



# **Managing Watersheds for a Better Future**

**Improved catchment management  
methodologies to achieve poverty  
alleviation through better access to water**

**Report on activities in Grenada for DFID Forestry  
Research Programme Project R7937:  
Catchment Management and Poverty**

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# Grenada Country Report

## 1 Executive Summary

Changes in land use and management in Grenada impact stakeholders locally and at a catchment scale, as they may often alter water availability and quality to upstream and downstream users. Alternative land use by stakeholders in one place impacts upon the water utilisation, economic productivity and livelihood strategies of other groups. Therefore, land use policies must account for hydrological impacts on the whole catchment and for the resultant economic trade offs among stakeholder groups. Forest-based activities form an important part of the livelihoods of many people of Grenada. Stretching from the coastal mangroves to the central slopes, these forests provide timber and non-timber forest products, as well as the benefits to local communities of ecotourism and recreation. Numerous smallholdings occur within the forest, often along the streams and rivers, and fisheries close to the mangroves provide additional opportunities to generate incomes. There is a significant overlap in livelihoods; for example, people employed in the towns will often own land on which they farm, while also participating in coastal fishing.

The participatory process employed to develop Grenada's Forest Policy allowed forest values to be determined and ranked according to their importance, and showed that the most important values were environmental services, including water supplies for domestic use and other activities such as tourism, landscape and biodiversity, and agricultural support systems including soil and water conservation. The policy calls for an integrated approach to watershed management, by conserving all ground and surface water resources, and reducing depletion, pollution and sedimentation. In addition, in all watershed areas, minimising soil erosion and the prevention of deforestation are important objectives. The problems of natural resource management in Grenada differ from those in South Africa, both in nature and in scale, but they are real and growing problems, which may increasingly impact on the well being of local communities.

Research activities in the Annandale and Concord catchments focussed on evaluating the impacts of land and water policies on livelihoods. Activities included mapping the linkages between key organisations; identifying water quantity issues in Annandale; identifying water quality issues in Concord; collecting economic, social and biophysical data; conducting household surveys on water, forest use and livelihoods and farmer surveys on current practices and interest in 'buffer strip' schemes; evaluating possible economic trade-offs.

Key policy-relevant outputs of the CAMP-Grenada project, include:

- Greater understanding of water related constraints to livelihoods in Grenada
- Policy briefing note distributed to target institutions
- Survey output data provided to further improve and extend the Grenada Land Information System (GLIS) at the Land Use Dept. (Ministry of Agriculture, Lands, Forestry and Fisheries) with a view to implement proper land zoning in Grenada
- Design of 'downstream-upstream' compensatory mechanism (Government approved) where a voluntary environmental fund would work together with water-use efficiency schemes for downstream water users (e.g. tourism, industry) to improve water supplies to upstream communities currently experiencing water shortages;
- Design of 'upstream-downstream' compensatory mechanism (Government approved) whereby good farming practice by poor upper catchment farmers is rewarded funded by reduced downstream water treatment costs;
- Institutional strengthening in forestry and water sectors
- Insights into the potential impacts of alternative policy instruments

The CAMP-Grenada project has contributed to DFID's developmental goals on the elimination of poverty and encouragement of economic growth, which benefits the poor, by developing innovative mechanisms that reward underprivileged upper catchment communities for improved management of environmental services consumed by lower catchment communities, visiting tourists and by industry.

## 2 Background and Introduction

The Grenada component of the CAMP project has been carried out to examine the relationship between water availability and welfare in two sample catchments, and to consider how ecosystem services provided by healthy watersheds can provide livelihood support for those who maintain them. While there was originally some suggestion that there would be an integrated model resulting from the work in South Africa which could be tested in Grenada, this did not prove to be the case, as modelling work carried out in South Africa was at a scale incompatible with the conditions in Grenada.

In addition, the lack of significant long term hydrological records<sup>1</sup> in Grenada (Geoghegan *et al.*, 2003) made it inappropriate to apply the type of hydrological models as used in the Levuvhu case study in South Africa. Adequate long-term records of stream flows and the quantity and quality of ground water are not available for much of Grenada, and efforts to obtain what data do exist have not been successful (Peters, 2001). For example, the minimum requirement of 30 years data (*e.g.* for precipitation) is only available from five weather stations, and only two of these data sets provide continuous runs of data, and this only as monthly values (see table 1 below). What stream flow data that are available are all sets of data of five years or less, while ground water data is limited to borehole tests for identifying supply sources for domestic purposes. While the location of aquifers is known, they still remain largely unmapped.

**Table 1: Availability of hydrological information for Grenada (from Peters, 2001)**

<b>Sensitive area</b>	<b>Data required</b>	<b>Availability</b>	<b>Data location and quality</b>
Ground water	<ul style="list-style-type: none"> <li>• Aquifer thickness (geology)</li> <li>• Aquifer boundaries</li> <li>• Yields</li> <li>• Chemical composition</li> </ul>	<p>Very little</p> <p>Very little Limited to a few sites Limited to test sites</p>	<b>NAWASA</b>
Surface water	<ul style="list-style-type: none"> <li>• Streamflow</li> <li>• Temperature</li> <li>• Precipitation</li> <li>• Catchment areas and hydrologic characteristics</li> <li>• Water demand, supply, storage and quality</li> </ul>	<p>Available for Castaigne Bridge (1989-1990), Nianganfoix (1989-90); St. Marks(1989-1990); Marquis 1987-1988)</p> <p>Available for Pearls and Point Salines on a continuous basis</p> <p>Available for many stations throughout the island</p> <p>All areas available</p> <p>All data available</p>	<p><b>NAWASA/CMI</b> Data records very short Some data missing from NAWASA</p> <p><b>PSIA &amp; Statistical Department</b> The minimum period of 30 years is not available for any set of data. Much of the data is non continuous</p> <p><b>Use Dept</b> Most data on GIS</p> <p><b>NAWASA</b> Good Data</p>

## 3 Project Purpose

The original project memorandum (PMF) noted that as a key objective in formulating their Forest Management Strategy the Grenada Department of Forestry had identified the protection and improvement of upland watersheds, through soil and vegetation management. This was to be achieved, in partnership with key stakeholders, while optimising water supplies in terms of quality, quantity and timing for present and future generations. Furthermore, there was a specific call in this strategy to develop and implement relevant legislation and regulations necessary for the effective management and protection of upland watersheds.

<sup>1</sup> Much of the national dataset relating to hydrology of Grenada was lost as a result of a fire several years ago

The PMF identified as intended project outputs (among others), water allocation mechanisms/compensation mechanisms as possible policy instruments for managing water demand relating to forestry-related activities in Grenada. It is important to note that whereas extensive commercial forestry exists (and was examined) in South Africa, no such sector is present in Grenada to any significant degree. Forestry-related impacts on water resources in Grenada are better considered in terms of ecosystem services that accrue from the areas of protected (and unprotected) national forest, and livelihood provision from numerous NTFPs that include a large nutmeg and mace production system.

The original idea of the project was to identify the 'Net Rainfall Value' and use it as a tool to investigate the distributional impacts of different land uses within the two CAMP project study watersheds: Concord (Black Bay) and Annandale (Beausejour). The lack of available data prevented this, together with the fact that water extraction and use in most of Grenada is conducted almost entirely via a reticulated system. Instead, the distributional impact of different water uses has been investigated through a range of participatory consultation and survey methodologies, with a view to developing up-stream down-stream compensation mechanisms.

### 3.1 Hydrology and Water Resources in Grenada

The state of Grenada (including the islands of Carriacou and Petit Martinique) has a total area of 344 km<sup>2</sup>. The main island of Grenada is 34 km long and 18km wide and has a land area of 120 km<sup>2</sup>. The climate is humid-tropical-marine, influenced by a constant northeast trade wind, and with little seasonal or diurnal variation other than rainfall.

In the mountainous interior, annual rainfall ranges from 3,750 - 5,000 mm and in coastal areas between 990 - 1,500 mm (IWCAM, 2001). Rainy and dry seasons are characterised by a significant difference in total precipitation which is most pronounced in the drier southern region of the island. There is an abrupt change in rainfall received over relatively short distances (*i.e.* 600mm km<sup>-1</sup>).

The landscape is divided into a well-defined system of watersheds, resulting in steep hilly topography almost everywhere, with the exception of the southwest and north east areas where low hills are prevalent (Paul, 2001). Flat or low-lying land most suitable for agriculture comprises only 1.9%

of the total area (~590 hectares with less than 2% slope), most of which is found close to the coast. In contrast, 77% of the total area is steeply sloping (>20% slope) (Peters, 2001).

The small size of the island and its geography mean that the entire island could be considered as a coastal entity, with integrated management of coastal areas and watersheds of critical importance future sustainability. Grenada is divided into 71 distinct watersheds (LUD 2000), with generally short basin lengths (maximum length 10.4 km) and rivers of varying sizes *i.e.* 7.0 m<sup>3</sup> s<sup>-1</sup> peak-flow during the rainy season (Hydropower Development Plan 1990). A watershed area is generally considered to be a hydrologically defined area from the hinterland to coastline, bounded by topographical features, drained by one major river system to a single location. (A watershed is sometimes referred to as a catchment or drainage basin). Each watershed can also be divided into smaller units, each containing a tributary of the main river system.



Figure 1 – Grenada and its constituent islands (including Carriacou and Petit Martinique)

Current threats to the management of water resources in Grenada include the following:

- Pollution from agricultural chemicals and waste. Agricultural practices in the watershed areas of these water bodies have the potential of introducing chemical residues into these ecosystems;
- Heavy sediment load of streams as a result of erosion cause by the removal of vegetation;
- Farming too close to the banks or farming on slopes that are too steep is a major concern;
- Direct and indirect discharge of sewage, grey water, solid waste, lubricants and other effluents from manufacturing plants;
- Over pumping of lakes during dry season, including the large Crater Lake near Grand Etang
- Over growth of lakeside vegetation due to low water levels in the dry season;
- Accelerated erosion and land slides;
- Absence of a water-balance to determine the amount of abstraction.

Grenada's water resources (on the main island) are almost entirely surface-water based (90%), with groundwater sources augmenting supplies during the dry season (Geoghegan *et al.*, 2003). The potential exists to supply 10% to 15% of the present requirement for drinkable water from additional groundwater sources, which are currently under-utilised, such as the aquifer located at Beausejour. The current exploited groundwater production capacity of the National Water and Sewerage Authority (NAWASA) is approximately  $1,890 \text{ m}^3 \text{ day}^{-1}$  with a total capacity of approximately  $3,973 \text{ m}^3 \text{ day}^{-1}$  (Peters, 2001). Little surface water storage exists in Grenada (IWCAM, 2001), with most storage comprising underground reservoirs or aquifers. Many of the dams and water catchment areas are inefficient due to silt accumulation because of natural erosion as well as upstream agricultural practices (e.g. ploughing every year for peanut production).

NAWASA is charged with the responsibility for all freshwater resources throughout Grenada and the protection of these resources is included in the act governing this institution (NAWASA Act No. 250, 1991). The company abstracts water from upland streams, which is then treated at supply facilities and delivered to users via a piped distribution system terminating in both public (standpipe) and private connections. Surface water comes from the 'South' and 'North' systems, which have maximum storage capacities of  $15,696 \text{ m}^3$  and  $4,896 \text{ m}^3$  respectively. It is considered that there is insufficient water storage capacity in the North of the country, while there is an excess storage capacity in the South (IWCAM, 2001). The public water supply comes from 34 separate water treatment and production facilities with a combined rated capacity of approximately  $37,300 \text{ m}^3 \text{ day}^{-1}$  (Smith, 1999), of which about 80% is treated conventionally.



**Figure 2 – an example of one of the many small dams from which water is abstracted by NAWASA**

Grenada's per capita water consumption is estimated at  $130 \text{ litres day}^{-1} \text{ person}^{-1}$ . The national water demand is 3.15 million gallons ( $11,924 \text{ m}^3$ ) per day, and is rapidly increasing. Supply is

between 7-8 million gallons (26,499 – 30,283 m<sup>3</sup>) per day. Peters (2001) suggests that only about 35% of the total production is consumed (based on daily production figures for the Southern region only), while wastage accounts for 16%. Estimates of current losses due to leakage from the reticulated network vary between 35% (Geoghegan *et al.*, 2003) and 50% (NAWASA personal communication, 2004), but these are lower than the previous estimate of 55% in 1994. There has been significant capital investment in water supply infrastructure in recent years (US\$18.2M during the 1990s, Smith 1990). Further investment is being considered by NAWASA, including EC\$ 72M for domestic supply (mostly coming from external loans and grants).

Water users in Grenada are categorised as either domestic (including agricultural users) or non-domestic (commercial users, industrial, hotels, schools and public services). Metered supplies for domestic users were introduced in 1994, subsequent to a particularly severe dry season, and the principle of metering had gained acceptance after a few years (Geoghegan *et al.*, 2003). However, there are still areas of the island where a flat rate tariff is applied. Recent figures suggest that around 20,000 metered households and 6,000 non-metered households are served by the water supply network (NAWASA personal communication, 2004). The fact that agricultural water users are considered as 'domestic' users means that they pay the same metered rate as household users, even though potable quality of water is not required for agricultural purposes. It has been suggested that these increased costs have forced some small scale farmers out of business (Geoghegan *et al.*, 2003). One negative impact of the introducing metering has been the reported increased use of river water in rural areas to supplement the public supply (IWCAM, 2001).

Most agriculture in Grenada is rain-fed, and irrigated agriculture is currently negligible (estimated at 40 acres, in addition to subsistence vegetable production in the back yards of private homes). However, the Ministry of Agriculture has plans to put 450 acres under irrigation, as studies have indicated 80% of future banana cultivation would need to be irrigated if the sub-sector is to be economically viable. In addition, the Government's Agricultural Diversification Project has suggested that the expansion of commercial vegetable production may require extensive irrigation in the dry season. The main source of irrigation is likely to be increased surface water pumped from local rivers, but there are currently no measures in place to deal with possible increased abstraction resulting from future irrigation schemes.



**Figure 3 – much of the available land for farming is steeply sloping. Cleared soil is prone to runoff following rainfall events**

Rural communities in upland watershed areas have commented that the 'off take' of water (e.g. from Concord and Annandale areas) to supply the heavy water consumption in the south-western region around St. Georges leaves them vulnerable to interruptions in water supply, particularly in the dry season when tourist numbers are at their highest (see results from the Household survey later in this report). The situation exists where downstream consumers (such as the tourist industry) benefiting at the expense of the upstream communities who provide watershed services. Peters (2001) commented that "Changing land use patterns in the upper watersheds have led to reduced flows in the streams and rivers and siltation of the dams. Growth in population and the tourism industry, and the future implementation of irrigation schemes would lead to a rapid increase in the total water requirements in the future".

#### 4 Research Activities

Currently (2004), water supply is just about adequate to meet demand. As the demand is increasing at a rapid rate, a reduction in this leakage rate will be needed if severe shortages are not going to arise in the medium term. Another way to address these potential shortages is to ensure that the water provision function of upland watersheds continues to provide a good quality and reliable source of water for human use. To ensure sustainable management of these resources, however, and maintain their ecological integrity, it is important that abstraction rates are monitored, and in stream flow requirements are met. The ability of the country to achieve this will be influenced by effective cooperation between those influencing land use, and those with responsibility for water resources.

The Forestry Department of the Grenada has responsibility for the maintenance of upland watersheds under its 10-year strategic plan (GFD 2000), and it is in a position to influence land use activities in upstream areas of all watersheds. Water resources are managed by NAWASA, and they can clearly benefit from good watershed management, and as a result, good understanding and cooperation between NAWASA and the Forestry Department on watershed management will be an essential prerequisite to the generation of a sustainable strategy for Integrated Water Resources Management (IWRM) in Grenada. Although the Department has direct control of both Forest Reserves and other protected areas it has only limited powers and responsibilities for managing privately owned land within the watersheds, many of which are not currently being properly managed.

One of the key ways in which land use can be influenced is through the introduction of fiscal or regulatory measures. In an attempt to address this, and after considerable consultation with many stakeholders in Grenada, it was agreed that the development of a *Watershed Compensation Scheme* to address upstream-downstream water use would be relevant to national policy. Consultation was carried out with NAWASA, local farmers, major hotels and other large scale water users, the Ministry of Tourism, the Grenada Board of Tourism, the Economic Affairs Division of the Ministry of Finance, the Ministry of Agriculture, Lands, Forestry & Fisheries, and GRENCODA. In addition, we have also consulted with a number of cruise ship tourists who were surveyed in St. George's on August 2<sup>nd</sup>, 2002. (See Appendix II for consultation activities).

The thrust of this project is to develop policy tools, which can be used to compensate some users for losses incurred as a result of the actions of others, while at the same time encouraging best practice to bring about real changes to address this overall loss of welfare. In these watersheds, there are two types of situation where negative impacts of water use may be felt. Firstly there are negative impacts from upstream activities, impacting on downstream users, but in Grenada, downstream water use also can impact on upstream users. In upland parts of the watershed, for example, agricultural practices may contribute to increased sedimentation and poor water quality. On the other hand, heavy water use for tourism and other downstream sectors creates water shortages and the need for rationing in communities upstream. On this basis, two distinct tools for use in this Watershed Compensation Scheme have been designed:



**Figure 4 – a cruise liner berthed at St George's, Grenada. A new terminal is being built and will replace the one shown here.**

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1. *A Riparian Compensation Scheme*
2. *A 'Sustainability Fund'<sup>2</sup>*

#### **4.1 Grenada Project Study Catchments:**

For the purpose of this study, two catchments were selected as pilot areas; descriptions of which are given below. See Appendix VII for maps of the catchments.

##### *Black Bay (Concord) Watershed:*

The watershed is 1525 acres (6.17 km<sup>2</sup>) in size and is located in the northwestern section of the island, comprising 18% by area of the parish of St. Johns. The parish size (35 km<sup>2</sup>) and population (8,557) suggest that an estimated population for the watershed would be approximately 1500. However this is likely to be an overestimate, as it assumes an even demographic spread and does not take account of the concentration of people living in the parish capital Gouyave). The watershed extends approximately 6 km inland from Black Bay at the coast up to the Grand Etang forest reserve at its eastern boundary, and is important from an aesthetic point of view, as it contains both the famous Concord and Fontainebleau waterfalls, as well as lush tropical rain forest, both of which attract many tourists.



**Figure 5 – One of the waterfalls in the Concord watershed. A popular tourist attraction.**

The watershed is predominantly comprised of clay loams (more than 90% of the soils found within the area). Other soil types found within the watershed include Perseverance clay containing stones and boulders. This soil type is found in a narrow belt on both sides of the river extending about 2.5km inland. There is also a small area of alluvial soil on the flat land by the coast where the river drains to the sea. It is sub-divided by steep sided valleys (Concord Valley) hills and hill ridges. The interior has several interfluves and waterfalls made by the river as it cuts through the rugged terrain. Apart from the narrow belt of flat land by the river close to the coast, most of the other land within the watershed is steep to very steep [30° or more] with the steepest section being the eastern area.

The watershed is drained by the Black Bay river (and its tributaries), which begins at an elevation of over 600 m. The river is one of the larger rivers on the western side of the island, flowing large volumes and velocities throughout the year. The river is considered by people living in the area to be the most unpredictable in the island, as it often erodes the riverbanks carrying mud, silt and other debris, and can cause localised flooding in the low land to the coast. As in most parts of the island, the climate is predominantly affected by elevation so that the land closest to the coast is the driest. The approximate annual rainfall ranges from 2000 – 4000 mm, with precipitation increasing in an eastwardly direction. The mean temperature is 27 °C by the coast, 26 °C in the interior and 24 °C in the very eastern section.

Over 90% of the watershed area is considered as inferior land with regard to intensive cultivation. Most of the agriculture is concentrated along the river, with the best area being the

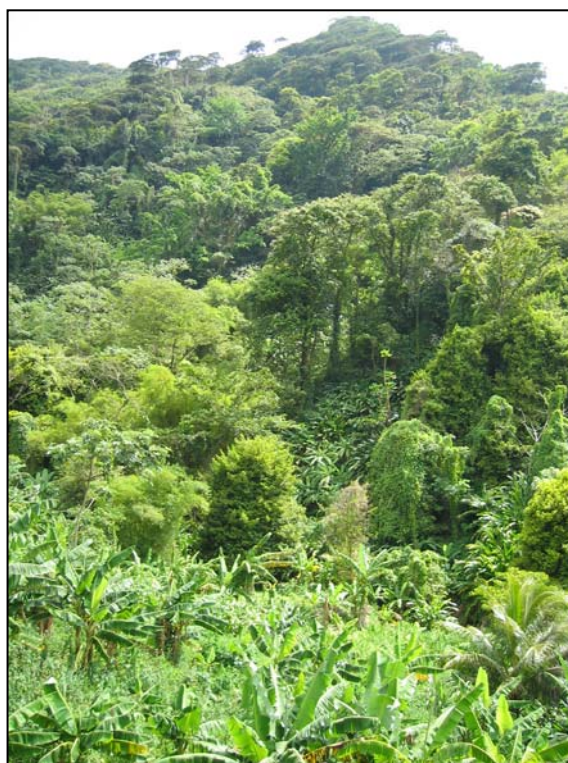
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<sup>2</sup> The final name given to this fund is to be determined after the final consultation workshop in February 2004, but this name will be used as a working title for this report.

alluvial terrace in the coastal area (Black Bay estate). Here, the dominant land use consists of cocoa and other tree crops. Further inland, mixed cropping using fruit trees, food crops, vegetables and tree crops (such as cocoa, banana, nutmeg and other spices) occupies most of the better agricultural land. The eastern section of the watershed (31% of the area) is located within the National Parks and other protected areas. These lands are mainly covered with evergreen montane rainforest, and are protected under Forestry, Soil and Water Conservation legislation. On private lands and non-forest state lands, there is neither specific soil or water conservation legislation nor any legislation covering environmental management (IWCAM 2001).

*Beausejour (Annandale) Watershed:*

The watershed is 3793 acres (15.35 km<sup>2</sup>) in size and is located in the southwestern section of the island, comprising 24% by area of the parish of St. Georges. The size (65 km<sup>2</sup>) and population (35,559) of St George's parish provide an estimated population for the watershed of approximately 8,397 (however this again assumes an even spread of population, and does not take account of the concentration of people living in the capital St Georges and other urban areas within the parish). The watershed stretches approximately 6.5 km from Beausejour Bay to the Grand Etang forest reserve in the interior of the island, with 18% of the watershed lying within the National Parks or other protected areas. Its northern boundary reaches as far as Mt Qua Qua, while its south eastern boundary is located at Mt Sinai. The watershed is the largest in this part of the island, and includes Beausejour, Grenville Vale and Annandale Estates; New Hampshire, Granton, Mango and Willis villages. Its eastern boundary is bordered by the Great River and Grand Etang watersheds.



**Figure 6 – Mixed forestry and agriculture on steeply sloping land in Annandale watershed**

The soil types within the watershed are predominantly clay loams on the western section with patches Perseverance Clay along the river west of the Beausejour stretch [western main road]. Alluvial soil covers the entire area. The eastern section of the watershed (including Granton, Annandale and Willis villages) up to its boundary with the Grand Etang forest reserve is covered with clay loam. More than 29% of the watershed has steep to very steep land. The only flat land [0 - 2°] is found along the western boundary close to the coastline and in a narrow belt along the river. Alluvial terraces (developed from soils eroded higher up the watershed) are found along the western section. There are also numerous hills, ridges and U-shape valleys resulting from the velocity of the river. There is also an inland wetland area found in the northeastern section of the watershed.

The watershed is drained by the Beausejour river (and its tributaries), which is approximately 9.5 km long and begins at an elevation of about 600 m. It flows with great speed and volume during the rainy season, causing flooding in the lowland area. The approximate annual rainfall varies from 1500 mm by the coast to between 2000 and 2500 mm in the interior, and between 3000 and 3500 mm in the eastern section of the watershed. The mean temperature is 26 °C. The areas of alluvial soils are considered as good land for intensive cultivation with few constraints. Most other land is classified as 'poor' land for cultivation, with a few patches of land that is of 'medium' use for agriculture. The very eastern section has land suitable only for forestry. Land use within the watershed is predominantly mixed cultivation consisting of mixed stands of fruit trees, food crops, vegetables and tree crops (such as cocoa, banana, nutmeg

and other spices). This is practiced mainly around the scattered villages and estates within the watershed. There are also several pure stands of banana, and food crops and vegetables (mainly corn, pigeon peas, sweet potatoes, yams, tannias, dasheen, carrot). The uncultivated land in the western section is covered with moist deciduous/semi-deciduous forest, while that in the eastern section comprises close evergreen primary and secondary rain forest.

Water from the two catchments is used both in the catchment area but also provides water for a large part of the south east of the island around St George's and the Grand Anse areas (see maps in Appendix VII). In Concord (Black Bay watershed) the reticulation is relatively simple: water is abstracted from the river at the Concord Dam, and piped water supplies downstream from the dam are connected to these mains. At Concord itself, the mains bifurcates and one line continues southwards towards the St George's area, supplying water to the lower part of the Annandale (Beausejour) watershed around Happy Hill.

In the Annandale (Beausejour) catchment, water distribution and supply is more complicated. Firstly, water is actually abstracted from Grand Etang (Crater) lake, which lies outside the catchment boundary, and is pumped across and into the catchment, where it is fed back into the upper reaches of the Beausejour River. This augments the water collected within this catchment. Water is removed from the river(s) at several points. There are several dams of various capacities located around Vendome, and another above the Annandale estate. Some of this water is provided to communities within the catchment, on a reticulated mains reaching as far as Mango to the North and then about half way down the main road down towards the coast. Water is abstracted from the catchment about midway along its length and diverted southwards towards St George's. This currently leaves communities located in the lower half of the watershed (*i.e.* around Grenville Vale and Beausejour estate) without any reticulated mains to which they can be connected. It is possible that this situation will be improved in the future, when unpaved stretches of the main road are upgraded, allowing for reticulated water pipes to be installed at the same time.

#### **4.2 Watershed/Catchment Surveys:**

Surveys of all major water users were conducted, including 231 individual households within the two catchments, or located close to the catchment boundaries (See Appendix II for details of the household surveys and Appendix III for analysis of the data from them). Detailed analysis has been carried out to identify how changes in water quantity and quality influence household welfare in these situations. Comparisons have been made between the communities in the two watersheds, and an attempt has been made to assess the impact of water availability on household activities and income levels. An assessment of household income levels has been made through survey responses and through expenditure analysis and Logit and Probit models have been used to identify key factors influencing household income. The findings from this analysis are provided in Appendices II and III.

Table 2 (below) summarises some of the responses from the Household Surveys conducted in Annandale and Concord watersheds.

On the basis of the results of the surveys, a compensation scheme was proposed to the Grenada Ministry of Agriculture in August 2002, (see Appendix IV) and it was approved in principle by parliament in March 2003. This has laid the groundwork for the implementation of the compensation schemes, and when presented to the final stakeholder workshop in February 2004, there was strong support expressed by the majority of those involved. This same workshop provided the means by which wide consultation was sought on the wording of a policy briefing note which has been prepared for delivery to the Grenada Government as an output from this project. For details on the policy briefing note and its development, see Appendix VI.

On the basis of this work, a mechanism has been conceived which will draw on information from both the hydrological and social sciences, and will provide a means by which livelihoods of forest communities can be improved. At the same time, the proposed approach will contribute to the maintenance of ecological integrity in upland forested watersheds, and will enable payments to be made for best agricultural practices implemented in those areas. The development of the 'sustainability fund' was also well received, with some support for it being

expressed by a wide variety of groups, and a call being made at the final project workshop for further work on the project to take the work forward to the implementation stage. As the Minister of Agriculture Mr. Gregory Bowen said in his keynote address the final workshop, *“Compensation mechanisms can be used to motivate farmers ... In the absence of efficient watershed protection mechanisms, efforts to improve water infrastructure would be wasted”*. He then went on to add, *“The Government of Grenada is pleased to be associated with the CAMP project, and Cabinet approval has been given to develop compensation mechanisms”*.

**Table 2: Selected characteristics of surveyed households, Concord and Annandale, 2002**

Household characteristic	Annandale responses		Concord responses	
		Yes		Yes
House condition 'Poor'		29%		7%
House condition 'Good'		65%		87%
Number of Rooms	1.93		1.64	
Private Water Pipe?		66%		83%
Average income in Rainy season (EC\$)	1,050.71		1,390.23	
Average income in Dry season (EC\$)	1,073.40		1,392.50	
Total average income (EC\$)	1,052.54		1,380.63	
Income spent on: Education	31%		15%	
Income spent on: Food & Drink	37%		26%	
Income spent on: Clothing	35%		15%	
Income spent on: Utilities	24%		15%	
Source of income: Forestry	8%		0%	
Source of income: Fisheries	12%		0%	
Source of income: Tourism	12%		3%	
Source of income: Agriculture (employed)	34%		21%	
Source of income: Sale of own produce	29%		41%	
Source of income: Other	47%		62%	
Households paying for water		74%		89%
Households collecting water		65%		47%
Total time spent by HH collecting water (mins)	62.05		105.56	
Water Shortages experienced?		66%		56%
Water Shortage: 'Often' (Few/Month) or 'V. Often'		21%		25%
Action: Reduce Consumption		26%		33%
Action: Purchase Water		13%		9%
Action: Try to store water		84%		62%
Action: Spend more time collecting		41%		60%
'Unhappy' or 'very unhappy' about water access		23%		18%
Water Quality 'poor' or 'very poor'		17%		3%

### 4.3 Analysis of economic data and livelihoods:

Grenada is a very small open economy, heavily dependent on tourism and exports of spices. However, in recent years, manufacturing paper products and electronic components, offshore financial services and telephone and internet-based marketing have become increasingly important. The overall growth rate for Grenada for the period 1990-2001 was 3.2% per annum, mostly achieved through progress in fiscal reforms and prudent macroeconomic management. The increase in economic activity has been led by construction, trade and communication, but in recent years, this rate of economic growth has slowed down. (CARICOM Statistics 2003). The current high level of public investment and of public finance is major concern over the medium term. As the remaining assets available for privatisation and the prospect for increased external assistance are limited, actions would be needed in the budget to raise public saving significantly and improve the external position.

The Government policy objective as enunciated in the Medium-Term Economic Strategy paper 2000-2002 is to respond to the challenges presented by globalisation, trade liberalisation and poverty reduction through the restructuring and re-positioning of the

economy as a more diversified, competitive and knowledge-based economy. The key elements of the Government's development strategy are agriculture, tourism, education and human resource development, financial services and information technology. The tourism sector will be promoted as the leading sector, greater emphasis will be placed on agricultural diversification, the transition in the banana industry will be supported by establishing an appropriate regulatory framework and the international financial services and informatics sectors will be developed.

Grenada still controls a quarter of the world nutmeg output and this is the biggest regional earner of foreign exchange in the agricultural sector. Grenada also has a large subsistence sector producing fruits, vegetables and livestock for the domestic and regional markets. The decline in agriculture which has taken place over the last decade has led to the creation of a serious imbalance in the development of the country with a heavy bias away from the rural areas and a dependence on tourism and other urban related activities. Overall poor performance of agricultural exports impacts not only on rates of growth of the economy as a whole, but also on Government's revenue and trade balance of payments.

The country relies on tourism as its main source of foreign exchange especially since 1996 when the agriculture sector, the other major source of foreign exchange, has declined its performance. Tourist facilities have been expanding since the construction of an international airport in 1985. The tourism market in Grenada has changed over the last ten years, particular in terms of the way tourists arrive in Grenada. More tourists are now arriving in Grenada by air, almost equalling the number of tourists arriving on cruise ships in 2002. Although the numbers arriving by cruise ship are larger, it has been estimated that only 4% of all tourism expenditure comes from Cruise ship tourists, with an average of 96% comes from visitors who stay on the island.

Despite the reduction of unemployment rate in the last few years, unemployment is still high especially among young people and females. The tourist industry represented by workers in the Hotel/Restaurant trade accounted for just 5.7% of all employees, the majority of whom were females. In 1998, just over half of the employed were earning less than EC\$ 1,000 per month, with 2.1% earning EC\$ 2,500 per month or more. In that year, the median monthly income was EC\$ 744, with females earning less (EC\$ 650)<sup>3</sup> than males (EC\$ 898). It is clear that there is a need to improve not only infrastructure and export performance, but also address gender discrimination and better targeted training to help youth to be absorbed into the labour market.

The problems associated with water resources in Grenada are not only those of quantity but also of quality, and are often caused by a party that does not bear the costs associated with these problems. These costs are referred to as 'externalities', as they occur outside the market. In fact there is not a market where the party impacted by the water problems can go to obtain compensation. Until now, the only way that they could obtain compensation for any losses has been through the legal process.

Grenada is faced with the challenge of addressing problems of both water quantity and of water quality. To examine each of these problems, two of its watersheds (the Black Bay (Concord) and Beausejour (Annandale) watersheds) were chosen as pilot sites. In the Concord watershed there is a problem of water pollution from eroded soil sediment and agrochemical misuse. In addition to natural erosion from steep topography, the problem of erosion is exacerbated by land use change from forestry to farming; in particular by farmers growing vegetables close to the river from which NAWASA abstracts water. Following costly water treatment, this water is supplied to downstream users. The costs associated with increases in dam sedimentation and agrochemical pollution are borne by NAWASA in terms of silt removal, and water treatment costs. These costs, (and their reduction as a result of better farming practices) form the basis of one of the compensation schemes suggested in this project (See Section 4.5.)

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<sup>3</sup> Minimum wage for shop assistants in St. George's is EC\$450 per month and for domestic workers across all Parishes is EC\$400 (2002).

Another aspect of the analysis carried out in this project has been to examine peoples' perceptions of their relative deprivation of water supplies. To examine this, respondents were asked whether they were willing to pay (WTP) for a more reliable supply of drinkable water to their home using a *bidding game* approach (Freeman 1994). It was found that 81% of households said they were willing to pay something, and the majority of households suggested a figure in the region of EC\$ 0.5 for 100 gallons of water. The average amount that households across the two watersheds were ready to pay was EC\$ 0.57 per 100 of gallons, a value very close to the proportional charge that metered domestic consumers pay for the first 2,200 gallons. This work revealed that households that collect water and do not have a mains supply are willing to pay more than those with a mains supply and who collect water, and more than those that do not collect water. In this case the willingness to pay reflects the implicit benefit associated with a better water supply. So the households with no private supply that have to collect water are the ones whose utility would be improved most from an improved water supply. Therefore, the marginal benefit from additional water follows a trend of diminishing returns. The more water a household has got available, the lower is the marginal benefit that it would gain from an additional unit of water supplied. As a result we can conclude that the lower the current level of water supply, the higher is the marginal benefit gained by households from additional water provision. It has also been shown that households living in Annandale are ready to pay more for a better water supply than those living in Concord. This reflects the fact that in Annandale there are more people with no piped supply and therefore more people collecting water.

To estimate the probability that a household with certain characteristics will be willing to pay for a better water supply a binary logit model was used. An example of this is shown below.

**Table 3: Output table from a logit model analysis of the Grenada Household data**

Table XX – Logit model using STATA						
logit 'willingness to pay for improvement' annandale taincocal tap watershortage						
Iteration 0:	log likelihood =	-51.049381				
Iteration 1:	log likelihood =	-38.733059				
Iteration 2:	log likelihood =	-37.687725				
Iteration 3:	log likelihood =	-37.614594				
Iteration 4:	log likelihood =	-37.614297				
Logit estimates		Number of obs =		74		
		LR chi2(4) =		26.87		
		Prob > chi2 =		0.0000		
Log likelihood = -37.614297		Pseudo R2 =		0.2632		
willingnes-t	Coef	Std. Err	z	P> z	[95% Conf Interval]	
annandale	1.510982	.698005	2.16	0.030	.142917	2.879047
taincocal	.0006456	.000325	1.99	0.047	8.40e-06	.0012829
tap	-2.031036	.674242	-3.01	0.003	-3.352527	-.7095449
watershort-e	1.5491	.602369	2.57	0.010	.3684784	2.729722
_cons	-1.434774	.851719	-1.68	0.092	-3.104115	.2345661
. fitstat						
Measures of Fit for logit of willingness to pay for improvement						
Log-Lik Intercept Only:	-51.049	Log-Lik Full Model:		-37.614		
D(69):	75.229	LR(4):		26.870		
		Prob > LR:		0.000		
McFadden's R2:	0.263	McFadden's Adj R2:		0.165		
Maximum Likelihood R2:	0.304	Cragg & Uhler's R2:		0.407		
McKelvey and Zavoina's R2:	0.472	Efron's R2:		0.295		
Variance of y*:	6.226	Variance of error:		3.290		
Count R2:	0.703	Adj Count R2:		0.353		
AIC:	1.152	AIC*n:		85.229		
BIC:	-221.752	BIC*:		-9.654		

All the above independent variables were statistically significant, so the probability will be greater that a household will be willing to pay for a better water supply if it:

- has experienced water shortages
- is located within the Annandale watershed
- does not use a private piped water supply for water for cooking and drinking

In addition the higher the household income, the greater will be the probability that it will be willing to pay for water. If a household is willing to pay for a better water supply it means that it perceives that such improvements will have a positive impact on its utility. So WTP provides an indication of how a certain activity impacts on the household's utility. The implications of

this are that by investing in water storage in Annandale, water shortages would be reduced; in particular, targeting households without private piped supplies will ensure that the largest number of people will be positively impacted by such development.

Another dimension of the compensation scheme proposed in this project is the riparian compensation mechanism, and this would involve the creation of buffer strips along watercourses running through farms. During this project, the majority of farmers surveyed said that they *would* consider growing alternative crops such as flowers in buffer zones (e.g. *Heliconia*, etc.), but they also suggested planting citrus, coconuts and cocoa. To investigate the economics of this, analysis was carried out on data collected from farmers in the pilot watersheds. On average, farm income per acre has been estimated at EC\$ 293/month (assuming average market prices, 10% of yield wasted and seed costing 10% of revenue). There was a large variability in these results ranging from EC\$ 84/month to EC\$ 718/month, although the labour cost of farmers has not been included. If it is included, the income drops to EC\$ 45/month, on the assumption that farmers in this area are will work mainly in the dry season (6 months) and the minimum wage for agriculture is EC\$ 5/hr. On the basis of these calculations, the loss of farm income from a piece of land (buffer strip) 10m x 3m would therefore be an average of EC\$ 2.2/month (based on the total income value of EC\$ 293/month). This equates to 4% of the usual monthly payment for water (EC\$ 55).

Agriculture is definitely not only the most frequent source of income, but also one of the major sources of employment. However, there has been a declining trend of the annual rate of growth for employment on farms between 1961 and 1995, with numbers employed dropping from 24,400 workers in 1961 to 16,800 in 1995. In addition, over this period, the employment distribution also changed, whereby in 1995, 78% of the total employment comprised farmers' unpaid relatives compared to only 57% in 1961. Over the same period, the percentage of paid workers overall in agriculture declined from 43% in 1961 to 22% in 1995. These figures highlight the changes taking place in the agricultural sector and the proposed compensation scheme is designed to help improve the well being of poor farmers, while at the same time reducing any negative impact they may have on the environment.

In contrast to agriculture, tourism employs relatively few people in spite of being the major source of foreign exchange. Direct employment in the tourist industry (represented mainly by workers in the hotel/restaurant trade) accounts for just 5.7% of total employment at national level. However, this sector contributes indirectly to employment as the driver for expansion of other many sectors such as transport and construction. The importance of this sector to the economy as a whole cannot be underestimated, and it is important that any scheme which may influence it must be approached with caution. This point was raised by a number of stakeholders when discussing the 'sustainability fund' which is based on tourist (and other) donations. (For details on consultation, see Appendix 1)

### **Conclusion**

Much work has been carried out to analyse data collected during this project. Key issues which have been addressed are water use in subsistence households, willingness to pay for water improvements, agricultural output values, tourism attitudes and willingness of stakeholders to participate in compensation schemes. The results of this analysis suggest that upstream downstream compensation mechanisms are acceptable as an economic instrument in Grenada, and key stakeholders who would be involved in that process are willing to participate in its further development. It has to be said however that the data has revealed that there are many issues which need to be addressed to improve the efficiency of resource use in these pilot watersheds, and so the described compensation mechanisms cannot be implemented in isolation, but should be seen as a part of a suite of tools used in combination with other schemes. For more information on the data collected and its analysis, see Appendices II and III.

### **4.4 Integration of socio-economic and environmental data within GIS:**

Natural resource management and planning for sustainable development require the collection and integration of data from many sources. Very few studies, however, attempt to combine socio-economic data with environmental data, such as that related to water

resources and land cover. For this study, the locations of communities and households surveyed for the CAMP project were referenced and integrated with other environmental data using the ArcGIS geographical information system (GIS). This approach can provide a way of better understanding the dynamic connections between household characteristics and livelihood strategies and water and land resources.

### **Introduction**

It has been recognised that achieving sustainable environmental management and development requires the collection and integration of more and different types of data, in order to be able to assess, monitor and predict changes in natural and human systems and their interaction. The use of GIS is regarded as an effective and powerful tool for the integration and analysis of often-disparate datasets from environmental (biophysical) and socio-economic research. The World Summit on Sustainable Development held in Johannesburg in August 2002 concluded that, for many developing nations, the use of GIS, together with Earth Observation data (remote sensing) and GPS (Global Positioning System) techniques, could provide the only cost-effective means of collecting and managing high-quality data to comprehensively map and monitor the extent of land-based environmental problems (GISD website).

Research in Grenada for the CAMP project required the undertaking of a Sustainable Livelihoods study of selected communities within two catchments together with the collection and analysis of data necessary to map the catchments and their communities, and their current land use and hydrological features. Working closely with partners in Grenada, existing spatial datasets for the study areas were collected, as well as hydrological and climatic tabular data, making these data available for input to modelling and other approaches planned to address the project aims and research questions.

Further, the nature of the research requirements gave the opportunity to develop a GIS methodology that would integrate the results of the household surveys carried out with the spatial geographical data held in the Grenada Land Information System. This approach would contribute to the better understanding of the human-environment linkages at the catchment scale in Grenada and is described here. This work has been informed by studies from a group of pioneering integrative scientists who have been investigating human-environment interactions through the linking of household and community surveys to GIS and remote sensing (Fox et al 2002, Walsh and Crews-Meyer 2002). Their work has particular emphasis on the drivers of land use change, and the expectation that decisions made at the household level are significant in influencing land use and land use change. Their case studies provide a guide to concepts and methods for integrating data from different sources and highlight the practical and methodological issues and challenges faced in conducting this type of research.

### **Collection of Data**

The first phase of data collection for this study was to access and extract the existing spatially referenced environmental data (GIS data) covering the study catchments held within the Grenada Land Information System. The second phase of data collection was to spatially reference the households surveyed in the livelihoods study.

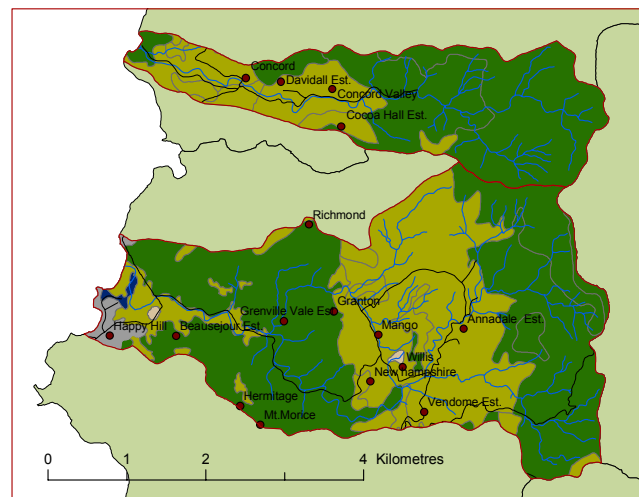
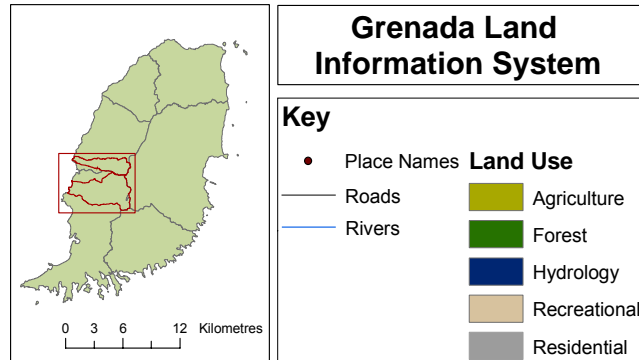
### **Grenada Land Information System**

The Grenada Land Information System, or GLIS, is a GIS-based decision-support system for land-use planning at national, parish and local levels. GLIS was established, and is managed, by the Land Use Division of the Ministry of Agriculture, Forestry, Lands and Fisheries (MALFF) in Grenada. The system contains layers of spatial data representing hydrological features, land cover and land use, soil type, elevation, agro-climatic zones, and topographic and infrastructure features including administrative boundaries and the water storage and distribution network. The system also holds data on crop and forest environmental requirements and crop-production and forest-production models. GLIS has many applications and is designed to aid decision-makers, managers and planners, farmers and other target users in Grenada in areas such as land use planning, land and crop suitability assessment, hazard vulnerability assessment, and Environmental Impact Assessment.

Working with staff in the Land Use Division, the island-wide datasets described were 'clipped' to extract subsets covering the Annandale and Concord catchments. The following 'layers' of GIS data were extracted both as points, lines or areas and with substantial attribute data:

- NAWASA distribution network (including water sources, storage and discharge sites)
- Rainfall stations (with monthly rainfall totals, up to 35-year data)
- Catchment boundaries
- Rivers and streams
- Roads
- Land use/land cover
- Soil type
- Agro-climatic zones
- Elevation
- Place names

Figure 7 shows the location of the study catchments on the island and illustrates a selection of the data layers extracted; roads, rivers, place names and the land use classification. These datasets were obtained in Shapefile format, the format used for the most commonly used GIS for environmental applications, ArcView/ArcGIS.



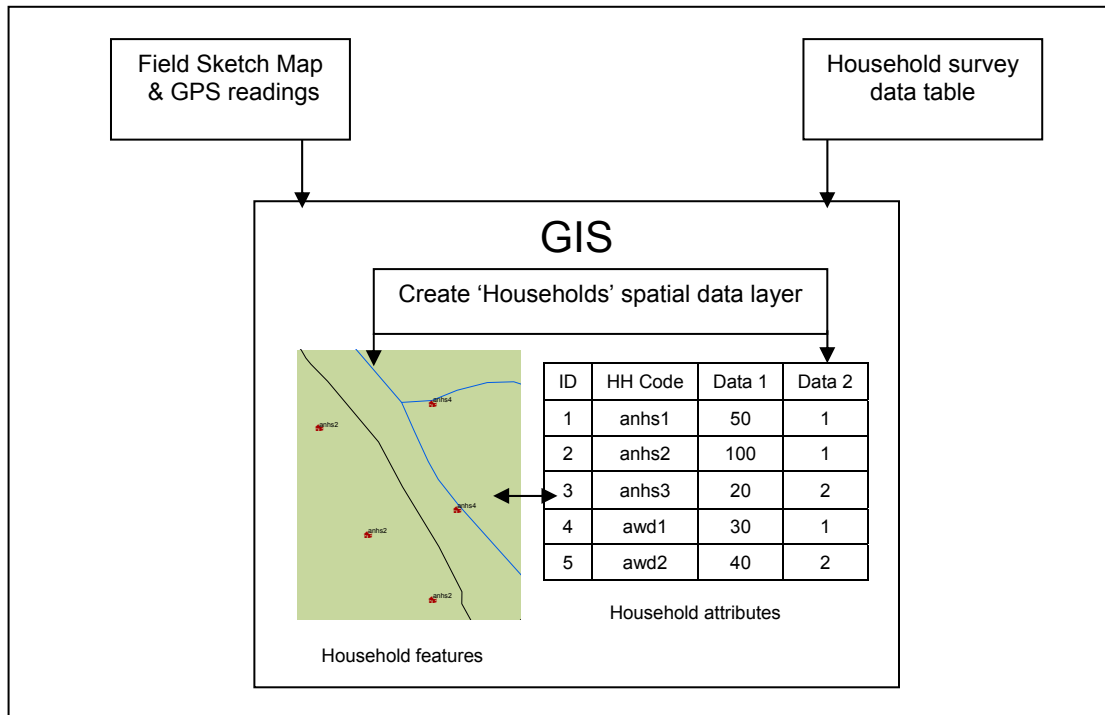
**Figure 7 – Catchment data from the GLIS**

### Household Surveys

During the undertaking of the household surveys of the Annandale and Concord catchments the two catchments were mapped. This involved creating a sketch map of the areas visited, marking the location of the households surveyed against roads, road junctions, rivers, bridges, and other buildings and landmarks. These maps were informed by copies of available topographic maps (1:25000) of the island and maps printed from GLIS. Each household responding to the survey was plotted on the sketch map and marked with a reference code. This code corresponded to the reference added to the specific questionnaire used for that household. This technique required regular interaction with the team of surveyors. This mapping approach was supplemented by the use of a hand-held GPS receiver, and coordinate readings were taken at specific landmarks (e.g. churches, hospitals, and trigonometrical points), water storage sites, road junctions, and bridges. Due to the insufficient availability of GPS receivers, the coordinates of individual households were not recorded.

### Method of Spatial Data Integration

Two relatively simple techniques were employed to integrate the data collected as described above. Firstly, a new GIS data layer was created to represent the locations of the surveyed households. Secondly, the tabular data collated from the survey questionnaires for each household were linked to the corresponding feature in the new data layer. This resulted in a new GIS spatial data layer representing surveyed households across the two catchments (see Figure 8).



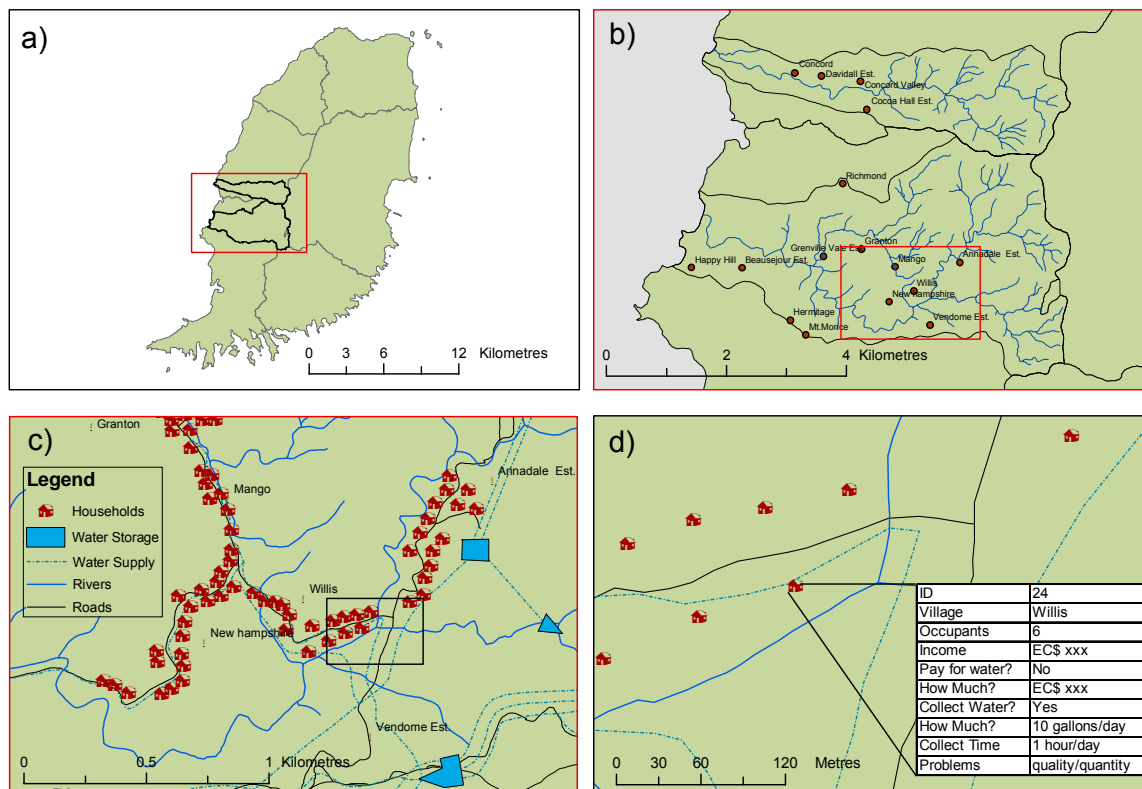
**Figure 8 – Conceptual model**

### Household Location

Due to the method employed to note the location of the study households against a representative map, a number of households were grouped according to a reference code noted by the surveyors. This grouping procedure also preserved the confidentiality of individual respondents. The components of the household identification code (e.g. AWD1) represented the catchment (e.g. Annandale), village (e.g. Willis), surveyor (e.g. Desmond), and a household number. On the sketch map, a group of households (3-10) were marked as belonging to each letter code. These households were then plotted 'manually' as point locations in the GIS against a base map containing GLIS data layers of roads, rivers, and place names. A new GIS layer was created ('Households') and for each household the identification code entered as an attribute. This method of 'retro-fitting' from the sketch maps was employed, as it was not possible to record exact household coordinates. The use of a GPS receiver by each surveyor would have enabled this, and the household locations could have been, in theory, automatically plotted from these readings against the existing spatial datasets. The GPS reading taken at landmarks and known points did, however, inform the siting of the surveyed households.

### Data Linking

Once the Household data layer was created, this could then be populated with attribute data from the tabulated results from the household survey instrument. Once in the form of a spreadsheet (in CSV format), these survey data were imported into ArcGIS and 'joined' to the attribute table created for the Household layer by using the GIS operation designed to link attribute data through the use of a common key field. Figure 9 illustrates this dataset described: 9a) shows the island of Grenada and the study area; .9b) is a 'close-up' of the study area showing the rivers and 'places' in the catchments; 9c) 'zooms-in' more to show the distribution of households in the area in relation to water resources and other infrastructure; 9d) shows a closer view and a sample of the type of household information collected that is linked to the land information within GLIS.



**Figure 9 – Integration of household data**

## Discussion

This study has briefly described a method exploring the feasibility of linking disparate datasets within a GIS for improved analysis of the dynamic relationships that connect people and the environment. In carrying out the work, a number of technical and practical issues were encountered which would need to be considered if this approach is to be developed and applied further, both within Grenada and generally, but which are not considered in detail here. Technical issues include data quality and the compatibility of datasets available. Practical issues include the accuracy and appropriateness of field mapping methods, the availability of technical equipment and knowledge (e.g. GPS), and the design of the survey instrument to complement such a research approach. Furthermore, the issue of confidentiality has to be considered and steps taken to protect the identity of survey respondents, especially if making the spatial data available outside the project team.

The most important challenge, however, is how to best use these data. The approach developed here provides the opportunity to extend the quantitative and qualitative analysis of the household survey results through the use of GIS approaches - to be able to ask the 'who?', 'what?', 'where?' and 'when?' questions of human-environment linkages. A simple first step is to have the ability to display visually the outputs of a household data survey analysis - to show clusters of those with particular problems, say, of water quality or water quantity. These groups of households could then be investigated at the spatial level with analysis of their location in relation to the land cover state, their location in the catchment (upstream or downstream), their proximity to water sources (natural or reticulated), etc. Beyond this, the data collected could be scaled-up to catchment level and combined with census data and other social and economic data sources. Such spatial analysis can also help to target infrastructural and policy development in the catchment.

In studying the impacts and influences of different livelihoods in the catchment on water resources and catchment management a more advanced and dynamic modelling approach is required. How do, for example, demography, income, water and land use, and attitudes and perceptions to resources influence sustainability of the resource (land and water) and the system (the catchment and the community/society) now and in the future? How can we

capture the increasingly dynamic human and policy-driven influences on water resources and catchments? It is clear that in order to address such questions, more and better quality data is needed to develop the Grenada Land Information System and other technical and practical issues overcome. For example, the CAMP project in Grenada developed over the research period to focus on the influence of upstream farming on downstream users and proposed the implementation of economic instruments for watershed management. Data collected from farmer surveys carried out could be linked to the plots they farm, after recording the location of these plots with GPS technology, and this information used for further analysis and an understanding of the drivers of certain farming practices and their impacts on the resource and the catchment as a whole.

The linking of data from socio-economic research with biophysical and other environmental data is ambitious and requires thorough planning at the inception phase and a high-level and amount of data, technology, and technical capacity. To begin to get a clear picture of the relationships (influences and impacts) of livelihood strategies and location on changes in land use and water resources, data needs to be collected from many sources and at different temporal and spatial scales. This study, as with the CAMP project as a whole, has proven a worthwhile exercise in giving a focus for interdisciplinary study, where specialists in forestry, water resources, economics, household survey and analysis, and GIS have needed to 'learn' the overall project and how the outputs are a synthesis of their own research. The approaches taken to collect and integrate the data for this study were developed in collaboration with the Land Use Division and Forestry Department in Grenada and this should help to develop the Grenada Land Information System in the directions required for it to be used to inform government policy in areas such as land use and water resources development and funding for infrastructural development.

Across the world, governmental and non-governmental organisations, such as those in Grenada, are continuing to acquire and make use of more advanced systems, technology and knowledge in areas such as GIS and Earth Observation for surveying, mapping and analysis. It is expected that such advances will allow for studies of data-linking and human-environment relationships to be carried out across wider areas, more comprehensively and with greater accuracy and less cost. Further, it is hoped that access to GIS technology will spread and that greater steps will be taken to promote the sharing of data between organisations and, in particular, that applications of the technology will become more and more accessible to decision-makers and stakeholders at all levels.

#### **4.5 Using compensation mechanisms in environmental policy:**

All forms of production ultimately depend on use of natural resources, and consequently, result in some form of their depletion (Ahmad *et al.*, 1989). Natural resources are thus a crucial part of the nation's capital stocks, and should be incorporated into macroeconomic planning (Huetting, 1991; Huetting *et al.*, 1998; UNSO, 1993). In addition, these need to be managed in a participatory way, so as to ensure equitable distribution of benefits (Singh and Khare, 1993; Daly, 1989). Where natural capital is included in national accounts (*e.g.* as timber values), it is almost without exception treated as part of an income flow, rather than capital, which can both appreciate and depreciate. This clearly has implications for its impact on macroeconomic performance, and there is much need to address this issue in environmental policy.

Many governments are committed to the introduction of Integrated Water Resource Management (IWRM), as first outlined in the 'Dublin Principles' (ICWE, 1992). To achieve this, account must be taken of actions by different water users within a watershed, and, in compliance with equity, losers should be compensated by winners. According to the theory of welfare economics, greatest benefit to an economy occurs when resources are used in a way which is '*Pareto optimal*', This means exchanges occur when no one agent can increase his level of benefit, without reducing the benefit of others. In practice however, this rarely happens, as there are few situations in which transfer of resources to compensate for any loss, does actually occur (Daly, 1998). It is to overcome this 'market failure' that compensation mechanisms can be used.

The development of more meaningful accounts of natural resource use is an essential step forward in the eventual achievement of a more integrated national accounting system. Quantifying the value of ecological services is an important part of this process (Faber *et al.*, 1996; Pearce *et al.*, 2002), and if this can be done, compensation mechanisms provide a way in which the distribution of benefits can be formalised. This project aims to identify the necessary information on which such mechanisms can be based in the Grenada context, and to evaluate the views of stakeholders as to the acceptability of such schemes in that country.

### **Capturing income flows from natural capital**

Natural capital<sup>4</sup> is generated by environmental services and is an essential component of any economic activity. While much literature exists on how the environment can be integrated into the economy, the key to most of the tools used to achieve this are based on the work of Pigou and Coase. Pigou (1920) advocated a full cost pricing model of resource use, where taxes and subsidies are used to close the gap which inevitably exists between the private costs (and benefits) of any activity, and the social costs (and benefits) associated with it. Coase (1988), on the other hand, advocated that a more equitable utilisation of resources depended on a clearer definition of property rights, and as a result, he argued that if rights over natural resources can be better defined, any externalities associated with their use will be overcome within the market mechanism.

Compensation mechanisms developed to influence impacts on ecological systems embody some aspects of both of these, as there needs to be a clear identification of property rights (and responsibilities) over some components of the system, in order for economic instruments (taxes and subsidies) to be applied. To ensure that this process contributes meaningfully to long term economic planning, it is important to recognise the need for maintenance of natural capital, and the importance it plays in the lives of future generations (Norgaard, 1991; Dore and Mount, 1999). In theory, the conversion of natural capital to man made capital can generate a constant consumption stream over time (Hartwick, 1977), but it is very important to recognise the limitations to this under real life conditions, where the assumptions behind economic theory don't always hold true. As a result it is therefore necessary that use of natural resources is closely monitored, and any depletion in their state should be signalled as a cause for concern by policy makers. The compensation mechanisms advocated here are designed to reduce such depletion by pre-empting the creation of the problem through fiscal incentives to different resource users.

There has been some attempt to develop innovative approaches to address the problems of resource management, especially in developing countries (Pearce *et al.*, 2002; Richards, M. 1999) Nevertheless, to date, little literature exists on the accurate quantification of natural capital, and few policies are designed to take it into account. There are, however, some examples of attempts to develop such policies, and some approaches to the management of ecological services are shown in Table 4.

### **Operationalising Watershed compensation mechanisms**

Key attributes will underlie the efficacy of Watershed compensation schemes. Firstly, there must be a clear and recognised link between the actions of one group within the watershed, and the impacts of their actions on another group. (property rights issues). These impacts must be quantifiable, and there must be a way to assign values to them. People who benefit from a reduction in these impacts must be committed to making a payment for the improved conditions, and there must be a flow of financial resources generated from them (following the implementation of Pigovian-type taxes and subsidies). People who take action to improve things are the ones who should get paid the compensation.

Any compensation scheme needs to be carefully managed. An appropriate authority needs to be identified or established to oversee financial arrangements, and this authority will have the duty to ensure responsible and equitable use of the money, which should be audited. In

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<sup>4</sup> Natural capital is an essential component of the livelihood capitals associated with the 'Sustainable Livelihoods framework' (Scoones, 1998), used by many donor agencies to assess the development process.

practice, the system works best when communities decide in a participatory way how the funds should be used, and this should be approved by the fund management board.

**Table 4 Some examples of compensation mechanisms in use (2004)**

Country	Ecological service	Service suppliers	Service buyers	Instruments in use/Impacts
USA	Improved water quality	Agricultural and industrial polluters who reduce their pollution levels and then can sell their 'nutrient' rights.	Polluters who need to discharge pollutants above the allowable levels	Finance mostly used to establish trees in riparian areas
Australia	Reduction in soil salinity and Water quantity provision	Upstream Farmers not using their water rights, and state forests.	Downstream irrigators (Murray Darling Basin)	Reforestation with desalination plants, irrigation rights financed by water markets
France	Good water quality provision	Upstream farmers and foresters	Perrier, Vittel and other water bottlers	Payments to upstream farmers to improve farming practices
Costa Rica	Private owners of upstream forests	HEP Utilities, government and NGOs	Payments from HEP company and Government made to landowners via NGO	Increased forest cover on upper slopes of private land, financed by utility payments
Colombia	Reliability of water supplies and water quality	(upstream) private land owners and municipalities	Industrial water users and municipalities. Eco-tax on industrial users.	Payments to private landowners for best practice, by municipalities and watershed authorities
Brazil	Rehabilitation of private and public land to restore ecological services	Municipalities and private landowners	The state of Parana	State funding to municipalities with protected areas and watershed providing them and others with ecological services

### Conclusion

Compensation mechanisms provide a realistic means by which economic agents within an economy can be motivated to conduct their activities in a certain way. Economic distortions currently exist within market economies, giving rise to environmental degradation. This is primarily the result of a failure of such systems to adequately evaluate (and appropriately price), essential productive components of environmental (natural) capital. While there of course are many limitations to the effectiveness of compensation mechanisms, they can nevertheless reduce some of these distortions, leading to more equitable and sustainable outcomes.

The two compensation mechanisms suggested in this report would fit in the macroeconomic context of Grenada in terms of facilitating the improvement of social welfare and stimulating the efficient use of natural resources. (For full details on the analysis behind this work, see Appendices II and III). The introduction of two compensation mechanism have been discussed with stakeholders, and would be justified both on the grounds of welfare and equity, as well as environmental benefits both at local and downstream level (e.g. marine/coastal ecosystems). The data shows that if a compensation mechanism were introduced that facilitated better access to water, greatest benefit from that would be derived by those households that currently do not have a piped (mains) water supply and have to collect water; and by those households that have experienced water shortages.

Finally, it is important to note that the implementation of the type of compensation schemes described here is best done as part of a suite of measures taken as part of a policy of

Integrated Water Resource Management (IWRM). If used in isolation, they will bring some benefits, but these will be strengthened when coupled with other measures such as demand management, water harvesting, leakage reduction and the raising of public awareness.

## **5 Conclusions:**

The research activities undertaken and compensation mechanisms developed during the CAMP Grenada project have contributed to the better understanding of water resource issues and livelihoods in Grenada.

The two compensation mechanisms suggested would facilitate the improvement of social welfare and stimulating the efficient use of natural resources, and would be justified both on the grounds of welfare and equity, as well as environmental benefits both at local and downstream level (*e.g.* marine/costal ecosystems). Community participation in managing shared water storage facilities should be encouraged and facilitated as this would ensure a better and fairer use of water resources. It is important to note however, that the 'sustainability fund' mechanism that has been proposed should not be implemented in isolation, but rather should be used in combination with other schemes to stimulate efficiency. Without these other schemes, sustainable management of watersheds will be unsuccessful.

Valuable data have been collected and significant progress has been made in terms of supporting the further development and implementation of government policy necessary for future sustainable access to, and use of, Grenada's water resources by all of the population in an equitable manner.

The approved submission to Cabinet for pilot studies to test the applicability of the two compensation mechanisms, together with the Policy Briefing Note developed in partnership with a broad range of local and regional stakeholders, will prove a valuable contribution to meet this end.

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## **7 Appendices:**

### **I Consultation activities:**

- Introduction
- Tourist surveys
- List of people interviewed
- Surveys of major/industrial water users

### **II Household and farmer surveys**

- Report on surveys
- Sample questionnaire
- Summary of questionnaire responses (% response by question)

### **III Economic analysis in Grenada**

### **IV Submission of Compensation Proposal to Government of Grenada**

### **V Final stakeholder workshop**

### **VI Preparation of the policy briefing note for Government of Grenada**

### **VII Physical maps and tables**

### **VIII Outputs**