days a year while, for several hours each day, most people are unable to obtain any tapwater. The Water Utilities do not keep official records of supply interruptions and, consequently, come in for aggressive criticism.

The origin of the problem in this part of the world is not, however, of the water authorities' making. The root cause of the east Caribbean's water-supply problems is largely bad catchment management, combined with a lack of political will to enact and enforce relevant legislation.

Resources for drinking-water supply are reaching a critical condition in three of the four Windward Islands, due, primarily, to the unregulated expansion of agriculture — particularly banana cultivation — in upland, forested catchment areas; an assertion which is strongly supported by the principal findings of CEHE (Centre for Environmental Health Engineering) research, which concluded that the most significant environmental variable influencing the reduction of diversity of the macroinvertebrate (biological) community of St Lucia's streams is the increase in agriculture, combined with the reduction of forestry above and around every water-supply stream intake. It is no coincidence that these are the same factors causing the major deterioration in water-supply quality and continuity.

Extreme circumstances

Rainfall on stable rainforest usually produces reliable stream base-flow throughout the year. By contrast, the interaction of erratic torrential rainfall on partially de-forested steep upper catchments is producing major quality and continuity problems. At one extreme are the high rainfall events such as the St Lucia tropical storm Debbie (September 1994), and the tropical wave of 26 October 1996, which produced 200mm of rain in less than 24 hours. At the other end of the scale, St Lucia experiences periods of relative drought during which stream-flow can fall rapidly below historic base-flows, and when the water utility has to take the entire residual flow of the sub-catchment, leaving downstream reaches bone-dry.

In the current project, now that we have defined the dry-season base-flow for all major catchments and sub-catchments used for water supply, we are proposing to demonstrate the future sustainability (or unsustainability) of supplies — and the land-protection measures required — with great precision. Our calculations have been hampered by a lack of hydrological data, particularly since, six months into the project, storm Debbie destroyed the few functioning gauging stations. Even so, we can conclude that the water authorities must take a more proactive approach, and investigate and routinely monitor available flow in all their sub-catchments, rather than in the few whole-catchment gauging stations as proposed in the current Government of St Lucia/World Bank (GoSL/WB) projects.

Ill-conceived intentions

The impact of extreme storm events, as evidenced by Debbie, was massive soil loss, land-slips, and the destruction or blocking of all of the water utility's intakes, thus depriving St Lucia almost completely of drinking-water for a week, and of safe drinking-water for months. The knee-jerk reaction of Government and donors was Phase 1 of a World Bank Watershed and environmental management project, a major part of which involved initiating civil engineering works to strengthen and channel a number of lower catchment streams on the basis that this would prevent flooding and loss of

St Lucia: Rivers Surveillance Sample stations

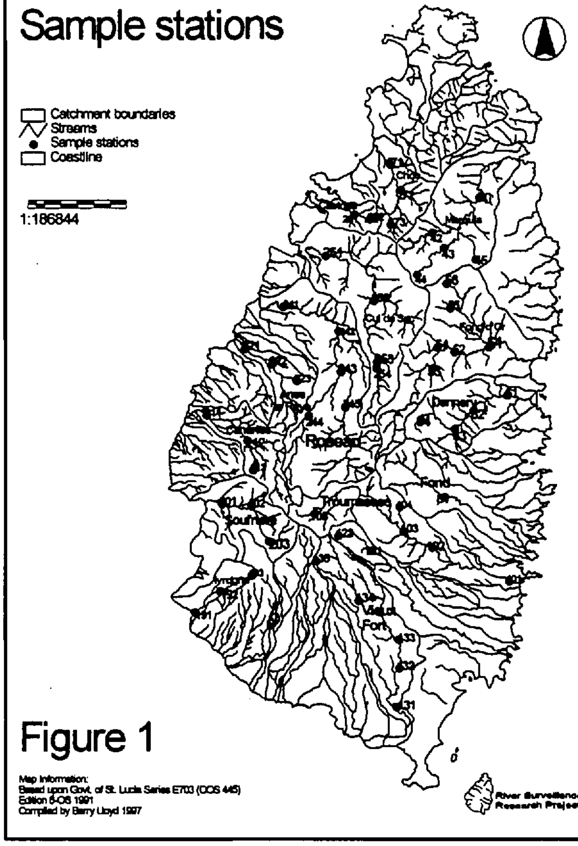

Figure 1

life. The tropical wave of 1996 demonstrated dramatically just what a waste of money this strategy was: in the space of 24 hours, large sections of the World Bank stream-bank strengthening works were washed away in some of the largest rivers, including the Fond d'Or, Troumassee, Roseau, and Cul de Sac. In the lowest reach of the Troumassee, the river actually reverted to an earlier route, by-passing the new civil works and washing away banana plantations on the edge of the river along a 5km reach where no buffer zone was in place.

The GoSL/WB stream-bank works were ill-conceived and disastrous from both an environmental and an economic perspective. The civil rehabilitation river works consisted of 'removing boulders and debris deposited in the river-beds, desilting their channels, reinforced-sectioning river-beds to permit safe passage of discharges, and restoring existing or applying new river training and bank-protection works.' (World Bank Report No. 14325-SLU 14 June 1995). In other words, the river-works were designed to promote the transportation of silt to sea, rather than retain it in the lower valleys where it should provide fertile silt for intensive agriculture in the most economically productive areas of the island. At the same time, channels increase siltation onto coral reefs — and its consequent damage — whilst the findings of the CEHE project described below demonstrate that the civil works destroyed the natural variability of stream habitat, and effectively and dramatically reduced biodiversity.[1]

Apart from the substantial cost of the civil works, it is also interesting to note that the Phase 1 project was in contravention of WB procedures since it was later admitted that work went ahead without the stipulated Environmental Impact Assessment (EIA).

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Taking biological samples of St Lucia streams for macroinvertebrates.

Barry Lloyd

The Troumasse river, showing the loss of banana plantation, following heavy rains.

Systematic surveillance

Hopefully, the Phase 2 GoSL/WB project will provide a sounder basis for managing upper catchments, where major investments in conservation are required. What is needed is a systematic macro- and micro-scale analysis of hazards and risks to define the interventions required to ensure the future sustainability of water resources in the middle and upper catchment areas. This should provide the information management system for the development of integrated-catchment management strategies. The primary objective of the CEHE river-surveillance research project — or to give it its full title, 'The Development and Integration of Biotic and Chemical Monitoring with Land-Use Assessment for Tropical River Resource Management' — is to develop both a catchment-surveillance methodology and an overall strategy to meet these needs.

To summarize, the overall project strategy is to:

- define priority stream-catchment study areas and establish a monitoring programme;
- acquire remote-sensing land-use data and conventional map data;
- carry out a stream-quality monitoring programme;
- validate and input data into databases and geographic informationsystem (GIS);
- integrate geographic and environmental-quality data;
- establish the analysis, identification, scaling, and geographical display of hazards; and classify risks at local level;
- identify high-risk micro-catchment zones for priority intervention;
- advise community groups and regulatory departments;
- apply policy and regulations to conserve water authority forest reserves; and
- intervene to conserve and manage precisely defined micro-catchment areas.

The value of the remote sensing/GIS component is that it enables the research team to make a geographical analysis of the multiple hazards present within micro-catchments on a precise $30m^2$ (pixel by pixel) basis. The most inappropriate land-use causes of water-resource deterioration are objectively identified, defined, and classified as 'areas most at risk' — those which require urgent attention.

The importance of the biological monitoring approach is that it has the potential to measure the effects of the various major categories of pollutants, as well as human disturbance. It has demonstrated successfully — from programmes worldwide — that it can provide powerful evidence of their impact on the stream biota, and how this correlates clearly with water-treatment and supply problems.

Results

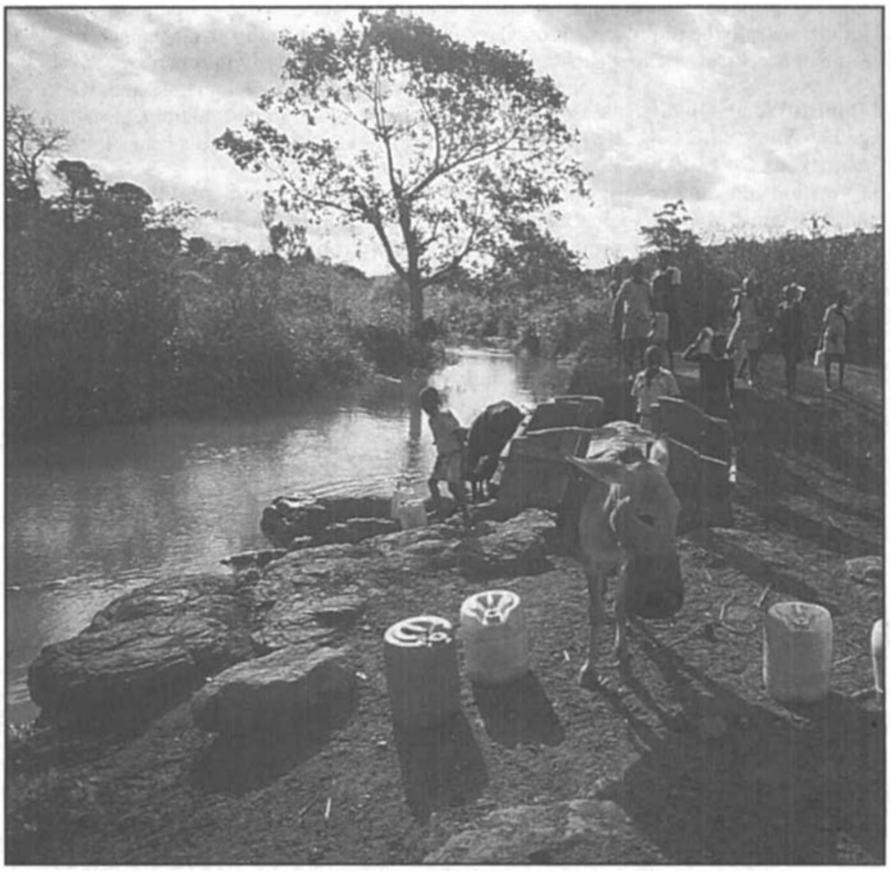
The method assesses, characterizes and compares the vulnerability of water resources according to a hazard analysis of land use in collections of catchments and sub-catchments using the GIS. For verification purposes, the hazard analysis is ranked and compared with the complementary biological indicators of stream quality and flow for each micro-catchment used for water supply. The vulnerability analysis provides a classification of all the water-supply sub-catchments, and enables government departments to decide, on a priority basis, where to invest in conservation measures in order to sustain water supplies.

The 'general' method should be applied as the best way of assessing the relative risk to which a collection of micro-catchments is subject. Once in possession of this information, government planners and regulators should be able to apply the most cost-effective, factually-based, interventions, to protect and manage increasingly scarce forest land and, therefore, water resources.

A general and individual analysis of the status of the 31 water sources in St Lucia's 13 catchment areas has been undertaken during the project over the last three years to assess how vulnerable they were, both in terms of flow-reliability, and with regard to the hazards in the catchment areas which have a negative impact on flow and quality. Results from each of the catchments allowed the team to identify which rivers, and stream reaches within rivers, had poor water quality and, based on a detailed knowledge of the area and GIS analysis, why this was the case.

The results indicated that, in general, poorer water quality was recorded at the downstream sites with biological scores improving further upstream. Poor to fair quality tended to be found at lower-middle sites, whereas at upper catchment sites, particularly those with more than 50 per cent natural forest cover and little or no agricultural activity, the water quality was good. Many of the best results, however, were recorded in 1994, before tropical storm Debbie. An assessment of the individual catchments gave a clear picture of which rivers have been affected by engineering works, current land use practices, severe weather events, and other disturbances. The data also highlighted improvements in biological water quality and the influence of physical characteristics on the faunal distribution.

Suitable upland sub-catchment areas — on which the people of St Lucia depend for their water supply — are progressively becoming 'smaller' as the water authority (WASA) is forced to move its river intakes ever further upstream to avoid both excessive siltation of intakes, and blocked treatment-plant filters. This has already occurred at Micoud and Vieux Fort where abstraction points have moved from below 100ft amsl (above mean sea level) to >500ft, and 1200ft amsl, respectively. In the case of the Vieux Fort river, even the high intake at Grace Woodlands is now considered at risk, and the Government of St Lucia is now having to make provision for the purchase and reforestation of degraded upper catchment areas. This scenario of conflict of use and reducing resources is repeated in the great majority of catchments used for water supply; the GIS is enabling the research team to define precisely which small parcels of agricultural land present the greatest threat to the water resource, and which may be selectively reforested.



Intermediate Technology/John Young

Biological assessments of individual catchments show clearly how rivers have been affected by engineering works, land-use practices, and severe weather.

Note

1. By contrast, river monitoring and management programmes in Europe and North America strive to maintain and improve biodiversity as a means of sustaining stream health.

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