Economic valuation study: action learning project on incentives for improved watershed services in the Buff Bay/Pencar watershed, Jamaica

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Developing markets for watershed protection services and improved livelihoods

Based on evidence from a range of field sites the IIED project, ‘Developing markets for watershed services and improved livelihoods’ is generating debate on the potential role of markets for watershed services. Under this subset of markets for environmental services, downstream users of water compensate upstream land managers for activities that influence the quantity and quality of downstream water. The project purpose is to increase understanding of the potential role of market mechanisms in promoting the provision of watershed services for improving livelihoods in developing countries.

The project is funded by the UK Department for International Development (DFID).

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Acronyms and abbreviations

BBPencar WMU	Buff Bay/Pencar Water Management Unit
BOD	Biological oxygen demand
CANARI	The Caribbean Natural Resources Institute
CASE	The College of Agriculture Science and Education
CIB	Coffee Industry Board
CIDCO	Coffee Industry Development Company
COD	Chemical oxygen demand
CPCD	Caribbean Policy Development Centre
CRIES	The Comprehensive Resource Inventory and Evaluation System Project
CVM	Contingent valuation method
DBH	Diameter at base height
EFJ	Environmental Foundation of Jamaica
EJASP	Eastern Jamaica Agricultural Support Programme
ENACT	The Canadian International Development Agency Environmental Action Programme
EU	The European Union
FAO	The UN Food and Agriculture Organization
FD	Forestry Department
FIDCO	Forest Industry Development Company
GCT	General Consumption Tax
GOJ	Government of Jamaica
IIED	International Institute for Environment and Development
JAMALCo	Alcoa Minerals of Jamaica, Inc.
JAS	Jamaica Agriculture Society
JCDT	Jamaica Conservation and Development Trust
LFMCs	Local forest management committees
LSDPF	Local Sustainable Development Planning Framework
MHD	Minimum harvestable diameter
NEPA	National Environment and Planning Agency
NGOs	Non-governmental organisations
NRCA	National Resources Conservation Authority
ODPEM	Office of Disaster Preparedness and Emergency Management
PAJ	Port Authority of Jamaica
PET	Potential evapo-transpiration
R2RW	Ridge to Reef Watershed Project
RADA	Rural Agricultural Development Agency
RI	Recurrence interval
SMBE	St. Mary’s Banana Estates Ltd.
STATIN	The Statistical Institute of Jamaica

TDS	Total dissolved oxygen
TEV	Total economic value
TFT	Trees for Tomorrow Project
TSS	Total suspended solids
UNCBD	UN Convention on Biological Diversity
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WINFA	The Windward Islands Farmers Association
WMU	Watershed management unit
WRA	Water Resources Authority
WTO	World Trade Organization

Executive summary

The objectives of this report are as follows:

1. Valuation of watershed services within the Buff Bay/Pencar watershed.
2. Estimation of the costs of incentives identified for maintaining and enhancing these watershed services.
3. Development of methods and indicators for monitoring the impact of incentives on targeted watershed services and their impacts on livelihoods.

This report addresses these objectives in seven (7) chapters, which follow on from the first chapter, the ‘Introduction’. Chapter 2 provides a review of the main physical, hydrological, soil and water quality characteristics and trends in the two watersheds. Chapter 3 provides a socio-economic profile of the Buff Bay/Pencar watershed. Chapter 4 provides a review of the literature on valuation of watershed services as a necessary introduction to the actual valuation estimates which follow in the next 2 chapters. Chapter 5 describes the main land uses and provides an estimate of the negative costs resulting from current land use patterns. Chapter 6 turns to estimating the direct and indirect use values within the watershed. Chapter 7 reviews existing and proposed incentives and management tools for watershed protection in Jamaica. This chapter also estimates the costs of targeted incentives and, outlines indicators for monitoring impacts of incentives. Finally, Chapter 8 provides a profile of the local forest management committees (LFMCs) as central, identified stakeholders for implementation of incentives.

For land-use planning purposes, the island of Jamaica has been divided into 26 watershed management units (WMUs). The Buff Bay/Pencar Watershed Management Unit (BBPencar WMU) is located in the north-eastern portion of the island, straddling the boundary between the parishes of Portland and St. Mary, and covers approximately 20,258 hectares.

The BBPencar WMU has an estimated population of 30,700, which is almost evenly distributed between the Buff Bay and Pencar sub-watersheds. The watershed area is predominantly rural and the population is generally scattered as there are many small villages stretching along the roads in both sub-watersheds and all valleys. The majority of people in the watershed are thirty years and under, and 62% of the population is female.

The most common land tenure pattern in the watershed is private ownership by individuals and families, and approximately 75% of the land in the watershed is privately owned with tenure patterns including leasehold (rent or lease), freehold, or occupation. The region remains highly agricultural, and farming is the main source of income for a majority of family units, followed by wage labour. The economy of the area is dominated by two main forms of agricultural activity – bananas on the St. Mary coast, and coffee in the Upper Buff Bay Valley in Portland. There is also substantial traditional Jamaican mixed farming agroforestry on the hills in between.

Coffee production in Jamaica has multiplied tenfold in the last 20 years, increasing from 40,000 to 400,000 boxes in 2000. The parish of Portland accounts for roughly 43% of the Blue Mountain coffee production, around two-thirds of which is produced in the Buff Bay sub-watershed.

The Pencar sub-watershed is dominated by banana production, which takes place on plantations. For the communities living in or close to the coastal area, banana producers (the most important being the St. Mary’s Banana Estates Ltd.) represent a major source of employment for men and women alike. However, small-scale peasant farming is still the dominant activity in the area, with just over 5,000 ha of land in the watershed dedicated to agroforestry systems. Other economic activities in the watershed include significant freelance logging and a few sites for recreation/tourism.

Forest land covers the remaining area (13,623 hectares) that is not agricultural or other non-forest land. Natural forests are mostly found around the perimeter of the watershed at higher elevations. However, the greatest portion of the lands can be classified as ruinate forests.

Secondary forests are the most common type of forest in the watershed. There is also a significant area of planted forest as there has been an active forest planting programme in the watershed. Overall, the watershed underwent land cover changes between 1991 and 1999 which showed a positive net increase in terms of forest cover. This change was mainly attributable to an increase in Caribbean pine plantations (or areas regenerated) and an abandonment of cultivated fields (coffee or food crops).

There already is evidence that changes in land-use patterns are having negative impacts on the Buff Bay/Pencar watershed. It is, however, very difficult to ascertain precise costs since the readily available documentation is at the parish level. Executive Summary Tables 1 and 2 (below) provide some quantitative estimates of flooding impacts in terms of damage to roads, bridges, houses and property, as well as agricultural output lost, over the past 10 years at the level of the parishes of Portland and St. Mary within (which are located Buff Bay and Pencar, respectively).

Executive Summary Table 1: Cost of flood damages in Portland 1993 –2002[1] (Source: ODPEM Flood Archives 2004; Ministry of Finance and Planning 2004)

Year	Type of damage	Costs (J$)	Costs (US$)	Fx rate (J$ to US$1)
1993	Crops, livestock, agriculture	12,097,600	36,2637	33.36
1994	-	-	-	33.41
1995	Not detailed	14,942,000	37,336	40.02
1996	Not detailed	37,996,000	1,083,433	35.07
1997	-	-	-	36.51
1998	Infrastructure, including housing	339,320,000	8,864,158	38.28
1999	-	-	-	42.14
2000	Not detailed	17,200,000	376, 532	45.68
2001	-	-	-	47.61
2002	Coffee	261,700,000	465,327	56.24

[1] The J$ and US$ estimates are rounded to the nearest $million and $100,000 respectively for this, and the following summary table.

Executive Summary Table 2: Costs of flood damages in St. Mary 1993 – 2003 (Source: ODPEM Flood Archives 2004; Ministry of Finance and Planning 2004)

Year	Type of damage	Costs ($J)	Costs ($US)	Fx rate (J$ to US$1)
1993	Crops, livestock agriculture	7,707,055	231,026	33.36
1994	-	-		33.41
1995	Not detailed	12,526,000	312,993	40.02
1996	-	-	-	35.07
1997	-	-	-	36.51
1998	Not detailed	20,000	522	38.28
1999	Not detailed	15,000,000	355,956	42.14

Although other types of value are important, economic values are necessary in order to make economic choices involving tradeoffs in allocating resources. A 2001 publication of the Secretariat of the UN Convention on Biological Diversity sets out a useful categorisation of the economic values of, *inter alia*, tropical forests, as captured below.

Executive Summary Table 3: Categorisations of economic values (Source: UNCBD 2001)

Direct use values	Timber Fuelwood Non-timber forest products such as: - Recreation/tourism - Research/education -Cultural/religious Genetic information Agricultural Pharmaceutical
Indirect use values	Watershed functions: -Soil conservation -Water supply -Water quality -Flood/storm protection -Fisheries protection Global climate: -Carbon storage -Carbon fixing Biodiversity Amenity (local)
Option values	
Existence values	
Land conversions values	Crops Grassland Agri-business Aquaculture Agroforestry

A range of valuation techniques is available to measure actual value of uses. These are outlined in the final table at the end of this 'Executive Summary'. Using these methods, and from the data currently available, an estimate has been made of the direct use values of several of the marketed goods that are produced in Buff Bay/Pencar watershed, namely coffee, banana, timber, agroforestry, and tourism/recreation, and the indirect use values of several non-marketed goods: water supply and carbon storage.

In summary, the Buff Bay/Pencar watershed was estimated to have a direct and indirect use value of between US$82.5 million and US$86.5 million in 2004. Excluding carbon storage, this value is estimated to be between US$49.5 and US$53.5 million. Executive Summary Table 4 (below) provides a summary of these estimates

Executive Summary Table 4: Total estimated direct and indirect use values (US$ 2004 prices)

Type of Value	US$ million
1. Direct use values:	
a. Coffee	13.5
b. Bananas	6.5
c. Timber	3.2
d. Agroforestry	4.0
e. Recreation/tourism	0.03
2. Indirect use values	
a. Water supply	17.5 - 20.3
b. Water quality	n.e.
c. Soil conservation	n.e.
d. Biodiversity protection	n.e.
e. Carbon storage	33.0
Total (without carbon storage)	US$82.5 – 86.5 million (US49.5 – 53.5 million)

n.e. = not estimated

Using the available data, the direct use values of several marketed goods from the Buff Bay/Pencar watershed have been estimated. With a market value of US$630 per 60lb box, the net benefit from coffee in 2004 is estimated at US$13.5 million. Banana, which is also a major export crop, is estimated at a value of US$6.5 million in 2004. Timber from the watershed is sold mostly within the parishes of St. Mary and Portland, as well as in the capital, Kingston. Annual net benefit from timber production is estimated, based on the annual allowable cut, at US$3.2 million in 2004. The direct use values for both mixed agroforestry and recreation/tourism were based on very conservative annual estimates of US$4 million and US$300,000, respectively.

Indirect use values were also calculated. Data were available to estimate the Buff Bay/Pencar water supply at a value of between US$22.3 -25.3 million per year. The potential benefit from carbon sequestration is approximately US$33 million.

Based on focus group meetings and discussions with the Forestry Department, it has been decided that two main incentives will be targeted. The first is for establishment of nurseries to produce seedlings for planting and the second involves actual use of these seedlings in reforestation programmes. At present there is an FD nursery facility established in conjunction with the LFMC and with an estimated annual direct cost of J$750,000. The indirect cost of support services provided by the FD is estimated to be an equivalent amount per annum and the total, current annual cost is therefore estimated to be J$1.5 million or US$ 24,000.

The estimated annual direct costs of an existing FD reforestation programme for 8 ha is estimated to be J$750,000 and an indirect FD cost of managing this is put at J$250,000 per annum giving a total current annual cost of J$1million(US$ 16,000). It is further estimated that to be effective both the number of nurseries or size of the existing nursery would need to be expanded together with a similar increase in the reforestation area. An estimated 10 fold increase in nursery operations and reforestation would therefore cost an estimated J$15 million (US$0.24million) and J$10 million (US$0.16million), respectively, per annum or, in total, J$25 million or US$0.41million.

This total estimated annual cost would be the equivalent of between 0.47-0.5% of the total estimated value of the direct and indirect use values produced in 2004 by the BBPencar WMU. If we exclude carbon sequestration values, these percentages increase marginally to between 0.77-0.8 % of the estimated value.

The local forest management committees (LFMCs) have been targeted to be involved in the expansion of the incentives programme. To involve stakeholders in managing the watershed's forest reserves, two LFMCs – one in Pencar and one in Buff Bay – were launched in late 2000. One meaningful role for the LFMCs is in identifying opportunities to improve local livelihoods, and especially the livelihoods of the poor, through the sustainable use of resources within forest reserves. The LFMCs have become a channel of communication between the Forestry Department and local stakeholders that is valued by both. They have contributed to the FD's watershed management plan; suggested ways in which forest management can be improved through collaboration with stakeholders; identified opportunities for increasing the contribution of forest reserves to local development; and translated some of these into small but ambitious projects. They are also having some influence on national policy and the institutional culture of the Forestry Department.

The intention of incentives is to bring about changes in behaviour which have positive impacts on the ecosystem functions of water supply and quality, soil conservation, biodiversity conservations, etc. These can be captured in the following objectives of forest management via the use of incentives.

Executive Summary Table 5: Indicators of impacts of incentives

Objectives	Watershed functions which benefit
1. Maintain existing forest cover	Water quality and quantity, biodiversity, soil conservation, protection of infrastructure, settlement, agricultural land assets
2. Increase forest cover	As above
3. Maintain existing shade coffee production	As above
4. Increase shade coffee production	As above
5. Maintain existing sustainable timber extraction	As above
6. Expand sustainable timber extraction	As above
7. Maintain existing good agroforestry practices	As above
8. Expand good agroforestry practices	As above
9. Increase proper disposal of solid waste	Flood control
10. Increase proper use of chemicals in agriculture and forestry as well as sewage disposal	Water quality

Executive Summary Table 6: Valuation methodologies

Method	Applicable to	Description/importance	Constraints and limitations
Market price method	Direct use values, especially watershed products	The value is estimated from the price in commercial markets (law of supply and demand).	Market imperfections (subsidies, lack of transparency) and policy distort the market price.
Productivity method	For specific watershed goods and services: e.g. water, soils	Estimates the economic values for watershed products or services that contribute to the production of commercially marketed goods.	The methodology is straightforward and data requirements are limited but the method only works for some goods and services.
Travel cost method	Recreation and tourism	The recreational value of a site is estimated from the amount of money that people spend on reaching the site.	This method only gives an estimate. Overestimates are easily made as the site may not be the only reason for travelling to that area. This method also requires a lot of quantitative data.
Hedonic pricing method	Some aspects of indirect use and non-use values	This method is used when watershed values influence the price of marketed goods. Clean air, large surface of water, or aesthetic views will increase the price of houses or land.	This method only captures people's willingness to pay for perceived benefits. If people are not aware of the link between the environment attribute and the benefits to themselves, the value will not be reflected in the price. This method is very data intensive.
Contingent valuation method	Tourism and non-use values	This method asks people directly how much they would be willing to pay for specific environmental services. It is often the only way to estimate non-use values. It is also referred to as a 'stated preference method'.	There are various sources of possible bias in the interview techniques. There is also controversy over whether people would actually pay the amounts stated in the interviews. It is the most controversial of the non-market valuation methods but is one of the only ways to assign monetary values to non-use values of ecosystems that do not involve market purchases.
Damage cost avoided, replacement cost, or substitute cost methods	Indirect use values: e.g. avoided erosion, flood control	The value of flood control can be estimated from the damage if flooding would occur (damage cost avoided).	It is assumed that the costs of avoided damage, or substitutes, match the original benefit. But many external circumstances may change the value of the original expected benefit and the method may therefore lead to under- or over-estimates. Insurance companies are very interested in this method.
Benefit transfer method	For ecosystem services in general and recreational uses in particular	Estimates economic values by transferring existing benefit estimates from studies already completed for another location or context.	Often used when it is too expensive to conduct a new full economic valuation for a specific site. Can only be as accurate as the initial study. Extrapolation can only be done for sites with the same gross characteristics.

1. Introduction

This report is a product of an action learning research project to examine and test the use of markets and incentives to improve the quality and delivery of watershed services such as water production, soil erosion, landslide and flood control, and biodiversity protection, for the purpose of improving local livelihoods, especially for the poor. The project, called 'Who Pays for Water? Preparing for the use of market-based mechanisms to improve the contribution of watershed services to livelihoods in the Caribbean' is implemented by the Caribbean Natural Resources Institute.

The project focuses on five countries: Grenada, St.Vincent and the Grenadines, Jamaica, St. Lucia, and Trinidad and Tobago. Project activities include action learning projects in St. Lucia and Jamaica to:

- Value watershed services.
- Test the usefulness of markets and incentives to address critical watershed management issues.
- Establish an Action Learning Group to validate and critique project findings and results.
- Research the potential effects of water sector privatisation and of the incentive opportunities from the tourism sector for watershed protection services.
- Give training activities in land use and hydrology tools, to be used in valuation for environmental services.

Project research is carried out in collaboration with the Sustainable Economic Development Unit of the University of the West Indies, and the Forestry Departments in Jamaica, St. Lucia, Grenada, St. Vincent and the Grenadines, and Trinidad and Tobago.

'Who Pays for Water?' is the Caribbean component of a global project: 'Developing Markets for Watershed Protection Services and Improved Livelihoods', which is being implemented by the International Institute for Environment and Development with financial support from the United Kingdom Department for International Development. The initiative includes activities in India, Indonesia, South Africa, China and Bolivia in addition to the Caribbean.

The objectives of this report are as follows:

1. Valuation of watershed services within the Buff Bay/Pencar watershed.
2. Estimation of the costs of identified incentives for maintaining and enhancing these watershed services.
3. Development of methods and indicators for monitoring the impact of incentives on targeted watershed services and their impacts on livelihoods.

This report addresses these objectives in the following seven (7) chapters[2].

Chapter 2 provides a review of the main physical, hydrological, soil, and water quality characteristics and trends in the two watersheds.

[2] The authors wish to acknowledge the research assistance provided by Mrs. Adonna Jardine-Comrie (Chapter 3) and Ms. Deneal Walters (Chapter 5).

Chapter 3 provides a socio-economic profile of the Buff Bay/Pencar watershed.

Chapter 4 provides a review of the literature on valuation of watershed services as a necessary introduction to the actual valuation estimates which follow in chapters 5 and 6.

Chapter 5 describes the main land uses and provides an estimate of the negative costs resulting from current land-use patterns.

Chapter 6 estimates the direct and indirect use values within the watershed.

Chapter 7 reviews existing and proposed incentives and management tools for watershed protection in Jamaica. This chapter also estimates the costs of targeted incentives and outlines indicators for monitoring impacts of incentives.

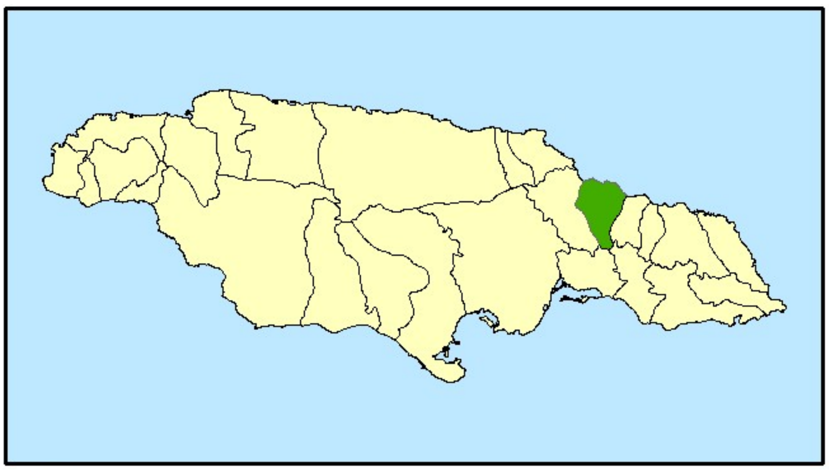
Finally, Chapter 8 provides a profile of the local forest management committees (LFMCs) as central, identified stakeholders for implementation of incentives.

2. Physical, hydrological, soil, and water quality characteristics and trends in the Buff Bay/Pencar watershed

2.1 Physical profile

The Buff Bay/Pencar Watershed Management Unit (WMU) is located in the north-eastern portion of the island, straddling the boundary between the parishes of Portland and St. Mary (Figure 1). The watershed covers approximately 20,258 hectares (Forestry Department 2001a). The watershed rises from sea level to 1,600 metres at Silver Hill Peak in the Blue Mountain Range and includes the main coastal towns of Annotto Bay and Buff Bay (Figure 2).

Figure 1: Location of Buff Bay/Pencar watershed (Source: digital images from the Forestry Department 2004)

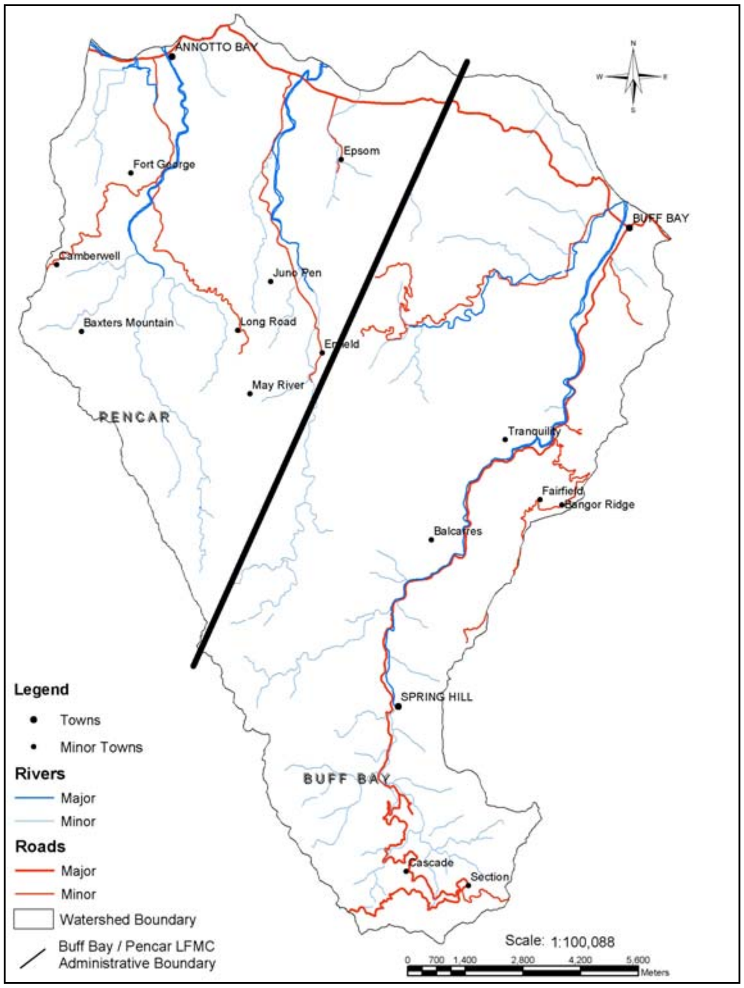


The watershed is comprised of very steep slopes, narrow ridges, numerous gullies, and many streams, which have confluence with one of the four rivers draining the watershed. The Buff Bay/Pencar watershed is characterised by 4 main drainage systems based on the major rivers (Buff Bay, White, Dry, and Pencar), and 2 smaller rivers (the Little Spanish River and the Enchanted River).

	Area (%)		Area (%)
Buff Bay sub-watershed		Pencar sub-watershed	
Buff Bay River	35.2	Pencar River	25.2
White River	17.9	Dry River	21.7

These primary river channels are supported by approximately 257 miles of tributaries, some of which are intermittent and gullies. The Buff Bay, White, and Pencar Rivers are used extensively to supply potable water to the adjacent communities and the coastal towns of Annotto Bay and Buff Bay. These rivers run from the northern reaches of the Blue Mountains, at heights of greater than 2,000m, down to the coastal towns of Annotto Bay on the Pencar River side and Buff Bay on the Buff Bay River side (Figure 2 below).

Figure 2: Buff Bay/Pencar watershed (Source: digital images from the Forestry Department 2004)



The mountainous terrain restricts the Buff Bay sub-watershed to a fairly narrow valley, which encompasses an approximate area of 7,131 ha and stretches 24.2 km. The sub-watershed is the wettest in the island. The land has mainly steep slopes, which are quite fragile and prone to erosions. With regard to the Pencar sub-watershed, it is estimated that one-third of this sub-watershed has slopes greater than 26º in tremendously long inclines Therefore, the removal of vegetation from these slopes results in severe erosion and desiccation. The uplands are very steep and highly erodable, and although the topography is not farmer-friendly, it is here that the greatest concentration of small-scale agriculture is to be found. In these areas were also found the greatest evidence of improper cropping of the land, such as slash-and-burn agriculture and loose rearing of livestock.

Natural conditions (steep slopes, heavy rainfall with high intensity, and soils that are highly erodable) in the Buff Bay/Pencar watershed make the hillsides particularly vulnerable to serious soil erosion and increased flood runoff on unprotected land. The different types of land use in the watershed area have exacerbated these natural vulnerabilities. The most critical issue related to type of land use in the watershed is the degradation of natural forests (Limbird, Cunningham and Scott 1993).

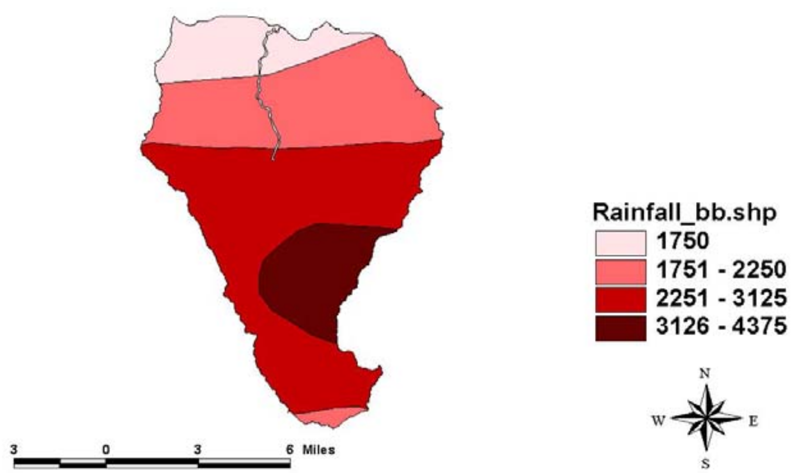
On the steeper landscapes of the upper basins of the watershed, loss of protective forest cover initiates a sequence of events that can have devastating effects on the immediate slopes, the adjacent lowlands, and even on the offshore reefs to the north. For example, there is a real landslide danger to settlements in the watershed. The vulnerability exists especially in villages of the upper basin of the watershed where homes can be located on sides of very steep slopes (Limbird et al. 1993). There are also problems with stream erosion and flooding.

2.2 Hydrological profile

2.2.1 Rainfall

Rainfall data was obtained from an examination of a rainfall map for the Watershed Management Unit. As indicated in Figure 3, the rainfall rates range from a low of 1,750 mm to a high of 4,375 mm.[3]

Figure 3: Rainfall distribution in the Buff Bay Pencar WMU



2.2.2 Temperature

Current information on temperature for the area is not yet available. The Climate Branch of the Meteorological Office has indicated that the station at the College of Agriculture Science and Education (CASE) in Buff Bay collects temperature data but this data has not yet been analysed and collated. However, Limbird et al. (1993) conducted a land use study of the Watershed Management Unit (WMU) and in the discussion on temperature indicated that variations in the Buff Bay/Pencar WMU tend to be similar to those in other areas in Jamaica in that the lower lands tend to be hot and the mountains cool. A general decrease of temperature of the order of 0.06 ^{o}C is expected for each 100 metres in elevation. Thus, 1,500m peaks may be nearly 10 ^{o}C cooler than the coast.

Seasonal variations in temperature are less than day-to-night variations. Limbird et al. (1993) further indicated that the night temperature near the ground in the mountains could be up to 6.0 degrees lower than standard air temperature in open herbaceous vegetation. Records show that within the montane forest of 1,500 metres, the mean monthly temperature varies

[3] The calculation of the average rainfall was done by multiplying the mean rainfall for each segment of the map by the area to which it applied and then dividing the sum of the result by the total area. The results showed that the average rainfall for the watershed management unit is 2,502.60 mm /yr.

from 18.5- 20.5 ^{o}C, while the night minimums range from 8.5-10 ^{o}C depending on the month. The daytime maximum ranges from 21.5-24 ^{o}C. Extremes in temperature are reduced even at the higher elevations by marine influences.

2.2.3 Surface water runoff and yield

Of the four main rivers in the WMU, an inventory of the water resources of Jamaica carried out in 1988 calculated surface water yields for only the Buff Bay, Dry, and Pencar rivers. An updated inventory is presently being undertaken but this document will not be available until about May 2005.

Information from the 1988 inventory indicates that the upper two-thirds of the Buff Bay River catchment are made up of basement rocks with low permeability. Average annual flow between 1955 and 1980 was put at 123.4 mm^3, the 30 year mean rainfall upstream of the stream-flow gauge at Tranquility is 3, 575 mm, and the river's reliable yield was determined to be 22.9 mm^3/ year.

The Dry and Pencar rivers were assessed to have a reliable surface water yield of 26.8 mm^3/ year. The surface runoff from the basement aquiclude catchment was estimated to average 168.8 mm^3/ year. Both streams are perennial only in their upper reaches and lose flow to the alluvium and limestone aquifers as they approach the coast. The hydrological profile for the area is summarised in Table 1.

Table 1: Hydrologic profile of the Buff Bay/Pencar WMU (Source: National Water Resources Development Master Plan 1988)

Hydrological profile	Buff Bay / Pencar WMU
Average annual rainfall (mm/yr)	2,502.60
Evapo-transpiration (mm)*	1,576
Surface water average annual yield (mm^3/yr) [1]	292.2
Surface water reliable yield (mm^3/yr) [2]	49.7

* This figure corresponds to the average annual evapo-transpiration rate from the Buff Bay and Aqualta Vale stations as given in the Tecsult International and Forestry and Soil Conservation Department, Ministry of Agriculture 2004 report.

[1] and [2] Sum of average annual yield of the Buff Bay, Pencar and Dry rivers.

2.3 Soil profile

The Rural Physical Planning Unit indicated that a full soil profile for the Buff Bay/Pencar Watershed Management Unit did not exist. However, from the soil maps provided, information about soil types, texture, mineralogy, and the parent material from which the soil originated, was obtained. Information on drainage and moisture conditions was obtained from the Jamaican Ministry of Agriculture CRIES Project and USAID (1982). No information was available on the presence of surface stone and rock outcrop, nor on the evidence of erosion and human influence, which would have been needed to complete the soil profile of the area.

Soils in the south-eastern section of the watershed, that is, in the upper regions of the Buff Bay sub-watershed, are classified as Halls Delight channery clay and Halls Delight association. These soils are found on slopes ranging from 20 to 35 degrees. They tend to be fairly shallow with shale being found at depths of 12 to 24 inches, have rapid internal drainage systems, and a high erosion hazard. The main soil found in this area, Halls Delight channery clay is usually low in both nitrogen and phosphorus. These soils are a function of the geological materials from which they were formed, which are fairly impermeable rocks. The rapid internal drainage therefore means that water moves through these soils very quickly; however, the impermeable nature of the rocks beneath means that very little infiltration into the subsurface takes place (very little ground water storage) and therefore surface runoff would be significantly greater than ground water replenishment.

The high erosion hazard associated with these soils and the steep slopes in the area suggests that forest cover is very important in preventing land degradation. This therefore means that this area is not suitable for agriculture crops that would require the clearing of lands and the establishment of monoculture farms. Extensive road construction, a necessary part of the infrastructure for export agriculture, would also not be recommended. Incidentally, coffee farming is extensively carried out in this region, with large areas being cleared of trees. Agroforestry as a farming strategy, with other crops being planted between trees, would seem to be the best option for this part of the watershed. Road construction and the construction of houses would also have to be carefully carried out to prevent landslides and soil erosion.

On the south-western side, stretching from the upper to the middle regions of the watershed, there is a varying mixture of Valda and Cuffy Gully soils. This area of the watershed is also characterised by steep slopes with the internal drainage being very rapid and the moisture supplying capacity of the soil being low or very low. The erosion hazards associated with these soils are also high and the soils tend to be low in nitrogen and, in the case of Valda, phosphorus as well. The characteristics of the soils in this region of the watershed are very similar to those in the south-eastern region. Shifting agriculture for the planting of food crops is very common and the practice of clean weeding agricultural fields accelerates the rate of soil erosion. Tree cover and soil conservation practices would therefore be critical to land management. Agroforestry, as well as conservation of the natural forest, would be more desirable than monoculture farming systems.

In the north-eastern region, stretching from the middle to the coastal areas, and corresponding with the lower regions of the Buff Bay and White River sub-watersheds, the soils are more diverse than in other portions. The dominant texture of most of the soils here is clay and the soils are therefore characterised by slow internal drainage and high moisture supplying capacity. According to local classifications, the most abundant soil in this area is a combination of Carron Hall and Wait-a-bit. These soils are found in the middle to lower regions of the watershed but not in the immediate coastal areas. In areas close to the coast, Agualta stony sandy loam and Agulata sandy loam soils are present, together with Fontebelle and Crane. These soils have rapid internal drainage and slight erosion hazards. The natural fertility of the Fontebelle and Agualta soils tend to be high. This would indicate that this area is more suitable for farming, however urban development constantly competes for land space. Proper land-use planning is therefore necessary to ensure the most efficient and productive use of the available lands.

In the north west, that is in the lower regions of the Pencar River, the most common soil types are Belfield clay and Belfield association. The internal drainage of these soils tends to be moderate and the moisture supplying capacity moderate to high while the erosion hazard tends to be moderate. This would suggest that with proper soil conservation methods these areas can be successfully used for farming.

In the lower regions of the Dry River, which falls in the north north-western portion of the watershed, the most common soils are Agualta sandy loam, Water Valley silty clay, Bonnygate stony loam, and Killancholly clay. These have moderate to very rapid internal drainage, and except for Bonnygate, slight to moderate erosion hazard.

2.3.1 Sedimentation flow

The sedimentation loads of rivers are not routinely monitored in Jamaica. About 3 years of data are available for the Hope River and a sedimentation budget (model) was recently undertaken for the Rio Minho and Yallahs Rivers. The raw data for the Hope River study could not be obtained but a detailed discussion of the results is given in a later section of this report.[4] The data for the Yallahs River were also being compiled but no indication of the time this process was expected to take could be obtained. No sedimentation data has been collected for the rivers in the Buff Bay/Pencar WMU.

2.4 Water quality profile

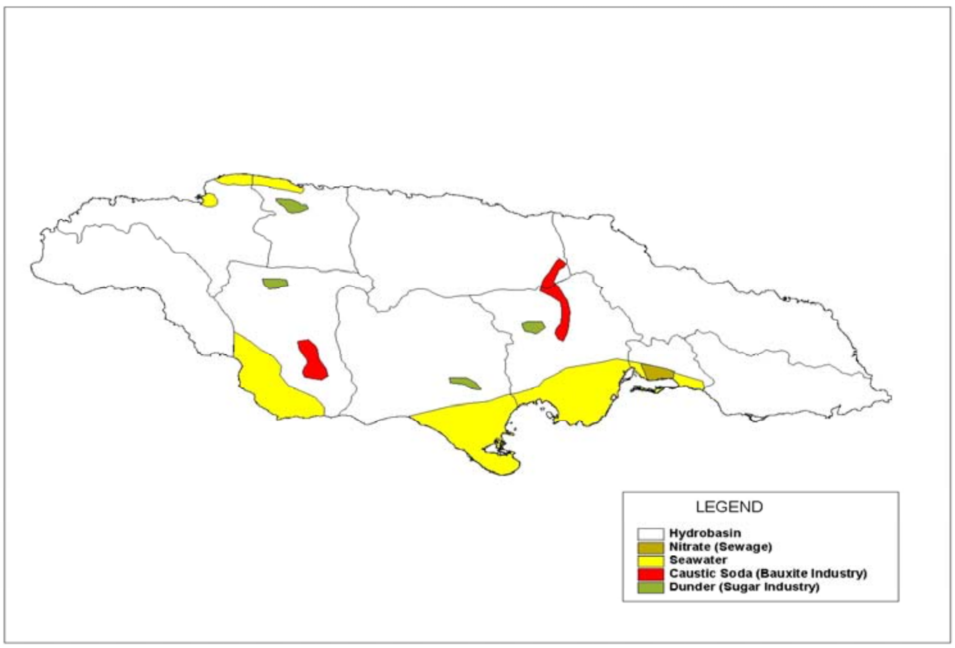


Figure 4: Jamaica groundwater pollution

Unlike some other areas in Jamaica, the groundwater resources in the Buff Bay/Pencar WMU have not been subjected to any major contamination (Figure 4 above). However, surface water continues to be the main source of potable water in this part of Jamaica.

Surface water quality in the WMU is monitored by two different agencies: the Water Resources Authority (WRA) and the National Environment and Planning Agency (NEPA). The WRA conducted water quality monitoring in the Pencar River in 1988 and 1989 and then again in 2003 and 2004. This data is present in Table 2 (below).

[4] The data for the Rio Minho River and the resulting model was done as part of an M. Phil research project sponsored by the Environmental Foundation of Jamaica (EFJ) in collaboration with the University of the West Indies, Mona and the Mines and Geology Department of the Ministry of Land and the Environment in Jamaica. The student has indicated that he is in the process of writing up the dissertation and so access to the data was restricted. It was indicated that the 'write-up' should be completed by May.

Table 2: Water quality of the Pencar River (Source: Water Resources Authority, Water Quality Database)

	Pencar River at Fort George									Pencar River at train line, Annotto Bay	
Date	**4/25/88**	**4/26/88**	**8/27/88**	**8/28/88**	**2/21/89**	**2/22/89**	**3/20/89**	**5/28/03**	**3/9/04**	**5/28/03**	**9/3/04**
Basin	Blue Mountain North										
Parish	Portland										
Metric East	274347.00									274620.00	
Metric North	176615.00									179707.00	
Temp									28.2/27.9		24.8/24.4
Conductivity micromhos/cm or microS/cm	290	300	310	310	250	259	259	292	28	322	352
pH [-]	8.38	8.42	8.6	8.68				7.78	8.2	7.79	8.03
Colour Hazen	5	5	5	5		<5	<5				
Turbidity NTU	0.45	8.63	1	0.59	1.4	0.5	1.2				
TDS [mg/l]	171	155	154	168				184		190	
TSS [mg/l]								8		2	0
COD [mg/l]								0		375	
BOD [mg/l]								0	0.45	0.5	2.2
Hardness [mgCaCO3/l]	110	114	114	114							
Alkalinity [mgCaCO3/l]	107	107	107	109							
Calcium [mg/l]	37	37	36	36							
Magnesium [mg/l]	4.4	5.3	5.8	5.8							
Potassium [mg/l]	0.96	0.95	1.24	1.04							
Sodium [mg/l]	10.5	10.5	10.5	10.5							
Total iron [mg/l]	0.011	0.011	0.02	0.02							
Bicarbonate [mg/l]	99	99	99	101							
Chloride [mg/l]	7.1	7.5	7.3	7.3	8	8.05	8				
Phosphate [mg/l]	0.08	0.08	0.1	0.08				0.23	0.14	0.21	0.16
Sulphate [mg/l]	16	16	18	18				13		13	25
Nitrate [mg/L]	0.00	0.00	0.20	0.20				<0.76	<0.76	0.88	1.32
Diss. oxygen [mg/L]									7.82		6.33
SAR	0.43	0.42	0.42	0.42							

When compared to the Jamaican national ambient water quality standard for fresh water (Table 3), the water quality in the Pencar River sample taken at Fort George can be considered to be fairly good with the readings for conductivity, pH, total dissolved oxygen (TDS), biological oxygen demand (BOD), chloride, phosphates, and nitrates tending to be within acceptable levels. The water was, however, found to have higher than acceptable levels of hardness, magnesium, potassium, sodium, and sulphates.

Table 3: Jamaica's national ambient water quality standards (freshwater) (Source: National Environment and Planning Agency website)

Parameter	Measured as	Standard range	Unit
Calcium	(Ca)	40.00-101.0	mg/L
Chloride	(Cl^-)	5.00- 20.0	mg/L
Magnesium	(Mg^{2+})	3.60- 27.0	mg/L
Nitrate	(NO_3^-)	0.10- 7.5	mg/L
Phosphate	(PO_4^{3-})	0.01 - 0.8	mg/L
PH	(-)	7.00- 8.4	-
Potassium	(K^+)	0.74- 5.0	mg/L
Silica	($Si0_4$ or Si_2^+)	5.00- 39.0	mg/L
Sodium	(Na^+)	4.50- 12.0	mg/L
Sulphate	(SO_4^{2-})	3.00- 10.0	mg/L
Hardness	($CaCO_3$)	127.00-381.0	mg/L (as $CaC0_3$)
Biochemical oxygen demand		0.80- 1.7	mg/L
Conductivity		150.00-600	Φμχ/Σ
Total dissolved solids		120.00-300	mg/L

As indicated in Table 2, a wide range of parameters was measured in 1988/89. However, in 2003 and 2004, only conductivity, pH, TDS, total suspended solids (TSS), chemical oxygen demand (COD), BOD, phosphates, sulphates, nitrates, and dissolved oxygen were examined. Tests were carried out on most of the parameters only once between 2003 and 2004, therefore it is difficult to compare the water quality over this period. However, a look at the results from the 1988/89 samples and those of 2003/2004 reveals that there has been some increase in the levels of TDS, phosphates, and nitrates indicating possible contamination of the river by fertilizers used in farming. It can be expected that fertilizers high in phosphates and nitrates will be heavily used in the upper regions of the Pencar sub-watershed since the soils in this region are naturally low in nitrogen and phosphorus.

There were no samples taken at the Annotto Bay train line in 1988 or 1989; however a comparison of the 2003 and 2004 samples indicates increasing levels of BOD – which is a symptom of organic pollution – as well as increasing levels of sulphates and nitrates. The levels of BOD and sulphates were above the ambient water quality standards in the 2004 samples. These results would also point to the possible impact of farming activities in the Pencar sub-watershed.

The NEPA (formally the Natural Resources and Conservation Authority) conducted water quality monitoring for the Buff Bay River over the period 1992 to 2003. This data is presented in Table 4.

Table 4: Water quality in the Buff Bay River (Source: National Environmental Planning Agency Laboratory 2005)

	Nitrate	**BOD**	**Faecal coliform**	**TSS**	**TDS**	**pH**	**Sulphate**	**Phosphate**	**Total alkalinity**
Date	mg/L	mg/L	MPN/100 ml	mg/L	mg/L		mg/L	mg/L	mg/L
12-Mar-92	0.083	0.3							
30-Apr-92	0.022	0.2				8.70			132.0
4-Jun-92	1.110	3.1							
9-Jul-92	0.021					8.67			168.0
7-Sep-92	0.056	1.3							
8-Oct-92	0.364	0.6							
26-Jun-93	0.123					9.17			
9-Mar-93	0.504	0.9				8.44			
22-Jul-93	0.031	1.1				8.76			
24-Sep-93									
10-Nov-93	0.250	2.3				8.10			
7-Jun-94		0.1		15.8	159	8.70			146.3
19-Oct-94	0.050	0.6		12.0	256	8.80			206.0
10-Mar-95	0.250	0.5		<10	187	8.70		0.050	172
11-Jul-95	0.010	3.2		6.4	716	9.85		<0.02	78.9
29-Aug-96	0.080	0.6	<10	285		8.98	32	<0.02	
14-May-97	0.050	0.9				8.82		0.230	
12-Nov-97	0.030	0.80					49	0.330	
20-Nov-98	0.440	1.0		<10	244	8.86	20	0.050	
22-Jun-02	0.192	1.36		<10	224	7.90	16	0.055	
16-Jan-03	0.430	0.58	350	<10	234	7.76	10	0.009	
12-Jun-03	0.320	1.61	220	<10		7.92	11	0.018	

Fewer parameters were measured in the Buff Bay samples compared to those from the Pencar River. The data presented in Table 4, when compared to that in Table 3, also indicates that the water quality in the Buff Bay River is generally good. All parameters, except ‘sulphates’ and ‘faecal coliform’, were found to be within acceptable levels for the ambient water quality of fresh water. However, as was the case with the Pencar River, there was a trend of increasing levels of nitrates and faecal coliform in the river. The former could be indicative of increasing farming activities in the upper watershed and particularly the increasing use of fertilizers high in nitrates, while the latter would indicate contamination of the river directly or indirectly by sewage effluents as a result of the establishment of human settlements.

No data could be obtained for the Dry and White Rivers, or for the coastal areas. The lack of water chemistry for the White River is particularly worrying since this river is used extensively for potable water supplied to areas of the parish of St. Mary.

2.5 Impacts of deforestation

According to data from the National Resources Conservation Authority (NRCA 1997), most of the Buff Bay/Pencar watershed is moderately degraded with a small portion having been severely degraded. In the Buff Bay/Pencar WMU, the impacts of deforestation on water flow, soil flow, and water quality have not been specifically studied. However, Michael White and Ivan Lowe, as part of an integrated watershed management investment programme, conducted a diagnostic study for the Ministry of Agriculture in 1996/97 assessing the impacts of deforestation on water availability, flooding, and erosion in five selected watersheds in Jamaica. The watersheds included in the study were: the Hope River, Rio Cobre, Rio Minho, Cabarita River and Great River.

The impact of deforestation on water yields was gauged by the identification of statistical trends in stream flow and rainfall depth over a 25 – 40 year period. Data on the minimum daily discharge of the river and the persistence of the annual low flow period were subjected to statistical testing for homogeneity, randomness, independence, and trend. When a trend was identified in the stream flow, annual rainfall depth in the respective watershed was also subjected to the same statistical tests, with the aim of isolating its possible role in influencing the trend observed.

To assess the impact of deforestation on flooding, the annual maximum daily discharge for the main rivers was subjected to the same statistical testing for homogeneity, randomness, independence, and trend. The results of the study contradict what is generally found in the literature and are discussed in more details in the sub-sections below.

2.5.1 The impact of deforestation on water production and quality

The Buff Bay/Pencar WMU provides a significant resource for water supply in the region (ORM-Tecsult 2001). About two-thirds of the upper areas of the watershed is volcanic/shale in origin and thus has relatively low permeability. Therefore, in this watershed, rainfall is the primary source of water, which flows as surface water mainly in rivers and streams. The four rivers in Buff Bay/Pencar watershed (Buff Bay, White, Dry, and Pencar rivers) provide significant water resources for water supply in the region. All four of the main rivers supply potable water to the adjacent communities, and to the coastal communities of Annotto Bay and Buff Bay. These rivers also serve domestic and stock watering uses in the watershed, as well as irrigation for bananas in Pencar and are used for swimming and food supply. The annual yield, which is estimated as the long-term mean flow, is 1,250-4,000 million cubic feet (MCF) per year along these rivers (ORM-Tecsult 2001).

Water from the rivers is utilised mainly for domestic and agricultural purposes. The watershed is in the portion of Jamaica that has the highest rainfall averages island-wide. As such, most of the watershed has ten months per year of dependable rainfall for agriculture (Scott et al. 1994). Some short dry spells are experienced in the summer months, but these do not have severe consequences for farming or the supply of domestic water. Irrigation and drainage are used by the St. Mary Banana Estate according to seasonal variations in rainfall. At the national level, the domestic water demand is estimated at between 15 cubic metres per year per capita (rural area) to 100 cubic metres per year per capita (urban area) (FD 2001). The domestic sector (island-wide) uses about 27% of total water consumed. With a population of 23,748 individuals, the domestic water consumption per year in the Buff Bay/Pencar WMU is a fraction of the potential annual yield.

The poor quality of the water has also been mentioned as being a problem in certain areas at certain times of the year. According to field officers working in the area – Rural Agricultural Development Agency (RADA) and NGOs – the improper and extensive use of pesticides, herbicides, and fertilizers by coffee producers in some parts of the watershed is affecting the surrounding communities (FD/TFT 2000). Although the problem of water pollution seems to be localised, there is a genuine concern about the long-term effect of the extensive use of chemicals in the upper part of the Buff Bay River and on the quality of the water for the town of Buff Bay.

A. The impact on water yields

The literature spoke of a general perception that trees attract rain and therefore forest preservation is a way of increasing precipitation. Lee (1980) pointed out that this perception is perhaps linked to the fact that higher precipitation generally characterises forested areas. However, the FAO (2003) *State of the World's Forest* report cautioned that the exact nature of the relationship between forest, atmospheric moisture, and water yields is still subject to much controversy. On a global scale, some are of the opinion that the impact of deforestation on precipitation would not be significant, with Lee (1980) concluding that on a global scale deforestation would result in a 1 to 2 percent decrease in precipitation. Brooks et al. 1997 pointed out that even in regions where precipitation is driven by internal circulation patterns, such as is the case in the Amazon, complete deforestation would only reduce precipitation by less than 20 percent.

The effect of deforestation on local precipitation in an area has been shown to be quite different from what was predicted as the global impact. Some types of forest, particularly cloud forest (i.e. temperate forest in coastal areas or tropical forest in montane areas where fog or low cloud conditions are common), are known to intercept fog or low clouds thereby adding moisture to the local area that would have otherwise remained in the atmosphere. Bruijnzeel and Proctor (1993) reported that for cloud forest the ratio of horizontal precipitation to annual rainfall fell between 4 and 85% while average horizontal precipitation varied between 0.2mm and 4mm per day. Annual stream flow for these forests was also shown to be higher than for other tropical forests.

More than 100 experiments carried out worldwide have demonstrated that stream flow is increased by tropical forest removal (FAO 2003; Bosch and Hewlett 1982), the exact magnitude of the change being subject to climatic conditions and the type of forest. The results in general showed that forest removal increased annual water yields by 60 to 650 mm (FAO 2003), while Asia and Kohl (1983) demonstrated that in a paired watershed study in sub-tropical Taiwan, the clear cutting and skyline logging of the forest resulted in a stream flow increase of 68% in the first year with a 108% increase in the dry season.

The diagnostic study in the Jamaican watersheds misguidedly started out on the premise that deforestation decreased stream flow. The results revealed that there was no statistically significant trend either of decreasing low flows or increase in the persistence of low flow for the Hope River, Rio Minho and Cabarita River. White and Lowe (1996/97) therefore concluded that the results implied that any changes that had occurred in the upper and middle watersheds of these rivers over a 26 to 40 year period had a negligible (if any) impact on surface water yield.

The results indicated a trend of diminishing flows for the Rio Cobre. However analysis of rainfall depth indicated that there was no declining trend in rainfall – which led to the conclusion that other reasons such as the increasing consumption abstraction ($<$1000 m^3/d in 1968 to 32,700 m^3/d by the mid 1970s) from the upper Rio Cobre limestone aquifer could be the contributing factor to the decrease in the Rio Cobre flow. The results for the Great River, on the other hand, revealed a statistically significant trend of deceasing dry season flow as well as a trend in decreasing rainfall depth. However, the latter trend was assumed to be part of a low frequency oscillation known to affect natural phenomena.

ORM-Tecsult (2001) in their discussion on the impact of deforestation on stream-flow in the Buff Bay/Pencar WMU, pointed out that stream flow depends on the difference between precipitation and losses such as vegetation interception (I), transpiration (T) and evaporation (E). If we assume that rainfall does not significantly vary with differences in forest cover, the important causative factors in stream flow rates would be I, T, and E.

In forested regions, I and T are concurrently increased whilst the evaporation is decreased as compared against the denuded areas that have bare soils. Therefore it is the balance between the changes in E that will determine how the stream flow is affected by changes in vegetation. Stream flow includes both surface runoff and water that infiltrates and contributes to the subsurface flow. Since Buff Bay/Pencar WMU belongs to a geological formation having low permeability, it is likely that deforestation and denudation would increase the surface runoff more rapidly than the ground water flow. Consequently we can expect the increased runoff to further raise the height of the floodwaters and the frequency of occurrences.

However, Tersult International (2001), by taking into account a natural deforestation rate of 0.1% per annum (Evelyn and Camirand 2000) and assuming that deforestation rates in the watershed were the same, concluded that deforestation may not significantly influence the water regulation in the Buff Bay/Pencar WMU.

Forest cover becomes an important influence in maintaining stream flow during the dry season since dry season flow depends on subsurface flows (base flow) whose source is infiltration. Forest cover increases soil permeability – and consequently the infiltration rate – as it decreases surface runoff. Denudation results in high flood potential and possibly lower minimum flow. Therefore when the forest cover is intact and adequate minimum stream flow is increased, the disparity between maximum and minimum flow could give some indication of the extent of the disturbance and degradation of the forest.

B. The impact on water quality

Forested watersheds discharge water with an exceptionally high quality. This is because forests have the ability to efficiently cycle nutrients and chemicals and decrease sediment export. This reduces pollutants such as phosphorus and some heavy metals. The lower rates of rainfall runoff also reduce the load of all nutrients and pollutants entering water bodies. The report *Water Resources Assessment of Jamaica* associates deforestation with larger peak discharge, and hence flooding, as well as increased sediment loads – which it noted impacts on coral reefs.

No studies were found providing empirical evidence of the effect of forest on water quality in Jamaica or the Caribbean. However, the results of work reported by Echavarria and Lochman (1999) points to the fact that well-managed forested catchments above reservoirs can result in minimal requirements for water treatment. The report from their work indicated that US $1 billion spent to improve the New York City watershed over a ten-year period could save an outlay of US $ 4 billion to $6 billion for construction of new water treatment facilities.

In the Buff Bay/Pencar watershed, the increases in landslides and soil erosion that result from forest removal for the establishment of agriculture farms can be expected to impact on water quality as fertilizers and pesticides used on farms are expected to enter water bodies as a result of landslides and soil erosion. The increasing levels of sulphates, nitrates, and phosphates in the Buff Bay and Pencar Rivers can be taken as some indication of the impact of deforestation on water quality.

2.5.2 The impact on sedimentation

Of all the land use types, the lowest levels of sediments are exported from watersheds with healthy forests (Brooks et al. 1997). Thus, forests are considered to be important in reducing levels of downstream sedimentation. As such, Larson and Alberton (1984) recommended reforestation to reverse a threefold increase in sedimentation in the Alhajuda reservoir in Panama after the clearing of 18.2% of the watershed. However, the lack of studies on the benefits of forest cover in reservoir protection has led to scepticism and claims such as that of Kaimowitz (2000) that the benefits are overstated. Rosgen (1994) and Tabacchi et al. (2000) concluded that downstream sediment delivery is affected both by changes in stream flow discharge from upland watershed, and by alterations in riparian areas along the stream banks. Degradation both of upland and riparian forests can therefore combine to increase sediment delivery downstream.

The diagnostic study in the five Jamaican watersheds was unable to analyse the effects of deforestation on sedimentation because of a lack of data. Data were only available for the Hope River (three years), and the researchers concluded that this was insufficient for the identification of a trend. However, Sheng (1983) in the *Forests of Jamaica* report, pointed to deforestation and the use of steep forestlands for cultivation as a major cause of severe soil erosion. Although the benefits of soil conservation methods were highlighted, the report indicated that for slopes of over 30 ^{0} these conservation methods were either cost-inhibitive or ineffective. Table 5 below provides the results of erosion figures obtained from cultivation on bare lands and moderate slopes from experimental plots. The results indicate that in general a layer of 7 inches would be eroded in 5 to 16.5 years.

The fact that the Hermitage Reservoir – located in the Wag Water River Watershed Management Unit and Blue Mountain North hydrological basin (the same basin as Buff Bay/Pencar WMU) – had lost 45% of its storage capacity only 36 years after its completion in 1927 was also highlighted by Sheng (1983) as an indication of the effect of deforestation on sedimentation rates.

Sheng (1983) also referred to an analysis done by Francis (1983) of stream flow from the 2,270 acre Rio Pedro watershed in 1981 (watershed management units have since been restructured and the names changed), which estimated a total of 9,970 tons of suspended sediments in the steam. Land use in that watershed was being allocated as follows: 284 (12.5%) in annual crops, 38% in forest, 39% in food forest, and 1.5% in grasslands. The sediment rate as calculated by this study was equivalent to 1,100 tons Km^{-2} yr^{-1}

In the absence of soil erosion data for the Buff Bay/Pencar WMU, ORM-Tecsult (2001) used data for the Hope River watershed since it had detailed information relating to sediment transport (three years of data mentioned above). It was pointed out that the concentration of the sediments carried in suspension for the Hope River watershed is a function of the rate of stream discharge. The analytic expression being:

$$Q_S = 0.1929\ Q_W^{\ 1.644}$$

QS = Sediment loads (t/day)

QW = Stream flow (cubic feet per second)

Table 5: Measured soil loss with no soil conservation. Treatments for experimental plots in Jamaica (Source: Sheng 1983)

	Soil loss		Remarks
	Weight	Depth	
	Tons ac-1 yr-1	in yr-1	
Cultivation of yams on 170 slope and wild-fence clay loam at Smithfield, Hanover	54.0	0.43	4-year average
Cultivation of bananas on 170 slope and wild-fence clay loam at Smithfield, Hanover	52.5	0.42	5-year average
Cultivation of yams and other root crops on 200 slope and Wait-a-bit clay at Olive River, Manchester	76.5	0.52	3-year average
Bare soils on moderate slope and Wait-a-bit clay soils at James Hill, Clarendon	206.0*	1.4	3-year average

The evidence that the removal of vegetation will increase surface runoff was thought to strongly suggest that erosion would likewise increase. The discussion highlighted the fact that the highest sediment load in water discharge occurred in 1988 (the year of Hurricane Gilbert) with 93,908 tons of soil material accounting for 83% of the year's total sediment yield. The mean annual sediment yield in the Hope River for the average 3-year period was an estimated 57,229 tons. The sediment delivery ratio was calculated to be 0.08 given an erosion rate of 163.5 tons/ha/yr (UNDP/UNEP/GOJ 1991).

Results for the Buff Bay/Pencar WMU can be expected to be similar or worst since as mentioned by Limbird et al. (1993) the gradient in this WMU changes from 5,250 feet (1,700m) to sea level in less then 14 miles (22km) by river channel. This indicates that stream flow would have very high velocity and therefore be capable of carrying large volumes of sediments, especially if the slopes and gullies are not protected by permanent cover. The possibility of this scenario increases given the highly erosive nature of the soil in the upper watershed and the susceptibility of the area to landslides. Over 90% of the watershed can be categorised as environmentally sensitive (Ahmad 1993, cited in Limbird et al. 1993) because of severe landslide hazards. Added to this, over 60% of the slopes greater than 40 degrees have had their natural vegetation periodically disturbed for the planting of cash crops and semi permanent crops.

Examples of the impact of landslides and increased sedimentation of the rivers in the watershed includes the 1993 experience when a large landslide in the Pencar River basin (on the Camberwell Road between Upper Fort George and Camberwell, as well as two very large landslides on Long Road and Cum See Road) made the roads impassable to vehicular traffic and deposited 4,500 tons of soil and debris into major tributaries through small streams and gullies. Landslides in Baxter Mountain and Pleasant Hill deposited 333 tons of soils and debris in the Pencar River. In May 1993, a tributary deposited 2,500 tons of limestone cobbles and other debris along its banks and into the main channel and floodplains of the White River.

2.5.3 The impact on flooding

When compared to other types of vegetation, forest contributes to greater soil stability and lower levels of storm flow. However, the extent to which forest can help prevent landslides, debris flow, and flooding has been shown to be dependent on the extremity of the rainfall event.

Experiments for example in Northern Minnesota in the United States have shown that rainfall-generated peak flows up to the 25-30 year recurrence interval (RI) increased when 70% of the forest cover on a small watershed was clear cut (Lu 1994; Verry 2000). Larger floods, for example with RI $>$ 100 years, were not affected by forest cover removal. These results supported Hewlet's (1982) claim that changes in forest cover have little or no effect on large floods in major streams. Importantly however, the 1.5-2 year RI peak flows more than doubled when forest cover was removed.

The results of the diagnostic study done in 1996/97 contradict these results since their analysis revealed that there was no significant trend of increasing magnitude or frequency of floods for the 40-year period 1955 to 1995. In the absence of such a trend it was concluded that changes in land use – including deforestation in the upper and middle watershed – had not produced any significant impact on flooding for the period in review.

The geological nature of most of the Buff Bay/Pencar watershed, especially the upper regions with their steep slopes, rapid soil internal drainage, and impermeable geological formation, would support high runoff during, and just after, rainstorms. Deforestation could be expected to compound the problem of torrents after rains and low flows at other times. The vulnerability of the area to landslides, and the fact that large amounts of sediments reduce the carrying capacity of the river channel, would therefore further precipitate the problem of flooding. For example, Limbird et al. (1993) pointed to the fact that even though the Pencar River has a fairly well-defined floodplain, there is active severe river erosion at Fort George and the entire town of Annotto Bay is vulnerable to the flooding capabilities of the river.

It also highlighted the disturbances in the upper basin of the Buff Bay River as having the effect of rearranging the drainage pattern in the area and contributing more water volume, sediment load, and pollutants to the river – which is used for potable water for settlements in the valley and for the town of Buff Bay.

River bank erosion on a tributary of the White River, which occurred in flood-causing rains in May 1993, was identified as contributing to severe downstream sediment deposition. The location of the Woodstock Housing Scheme in the centre of the lower White River floodplains – incidentally also unprotected from the lower Buff Bay River floodplain and therefore subject to flooding from both rivers – was highlighted as an indication of the vulnerability of human lives and property.

A similar situation exists for the Dry River, whose floodplains are only active during heavy rains. The slopes draining the Dry River are very steep thus there is rapid runoff wherever the natural forest has been removed or disturbed. Approximately 90% of the population in Enfield and Juno Pen reside in close proximity to the river and are vulnerable to flooding whenever the river is in spate.

3. Socio-economic profile of the Buff Bay/Pencar watershed

The valleys of the watershed are geographically separate and spread over the parishes of Portland and St. Mary, which account for 3.3 % and 4.6% respectively of the total population of Jamaica[5].

3.1 Demographics of the watershed

The total population of the watershed is 30,700 (Headley 2003) and is almost evenly distributed between the Buff Bay and Pencar sub-watersheds. The watershed area is predominantly rural, with 68% of its population living in the countryside (Scott et al. 1994). Except for a few bigger settlements, the population is generally scattered and there are many small villages stretching along the roads in both sub-watersheds and all valleys (Forestry Department 2000).

Although data on population growth and migration for the watershed is subsumed in parish totals, it can be assumed that the watershed sections of the parish are not unique. Since 1921, the population in the parishes of Portland and St. Mary have suffered severe out-migration, and has steadily declined relative to the population of the island as a whole.

Table 6: Socio-economic indicators (Sources: The Statistical Institute of Jamaica 2000; Headley 2003)

Social indicators	Portland	St. Mary	Buff Bay/Pencar watershed
Population	(2001) 80,205 (STATIN)	(2001) 111,466 (STATIN)	(2003) 30,700 (Headley)
Population density (sq. mile)	(1991) 93	(1991) 176	N/A*
No. of persons per dwelling	(1997) 3.74	(1997) 3.97	(1991) 4.7
Rate of functional illiteracy	(1994) 31.5%	(1994) 33.1%	N/A
Access to electricity	N/A	N/A	(1994) 60%**
Access to piped water	N/A	N/A	All settlements***
Public hospitals****	1 Type C	2 Type C	1 Type C
Rate of unemployment	(1997) 30%	(1997) 20.5%	N/A

* N/A= not available.
** This figure is probably close to 100 % today.
*** Not necessarily to houses.
**** Type C Hospital provides primary health care and includes a prenatal clinic

The majority of people in the valley are thirty years and under, and 62% of the population is female. Illiteracy is above the national average. In the Buff Bay sub-watershed young people tend to look outside the valley for employment as soon as they complete school. The opportunities for employment in the valley are few, and the majority of people are involved in farming – either on a full-time or part-time basis. In the Pencar sub-watershed, farmers are predominantly males over fifty years old (with the exception of Tinsbury, where many men under thirty were turning to carrot cultivation to make a living).

[5] The data for this section are drawn from the following sources unless otherwise stated: Mills (2001), Wright (2002), and the Forestry Department (2001a).

3.2 Land access and tenure

Approximately 75% of the land in the watershed is privately owned while the balance constitutes public land. With the exception of the large estates, such as the St. Mary Banana Estate, the most common tenure pattern in the watershed is private ownership by individuals and families. Land access is usually not a problem, except in the upper part of the watershed where most of the land is occupied by large coffee plantations. Exact information on land tenure is difficult to find; tenure can be in the form of ownership, leasehold (rent or lease), freehold, or occupation. Table 7 provides some further details on land tenure.

Table 7: Area by land tenure type in the Buff Bay/Pencar watershed (2000) (Source: Forestry Department 2001a)

Land tenure type	Area (ha)	%
Public land		
-Crown land	488	2.4
-FIDCO freehold	1,747	8.6
-Forest reserve (including park)	2,815	13.9
-National Water Commission land	47	0.2
Total public land	5,097	25.2
Private land		
-Own land	1,971	9.7
-Have title	3,942	19.5
-Family land	6,216	30.7
-Rented or leased	1,971	9.7
-Captured	1,061	5.2
Total private land	15,161	74.8
TOTAL	20,258	100.0

Based on available records, there were 7,443 parcels owned within the watershed in 1993 (Table 8). The great majority of parcels (6,053) were 5 acres or smaller in size. About 8% of these smaller parcels are lots facilitating housing schemes and are less than one-quarter acre in size.

Table 8: Land ownership in the Buff Bay/Pencar watershed (1993) (Source: Limbard et al.1993)

Categories of parcels	Number of parcels
0 to 5 acres	6,053
6 to 10 acres	986
11 to 20 acres	303
> 20 acres	101
TOTAL	7,433

At the other size extreme, there were only a few parcels (101) larger than 20 acres in size. Approximately 80% of this category is lands owned by the Commissioner of Lands and operated by different government agencies such as the Coffee Industry Board, Forestry Department, and St. Mary's Banana Estates Ltd. Large private owners account for the rest (Limbird et al. 1993).

Approximately 90% of the coffee and bananas presently being grown for export is on parcels larger than 5 acres. Approximately 80% of the fruit trees, other permanent crops, and mixed agroforestry, is grown on parcels less than 20 acres in size and in most cases the trees and permanent crops are adjoining dwellings. Export horticulture occupies one parcel in the Pencar sub-watershed (Limbird et al. 1993).

On the whole, land access is not a problem in the watershed, except in the upper part of the watershed. This is because most of this upper area is occupied by large coffee plantations or under Forest Reserve or National Park jurisdiction, thus very little land is left available for newcomers, and if any is available it is only at a high price[6] (Forestry Department 2001a).

3.3 Economic profile of the Buff Bay/Pencar watershed

Although there have been some important variations in the total production over the years, the region remains highly agricultural, and farming is the main source of income for a majority (40%) of family units, with wage labour following second at 20 % (Scott et al. 1994). About 50% of the farms in the two parishes (Portland and St. Mary) have their major earning coming from export crops that occupy more than 50% of their agricultural land (FD/TFT, 2002). These figures are even higher for the Buff Bay sub-watershed. Here the production of an export crop of such high value as Blue Mountain coffee represents the major source of income for a majority of farmers. The economy of the area is dominated by two of the main forms of agricultural activity – bananas on the St. Mary coast and coffee in the Upper Buff Bay Valley in Portland. There is also substantial traditional Jamaican mixed farming agroforestry on the hills in between.

3.3.1 Coffee production

The coffee farms in the Buff Bay valley are a recent development. In the 1980s, urban upper-middle class professionals from Kingston and St. Andrew established coffee farms on land leased from the Coffee Industry Development Company (CIDCO). The land was originally vested in the Forest Industry Development Company (FIDCO) for afforestation purposes but was subsequently leased to private individuals. As the land is at a high altitude and in the designated Blue Mountain coffee area, the coffee fetches premium prices and growing it is a lucrative business.

Coffee is grown using beans of two main species of coffee – *Coffea arabica* (Arabica variety of coffee) and *Coffea canephora* (Robusta variety). These two varieties make up 95% of the world's production of coffee beans. Arabica coffee accounts for 70% of production, and the best known strains are 'Typica' and 'Bourbon.' Coffee is mainly traded on the New York and London futures (terminal) markets, which exert a strong influence on world coffee prices (which are notoriously volatile).

At January 9, 2004, coffee was selling for approximately 56.16 U.S. cents/lb on the world market, up from 52.65 U.S. cents/lb on December 30 2003. Jamaican Blue Mountain is the world's most celebrated, most expensive, and most controversial coffee. Blue Mountain coffee prices have ranged from US$9-13/lb of green beans since the late 1980s, and are currently ranging between US$10-11/lb. These high prices can be accounted for by the fact that Jamaican Blue Mountain coffee is not traded on the world market. The majority of the Blue Mountain coffee produced, approximately 85%, goes to Japan, and the remaining 15% is sold to the US, Canada, UK, and CARICOM. This coffee, when harvested, is not processed – ninety percent of the world's Jamaican Blue Mountain coffee trade is in green (un-roasted) coffee beans. The beans are exported (largely to Japan) where they are used for blending and the flavouring of a wide range of confectionary products.

[6] The price of land under coffee varies from J$1,111,972 (US$18,229) to J$1,729,735 (US$28,356) per ha, as compared to the price of other types of land. E.g. the price of land under timber is J$30,887.5 (US$5,105) per ha.

Data from the Coffee Industry Board show that overall Jamaican coffee production has multiplied tenfold in the last 20 years, increasing from 40,000 to 400,000 boxes in 2000. In Jamaica, the total acreage planted in coffee is approximately 10,522 ha distributed among some 23,000 farmers. About half of the land is in the area of the Blue Mountains that has been gazetted since 1857 as a special coffee production area, and which extends over the parishes of Portland, St. Andrew, and St. Thomas. Coffee produced in this area is labelled 'Blue Mountain' (see Table 9).

The parish of Portland accounts for roughly 43% of the Blue Mountain coffee production, with total acreage of 1,802 ha under coffee cultivation, distributed among approximately 1,942 farmers. Around two-thirds of the coffee grown in Portland is produced in the Buff Bay sub-watershed (see Table 9).[7]

Table 9: Distribution of coffee production in hectares (1999) (Sources: Forestry Department/Trees for Tomorrow Project, 2000; Forestry Department 2001a; and estimated data from the Coffee Industry Board)

Area	Hectares in coffee	Number of coffee farms
Jamaica	10,522	23,000
Blue Mountain area	4,856	6,000
Portland	1,802	1,942
Buff Bay sub-watershed	1,205	1,176
-Bangor Ridge	348	265
-Balcarres	229	270
-Tranquillity	175	199
-Spring Hill	382	316
-Cascade	72	127
Pencar sub-watershed	Data not available	Data not available

The coffee industry is administrated by the Coffee Industry Board (CIB), a statutory body of the Ministry of Agriculture. The CIB used to be the sole marketing agency for Jamaican coffee, as well as being responsible for regulation of the industry. However, since the deregulation of the market in 1980s, the CIB is no longer the sole purchaser of coffee. Still, it continues to be the major buying agent as well as the major processor for most coffee produced in Jamaica, purchasing approximately 75-80% of the Blue Mountain coffee and almost 100% of lowland coffee produced in Jamaica.

In the last two years, the CIB has separated its operations into a commercial arm and a regulatory arm. The commercial arm has been known since 2004 as the Walenford Coffee Company and deals with the buying and marketing of coffee abroad. The CIB now only consist of regulatory functions – mainly quality control.

The CIB also owns coffee farms in the Blue Mountain area, formerly managed mainly as demonstration plots and for research purposes. Since 2000, however, the entire acreage (1,620 ha) leased from the Forestry Department (FD) by the CIB has been sublet to farmers, and there are no farms currently managed by the CIB.

Initially, the local group of coffee farmers comprised relatively large-scale farmers. However in recent times, coffee farming has been extended on a substantial scale to small-scale farmers. The majority of these small- and large-scale farmers now report that coffee is their main crop and they grow far fewer other crops on their land than do their counterparts in the

[7] Data for the Buff Bay sub-watershed is taken to represent the entire Buff Bay/Pencar WMU as coffee production in the Pencar sub-watershed is negligible according to CIB sources.

agroforestry land-use area (Scott et al. 1994). Thus, shifts towards a small-scale farmer coffee monoculture are arising out of large-scale farmer coffee monoculture.

The largest numbers of coffee-producing farms are found in the Tranquillity, Bangor Ridge, and Cascade areas of Buff Bay (Table 9 above). In some communities, mostly in the Bangor Ridge and Cascade areas, labour on coffee farms is the main source of income for a majority of the families (FD/TFT 2002). At picking times, the labour utilised on coffee farms is about 15 people per acre. Coffee pickers are paid according to the number of boxes they fill (usually 2-3 boxes per day). In addition, many local people are employed as managers and workers on the coffee farms of the absentee landowners. Thus, coffee production alone accounts for a majority of occupations (producers and hired labour) and generates most of the income in the Buff Bay sub-watershed.

3.3.2 Banana production

The Pencar sub-watershed is dominated by banana production, which takes place on plantations in two main areas. The main production area is located on the floodplain of the lower Pencar River and on an adjacent coastal plain in the vicinity of Grays Inn and Fort George Halt. Most of this land has been converted to banana production since 1982 (Scott et al. 1994). The other site stands in the lower Dry River floodplain and extends eastward to the mouth of the Enchanted River. Virtually all the banana plantation land in this area was in sugar cane in 1982 (Scott et al. 1994).

Much of the banana in the watershed is owned and operated by the St. Mary's Banana Estates Ltd. It is the latest incarnation of one of the oldest and largest private banana companies in the island. The bananas are grown on 2 farms which are tended and reaped by a wage labour force organised into teams and who are paid a basic rate plus a bonus depending on performance, measured largely in quality and quantity of fruit. The workers on these farms, approximately 1,600 people, come from the surrounding hills of the eastern St. Mary section of the watershed in the hills overlooking Annotto Bay (FD/TFT 2000; Scott et al. 1994). For the communities living in or close to the coastal area, banana producers (the most important being the St. Mary's Banana Estates Ltd.) represent a major source of employment for men and women alike.

3.3.3 Mixed agroforestry

Although banana and coffee investments have the highest economic value in the watershed, they are not the most important economic activities for the labour force. Small-scale peasant farming is still the dominant activity in the area involving 40% of the labour force (Scott et al. 1994). Present land use dedicated to agroforestry systems in the Buff Bay/Pencar watershed is just over 5,000 ha (see Table 13). Here we have the traditional mixed farming of the Jamaican small-scale farmer producing a large variety of crops on small plots of primarily hillside land. In Portland, coffee has become the main crop and on the St. Mary side, banana is the main crop among small-scale farmers (20%), followed by carrots (19%), cocoa (11%), and plantain (10%) (Scott et al 1994).

3.3.4 Timber production

The latest available data (Scott et al. 1994) indicates that timber trees are grown by an average of 40% of the population in the upper watershed, mostly for immediate sale, although at least a quarter are also using the timber for construction purposes. Tradesmen, rather than sawmills, are the main buyers, with sawmills accounting for about a quarter of sales. The highest percentage of logging activity takes place in eastern St. Mary (the mixed agroforestry area), and much less takes place in Bangor Ridge and Mahoe, in the coffee monoculture area. While in many cases annual sales may be underestimated, it is clear that for some residents logging is a highly profitable business, with 4 out of 54 respondents in Scott et al.'s (1994) survey giving annual sales figures of J$170,000-J$400,000 per year.

Table 10: Annual timber sales* by respondents in survey area (1993) (Source: Scott, et al. 1994)

	Total	**Monoculture coffee**	**Agroforestry coffee**	**Mixed agroforestry**	**Agroforestry livestock**
% Respondents	8% (54)	1% (3)	7% (15)	15% (32)	5% (4)
Mean	$27,719	$5,667	$32,133	$24,527	$53,250
Range	$400-$400,000	$300-$10,000	$400-$400,000	$500-$180,000	$2,000-$155,000

* Although the question regarding annual timber sales was set in the context of timber trees grown or 'cared for', no assumption can be made as to where all the timber came from for these sales. These sales figures are quoted in Jamaican 1993 dollars.

The interest in obtaining timber trees is growing and the recent Agroforestry Survey (FD/TFT 2000) shows that farmers, mostly from Balcarres and Bangor Ridge, are planting timber trees on the uncultivated part of their farmland, sometimes in plantations of a hundred trees or more. Timber trees on the farm (whether planted by the farmer or not) are harvested and used to meet the needs of the family for poles, construction material, and other uses. Felling and cutting of trees on private land is usually contacted out. Overall, lumbering activities and charcoal production in the watershed are not done on a large scale and do not actually seem to be a threat to the forest (FD/TFT 2000). Nevertheless, the use of chainsaws is common and it is likely that their utilisation is not limited to land clearing.

3.3.5 Recreation/tourism

Recreation/tourism is point- or site-oriented rather than using large tracts of land, especially in this watershed. At present there are a few stopping points for bus tours and downhill bicycle riders in the Buff Bay River Basin, and there are trails in the watershed used by hikers to reach vistas or the higher mountains of the Grand Ridge of the Blue Mountains. Drive-through tours to see the high mountains and the 'Blue Mountain' coffee farms also represent an existing activity. None of these sites is being exploited by large numbers of visitors, nor are these sites being advertised widely as tourism destinations. However, two ongoing developments in the Portland parish capital, Port Antonio, and in the parish as a whole, may bode well for increased tourism revenues in the Buff Bay area.

The Port Authority of Jamaica (PAJ) has been implementing a number of development initiatives in Port Antonio over the past three years, in its continuing effort to make the town more attractive and to increase its appeal as a cruise ship and tourist destination. The Ken Wright Pier and Marina was the first leg of a comprehensive investment by the PAJ to transform Port Antonio into a major cruise ship and yachting destination. There is the potential for increased tourism traffic in the parish capital to spill over in other areas of the parish, especially the Buff Bay sub-watershed, which has already developed an eco-tourism activity, if only on a small scale.

In addition to the developments in Port Antonio, US$1.6 million is to be spent to help to reposition Portland parish as a 'green' tourism destination, and to make its tourism product more sustainable. It is expected that the development and certification of the parish as a 'green' destination will have positive spin-off effects for the economy of the Buff Bay sub-watershed.

3.4 Summary overview

Although major sources of income may differ from one area to the other within the watershed, a family has generally more than one means of making a living and in most cases, the marketing of farm products is combined with wage labour (seasonal or year-round) (FD/TFT 2000). Other sources of income are the different trades and jobs; tradespersons and the usual public service professionals – teachers, health workers, ministers of religion, lawyers – complete the social picture. Remittances from relatives working abroad, and old age pension or other retirement benefits, represent additional incomes for a few families. Furthermore, production for the internal food market, and wage labour on coffee and banana farms and other ancillary activities, provide the basis for a number of shops and other services in the two main towns.

4. Review of the general methodology of the economic valuation

Although other types of value are important, economic values are necessary in order to make economic choices involving tradeoffs in allocating resources. In terms of the valuation of environmental resources, the literature seeks to measure total economic value – which itself is made up of the following:

- Direct use values are those values derived directly from use by society.
- Indirect use values are those values derived from the indirect support and protection provided to economic activity and property by functions of nature, or regulatory environmental services.
- Non-use values are those values derived neither from current direct nor indirect use of the watershed.

Related to use values are 'option values', which can be direct or indirect, and arise because individuals value the option to use an environmental good or service in the future. A special category of option values is 'bequest values', which result from individuals placing a high value on the conservation of environmental goods and services for future generations to use. People may also gain satisfaction from the knowledge that certain environmental goods and services exist and therefore may be willing to pay for their continued existence. This component of the non-use value is known as the 'existence value'.

The total economic value (TEV) of an environmental good or service comprises use and/or non-use values and is captured in the following equation:

TEV = direct use values + indirect use values + non-use values

These categorisations facilitate the understanding of the origins of different values. Separating each component may not be as important as estimating them as accurately as possible. The TEV framework is therefore primarily a means of identifying different uses and services that a particular environmental good or service provides. This will help to ensure that all important values are considered in the valuation exercise.

4.1 The valuation of forest ecosystems

A 2001 publication of the Secretariat of the UN Convention on Biological Diversity sets out a useful categorisation of the economic values of, *inter alia*, tropical forests as captured below:

Table 11: Categorisations of economic values (Source: UNCBD 2001)

Direct use values	Timber Fuelwood Non-timber forest products such as: - Recreation/tourism - Research/education -Cultural/religious Genetic information Agricultural Pharmaceutical
Indirect use values	Watershed functions: -Soil conservation -Water supply -Water quality -Flood/storm protection -Fisheries protection Global climate: -Carbon storage -Carbon fixing Biodiversity Amenity (local)
Option values	
Existence values	
Land conversions values	Crops Grassland Agri-business Aquaculture Agroforestry

4.1.1 The economic assessment approach

There are essentially three types of issues or problems that arise in the economic valuation of tropical watersheds (IIED 1994). Corresponding to each of these is a specific economic assessment approach. These are:

1. Impact analysis – assessment of the external damages arising from a specific land use. This is most relevant in situations where a particular land-use option results in specific environmental impacts.

2. Comparative valuation – assessment of two or more alternative land-use options. This is the principal method used to evaluate alternative land-use options in the watershed.

3. Total valuation – assessment of the total economic contribution, or net benefit, of a particular land use or uses.

The total valuation approach is the most appropriate where a full accounting of the costs and benefits associated with a particular land-use option, or group of options, is required.

Thus, a full accounting of the total economic value (TEV) of any land-use option(s) involves the valuation of the net production or direct benefits, NB^D, plus (or minus) any net environmental impacts, NB^I, less any other user costs, C^U, resulting from watershed degradation associated with that land-use option (IIED 1994). Hence:

$$TEV = NB^D + NB^I - C^U$$

$$\text{where: } NB^D = B^D - C^D$$

$$NB^I = B^I - C^I$$

Total valuation as implied by the equation above is clearly data and research intensive. This is largely due to the difficulty in obtaining reasonable monetary estimates of non-marketed benefits, and especially external environmental impacts. Since most attempts at a total valuation of watersheds have difficulty in obtaining realistic estimates of net external environmental impacts, (NB^I), there tends to be a concentration instead on deducting a measure of user cost, (C^U), from the direct production or income benefits earned, (NB^D), (IIED 1994).

4.1.2 Valuation techniques

A wide range of valuation techniques is available to measure actual value of uses. Price-based valuation techniques are generally the first techniques considered. However, in the absence of market prices and/or where price distortions cannot be adequately allowed for, alternative valuation techniques may be employed. Table 12 summarises the most common quantitative evaluation methods used, their constraints and limitations.

A. Many goods and services from watersheds are traded, either in local markets or internationally including: wood products (timber and fuel); non-wood forest products (food and medicine); crops and livestock products; wildlife (meat and fish); and recreation. For those products that are commercially traded, prevailing market prices can be used to compare the costs and benefits of alternate land-use options. Price-based valuation includes the ‘market price method’ and the ‘productivity method’.

B. The surrogate market valuation approach uses information about a marketed product to infer the value of a related, non-marketed product. In developing countries, there have been few attempts to research the value of non-marketed goods (e.g. the market for recreation services, and land and labour markets) with these techniques (IIED 1994). These methodologies include the ‘hedonic pricing method’ and the ‘travel cost method’.

C. Price-based valuation and surrogate market techniques rely on preferences revealed in real markets. An alternative to relying on revealed preferences is to directly elicit consumer preferences by constructing markets. These methods are called ‘stated preference methods’, the most popular of which is the ‘contingent valuation method’ (CVM).

D. A final set of valuation techniques for non-marketed goods and services can be grouped together under the heading ‘cost-based valuation’. These techniques assess the costs of different measures that would ensure the maintenance of the benefits provided by the environmental good or service that is being valued. These cost estimates are then used as proxies for the unknown environmental benefits. These techniques include the ‘damage cost avoided’, ‘replacement cost’, and ‘substitute cost’ methods.

E. Also available is the ‘benefit transfer method’, which is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context. Benefit transfer is often used when it is too expensive and/or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. It is important to note that benefit transfers can only be as accurate as the initial study.

Table 12: Valuation methodologies

Method	Applicable to	Description/importance	Constraints and limitations
Market price method	Direct use values, especially watershed products	The value is estimated from the price in commercial markets (law of supply and demand).	Market imperfections (subsidies, lack of transparency) and policy distort the market price.
Productivity method	For specific watershed goods and services: e.g., water, soils	Estimates the economic values for watershed products or services that contribute to the production of commercially marketed goods.	The methodology is straightforward and data requirements are limited but the method only works for some goods and services.
Travel cost method	Recreation and tourism	The recreational value of a site is estimated from the amount of money that people spend on reaching the site.	This method only gives an estimate. Overestimates are easily made as the site may not be the only reason for travelling to that area. This method also requires a lot of quantitative data.
Hedonic pricing method	Some aspects of indirect use and non-use values	This method is used when watershed values influence the price of marketed goods. Clean air, large surface of water, or aesthetic views will increase the price of houses or land.	This method only captures people's willingness to pay for perceived benefits. If people are not aware of the link between the environment attribute and the benefits to themselves, the value will not be reflected in the price. This method is very data intensive.
Contingent valuation method	Tourism and non-use values	This method asks people directly how much they would be willing to pay for specific environmental services. It is often the only way to estimate non-use values. It is also referred to as a 'stated preference method'.	There are various sources of possible bias in the interview techniques. There is also controversy over whether people would actually pay the amounts stated in the interviews. It is the most controversial of the non-market valuation methods but is one of the only ways to assign monetary values to non-use values of ecosystems that do not involve market purchases.
Damage cost avoided, replacement cost, or substitute cost methods	Indirect use values: e.g. avoided erosion, flood control	The value of flood control can be estimated from the damage if flooding would occur (damage cost avoided).	It is assumed that the costs of avoided damage, or substitutes, match the original benefit. But many external circumstances may change the value of the original expected benefit and the method may therefore lead to under- or over-estimates. Insurance companies are very interested in this method.
Benefit transfer method	For ecosystem services in general and recreational uses in particular	Estimates economic values by transferring existing benefit estimates from studies already completed for another location or context.	Often used when it is too expensive to conduct a new full economic valuation for a specific site. Can only be as accurate as the initial study. Extrapolation can only be done for sites with the same gross characteristics.

In the following two chapters, this valuation literature is applied to the Buff Bay/Pencar watershed, beginning in Chapter 5 with the first type of economic assessment approach identified above (Impact analysis). Chapter 6 then provides an application for the valuation approach to the Buff Bay/Pencar watershed.

5. Main land uses in the Buff Bay/Pencar watershed and estimates of negative impacts

5.1 Present land use in the watershed[8]

Forest land cover types total 13,623 hectares (67.2%). The remaining 6,635 hectares (32.8%) are agricultural and other non-forest land cover types, of which 467 hectares show little or no human interference (grassland, herbaceous wetland, and water bodies). The majority (92%) of these non-forest land cover types are on private land.

By sub-watershed,[9] the montane closed broadleaf forest types are distributed as follows: Buff Bay River (37%); White River (25%); Dry River (27%), and Pencar River (11%). The pasture type is most prevalent in Pencar River (60%), and Dry River (27%). The coffee land cover type is dominant in Buff Bay River, while the banana cultivation (in terms of land cover) is split evenly between Pencar River and Dry River. Overall, the Pencar River and Dry River sub-watersheds are more cultivated than the other two sub-watersheds (Forestry Department 2001b).

Table 13: Area by land-use cover/use type (1999) (Source: Forestry Department 2001a)

Land cover types	Hectares	%
Bamboo	1,676	8.3
Modified closed broadleaf forest – upper montane	1,009	5.0
Modified closed broadleaf forest – lower montane	7,506	37.1
Forest plantation	1,537	7.6
Mangrove forest and riparian forest	130	0.6
Fruit tree gardens with food crops	1,751	8.6
Total forest land cover/use types	13,623	67.2
Banana plantation	530	2.6
Coffee plantation	553	2.7
Citrus plantation	161	0.8
Coconut plantation	229	1.1
Plantation – mixed	14	0.1
Fields – food crops	3,332	16.4
Fields – pasture, grassland, herbaceous wetland	1,126	5.6
Grassland	224	1.1
Buildings/infrastructure/ beaches	560	2.8
Clear cut and windfall	64	0.3
Water bodies	81	0.4
Total other land use cover/use types	6,635	32.8
TOTAL	20,258	100.0

The watershed is dominated by coffee production in its upper eastern end in the Buff Bay valley; by banana cultivation on the coast at the St. Mary end; and by traditional Jamaican mixed farming agroforestry on the hills in between. There is also a small ‘eco-tourism’ activity in operation and significant freelance logging by young farmers using Alaskan chain saws, especially on the eastern St. Mary side of the watershed.

[8] Data for this section is taken from the Forestry Department (2001b) unless otherwise stated.
[9] The Buff Bay and White Rivers cover the Buff Bay sub-watershed, and the Pencar and Dry Rivers cover the Pencar sub-watershed.

Natural forests are mostly found around the perimeter of the watershed at higher elevations. There are also important natural forests in the central portion of the watershed, especially along the Great Ridge. The upper reaches of the watershed include portions of the Blue and John Crow Mountains National Park, a forest reserve, but much of the forest outside the Park, especially on the Buff Bay side, has been converted to coffee plantations over the past twenty years. Between 1980 and 1990, more than 50% of the planted forests (stands of Caribbean pine and limited blue mahoe) in the watershed have been clear cut and leased to monoculture coffee growers (Scott et al. 1994). This acreage lies in the heart of the Blue Mountains and stretches across the top of the Buff Bay Valley and along the Bangor Ridge to its east.

5.1.1 Natural forest

This type of vegetation is restricted to small areas of lowland rainforest extending from sea level to 2,500 feet; small inaccessible areas of the lower montane rainforest; and the upper montane mist forest (which represents one of the few areas of untouched forests in Jamaica). The natural forests in all areas are characterised by high biodiversity and endemism. However, the forest in the upper regions of the watershed has been classified as being very rare and in urgent need of protection (Scott et al. 1994).

5.1.2 Ruinate lands

The greatest portion of the lands can be classified into this land-use group and are the result of the re-establishment of a woodland cover after forest lands – which had been previously cleared – were abandoned. A few grassland areas are found which are thought to be maintained by fires, while several places above 600 metres are covered by 'fernlands.' These areas are much less diverse than the areas covered by natural forest and the soils tend to be degraded.

5.1.3 Secondary forest

These areas result from the regeneration of forest on lands abandoned more that 100 years ago and are the most common type of forest in the watershed. The analysis of the twenty dominant tree species confirms that the forest in this watershed is very disturbed and relatively young (Forestry Department 2001a). The importance of Caribbean pine (the dominant species with $2.01m^2/ha$), together with trumpet tree (the sixth most dominant species with $0.83m^2/ha$), is a good indicator of the high degree of disturbance of the watershed's natural forestland (Forestry Department 2001a). Overall, the presence of rose apple, mango, teethe ache, African tulip, and breadfruit characterise the forest as mixed 'secondary forest' and 'agro-forest', particularly if we include the area of 8% in bamboo forest (mixed natural forest and bamboo) (Forestry Department 2001b).

5.1.4 Planted forest

There had been an active forest planting programme in the watershed between 1982 and 1993. Caribbean pine is usually the tree of choice. Some of the pine plantations have been leased to coffee farmers in the upper Buff Bay sub-watershed, which has resulted in the removal of the pine and the establishment of coffee farms.

5.1.6 Mangrove forest

This land-use type is found in the coastal areas between Annotto Bay and Buff Bay. However, the cutting of the mangrove plants for fuel and poles, as well as the clearing of the area for pasture, other agricultural use, and coastal urban development, continues to threaten its survival.

5.2 Dominance of agriculture

Although there have been some important variations in the total production over the years, the region remains highly agricultural, and farming is the main source of income for a majority (40%) of family units, with wage labour following second at 20% (Scott et al. 1994). About 50% of the farms in the two parishes (Portland and St. Mary) have their major earning coming from export crops that occupy more than 50% of their agricultural land (FD/TFT 2002). These figures are even higher for the Buff Bay sub-watershed, where the production of an export crop of such high value as Blue Mountain coffee represents the major source of income for a majority of farmers.

5.2.1 Monocultures

Banana and coffee are the two cash crops grown in monoculture plantations in the watershed. Banana is grown on the flood plains of the lower Pencar and Dry Rivers while coffee is grown on the eastern side of the Buff Bay River and in the upper Buff Bay River basin.

A. Coffee production. The parish of Portland accounts for roughly 43 percent of the Blue Mountain coffee production, and around two-thirds of this high value crop is produced in the Buff Bay sub-watershed (Table 14). The Pencar sub-watershed does not fall under the Blue Mountain gazetted area, hence coffee cultivation is less important in that area.

Table 14: Blue Mountain coffee production in 5 different areas of the Buff Bay watershed (Sources: CIB 1999; FD/TFT 2000)

Area	Hectares in coffee	No. of farmers	Average ha per farmer
Tranquility	175	199	0.88
Balcarres	229	270	0.85
Bangor Ridge	348	264	1.32
Shentamee/Spring Hill	382	316	1.21
Cascade	72	127	0.57
Total	1,205	1,176	1.02

B. Banana production has been concentrated on the outskirts of Annotto Bay since 1982, where 460 ha are under production, completely under the management of the St. Mary's Banana Estates Ltd.

5.2.2 Agroforestry

The middle and lower reaches of the watershed are dominated by mixed farming by small-scale farmers, and mixed agroforestry and mixed plantation crop combinations predominate throughout the watershed, with woody perennials (trees, shrubs, etc.) grown in association with herbaceous plants (crops, pastures). In some cases fruit trees are part of an agricultural production scheme that includes other crops such as coffee, mixed vegetables, and animal husbandry practices such as goat rearing or apiculture. In other cases, agroforestry is the dominant farm system with coffee, cocoa or pimento being the most significant tree/shrub crop.

Compared to Buff Bay, Pencar has a greater diversity of fruit tree crops, banana, plantain, and coconut. The agroforesty baseline survey completed by the Forestry Department and

Trees for Tomorrow (2000) identifies seven groups of perennial tree crops and annual crops cultivated in the watershed. These are:

- Traditional crops (coffee, cocoa, coconut).
- Banana and plantain.
- Fruits.
- Legumes (red peas, gungo peas).
- Vegetables.
- Roots and tubers.
- Timber trees.

In addition, in some areas of the watershed coffee, pimento, cocoa, livestock, and a mixture of fruit trees and permanent crops are grown in conjunction with trees as part of the agriculture production scheme.

5.3 Urban coastal development

This type of land use is restricted to the coastal areas between Annotto Bay and Buff Bay. Six housing schemes can also be found in this area.

5.4 Transportation/roads

Roads have been constructed throughout the watershed irrespective of the terrain, thus exacerbating the problem of landslides. Roads constructed to harvest timber (and more recently to plant coffee) in the upper basin of the Buff Bay River especially, are on steep slopes with steep grades – which contributes to concentration of water flow and to both overloading slopes and undercutting them (Limbird et al. 1993). In addition, the majority of roads in mountainous terrain are poorly constructed and maintained, and their drainage systems lack adequate capacity to evacuate the flood discharge safely.

5.5 Recreation and tourism

This type of land use is not very prevalent in the watershed at present although a few hiking trails exist and there also are a few stopping points for bus tours in the Buff Bay River basin.

5.6 Land-use change: 1991/2 to 1999

A study of the land-use changes in the watershed was done using 1991-92 colour photographs and 1999 black and white photographs (Forestry Department 2001a). The watershed underwent land cover changes between 1991 and 1999 that affected a total of 908 hectares over the eight-year period, equivalent to 6.7% of the forested area and 4.5% of the total watershed area. In terms of forest cover, the net balance is positive (+ .026%/yr). An area of 139 hectares of forest was lost to another land cover but over the same period, 419 hectares shifted from other land cover types to forest types. This change was mainly attributable to an increase in Caribbean pine plantations (or areas regenerated) and an abandonment of cultivated fields (coffee or food crops) (Forestry Department 2001a).

5.6.1 Impacts of deforestation on water yield

A 2000 report by Kiet developed a model for the BBPencar WMU which estimates, as shown below, that percentage increases in deforestation would increase water yields and hence the prospect of negative downstream effects.

Extent of deforestation (%)	Increase of water yield (%)
0	0
10	11-13
30	30-37
50	48-58
70	65-79

(Source: Kiet 2000)

5.7 Estimated negative impacts of land-use patterns

Already there is evidence of negative impacts of flooding. However, the available data are collected at the level of the parish. A profile of the parishes of Portland and St. Mary – within which the watershed under study is located – follows. Reasonable inferences are then made as to the likely contribution of the Buff Bay/Pencar watershed both to the problems of flooding and in terms of sharing the burden of the impacts of flooding. This impact on flooding is informed by both data availability and the focus of the project on indirect use values such as soil conservation.

Table 15: Overview of the parishes of Portland and St. Mary

	Portland	St. Mary
Location	North-eastern tip of Jamaica	North-eastern section of Jamaica
Area	8,144 sq. km	657.86 sq. km
Main land use	Agriculture (coffee, subsistence farming)	Agriculture (banana, mixed crops) and fast growing tourism sector
Major rivers	Rio Grande, Swift, Buff Bay and Spanish rivers	Wag Water River, Dry River, Rio Nueva and White River
Minor rivers	Daniels, Little Spanish, Priestmans and Back rivers	
Watershed units	Five (5) watershed units comprising the Buff Bay River, Spanish River, Swift River, Rio Grande, and Drivers River	Four (4) watershed units comprising the Pencar River, Rio Nuevo River, Wag Water River, and Oracabessa and Pagee Rivers

5.7.1 Costing the negative impacts of land-use patterns

The impacts of flooding have been of substantial cost to the parishes of Portland and St. Mary. Houses have been washed away and some have been completely destroyed – especially those located near to river banks and near gullies, or located on low lying areas near the coast (alluvial fans). Roads have been badly eroded by flood waters, and soil erosions have caused landslides in some areas, blocking roadways and making them impassable both to vehicular traffic and by foot. Some areas become totally inaccessible, hindering the free movement of people in and out of communities. Bridges have been washed away with the result that people then use the riverbed as means of transportation, which can be dangerous.

It is, however, very difficult to ascertain the impact of these costs specifically on the Buff Bay/Pencar watershed due to the lack of readily available documentation of the cost to individual communities (houses, property, roads, etc.) located in the two sub-watersheds. Most information regarding the costs of flooding concerns the parish in general and is usually estimated, and hence does not always reflect the true costs of the total damages incurred.

5.8 Quantitative estimates of impacts of flooding

Tables 16 and 17 (below) provide some quantitative estimates, for example, of flooding impacts in terms of damage to roads, bridges, houses and property damaged, agricultural output lost, and human beings injured or killed over the past 10 years. The available information, as noted earlier, is not specific to the area of the Buff Bay/Pencar watershed, but for the parishes in general. Some judgement is then exercised in terms of the causal factors in these two sub-watersheds which contribute to the overall parish-level impacts.

Table 16: Cost of flood damages in Portland 1993 –2002[10] (Source: ODPEM Flood Archives 2004; Ministry of Finance and Planning 2004)

Year	Type of damage	Costs (J$)	Costs (US$)	Fx rate (J$ to US$1)
1993	Crops, livestock, agriculture	12,097,600	36,2637	33.36
1994	-	-	-	33.41
1995	Not detailed	14,942,000	37,336	40.02
1996	Not detailed	37,996,000	1,083,433	35.07
1997	-	-	-	36.51
1998	Infrastructure, including housing	339,320,000	8,864,158	38.28
1999	-	--	-	42.14
2000	Not detailed	17,200,000	376, 532	45.68
2001	-	-	-	47.61
2002	Coffee	261,700,000	465,327	56.24

In 1993, between April 14-24, flood rains caused damage to agricultural enterprises in the parishes of Portland and St. Mary, with the estimate of total damage to crops, livestock, and infrastructure being J$12,097,600 million in Portland and J$7,707,055 million in St. Mary (ODPEM). Damages due to floods in Portland and St. Mary between November 24-28, 1995 were J$12.482 million and J$1.372 million, respectively. Between December 24-27, 1995, flood damages were estimated to be J$2.460 million in Portland and J$11.154 million in St. Mary (ODPEM).

In January 1996, flooding occurred in Portland. The estimate of damage was J$18.536 million (ODPEM). In January 1998 heavy rains caused extensive flooding in Portland. Houses were destroyed and many families were dislocated. Fives lives were lost. The cost of damages incurred was J$339,320,000. In December 1998 heavy rain pelted the parish of Portland. The western end of the parish leading to Buff Bay, the Balcarroe Main Road, was completely blocked due to a landslide. The White River overflowed its banks. The bridge in Mullet Hall was washed away and residents were marooned in the village. Cattle were also washed away (ODPEM).

In March 1999 heavy rains over a two-day period caused extensive flooding in St. Mary. One community was completely isolated. In the Bellfield area a vehicle was washed away by floodwaters. Bottom Bay, Annotto Bay, Haughton River, Green Castle, and Lewis Store were flooded out. In Bellfield two people died after attempting to cross a fording. The Fort George Bridge in Annotto Bay collapsed and the communities of Long Road, Pleasant Hill, Fort George and Baxters Mountain were completely cut off. The damages sustained were approximately J$ 15,000,000, (ODPEM). The November 3, 2001, flood damage in Portland was estimated as J$150 million (The Gleaner November 3, 2001).

[10] The J$ and US$ estimates are rounded to the nearest $million and $100,000 respectively for this, and the following table.

Table 17: Costs of flood damages in St. Mary 1993 – 2003 (Source: ODPEM Flood Archives 2004)

Year	Type of damage	Costs (J$)	Costs (US$)	Fx rate (J$ to US$1)
1993	Crops, livestock agriculture	7,707,055	231,026	33.36
1994	-	-		33.41
1995	Not detailed	12,526,000	312,993	40.02
1996	-	-	-	35.07
1997	-	-	-	36.51
1998	Not detailed	20,000	522	38.28
1999	Not detailed	15,000,000	355,956	42.14

In 2001, a preliminary estimate for repairs to parish council roads damaged by flooding in Annotto Bay, Enfield and Fort George, St. Mary was JA $ 17.2 million, (The Gleaner, November 10, 2001).

In 2002– due to heavy rains in the months of May, June, September and October – millions of dollars worth of damage was done to the agricultural sector. The coffee sub-sector was hardest hit with reported crop losses of 135,800 boxes of coffee valued at J$261.7 million. Of this total, 135,000 boxes were Blue Mountain coffee, 80,000 of which were lost in the Portland area in 2002. In St. Mary 5,000 mature banana plants were destroyed at the St. Mary's Banana and Eastern Banana Estates (The Gleaner January 13, 2003).

5.9 Addressing the issue of flooding in the Buff Bay/Pencar watershed

To address the issue of flooding in the Buff Bay/Pencar watershed area there is the need to:

- Identify the causes of flooding.
- Determine the vulnerability caused by hazards.
- Identify the needs and priorities of the areas/communities.
- Empower the people to take better care of their environment and by extension protect their livelihoods.

In the Buff Bay /Pencar watershed, there has been a move to address issues of disaster vulnerability by increasing public awareness campaigns and implementing zoning so as to ensure that some areas are not used. A plant nursery has also been established in Pencar, where seedlings are sold for replanting and for reforestation. In Buff Bay there is the development of eco-tourism and plans to open a forestry museum.

There are two local forestry management committees (LFMCs) that work with the citizens of the Buff Bay/Pencar watershed to co-manage the watershed and the forested areas. There is also a hazard map for the Buff Bay/Pencar watershed that shows the communities that are prone to flooding. In Buff Bay the communities of Kildare, Hart Hill, and Windsor are prone to flooding. In Pencar, the communities of Dover, Golden Grove, Fort Stewart, Fort George, Fory Land Pen, Grays Inn, Lady Have Pen, and Iter Boreale are prone to flooding.

6. Estimated total economic value of the ecosystem services provided by the Buff Bay/Pencar watershed

As noted in the review of valuation methodology given in Chapter 4, a range of direct and indirect use values, together with option and existence values, can be identified and potential measured. The universal problem in making such estimates is the availability of data.[11]

From the data currently available, it is possible to estimate the direct use values of several of the marketed goods that are produced in the Buff Bay/Pencar watershed: coffee, banana, timber, agroforesty, and tourism/recreation, and the indirect use values of several non-marketed goods: water supply and carbon storage. Table 18 is a modified version of the fuller table of forms of forest value illustrated in Chapter 4. It provides a summary of the estimated values and this is followed by some supporting explanation in the rest of this chapter (and in Appendix 2).

In summary, the Buff Bay/Pencar watershed is estimated to have a direct and indirect use value of between some US$83- US$87 million in 2004. Excluding carbon storage, this value is estimated to be between some US$50- US$54 million. Elaboration follows below as to the methodologies used to derive these estimates with further details provided in Appendix 2.

Table 18: Total estimated direct use values (US$, 2004 prices)

Type of value	US$ million
1. Direct use values:	27.2
a. Coffee	13.5
b. Bananas	6.5
c. Timber	3.2
d. Agroforestry	4.0
e. Recreation/tourism	0.03
2. Indirect use values	55.3-59.3
a. Water supply	22.3-26.3
b. Water quality	n.e.
c. Soil conservation	n.e.
d. Biodiversity protection	n.e.
e. Carbon storage	33.0
Total	US$82.5 – 86.5 million
Total (without carbon storage)	(US49.5 – 53.5 million)

n.e. =not estimated

6.1 Direct use values

6.1.1 Coffee[12]

The parish of Portland accounts for roughly 43% of Jamaican Blue Mountain coffee production, (with total acreage of 1,802 ha under Blue Mountain coffee cultivation), and around two-thirds of this coffee grown in Portland is produced in the Buff Bay sub-

[11] See CBD (2001); Adger et al. (2002); and Pearce (2001) for further details on the estimation challenge in terms of forest values.
[12] Data for this section was garnered from personal communication with Mr. Gusland McCook, Regional Advisory Services.

watershed. Of the 10,522 ha in coffee in 1999, 1,205 ha are cultivated in Blue Mountain coffee in the Buff Bay/Pencar watershed. It can therefore be extrapolated that 11.45% (1,205/10,522 ha) of the coffee produced each year is cultivated in the Buff Bay/Pencar watershed. With a market value of US$630 per box of green beans in 2004 (see Appendix 2 for further details), the total gross income earned from Blue Mountain coffee production in the Buff Bay/Pencar watershed in 2004 is estimated to be US$16.8 million.[13]

6.1.2 Bananas

The St. Mary's Banana Estates Ltd (SMBE) is the major banana producer in the watershed and cultivates on approximately 648 hectares of land, 460 hectares of which are in the Buff Bay/Pencar watershed. The SMBE accounts for 81% of the total cultivation in this area. From the data above, we can calculate that there are 568 ha under banana cultivation (460 ha is 81%) in the BB/P watershed, 530 ha of which are strictly under banana cultivation, the remainder being classified as being under 'mixed cultivation' or as 'food crops'.'

Yields of the SMBE are reported to be 12.94 tons per acre (equivalent to 31.96 tons per hectare), with yields in the smaller farm categories ranging from 0.94 to 3.52 tons per acre (2.32 to 8.69 tons per hectare). At an average price per ton of US$528.02 (see Appendix 2 for further details), total gross income derived from banana production in the watershed is estimated at US$ 8.1 million in 2004.

6.1.3 Timber

A biophysical inventory was conducted of the Buff Bay/Pencar watershed between 1998 and 1999, covering the natural forests and forest plantations (Forestry Department 2001a). Approximately half of the species identified (185 species or 47%) were assigned to 8 tree species groups, with the remaining 210 species being assigned to the group 'other'.

- Groups 1- 3 (92 species): native timber species, quality classes 1-3
- Group 4 (5 species): exotic coniferous species
- Group 5 (6 species): exotic non-coniferous species
- Group 6 (27 species): fruit tree species
- Group 7 (20 species): medicinal tree species
- Group 8 (35 species): threatened tree species
- Group 9 (210 species): other species

The total standing volume of forested land in the watershed is approximately 2 million cubic metres and the potential gross merchantable volume (all species, diameter at base height, DBH>=10cm) represents an average of 68.6% of the total volume (Forestry Department 2001a). However, in the present timber market, only the species classed in tree species groups 1, 2, and 3 found in the watershed are effectively merchantable or commercial (Forestry Department 2001a). The main commercially harvested species are blue mahoe, cedar, santa maria, sweetwood, bullet, and plantation species such as Caribbean pine.

[13] Net benefits (after production costs) are assumed to be 80% of gross income for coffee and, as well, for banana and timber.

For the biophysical inventory in the watershed, two volume types have been calculated for tree species with DBH>=10cm: total volume and gross merchantable volume. The gross merchantable volume immediately extractable and marketable from natural forests is only 10% of the standing total volume (DBH>=10cm) in the watershed, and only a portion of this volume is environmentally and economically sustainable for harvesting. The potential gross merchantable volume of potentially ready-to-harvest native timber (quality classes 1, 2, and 3) for DBH>=30cm available from the montane forest type is 239,000m^3 (of which Caribbean pine forest types represent 118,000m^3).

If we transform this into board feet, 1.27 million bd. ft. of Caribbean pine and 5.38 million bd. ft. of other native species (tree species groups 1, 2, and 3) are available annually to be cut. At an average selling price of J$18.00 per bd. ft. for Caribbean pine and J$40.30 per bd. ft. on average for the other native species, the annual direct use value from timber in the watershed is estimated at some US$4 million 2004.

6.1.4 Mixed agroforestry

Although banana and coffee investments have the highest economic value in the watershed, they are not the most important economic activities for the labour force. Small-scale peasant farming is still the dominant activity in the area involving 40% of the labour force (Scott et al. 1994). In the absence of adequate data, however, the direct use value was assumed to be US$4 million.

6.1.5 Recreation/tourism

Recreation/tourism is point-or site-oriented rather than utilising large tracts of land, especially in this watershed. The Buff Bay Valley Road has excellent potential as a scenic route and the road has recently been improved. Tourists use this panoramic road for travel between Kingston, Newcastle, Hardware Gap (Blue Mountain Ridge), and the North Coast. At present, there are a few stopping points for bus tours and downhill bicycle riders in the Buff Bay River basin, and there are trails in the watershed used by hikers to reach vistas or the higher mountains of the Grand Ridge of the Blue Mountains. Thus, the drive-through tours to see the high mountains and the ‘Blue Mountain’ coffee farms represent not so much a ‘land use’ as an activity at present (Scott et al. 1994). The road is also used by bicycle tour agencies. None of these sites is being exploited by large numbers of visitors, nor are these sites being advertised widely as tourism destinations.

The Buff Bay/Pencar watershed includes a part of the Blue and John Crow Mountains National Park, as well as the Holywell Recreational Area. The Blue and John Crow Mountains National Park covers 78,509 ha and represents 6% of Jamaica‘s total landmass. The country's largest national park, it includes Blue Mountain Peak, the Clydesdale Forest Reserve, and Holywell Recreational Park.

The Holywell Recreational Area is open to visitors and offers nature trails, camping grounds, and cabins. (Appendix 2 provides an overview of the income of the Holywell and the Portland Gap recreational areas, along with visitor statistics). Again, in the absence of specific data, a very conservative estimate of US$30,000 was assumed in terms of WTP (willingness to pay).

The future offers more potential opportunities for recreation/tourism land use, especially the use of existing trials and forestry roads for hiking and bird watching, and of river rapids and pools for water sport activities (Limbird et al. 1993). If these forms of recreation become established, then there will be a need to develop parking areas at trail heads, picnic grounds near water activities, and similar tourism-orientated enterprises.

6.2 Indirect use values

6.2.1 Water supply

Annual water supply from the Pencar River and Buff Bay/White Rivers is estimated at some 7 billion gallons. At a per gallon charge of between J$219 and J$259, and assuming an average annual consumption of 6,000 gallons per household, and further assuming a net 70% availability, the Buff Bay/Pencar watershed water supply is estimated at a value of between US$17.5 million and US$20.3 million (See Appendix 2 for further details).

6.2.2 Water quality

No estimate was made of the water quality indirect value in the absence of adequate data.

6.2.3 Carbon storage

One functional value of forests is estimated here: the value of forests in their role in the global carbon cycle. The appropriate economic technique in estimating TEV is that of the loss in economic activity avoided by conserving the resource. In the case of the global carbon cycle, this means the avoidance cost or postponement of the impact of future climate change through the build-up of atmospheric greenhouse gases (Adger et al. 2002).

Several studies now exist attempting to put a money value on global warming damages. Using these studies, Adger et al. (2002) estimated that the value of avoiding the carbon fluxes associated with changing land use range from about US$650 to US$43,400 (equivalent to US$20 to US$100 per ha per year), depending on the forest type and the subsequent land use.

There are 13,623 ha of land in the Buff Bay/Pencar WMU that is under some type of forest cover (Table 13). Based on these estimates, the functional value (indirect use value) of carbon sequestration in the Buff Bay/Pencar WMU can be estimated to be some US$33 million. However, one needs to add two caveats. The first concerns the critique of the legitimacy of benefit transfer procedures from one tropical site to another.[14] Secondly, as both Pearce (2001) and Adger et al. (2002) also note, carbon storage is a benefit external to the economy itself and is extremely difficult to internalise although there is a fledgling carbon trading market already in existence.

6.2.4 Soil conservation

There is significant sunk investment in assets in the Buff Bay/Pencar watershed: agricultural, roads and other physical infrastructure, housing, and commercial/industrial enterprises. To this has been added the estimated value of agricultural land. Already there is evidence of these assets being impacted upon negatively through flooding (as detailed in Chapter 5). An estimate of US$23 million has been arrived at in terms of the current replacement value of these assets excluding agriculture and US$57 million when it is included. Table 19 provides a summary of these values, which is followed below by a description of the methods used to derive these estimates.

[14] See Adger et al. (2002), p.331 for a discussion on this.

Table 19: Estimated replacement cost for main assets in Buff Bay/Pencar watershed

Asset	Estimated replacement cost (US$ million)
1. Road infrastructure	12.0
2. Other physical infrastructure	5.0
3. Housing, commerce, industry	6.0
4. Agricultural land	34.0
Total (without agricultural land)	US$57.0 million ($23.7 million)

6.3 Estimating what is at risk

The value of some environmental services can be measured by estimating people's willingness to pay, or the cost of actions they are willing to take, to avoid the adverse effects that would occur if these services were discontinued, or to replace the lost services, or revive the services. Three very closely-related valuation technique methods have been proposed that are based on these considerations. These methods are:

1. Damage cost avoided method.
2. Replacement cost method.
3. Substitute cost method.

These methods are based on the assumption that, if people incur costs to avoid damages caused by lost environmental services, or to replace them in case they are lost, then those services must be worth at least what people paid to maintain or replace them.

Damage avoidance or replacement methods of valuation are best suited only to cases where damage avoidance or replacement expenditures have actually been, or will actually be, made. To give an example: road repairs/replacements have to be done every time there is a natural disaster such as a flood or landslide, both of which are prevalent in this watershed.

Although, as noted earlier, there are already signs of negative impacts of flooding on infrastructure and agriculture in the watershed, the existing forest cover still provides protection for such assets. Put differently, significant further deforestation will increase the risk potential for existing assets. The existing forest cover therefore provides benefits which can be seen as those of costs foregone from damage to infrastructure and agricultural land. Below, estimates are made of the current value of road infrastructure followed by that of other public infrastructure, and then settlement and agricultural land. In summary the aggregate, estimated value of assets at risk are placed at some US$57 million.

A. Estimated value of road infrastructure in the Buff Bay/Pencar watershed. Primary roads are estimated to cover 50.38 km in the watershed with secondary roads estimated at some 50 km[15]. The current replacement value for these roads is J$ 722.7607 million (US$11.8 million)[16].

B. Estimated value of other physical infrastructure (water, sewerage, telecommunications). In the absence of any readily available database, this is assumed to be roughly 40% of the replacement cost for roads, or some US$5 million.

[15] Mr. Morgan of the Trees for Tomorrow Project (FD) provided these estimates in January 2005, based on their data.
[16] Mrs. Hazel Facey-Jackson of the National Works Agency provided the estimate of the replacement costs per km of J$7.2 million per km based on the cost of repaving 56.8 km road between Papine and Buff Bay in 2001 (i.e. 50.38 km of primary roads + 50.22 km of secondary roads = 100.6 km x J$7.1845 million.

C. Estimated value of settlement and commercial assets.
Also in the absence of adequate, accurate data on these assets, the replacement cost for housing and commercial/industrial/agricultural infrastructure is assumed to be US$6 million.

D. Estimated value of agricultural land in the Buff Bay/Pencar watershed.
Many goods and services from the watershed are traded. For these products, prevailing market prices can be used to compare the costs and benefits of alternate land-use options. With the market price method, the value is estimated from the price in commercial markets. In this case, the value of the agricultural land in the Buff Bay/Pencar watershed is estimated based on the current going price for land under different crops.[17]

Table 20: Total estimated value of agricultural land in the Buff Bay/Pencar watershed

Land cover types	Hectares	Estimated market value per hectare (US$)[18]	Total estimated market value (US$)
Banana plantation	530	5,039[1]	2,670,670
Coffee plantation	553	23,178[2]	12,817,557
Citrus plantation	161	5,039	811,279
Coconut plantation	229	5,039	1,153,931
Plantation – mixed	14	5,039	70,546
Fields – food crops	3,332	5,039	16,789,948
Total land under agricultural cover/use	6,635		34,313,931

1. This is based on an estimate of J$125,000 per acre (J$30,887.5 per ha) from the Forestry Department for most other land in the watershed.

2. The price of land under coffee varies from J$450,000 to J$700,000 per acre [J$1,111,972.5 (US$18,258) to J$1,729,735 (US$28,218) per ha]. This will depend mainly on the plant population density and the location of the area (which will affect accessibility). A farm that sells at the upper range would be relatively accessible and have approximately 870 plants per acre (2,150 plants per ha). The maximum planting density recommended by the CIB is 872 plants per acre (2,155 plants per ha).

[17] These estimates are obtained from the following sources: price of land under coffee (Coffee Industry Board12/2004); all others (Forestry Department 2005).
[18] Based on an exchange rate of US$1 to J$61.30 as at March 2005.

7. Existing and proposed incentives/management tools for watershed protection in Jamaica and indicators of impacts of incentives

To date, public investment in the forestry sector and in watershed protection has been modest (Forestry Department 2001b). Government budget allocations have been inadequate to fund the necessary management and conservation practices on forest lands, and management on a sustainable basis. Another important consideration is that most of the land with the greatest potential for forestry development in Jamaica is privately owned; hence the private sector must be encouraged to engage in forestry/plantation development. To fill the funding gap for forest management and conservation, the Forestry Department will establish the Jamaica Forest Management Fund. The Fund would be used to support activities and projects identified by the Forestry Department as requiring external funding (Forestry Department 2001b).

7.1 Existing incentives/management tools for watershed protection

Several agencies are offering incentives for watershed/forest protection within the Buff Bay/Pencar watershed, chief among which is the Forestry Department.

7.1.1 The Forestry Department – incentives for investment

The following incentives are currently being provided to encourage investment in forestry development and conservation.

A. Free timber seedlings (from the nursery site), along with technical advice (the Private Planting Programme). The provision of additional seedlings is dependent upon care of the first batch. The Private Planting Programme has distributed over 377,000 (~ 400,000) seedlings since the programme was overhauled in 1997. Distribution has taken place across the entire island, serving over 500 private woodlot owners. In the Buff Bay/Pencar watershed, almost 400 people have benefited from the distribution of 46,383 seedlings since 1999 (see Table 21). There has been a very high demand for seedlings (31,704 seedlings delivered to farmers in the Buff Bay/Pencar watershed during the 1999/00 planting season), which proves that the incentive has been effective.

Table 21 – Buff Bay/Pencar seedling distribution (Source: Ms. Ingrid Blackwood, FD 2004)

Year	Amount	Species	Number of farmers
1999	4,216	H. mahogany, cedar, mahoe	12
2000	25,443	H. mahogany, cedar, mahoe	240
2001	10,564	H. mahogany, Cedar, mahoe, Spanish elm, Caribbean pine	60
2002	1,780	H. mahogany, cedar, Caribbean pine	32
2003	2,280	H. mahogany, cedar, Caribbean pine	30
2004	2,100	H. Mahogany, cedar	18
Total	46,383		392

B. The remission of property taxes on lands declared as forest management areas or as forest reserves – landowners can apply to have their land (or a part thereof) declared a protected area and so be eligible for a remission in their property taxes. The success of this incentive is demonstrated by the fact that people have been applying for the remission despite the need to prepare a management plan and other requirements. One person is now in the process of claiming their refund, and a second person has had his land declared a protected area. (After the land is declared protected, it must be kept under conservation cover for 1 year before a claim can be made for a rebate of the tax paid.) In total, the Minister of Agriculture has approved 498.02 hectares of land for declaration (2 estates).[19]

C. For landowners with approved farmer status,[20] duty concessions on motor vehicle purchase, and waiver of General Consumption Tax (GCT) on capital goods, activities, and supplies prescribed under a forest management agreement and approved forest management plan.

D. Long-term conditional leasing at competitive rates of public land for reforestation, agroforestry, and other purposes prescribed in an approved Local Forest Management Plan, including investiture of full ownership of planted trees on the lessee.

In addition, the following incentives are proposed, subject to the availability of capital in the Jamaica Forest Management and Conservation Fund, and priorities established by the Fund's Board of Directors (Forestry Department 2001b). All incentives will be subject to activities being prescribed in an improved Local Forest Management Plan and performance verification by the Forestry Department.

- Grants for plantation establishment on lands qualifying for reforestation under the Forest Plan.
- Direct acquisition or leasing of lands for maintenance as protection forest.
- Annual grants to landowners, up to 50% of the land rental value, for maintaining protection forests.
- Grants and/or long-term low-interest loans for community forestry and recreational ventures.
- Maintenance of boundaries, trails, and fire breaks.
- Surveying of suitable Crown lands for leasing for forestry or agroforestry uses.

There are also a number of incentives being provided to the Buff Bay and Pencar local forest management committees (described in the next chapter) to continue their work in the watershed. In this case, the aim of the incentive is not to reduce the impact of human activities in the watershed, but to maintain the involvement of LFMC members. One such incentive is the leasing of forest reserve or other Crown land to the Buff Bay and Pencar LFMCs by the FD for economic activities compatible with watershed management objectives, such as the development of plant nurseries and eco-tourism development. Another incentive is employment by the FD (in reforestation projects, etc.).

The success of these incentives is evidenced by the role of LFMC economic development projects in maintaining continued interest and involvement of LFMC members and an expanding network of stakeholders. LFMC members also have the opportunity to have their farm(s) used as demonstration farms. The effectiveness of this incentive has been demonstrated by the continued maintenance of these demonstration farms and the satisfaction of the participants. However, so far, there has been no evidence that it has improved watershed services.

[19] This information was obtained through personal correspondence with Ms. Rainee Oliphant who is a lawyer with the Forestry Department and who deals with this scheme.
[20] Landowners can get 'approved farmer status' if land is planted with timber.

The FD has also engaged in other co-management arrangements, for example, with the Jamaica Conservation and Development Trust (JCDT) for managing the Holywell National Park located in the Blue and John Crow Mountains. The FD is also involved in partnerships with the private sector – for example, reforestation projects with the Cigarette Company of Jamaica Ltd. and Alcoa Minerals of Jamaica, Inc. (JAMALCo).

7.1.2 Incentives from other agencies

There are also several other agencies in the area providing incentives to the residents of the Buff Bay/Pencar watershed to protect the environment. These include the Eastern Jamaica Agricultural Support Programme (EJASP), which provides residents with advice on land husbandry and animal husbandry, as well as other services such as road repairs. The CIB is also responsible for ongoing education/moral suasion relating to land husbandry and coffee best practices to coffee farmers.

Outside of the Buff Bay/Pencar watershed, residents of other watersheds are being provided with incentives to protect the environment. In the Rio Grande (Portland/St. James) and Great River (St. James/Hanover) watersheds, residents receive a reward/recognition for good behaviour/best practices, e.g. in the form of a 'best community' competition. These incentives are being provided by the Ridge to Reef Watershed Project (R2RW), being carried out by the National Environment and Planning Agency (NEPA) and the United States Agency for International Development (USAID). The R2RW promotes awards aimed at building the notion of stewardship of the water cycle through competitions aimed at finding the winning examples of community-based best practice and behaviours. The award includes a monetary element and is featured in their public relations campaign.

7.2 Proposed incentives/management tools for watershed protection

In the Buff Bay/Pencar watershed, several other incentives/management tools have been proposed and these are outlined below:

A. Carbon trading: trading carbon sequestration credits for money which is than used to pay landowners who plant new trees.

B. Tourism certification for areas: by certifying Portland as a 'green' destination – residents have to do certain things to retain this certification.

C. Providing the LFMCs with lumber licences.

D. The development of two incentives – to encourage shade planting of coffee, and the use of tree crops by coffee farmers – has also been proposed. One possibility is the introduction of a 'water levy' that would be paid by coffee farmers who do not practise shade planting. Another possibility is the development of a financial incentive for shade planting, to be tested in the Buff Bay/Pencar watershed, and which could eventually be expanded to the Hope watershed (Kingston) and the Yallahs watershed (St. Thomas).

E. Eco-labelling: branding and marketing of horticultural, fresh, and processed agricultural products, as well as bottled water, based on agreed and applied standards of practice. There are several possible incentives, apart from the obvious market-led incentives from sales to discriminating markets. They include streamlining government procedures for allocating rights and for planning development control; and branding and marketing agricultural, horticultural, and industrial products and bottled water based on agreed and applied standards of practice (the proposed 'Great River' brand).

F. Create a system of payments for environmental services by establishing a Forestry Fund that could fund a type of 'Conservation and Management Certificate'.

7.3 Costing of targeted incentives

Based on focus group meetings and discussions with the Forestry Department, it has been decided that two main incentives will be targeted. The first is for establishment of nurseries to produce seedlings for planting, and the second involves actual use of these seedlings in reforestation programmes. At present there is an FD nursery facility established in conjunction with the Pencar LFMC and with an estimated annual direct annual cost of J$750,000. The indirect cost of support services provided by the FD is estimated to be an equivalent amount and the total, current annual cost is therefore estimated to be J$1.5 million or US$0.024 million.

The estimated costs of an existing FD reforestation programme for 8 ha is estimated to be J$750,000 and an indirect FD cost of managing this is put at J$250,000 and hence a total cost of J$1million (US$0.016million). It is further estimated that to be effective both the number of nurseries or size of the existing nursery would need to be expanded together with a similar increase in the reforestation area. An estimated 10 fold increase in nursery operations and reforestation would therefore cost an estimated J$15 million (US$0.24million) and J$10 million (US$0.16million), respectively, per annum: or, in total J$25 million or US$0.41million.

This total estimated annual cost would be the equivalent of between 0.47-0.5% of the total estimated value of the direct and indirect use values produced in 2004 by the Buff Bay/Pencar watershed. If we exclude carbon sequestration values, these percentages increase marginally to between 0.77-0.8 percent of the estimated value.

7.4 Indicators of impacts of incentives

The intention of incentives is to bring about changes in behaviour which have positive impacts on the ecosystem functions of water supply and quality, soil conservation, biodiversity conservation etc. These can be captured in the following objectives of forest management via the use of incentives (Table 22).

Table 22: Indicators of impacts of incentives

Objectives	Watershed functions which benefit
1. Maintain existing forest cover	Water quality and quantity, biodiversity, soil conservation, protection of infrastructure, settlement, agricultural land assets
2. Increase forest cover	As above
3. Maintain existing shade coffee production	As above
4. Increase shade coffee production	As above
5. Maintain existing sustainable timber extraction	As above
6. Expand sustainable timber extraction	As above
7. Maintain existing good agroforestry practices	As above
8. Expand good agroforestry practices	As above
9. Increase proper disposal of solid waste	Flood control
10. Increase proper use of chemicals in agriculture and forestry as well as sewage disposal	Water quality

7.4.1 Methods and indicators of costs and benefits resulting from the implementation of incentives

The methods which would be utilised to measure the costs and benefits of implementation of incentives would be the valuation techniques discussed earlier in Chapter 4. Costs will be largely market-based, while benefits will take into account direct and indirect use values.

7.4.2 Allocation of costs and benefits among stakeholders

The costs will be borne by the current and future users of the land in the Buff Bay/Pencar watershed in terms, for example, of direct costs of shifting from non-shade to shade production, or in terms of benefits foregone from an inability to expand non-forest, or unsustainable forest, production land uses. These costs will be shared by the community as a whole insofar as they are based on fiscal incentives or expenditure by the state.

The beneficiaries will be the downstream forest and agricultural users together with those people living in the watershed or having business operations there. Jamaican society as a whole will also benefit in terms of the foregone fiscal costs – including government debt – for rehabilitation of public and other infrastructure damaged through enhanced forest loss.

8. Profile of the local forest management committees (LFMCs)[21]

The modern trend towards stakeholder participation in natural resource management has spread throughout the developing world as governments have tried to come to terms with growing demands on natural resources in the face of their own human and financial constraints. In Jamaica, the *Forest Act* (Government of Jamaica 1996) promulgates the appointment of 'a forest management committee for the whole or any part of a forest reserve, forest management area or protected area'. In addition, the five-year *National Forest Management and Conservation Plan*, prepared by the Forestry Department and adopted by the national Cabinet in July 2001, proposes community participation as a key strategy in national forest management.

The question of watershed management cannot be isolated from the livelihood options of residents in watersheds. The efforts to create local forest management committees (LFMCs) in Jamaica are therefore a step in the right direction in terms of integrating concerns about sustainability with those of development. A profile now follows on the LFMCs created in the Buff Bay/Pencar watershed.

Using the watershed management unit system that had been developed for the country, the Buff Bay/Pencar watershed was selected as the pilot watershed by the Trees for Tomorrow Project, (based on a range of biophysical, social, and logistical criteria), for the development of new approaches to watershed management (Cunningham and Limbird 1993). In September 2000, the Forestry Department (FD) held preliminary meetings with potential LFMC member organisations in each sub-watershed to confirm community interest and get feedback on proposals regarding the committees' objectives, composition, and structure. Based on the interest demonstrated at these meetings, the local forest management committees (LFMCs) – one in Pencar and one in Buff Bay – had their first regular meetings in November 2000 and were officially launched at a joint meeting in Buff Bay in December 2000.

Membership in the LFMCs is open to all community groups, organisations, NGOs, and private sector entities present in the Buff Bay and Pencar sub-watersheds. Invitations were extended to a wide range of organisations that were identified during earlier sociological fieldwork. National and local government agencies with an interest in watershed management were also invited to participate. The design of the LFMCs was based on a belief that the interests of individual stakeholders could be adequately represented by existing organisations, such as citizens' associations and the local chapters of the Jamaica Agriculture Society (JAS). So, whilst membership in the LFMC is open to all individual stakeholders in theory (and occasionally people have attended meetings in a personal capacity), in practice it is legal entities and formal organisations that have been targeted and invited to join.

Both LFMCs are registered as community organisations. The committees elect their own officers and meet bimonthly, with joint meetings of the two sub-watershed LFMCs twice a year. The FD serves as the secretariat for the committees until the capacity of either reaches a level at which it can consider setting up its own office. Since their establishment, both LFMCs have met regularly and their meetings have addressed a range of matters, such as securing licences to harvest trees within the watershed; assisting with reforestation; and serving as honorary game and forest wardens. The discussions have also revealed how effective the FD's private tree planting programme has been in increasing local environmental awareness and benefiting farmers, and members successfully made a case for expanding the programme to include fruit tree as well as timber tree seedlings.

[21] Data for this chapter is taken from the following sources unless otherwise stated: Geoghegan and Bennett (2002); Headley (2003); and personal correspondence with Noel Bennett in December 2004/January 2005.

Both LFMCs started with over 30 members. However, attendance has dropped since the groups' inception. Nevertheless, this has not been significant enough to affect operations, and the number of people attending meetings has remained relatively stable, more so for the Buff Bay LFMC than the Pencar LFMC. The economic situation of the residents has impacted meeting attendance, as most live at subsistence level. The area is among the poorest in Jamaica (Statistical Institute of Jamaica and Planning Institute of Jamaica 1998), with poverty rates on both sides of the watershed estimated to be in excess of 25% (Mills 2001; Wright 2002). For this reason, the FD had suggested that the committees be merged. However, the LFMCs decided to keep their meetings separate and to try to mobilise more people to attend.

The Buff Bay/Pencar LFMCs are still in their infancy; their role and purpose are evolving in practice and, as presently structured, they provide only partial support in addressing the complex issues of forest management. They have, however, managed to survive and develop over a period of four years and to make small but important contributions to forest management in the area. One meaningful role for the LFMCs is in identifying opportunities to improve local livelihoods – and especially the livelihoods of the poor – through the sustainable use of resources within forest reserves. Although the poor, who mostly live in the upper reaches of the watershed, currently make little use of the forest except to capture land for farming, opportunities in tree plantation, nature tourism, and timber extraction exist and are being explored by the committees.

In the Pencar sub-watershed, the LFMC, with the support of the FD, has opened a nursery to grow timber, coffee, and other seedlings for sale. In the Buff Bay sub-watershed, the LFMC has proposed the development of the Lancaster Nature Heritage Site. A project proposal has been submitted in which the first step would be to link the Heritage Site to the Holywell National Park to facilitate hiking and bird watching. Much of the work has been done in clearing a path between the two sites to allow visitors to move between them, and people are already using the trail. The next step is to put up a multipurpose building and a gazebo. The final stage would be to build cabins in which people could stay overnight. Preliminary drawings of the final site have been done, and funding is being sought to develop the plan, including market surveys and architectural drawings.

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The following articles may also be useful and are available online.

Visit the Jamaica Forestry Department/Ministry of Agriculture website at <http://www.forestry.gov.jm/> and click on 'Documents' to view these following articles:

8: *Buff Bay/Pencar Socio-Economic and Agroforestry Report*, Forestry Department (2000).

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Mr. Danny Simpson, the Regional Forestry Supervisor responsible for the parishes of St. Mary and Portland at the Forestry Department, Folley Road, Port Antonio, Portland (11 December 2004).

Mr. Noel Bennett, Rural Sociologist, Trees for Tomorrow Project, Forestry Department, 17 Constant Spring Road, Kingston 8, Jamaica (December 2004/January 2005).

Mr. Morgan, Trees for Tomorrow Project, Forestry Department, 17 Constant Spring Road, Kingston 8, Jamaica (December 2004/January 2005).

Ms. Ingrid Blackwood, Forestry Department, 17 Constant Spring Road, Kingston 8, Jamaica (December 2004/January 2005).

Ms. Rainee Oliphant, lawyer, Forestry Department, 17 Constant Spring Road, Kingston 8, Jamaica (December 2004/January 2005).

Mr. Gusland McCook, Regional Advisory Services Officer, Coffee Industry Board (Regulatory Division) (29 March 2004).

Appendix 1: Mean monthly temperatures 1931-1977, evapo-transpiration, and soil types

1. Mean monthly temperature[22]

Monthly temperature data for the period 1931-1977 at the Buff Bay Meteorological station indicates that the warmest months are July and August while the average lowest temperatures are from January to February 24. This data as cited in Tersult International (2004) is presented in the Appendix Table 1.1.

Appendix Table 1.1

Mean monthly temperature 1931 to 1977 ^0C												
Stations	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Buff Bay	23.9	23.8	24.1	25	25.9	26.5	26.8	27.1	26.7	26.5	25.8	24.8
Annotto Bay	23.9	23.8	24.1	25	25.9	26.5	26.8	27.1	26.7	26.5	25.9	24.9
Castleton	22.5	22.5	23.1	23.8	24.3	26.5	26.3	25.3	24.8	24.4	23.8	22.9

2. Relative humidity

There is no data specific to the Buff Bay/Pencar watershed, however the relative humidity for different areas can give some indication of what we can expect to find there.

Kingston	63%	February
	75%	October
Port Antonio	81.5%	April/May
	84%	Nov /Dec

The average relative humidity using the Hargreave 1985 equations is presented in Appendix Table 1.2 below.

Appendix Table 1. 2

Average relative humidity												
Station	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Port Antonio	82	82.5	82	81.5	81.5	82.5	81.5	81	81.5	83	84	84

3. Sunshine

Appendix Table 1. 3

Sunshine (hours per day)												
Station	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Port Antonio	6.1	6.3	6.8	7.4	7.2	7	7.6	7.6	7.2	6.9	6.5	6.1

[22] Data in this section and contained in Appendix Tables 1.1 to 1.4 are sourced from the Rural Physical Planning Unit as cited in Tersult International 2004.

4. Evapo-transpiration

Information from the *Water Resources Authority Development Master Plan* indicated that 56 % of the total mean annual rainfall in Jamaica is lost to evapo-transpiration, whilst 44% contributes to ground and surface water (i.e. the average annual yield).

The Water Resources Authority was unable to be more specific in terms of evapo-transpiration data because they have no evapo-transpiration stations in the Buff Bay/Pencar Watershed Management Unit area.

The evapo-transpiration rates for the Blue Mountain North hydrological basin in which the Buff Bay/Pencar Watershed Management Unit is found is set at 2,346 10^6 m^3 / yr. Andreas Haiduk from the Water Resources Authority suggested that in the absence of evapo-transpiration data specific to the Buff Bay/Pencar WMU, the evapo-transpiration rates for the Blue Mountain North hydrologic basin or southern St. Mary be used as a proxy.

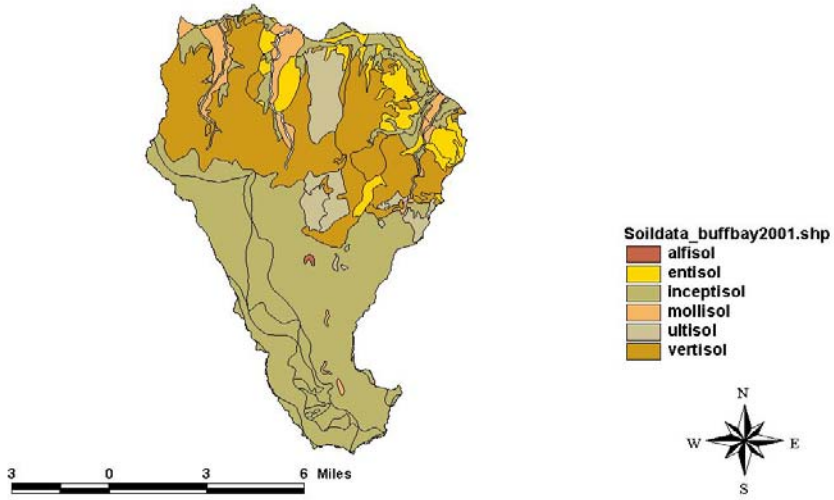
However, the Tersult International (2004) report presented data from the Rural Physical Planning Unit in the Ministry of Agriculture that indicated potential evapo-transpiration (PET) rates for the Buff Bay/Pencar Watershed Management Unit as presented in Appendix Table 1.4. The PET figures presented were calculated using a modified FAO formula along with the relevant hydrological data for the area. Although there is no indication of the time period to which this data applies, it is assumed that it would have been collected some time prior to the publishing of the original report in 2001 and that if it was deemed necessary, this data would have been updated when the report was revised in 2004. In light of this one can consider this information to be the most appropriate proxy for current evapo-transpiration rate in the BBPencar WMU.

Appendix Table: 1.4

Potential evapo-transpiration (mm)													
Station	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Buff Bay	106	112	143	147	155	149	158	147	124	125	107	106	1,581
Aqualta Vale	105	111	142	146	153	148	157	146	126	124	106	105	1,571

5. Soil types (international classification)[23]

Appendix Figure 1.1: International classification of soil types in the Buff Bay/Pencar WMU



[23] Tables and Figures in this sub-section are sourced from CRIES and USAID (1982).

As indicated on the map in Appendix Figure 1.1, soils in the Buff Bay/Pencar WMU can be classified into six main soil types, according to the international classification system. In terms of area occupied the soil type, inceptisol is the most common, being found in approximately half of the watershed area stretching from the upper reaches to the middle section. The middle to lower reaches of the watershed have alfisol, entisol, mollisol, utisol and vertisol soil types with vertisol being the most abundant. Alfisol is the least common soil type, being found only in a tiny area close to the middle of the WMU. Detailed information on these soil types was not available. Soils would be discussed in detail according to their local names, below.

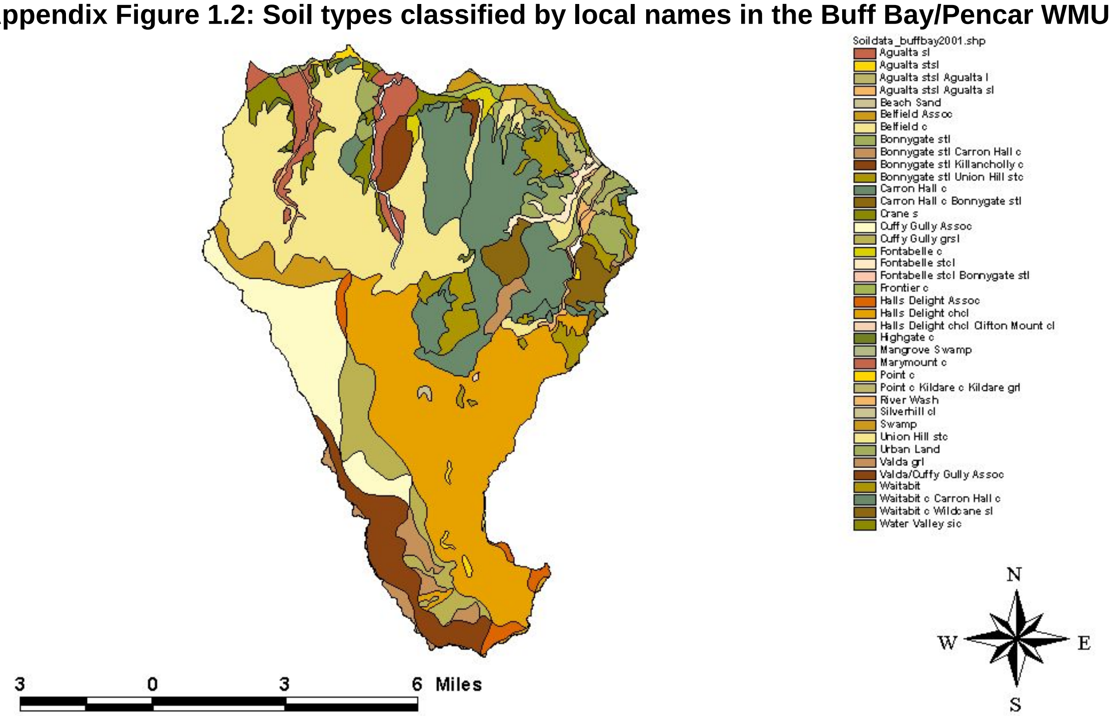
6. Soil types (local name)

The classification by local soil names is more complex and diverse, with 39 different types of soil being identified. These are presented in Appendix Figure 1.2, below. Each of these soils will be discussed in terms of the root limiting layer, pH, moisture supplying capacity, soil internal drainage, and erosion hazard. These characteristics would be linked to the surface drainage present in the area as well as suitable land use.

Soil pH is a measure of the acidity or alkalinity of the soil and is expressed in this report as:

Extremely acidic: below 4.5
Very strongly acidic: 4.5 to 5.0
Strongly acidic: 5.1 to 5.5
Medium acidic: 5.6 to 6.0
Slightly acidic: 6.0 to 6.5
Neutral: 6.6 to 7.3
Mildly alkaline: 7.4 to 8.0
Strongly alkaline: 8.1 to 9.0
Very strongly alkaline: 9.1 and higher

Appendix Figure 1.2: Soil types classified by local names in the Buff Bay/Pencar WMU



The internal drainage is the rate at which water moves through the soil and depends on the soil permeability and the material below. This is expressed as:

Very rapid: faster than 5.0” / hour
Rapid: 4.1 to 5.0”/ hour
Moderately rapid: 3.1to 4.0” / hour
Moderate: 2.1 to 3.0 /hour
Moderately slow: 1.1 to 2.0” /hour
Slow: 0.2 to 1.00” /hour
Very slow: slower than 0.2” /hour

The soil ‘moisture supplying capacity’ is the amount of water stored in the soil; it depends largely on the soil texture and is expressed as:

High (usually clay texture): 1.75 to 2.00” water/foot soil depth
Medium, (Loam texture): 1.25 to 1.50” water/foot soil depth
Low (sandy texture): 1.75 to 1.00” water/foot soil depth

‘Erosion hazard’ speaks to the susceptibility of the soil to erosion and is expressed as:

Slight

Moderate

Moderate to high

High

Appendix Table 1.6 (on the following page) gives a summary of the characteristics of some of the soils in the watershed management unit.

7. Soil texture

Eleven soil textures could be identified from Appendix Figure 1.3, below. These are presented with their abbreviations in Appendix Table 1.5 below.

Appendix Table 1.5: Abbreviations and soil textures

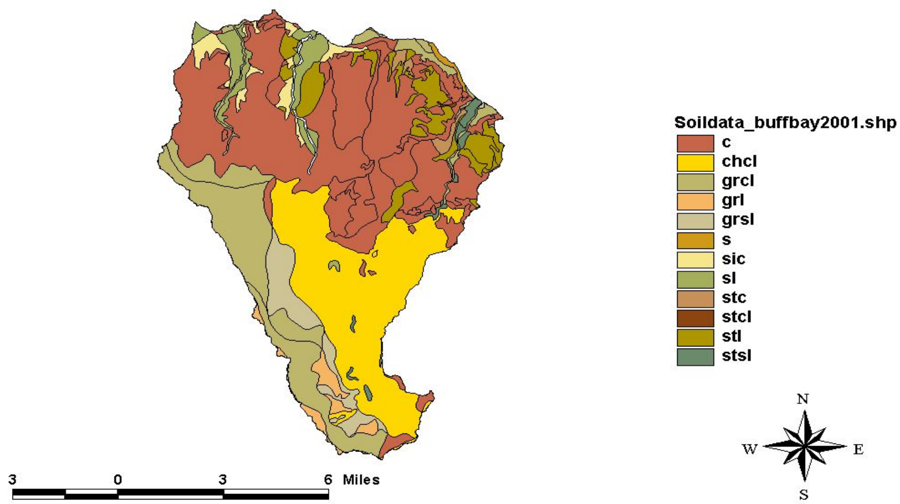
Abbreviation	Soil texture
c	clay
chcl	channery clay loam
grcl	gravelly clay
grl	gravelly loam
grsl	gravelly sandy loam
s	sand
sic	silty clay
sl	sandy loam
stc	stony clay
stcl	stony clay loam
stl	stony loam
stsl	stony sand loam

Appendix Table 1.6: Characteristics of soils in the BB/Pencar WMU

Soil name	Texture of surface layer	Root limiting layer	Slope range (degrees)	Internal drainage	Moisture		Natural fertility			pH
					Supplying capacity	Erosion hazard	N	P	K	
Agualta	sicl	none	0-5	slow	high	slight	high	high	high	neutral
Agualta	sic	none	0-2	slow	high	slight	high	high	high	neutral
Agualta	stsl	none	0-6	rapid	low	slight	high	high	high	mildly alkaline
Agualta	sl	none	0-6	rapid	moderate to low	slight	low	high	medium	mildly alkaline
Belfield	c	none	10-35	moderate	moderate to high	moderate	low	low	high	slightly acidic
Bonnygate	stl	bedrock at 1-12"	20-35	very rapid	very low	high	low	medium	low	mildly alkaline
Carren Hall	c	bedrock at 18-48"	5-30	moderate to slow	high	moderate	low	low	high	slightly alkaline
Crane	s	none	0-20	rapid	very low	slight	low	low	low	
Cuffy Gully	grsl	bedrock at varying depths	10-35	very rapid	low	high	low	medium	medium	slightly acidic
Fontabelle	c	none	0-2	moderate	high	slight	low	medium	high	strongly alkaline
Fontabelle	stcl	none	0-5	moderate to rapid	high	slight	high	high	high	slightly alkaline
Frontier	c	water table 8-20"	0-2	very slow	very high	slight	low	low	high	strongly alkaline
Halls Delight	chc	shale at 12-24"	20-35	rapid	low to moderate	high	low	low	high	neutral
Highgate	c	compact subsoil 12-20"	10-35	slow	moderate to high	slight	low	low	high	strongly acidic
Kildare	c	none	0-20	moderate to slow	moderate	moderate	low	low	low	strongly acidic
Kildare	gl	none	20-30	rapid	low	moderate to high	low to medium	low to medium	low to medium	acidic
Point	c	acid clay subsoil 7-12"	0-5	moderate to slow	high	slight	low	low	low	strongly acidic
Silverhill	cl	parent material if shallow	10-30	moderate to rapid	high	moderate	medium	medium	medium	neutral
Union Hill	stc	rock at 15 - 40"	10-30	moderate	high	moderate to high	low	medium	medium	neutral
Valda	gsl	bedrock	20-35	very rapid	very low	high	low	low	high	medium acid
Wait-a-bit	clay	none	5-30	slow	high	high	low	low	high	strongly acidic
Watervalley	sic	none	0-2	moderate	high	slight	low	low	high	mildly to strongly alkaline

The main soil textures found in the upper to middle regions of the watershed are channery clay loam (which is the most abundant), gravelly clay with smaller pockets of gravelly sandy loam, gravelly loam clay, and stony sandy loam. Soils in the middle to lower regions of the watershed have mainly clay texture with small areas having silty clay, sandy loam, stony loam, and gravelly sandy loam textures. There are also tiny areas of stony sandy loam, stony clay, and stony loam.

Appendix Figure 1.3: Soil textures in the Buff Bay/Pencar WMU



8. Parent material

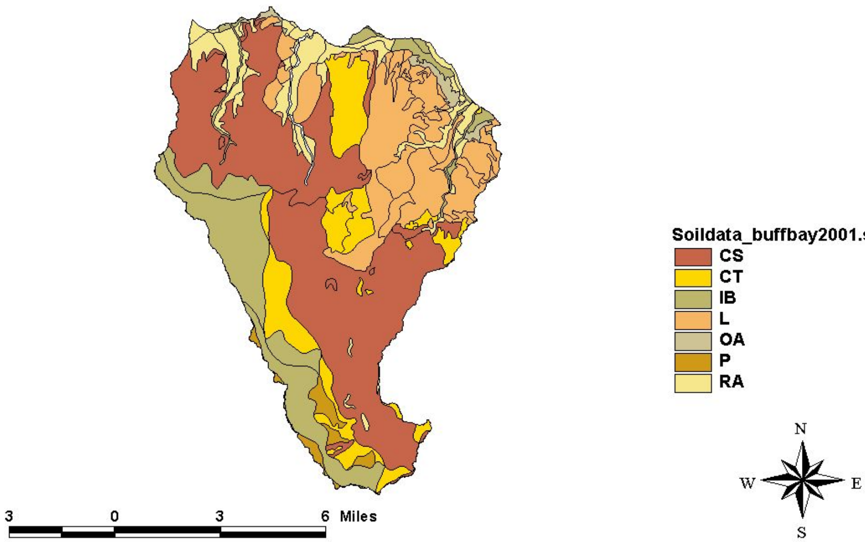
The list of parent rock with the abbreviations found in the legend for Appendix Figure 1.4 is presented in Appendix Table 1.7 below.

Appendix Table 1.7: Abbreviations and parent material for soil

Abbreviation	Parent material
CS	Conglomerates shale
CT	Conglomerates and tuffs
IB	Inland basin
L	Limestone
OA	Old alluvium
P	Plains
RA	Recent alluvium

In the upper regions of the watershed conglomerate shale, inland basin and conglomerate tuffs are the parent material from which the soils were formed, whilst the parent materials plain and recent alluvium are found in smaller areas. These tend to be impermeable rocks and would explain the high levels of surface drainage that take place in this region. In the eastern half of the middle to lower regions, limestone is the most abundant parent material with smaller areas of recent alluvium, old alluvium, and inland basin. Limestone rocks are highly permeable and this would explain the fact that the White River loses its flow as it approaches the coast, as well as the existence of springs in this part of the Buff Bay/Pencar watershed. Conglomerate shale dominates the western portion of the middle to lower regions with small areas of limestone, recent alluvium, and inland basin.

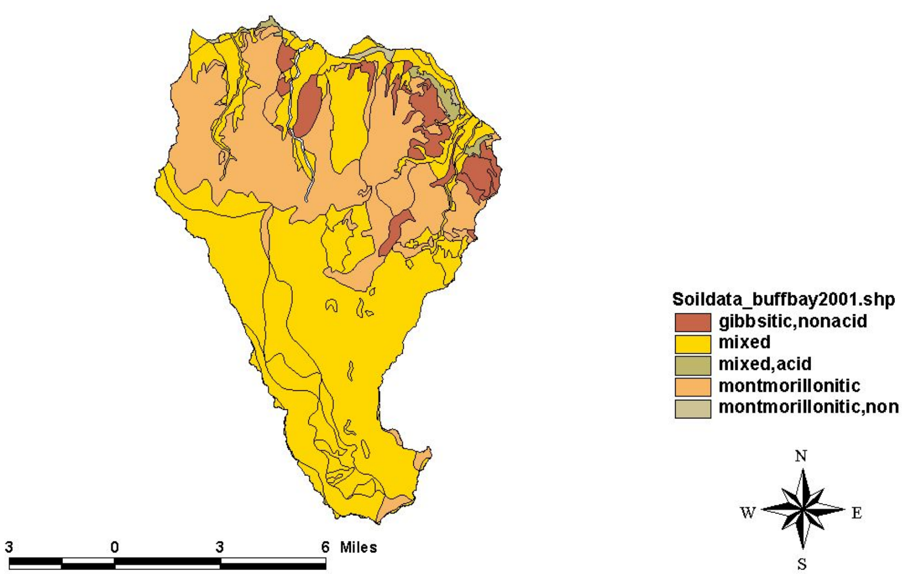
Appendix Figure 1.4: Parent material of soils in the Buff Bay/Pencar WMU



9. Mineralogy

As shown in Appendix Figure 1.5, the mineralogy of the soils in the majority of the WMU can be described as being mixed. This is true of the entire upper region and large areas of the middle to lower regions. The description best suited for the mineralogy of the middle to lower regions is: large areas of mixed and montmorillonitic with smaller areas of gibbsitic nonacid and mixed acid, and a tiny area of montmorillonitic nonacid.

Appendix Figure 1.5: Mineralogy of soils in the Buff Bay/Pencar WMU



Appendix 2: Methodology used to estimate direct use value from coffee, banana, mixed agroforestry, and timber production and indirect uses values together with road infrastructure and settlement values

1. Estimated direct use value of coffee produced in the Buff Bay/Pencar watershed[24]

A. Revenue per box of coffee sold.
Jamaica's Blue Mountain coffee prices have ranged from US$9 to S$13 per pound of green beans since the late 1980s, and are currently ranging between US$10 and US$11per pound.[25] Taking the average of the current price range (US$10+US$11/2), average price earned per pound of green bean = US$ 10.50. Therefore, for each box of green beans (60 lbs) that is sold at this price, the revenue earned if US$ 630.

B. The direct use value of coffee produced in the Buff Bay/Pencar watershed.
Of the 10,522 ha in all types of coffee in Jamaica in 1999, 1,205 ha were being cultivated in Blue Mountain coffee in the Buff Bay/Pencar watershed. It can therefore be extrapolated that 11.45% (1,205/10,522 ha) of all coffee produced each year by Jamaica is cultivated in the Buff Bay/Pencar watershed. This means that the value of the coffee produced in the Buff Bay/Pencar watershed can be estimated as follows.

Appendix Table 2.1: Estimated direct use value of coffee (in US$)

Year	**Number of boxes**		**Direct use value[a] (US$000)**
	In Jamaica	From BB/P	From BB/P
2002	200,000[26]	22,900	$14,427
2003	154,400	17,679	$11,138
2004	232,200	26,587	$16,750

[a] Estimated direct use value of green bean Blue Mountain coffee: 60 lbs/box x US$10.50/lb = US$630 per box x number of boxes/year

2. Estimated direct use value of banana produced in the Buff Bay/Pencar watershed[27]

In Jamaica, banana is grown by a large number of small farmers for local consumption. In 1999, three large estates (St. Mary's Banana Estate Ltd., Victoria Banana Company, and the Eastern Banana Estates Limited) accounted for 73% of the production of banana in Jamaica, and about 70% of the market share of total exports.

St. Mary's Banana Estates Ltd. (SMBE) cultivates banana on approximately 648 hectares of land, 460 hectares of which are in the Buff Bay/Pencar watershed. In this area, the SMBE

[24] Data for this section were garnered from personal communication with Mr. Gusland McCook, Regional Advisory Services Officer with the Coffee Industry Board (Regulatory Division) in March 2004, unless otherwise stated.
[25] This can be compared to 65.82 U.S. cents/lb – the average price paid per pound of green beans (Arabica variety of coffee) sold on the world market in December 2003.
[26] The CIB, through Walenford Coffee Company, retails approximately 90% of the green beans produced in Jamaica. As such, these figures are 111% of the number of boxes that pass through the CIB to approximate all the green beans produced in the Blue Mountain area.
[27] Data for this section is taken from the following sources: Pantin et al. (1999) and Annual Reports of the Jamaica Producers Group Limited (2002 and 2003).

accounts for 81% of the total cultivation. Yields of the SMBE are reported to be 12.94 tons per acre (equivalent to 31.96 tons per hectare), with yields in the smaller farm categories ranging from 0.94 to 3.52 tons per acre (2.32 to 8.69 tons per hectare).

From the data above, we can calculate that there are 568 ha under banana cultivation (460 ha is 81%) in the Buff Bay/Pencar watershed, 530 ha of which are strictly under banana cultivation, the remainder being classified as being under 'mixed cultivation' or as 'food crops'.

Appendix Table 2.2: Price earned per ton of banana on export market

Year	Export (tons)	Export (US$'000)	Price per ton (US$)
1992	76,723	39,560	515.62
1993	76,777	35,887	467.42
1994	78,577	43,560	554.36
1995	85,223	48,190	565.46
1996	88,917	44,100	495.97
1997	79,709	45,000	564.55
1998	61,938	33,000	532.79

SMBE = 460 ha x 31.96 tons x US$528.02 [28] = US$7,762,739

Other = 108 ha x (2.32+8.69 tons/2) x US$528.02 = 108 ha x 5.505 tons x US$528.02 = US$313,929

Total direct use value of banana in the watershed = US$7,762,739 + US$313,929 = US$ 8,076,668

3. Estimated direct use value of timber produced in the Buff Bay/Pencar watershed

Using the income value method, the value of the timber in the watershed is derived below.

A. Allowable annual cut.
   For the biophysical inventory in the watershed, two volume types have been calculated for tree species with DBH>=10cm: total volume, and gross merchantable volume. The total standing volume of forested land in the watershed is approximately 2 million cubic metres and the potential gross merchantable volume (all species, DBH>=10cm) represents an average of 68.6% of the total volume (Forestry Department, 2001a). However, in the present timber market, only the species classed in tree species groups 1, 2, and 3 found in the watershed are effectively merchantable or commercial (Forestry Department, 2001a). The main commercially-harvested species are blue mahoe, cedar, santa maria, sweetwood, bullet, and plantation species such as Caribbean pine.

   The gross merchantable volume immediately extractable and marketable from natural forests is only 10% of the standing total volume (DBH>=10cm) in the watershed, and only a portion of this volume is environmentally and economically sustainable for harvesting. The potential gross merchantable volume of potentially ready-to-harvest native timber (quality classes 1, 2, and 3) for DBH>=30cm available from the montane forest type is 239,000m^3 (of which Caribbean pine forest types represent 118,000m^3). There is also 21,000m^3 available from the agro-forest types.

[28] This was calculated based on an average of the price earned per ton from 1992 to 1998.

The timber quality class 1 represents approximately 12% of the gross merchantable volume in these montane forests. However, in the agro-forest group, this timber quality class accounts for 90% of the standing gross merchantable volume, represented mainly by cedar planted on private lands.

Appendix Table 2.3: Gross merchantable volume and allowable annual cut (Source: Forestry Department 2001a)

Species/forest type	Gross merchantable volume	Allowable annual cut	
	Cubic metres	Cubic metres	Board feet[a]
Caribbean pine	118,000	3,000	1.27 million bd. ft.
Other native species (tree species groups 1, 2, and 3)	121,000	12,700	5.38 million bd. ft.
Total	239,000	15,700	6.65 million bd. ft.

[a] $0.00236m^3$ = 1 board feet

The allowable annual cut is defined as the number of cubic metres (or area) allowed annually for harvesting on a sustainable basis, i.e., a percentage to be extracted from the forest not exceeding the growth-mortality rate, and allowing time for the forest to regenerate (Forestry Department 2001b).

Using a rotation of 20 years for Caribbean pine, the allowable cut per year from the watershed is $3,400m^3$, with 70% of this volume being larger than minimum harvestable diameter (MHD) of 30cm. Allowing for an inventory error of +/-10%, a conservative allowable cut of $3,000m^3$ is recommended (Forestry Department, 2001b). For the native species in modified lower montane forest, approximately $44,500m^3$ are potentially available for harvesting. However, to reduce the disturbance per cubic metre extracted, the potential harvestable volume is more consistent with approximately $12,700m^3$ per year (Forestry Department 2001b).

In terms of timber planted by small landowner (agroforestry types), there is no such thing as an annual allowable cut, as these people behave differently from plantation owners, and sow and reap as they see fit. It was therefore virtually impossible to approximate how much of the timber on these lots are reaped annually, and as such this has not been included in the analysis.

B. Average selling prices for timber
Farmers in the watershed generally sell to local lumberyards, while the woodcutters sell both locally and to buyers in Kingston (Latham 2001). Tradesmen, rather than sawmills, are the main buyers of timber, with sawmills accounting for about a quarter of sales. The highest percentage of logging activity takes place in eastern St. Mary, the mixed agroforestry area, and much less takes place in Bangor Ridge and Mahoe, in the coffee monoculture area. As can be seen from Appendix Table 2.4, woodcutters in the area reported higher selling prices than farmers.

Appendix Table 2.4: Average selling price for selected timber species (Source: Latham. 2001)

Species	Local selling price (average J$ per board feet)		Selling price in Kingston[c] (by woodcutters) (average J$ per board feet)
	Smallholder farmers[a]	Woodcutters[b]	
Blue mahoe	24.00	33.75	40.00
Cedar	33.00	60.00	47.50
Mahogany	26.25	80.00	60.00
Caribbean pine	18.00	n/a	n/a
Spanish elm	30.00	31.25	33.00
Sweetwood	n/a	37.50	33.00

[a] Lumber is usually sold green by farmers
[b] This lumber has been air dried for 4 to 6 months
[c] Lumber sold by woodcutters in Kingston is sold green

C. Direct use value

Appendix Table 2.5: Annual direct use value

Species/forest type	Allowable annual cut (Board feet[a])	Average selling price* (J$ per board feet)	Annual direct use value	
			J$ million	US$ million
Caribbean pine	1.27 million bd. ft.	18.00	22.86	0.37785
Other native species (tree species groups 1, 2, and 3)	5.38 million bd. ft.	40.30	216.814	3.5837
Total	6.65 million bd. ft.	-	239.674	3.96159

*This is the average local selling price (for smallholder farmers and woodcutters) and the price for which lumber is sold in Kingston.

4. Estimated direct use value of recreation/tourism in the Buff Bay/Pencar watershed

The Buff Bay/Pencar watershed includes a part of the Blue and John Crow Mountains National Park, as well as the Holywell Recreational Area. The recreational area is open to visitors and offers nature trails, camping grounds, and cabins. Below is an overview of the income and expenses of the Holywell and the Portland Gap Recreational Areas, along with visitor statistics.

The future presents opportunities for more recreation/tourism land use, especially the use of existing trials and forestry roads for hiking and bird watching, and of river rapids and pools for water sport activities (Limbird et al. 1993). If these forms of recreation become established, then there will be a need to develop parking areas at trail heads, picnic grounds, near water activities, and so forth. In addition, two ongoing developments in the parish capital, Port Antonio, and in the parish as a whole, may bode well for increased tourism revenues in the Buff Bay area.

Appendix Table 2.6: Recreational areas income statement, Holywell and Portland Gap Recreational Areas, 2002-04

Description	Jan-Dec 2004	Jan-Dec 2003	Jan-Dec 2002
Holywell	J$	J$	J$
User fee	642,500	396,840	243,657
Cabin	426,700	417,837	431,985
Trail tour	55,710	94,234	44,234
Tent site	49,464	25,688	18,650
Special package	183,394	296,710	33,936
Tuck shop	-	200	10,995
Others	48,268	16,591	26,200
Security deposit	67,600	61,400	58,800
Total	1,473,636 (US$ 24,561)	1,309,500 (US$ 21,825)	868,646 (US$ 14,477)
Portland Gap			
User fee	82,200	95,675	91,040
Cabin	272,650	322,0505	281,261
Tent site	-	2,400	360
Sponge	23,150	27,950	22,203
Tuck shop	39,870	87,165	69,570
Others	13,230	2,700	-
Total	431,100 (US$ 7,185)	537,940 (US$ 8,966)	464,434 (US$ 7,741)
Grand Total	1,904,736 (US$ 31,746)	1,847,440 (US$ 30,791)	1,333,080 (US$ 22,218)

Appendix Table 2.7: Visitor statistics, Holywell and Portland Gap Recreational Areas, 2002-04

Year	Holywell			Portland Gap			Total
	Locals	Foreigners	Total	Locals	Foreigners	Total	
2002	4,155	316	4,471	3,342	259	3,601	8,072
2003	6,903	396	7,299	2,740	114	2,854	10,153
2004	8,359	187	8,546	1,750	30	1,780	10,326
Total	19,417	899	20,316	7,832	403	8,235	28,551

The Port Authority of Jamaica (PAJ) has been implementing a number of development initiatives in Port Antonio (in the parish of Portland) over the past three years, in its continuing effort to make the town more attractive and to increase its appeal as a cruise ship and tourist destination. The Ken Wright Pier and Marina was the first leg of a comprehensive investment by the PAJ to transform Port Antonio into a major cruise ship and yachting destination. There is the potential for increased tourism traffic in Port Antonio to spill over in other areas of the parish, especially the Buff Bay watershed which already has developed some eco-tourism activity, if only on a small scale.

In addition to the developments in Port Antonio, US$1.6 million is to be spent to help to reposition Portland as a ‘green’ tourism destination, and to make its tourism product more sustainable. It is expected that the development and certification of the parish as a ‘green’ destination will have positive spin-off effects for the economy of the Buff Bay sub-watershed.

5. Indirect use values, water

A. Water supply: rates.
Water charges have a fixed and variable component. The fixed component is the service charge, and covers costs such as depreciation. The variable component is billed per thousand gallons (kgls) – in an increasing block – and is a function of the amount of consumption per household. The rates charged are: J$131.13 for the first 3,000 gallons, J$231.16 for the next 3,000 gallons, and J$249.59 for the next 3,000 gallons.

B. Water supply: yield.
The Water Resources Authority has indicated that the Buff Bay/Pencar watershed has 32 million m^3 of water available per year (including the amount extracted by St, Mary's Banana Estates Ltd.). This is converted to litres using the conversion rate of 1,000 litres = 1 m^3. Litres are then converted to gallons using the conversion rate of 4.541 litres = 1 gallon. This results in a total yield of 7,040 million gallons (Mg).

C. Water revenue yields[29]
Data from the National Water Commission indicates that a majority of households consume an average of 6,000 gallons per month. Thus, the rates of $131.13 (for the first 3,000 gallons) and J$231.16 (for the next 3,000 gallons) are applied to derive the revenue, which is then annualised. Residential customers usually have either 5/8 inch or 3/4 inch meters. The service charge for 5/8 inch meters is J$229.98 and for 3/4 inch is J$472.05. If a household's consumption is in the 3,000-6,000 gallon range, it usually has a 3/4 inch meter and the higher service charge is applied. This is annualised and added to the annual volumetric revenues to yield J$15,802 or J$18,707, depending on the service charge applied. The total revenue is then divided by 6,000 gallons to get the rate per gallon. This rate is then applied to the annual water yield of 6,187 Mg) to get the total water revenue from the watershed, which is between J$1,358 million (US$22.3 million) and J$1,608 million (US$26.3 million) [30].

6. Indirect use values: value of road and other physical infrastructure and settlement in the Buff Bay/Pencar watershed

A. Road Infrastructure.
Value of road infrastructure in the Buff Bay/Pencar watershed = No. of km of road x cost per km = (50.38 km of primary roads + 50.22 km of secondary roads)[31] x J$7.1845 million per km[32] = 100.6 km x J$7.1845 million = J$ 722.7607 million (US$11.79 million)[33]

B. Other physical infrastructure (water, sewerage, telecommunications).
In the absence of any readily available database, this is assumed to be roughly 40% of the replacement cost for roads or some US$5 million.

C. Settlement and commercial.
Also in the absence of adequate, accurate data on this asset, the replacement cost for housing and commercial/industrial/agricultural infrastructure is assumed to be US$6 million.

[29] Ms Marie James' assistance is acknowledged in making these water supply revenue estimates.
[30] The assumption is that the parishes of Portland and St. Mary are predominantly residential.
[31] Mr. Morgan of the Trees for Tomorrow Project provided me with these estimates in January 2005, based on their data.
[32] This estimate was based on data obtained from Mrs. Hazel Facey-Jackson of the National Works Agency in Jamaica. The replacement value per km is based on the cost incurred per km on a 56.8 km road that was repaved through funding from the EU and FAO in 2001. This road runs from Papine in St. Andrew to Buff Bay in Portland.
[33] The exchange rate as at 12 March 2005 is US$1.00=J$61.30.