Drought Hazard Assessment and Mapping for Nevis

Post-Georges Disaster Mitigation Project in Antigua & Barbuda and St. Kitts & Nevis

April 2001

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CONTENTS

CONTENTS (Continued)

Tables

1.0 BACKGROUND

1.1 Introduction

The Organization of American States (OAS) as part of its Post-Georges Disaster Mitigation Project (PGDM) commissioned this drought hazard assessment and mapping study for Nevis.

One of the major objectives of the PGDM is the "development of national goals, objectives and actions to reduce the vulnerability of Nevis … to the effects of natural hazards."

1.2 Terms of Reference

The Terms of Reference (TOR) for the study is attached as Appendix 1. There are two major component products of this assignment, (i) a drought hazard assessment report and (ii) island wide GIS data layers that can be used to depict drought hazard risk areas and produce a drought hazard map for Nevis.

1.3 Methodology

1.3.1 Data Collection

Data for map preparation and for drought assessment were collected from secondary sources such as reports and maps, personal communication and limited field observations.

1.3.2 Mapping

Maps were first manually prepared and then digitized using GIS application, Arc View.

1.4 Definitions

For the purposes of the study and in agreement with relevant authorities, a definition of drought has been drafted as indicated below. Other relevant definitions are also provided to facilitate both the drought hazard assessment and mapping work.

1.4.1 Drought

Drought is a recurrent feature of Nevis' climate. It occurs when there is an extended period of deficiency in precipitation (relative to what is considered normal), which is then insufficient to meet economic, social and environmental demands. Given its relative small size, drought effects in Nevis are felt island wide.

For reasons of analysis, and in view of the need to determine appropriate responses to drought impacts and vulnerability, drought is defined as having three critical but inter-related components (as taken from the US National Drought Mitigation Center's definition) namely:

- Meteorological drought
- Agricultural drought
- Hydrological drought

a) Meteorological drought

Meteorological drought for Nevis is used in direct relationship to precipitation deficiencies determined to be approximately 85% or less of average annual rainfall.

Drought conditions may be accompanied or aggravated by high temperatures, strong winds, low relative humidity, greater sunshine and less cloud cover.

These conditions can be expected to bring increased evaporation and transpiration, reduced water infiltration into soils and reduction in deep percolation and ground water recharge.

b) Agricultural drought

Agricultural drought occurs when plant water demands cannot be met due to soil water deficiency resulting from dryness brought on by meteorological or hydrological drought. In such cases plant water stress may be evidenced from reduced biomass and plant yield.

c) Hydrological drought

Conditions associated with meteorological drought represent the earlier signs of drought, followed by effects of agricultural drought because plants are highly dependent on stored soil water.

Hydrological drought may be considered a third stage in the evolution of drought conditions, evidenced by significant reduction in surface reservoirs and drying of dams and wetlands. In this phase of drought, livestock may be severely impacted and other sectors begin to feel the devastation.

1.4.2 Drought Hazard

A drought related hazard is an event in which a significant reduction of water is experienced enough to bring about severe economic, social and environmental hardships to the population of Nevis.

1.4.3 Drought Vulnerability

Vulnerability to drought is defined as economic, social and environmental characteristics and practices of the country's population that make it susceptible to the effects of a drought. Vulnerability is reduced by the ability to effectively plan for, anticipate, cope with and recover from droughts.

1.4.4 Drought Risk

The potential adverse effects of droughts viewed in relation to their frequency and severity combined with the vulnerability of Nevis' population determines the risk to such events.

1.4.5 Use of the Term Drought

In this report, reference is made to the meteorological, hydrological or agricultural drought as appropriate. A simple working definition of drought could not be developed for this assessment because of varying perceptions of drought even for persons familiar with drought hazard assessment literature.

Broad-based discussions are needed between persons involved with drought mitigation planning and those involved with sectors affected by drought in order to build consensus and capacity to manage drought.

2.0 ASSESSMENT

2.1 Meteorological Conditions

2.1.1 Precipitation

Average annual rainfall for Nevis is about 46 inches/year. However, there are distinct variations in the amount of rainfall between different sections of the island. Rainfall data is measured from nine (9) stations around the island over periods from 23 to 43 years.

The elevation of recording stations varies from 30 ft to 800 ft. Mean monthly and annual rainfall data for the island is given in Appendix 2.

Average annual rainfall isohyets for Nevis indicates a progression in rainfall amounts from 35 inches/year on the east coast to 90 inches/year at Nevis Peak (3,232 ft in elevation).

The data from the rainfall stations indicate variability in monthly rainfall and established patterns of dry and wet seasons. January to June can defined as the dry season with a rainfall average of 13.27 inches/yr for all stations, although precipitation in May is consistently above average for this period. July to December can be defined as the wet season, with an average of 22.9 inches/year for all stations, although rainfall in December equals that for January at some stations.

In seeking to determine a precipitation - based definition for drought, the average rainfall recorded at all stations for the dry months was calculated as seen in Table 1.

Table 1 Average Rainfall for the Months January to June at nine Stations Measured from 17 to 43 Years

Month	Ave. Rainfall (in.)
January	2.72
February	1.65
March	1.47
April	2.37
May	2.89
June	2.17
Total	13.27

(Source: calculated from IRF, 1991)

Two assumptions are made. Firstly, if rainfall conditions for the lowest month (March) were extended over the six (6) months of the dry season, this would be perceived as a six-month drought. The total rainfall would be 8.82 inches, or 66.46% of the normal dry season rainfall for the period January to June.

Secondly, if the total average rainfall for wet season months, July to December, is equal to or less than the total average rainfall for dry season months, (<13.27 inches) then dry season conditions would exist for the entire year. This would constitute what could be considered a year-long severe drought.

Severe drought conditions as related to precipitation deficiency would exist if rainfall precipitation for the year fell below 26.5 inches or less than 60% of what is considered the yearly average.

The Department of Agriculture considers it a dry year if average rainfall is below 45 inches/yr. In addition the Department believes that drought conditions exist when there are "small amounts of rainfall" during the rainy season.

For this assessment, a middle road is taken between dry conditions and severe drought conditions in setting an average rainfall level, below which the public would perceive that drought conditions exist. The line would be 39 inches/yr or just about 85% of the average annual rainfall.

2.1.2 Temperature

Average minimum and maximum temperatures for Nevis in the cooler months are 22° and 29° C and in the warmer months 25° and 32° C. Although the seasonal differences are minimal, the cooler temperatures are significant for persons who dislike the "heat" and to water loss through evaporation and transpiration.

Since temperature reportedly drops 1° C for every 100 meters in altitude above sea level, the higher parts of the island are relatively cooler. The Island Resources Foundation (IRF, 1991) reports temperatures of below 17° C (60° F) at higher elevations.

The cone shaped nature of Nevis does not allow for topographic conditions (deep valleys, etc.) that encourage discernable micro-climatic differences in various parts of the island. However, at the windswept and drier east coast, relatively higher rates of water loss from soils through assumed higher rates of evaporation would adversely affect plant growth and hence crop performance.

Also, urban influences in Charlestown where heat is absorbed or reflected from varying surfaces (e.g., concrete, metal) would result in temperatures that would be different from some rural areas.

Such temperature differences are not captured due to a shortage of temperature recording stations.

Existing temperature stations record surface temperatures. Soil temperatures, which are critical to the performance of some plants and agricultural crops, are not recorded.

2.1.3 Winds

The prevailing winds blow from directions between northeast and southeast. Highest wind speeds normally occur in the drier months of January to April.

The slightly stronger winds, combined with soils deficient in moisture at this time of year, make soil particles more susceptible to displacement and hence higher erosion rates are likely. Dust also becomes a problem when the dry conditions extend beyond the normal dry period.

The direct physical effects of the wind, combined with salt in the air contribute to the wilting of plants, which also occurs from deficiencies in moisture. These localized effects have not been sufficiently studied, although their understanding is critical to an assessment of areas susceptible to drought.

2.1.4 Relative Exposure of Slopes

The exposure of slopes to wind and sunlight affect vegetation and soils as well as rates of evaporation and transpiration. In turn, this influences localized climatic conditions, which may affect conditions for grazing and growing crops.

For example, light increases transpiration (evaporation of moisture from leaf surfaces) rates more than it does evaporation rates (from water bodies, soil). On the other hand, wind increases evaporation rates more so than it does transpiration rates (OAS, 1991).

East facing slopes, particularly those at the shoreline, therefore experience relatively higher evaporation and transpiration rates than western facing slopes, where the afternoon sun has a greater effect on transpiration rates than does exposure to winds.

Western facing slopes on Nevis enjoy relatively better precipitation due to convective influences. In this case, warmer air rising over the land surface at the higher elevations cools and condenses releasing relatively more moisture on western facing slopes of Nevis Peak.

Here, the area of influence is relatively small and the elevation not high enough to cause the warming of descending air and subsequent withholding of moisture. As a result, the arid conditions experienced on the lee of mountains in Central America, for example, from orographic precipitation do not exist.

2.1.5 Relative Humidity

The IRF (1991) claims an average mean relative humidity for Nevis of 76% and average ranges from 70% in March to 78% in September, October and November.

2.1.6 Sunshine and Cloud Cover

Nevis experiences ample periods of sunshine throughout the course of a year, including the wet season. A crude estimate of an average nine hours of sunshine per day for the island is given by IRF (1991) but without the benefit of supporting meteorological data.

Nevis Peak exerts a physical and climatic dominance on the small island – the latter in regard to the cooling of air, cloud formation and moisture condensation. Cloud cover averages between 40 and 50%, contributing to a relatively low evapo-transpiration rate of 40 to 50 inches per year.

2.1.7 Evapo-transpiration

Evaporation rates for specific water bodies on Nevis could not be secured, presumably because they do not exist. IRF (1991) cited data from Kennedy and Robins (1988), which gave evapo-transpiration rates for Nevis of 50.89 inches per year, with relatively higher monthly values of over 4.5 inches occurring between April and August.

IRF also made reference to work done by Halcrow (1983) on a rough water balance done for Nevis. This was based on 105.3 million cubic meters (mcm) of precipitation per year. From this, 85.5 mcm was lost through evapo-transpiration and 4.5 mcm from run-off to sea, while 15.3 mcm went the route of ground water intake.

From the total ground water intake, 14.8 mcm recharged ground water sources and 0.5 mcm flowed to springs. Estimated ground water extraction at the time was 0.9 mcm year.

Evapo-transpiration and run-off figures were not based on actual hydro-geologic field data, but were analytically derived.

They should therefore be treated with caution, mindful that different figures could result from different analytical approaches. The Halcrow calculations indicated recharge as 14% of precipitation, when the standard assumption used by some hydrologists in estimating ground water recharge is closer to 20%.

The availability of more reliable estimates of run-off and recharge requires a reliable data base that would be realized through field measurements and observations.

2.2 General Environmental Conditions

2.2.1 Geology

Nevis is primarily a volcanic island but the oldest rocks are of limestone origin. Evidence of limestone formation is at the southern slopes of Saddle Hill where re-crystallized limestone exists in blocks of outcropped rocks (IRF, 1991).

Volcanic rocks were formed at different times. The oldest are found at the northwest coast and the youngest forms Nevis Peak. Erosion of the volcanic centers provided the volcanic sediment that covers most of the island, despite the evidence of marine outcropped rocks.

Most of Nevis is comprised of dacites. Andesites are found in three centers, namely, Cades Bay, Saddle Hill and the main cone of Nevis Peak (IRF, 1991).

2.2.2 Soils

A simplified soil map of Nevis adopted by IRF (1991) from Atkins (1983) shows four (4) categories of soil distribution on the island. These categories were used in preparing the Soils data map, after a comparative analysis of a detailed soils map prepared by the Land Resources Development Centre (LRDC), 1987.

This map contains 36 soil types. A suitable use (with reference to potential to agriculture) was attached to each soil type. The four classifications adopted from IRF and Atkins are summarized below with appropriate reference to the LRDC map:

- *Montmorillonitic clay with silica pan (Charlestown loam)* covering about 2/3 of the island from middle elevations to the coast mostly on slopes < 20%. Also referred to as "shoal" soil, it is considered "loamy and clayey" and difficult to cultivate. This grouping of soils includes all but six (6) of the 36 soil types mapped by the LRDC. Well over 50% of the combined acreage of the remaining 30 soil types is placed in two soil types on the LRDC map, namely, Charlestown Clay Loam (of stony type) and Charlestown Clay Loam (of bouldery type). Moisture retention varies in the entire grouping of soils in this classification and vulnerability to drought is therefore variable.

- *Nevis Peak Silty Clay* at the summit of the Peak. Over ¾ of the land is in slopes >40% and the rest slopes > 20%. The soil is strongly acidic and of little importance to agriculture.

The area covered by this classification was not mapped by the LRDC. Relatively undisturbed forest cover would help moisture retention capacity. This together with relatively high rainfall makes the area less vulnerable to drought.

- *Shallow Hilltop Sandy Loam* found northeast of the Nevis Peak summit, mainly in the Parish of St. James, on slopes >20%. The soils are considered good agricultural land but cultivation is constrained by boulders and steep slopes. Most of this area is also mapped as hilltop sandy loam by the LRDC. Although soil texture suggests good to rapid drainage, reasonable moisture retention is presumed because of good forest cover. Vulnerability to drought is low while forest cover is maintained.

- *Deep, coarse-textured Rawlin's Gravelly loam* found mainly south and east of the Nevis Peak summit and extending on the east to the coast in the Butlers/Mannings area – boulders and steep slopes limit cultivation potential. Most of the area is also labeled Rawlin's Gravelly Loam on the LRDC map. Vulnerability of soils in parts of the area is linked to settlement and agricultural land use.

This simplified version of soil distribution on Nevis draws on soil surveys done in 1940 (College of Tropical Agriculture in Trinidad) and in 1963 (Lang and Carroll).

The detailed soil map of the LRDC is a good reference for agricultural planning but is not absolutely necessary to drought assessment and mapping. The Atkins' soil map has therefore been used in the mapping for this project.

Of significance to this study is past soil loss and the potential for accelerated future erosion that could contribute to further soil loss. According to Atkins (mapped information), over 50% of topsoil loss occurred from the middle elevations to the coast at the north, east and south sections of the island. No topsoil loss was mapped for Nevis Peak, presumably because of intact vegetation and no cultivation. Topsoil loss in upper elevations below Nevis Peak, to its south and north, and on the west and southwest coasts of the island was up to 50%.

With respect to the potential for accelerated future erosion, Atkins places 61% of the country (mainly middle and lower elevations around the island) in the category of moderately severe to severe potential.

Areas where accelerated erosion is not expected to occur are Nevis Peak summit and areas immediately below to its east, north and west, Round Hill and Saddle Hill.

The potential for accelerated erosion is linked directly to land use practices. In this regard, areas under settlement, farming and grazing are those most prone to erosion hazards.

It is difficult to predict erosion rates but Atkins' analysis is indicative of what could occur based on land use and is therefore a good reference in assessing the vulnerability of Nevis to future droughts.

2.2.3 Vegetation

Vegetation zones were mapped by IRF (1990) using Rodriques (1990) as a source. The vegetation map for this drought hazard assessment is adopted from the IRF map.

Vegetation zoning indicates that Nevis Peak is comprised of three vegetation types, namely, Elfin Woodland, Palm Break, Montane Forest, which together could be considered the wet forest of the island.

Surrounding Nevis Peak and extending to its east, north and west, is the Dry "Evergreen" forest. Dry Scrub Woodland covers Round Hill/Hurricane Hill and an area between Fountain Ghut and the ghut south of Scarborough. Cactus Scrub covers the southern coastal area from Saddle Hill west to Sulphur Ghut (south of Farm Estate).

An important vegetation type is the Riparian Forest of Nevis' many ghauts. Coconut Plantation and mangroves (mainly on the west coast) and Littoral Woodland (windswept vegetation on the east and north coasts) form pockets of coastal vegetation.

The rest of the island is designated as Urban, Suburban and Agriculture. Grass cover is a feature of this category, whose designation is indicative of land use more so than vegetation type.

Sections of this zone, e.g., Hermitage to Stony Grove, are characterized by fruit and ornamental trees mixed between buildings. Tree cover is helpful in mitigating human discomfort from dust and heat during dry periods.

2.2.4 Slopes

Slopes of Nevis have been mapped by the Overseas Development Administration (1987) and adopted for this study. The steepest slopes (> 40%) are found in places such as the upper areas of Nevis Peak, Round Hill and Saddle Hill, which fortunately are some of the best covered least disturbed landscapes.

Slopes between 0% and 10% are found mainly in coastal areas (west, southwest, east, northeast and north of the island), while slopes between 10 and 40% exist mainly south of Saddle Hill and at the middle to middle-upper elevations around the island.

2.2.5 Hydrological Conditions

Watersheds and Drainage Basins

Watershed boundaries for Nevis have not been mapped due to topography and the presence of numerous ghauts that ring the island. For the most part, these drain directly to the sea without meandering tributary watercourses. The areas drained by the ghauts are relatively small and without prominent valleys. Deposits of deep alluvial soil are therefore not common.

Aquifers and Wells

Coastal aquifers have been identified for Nevis. The west coast aquifer (extending over ¾ of the west coast) averages just under 1 mile in width. This and three other aquifers were identified by IRF (1991), who cited KPA (1986) as a source.

Wells of Nevis are listed in Appendix 3 (c). There are 16 wells distributed around the island, with major well fields occurring in Maddens, Butlers (east coast aquifer), Charlestown, Hickmans and Padlock.

2.3 Land Use and Land Management Practices

2.3.1 Crop and Vegetable Farming

a) Constraints

Crop and vegetable farming in Nevis is done with a number of constraints, namely:

- Stony, bouldery and heavy clay soils with limited infiltration
- Limited soil moisture
- Relatively low soil fertility due to overgrazing and poor farming practices
- The loss of several good farmers in an inter-island ferry accident in 1970. Although most of the farmers would have retired at this time, the general feeling is that this incident was a major setback to farming from which the island has still not fully recovered.
- Inadequate irrigation infrastructure – less than ideal conditions exist for plant growth and yield during the dry months and crops are readily affected by deficient soil water during breaks in rain during the wet season.

b) Agricultural Land Use

In 1975, 31% of the land was in agriculture, 41% was defined as grazing pastureland, 10% wooded forest, 8% woodland/scrub and 10% settlement and other uses.

The amount of land under agriculture decreased since then to approximately 14% in 1999. Land is being transferred into housing, golf course and tourism uses.

Changes in farming policy or practice have not increased production yield to acreage so that the trend in the decline of land available to agriculture is likely to result in future decline in produce.

c) Vegetable Production

Production of vegetables and legumes from available data is as shown in Table 2.

Table 2 Production of Vegetables and Legumes

Year	Lbs
1986/87	140,650
1987/88	159,000
1988/89	215,000

(Source: IRF, 1991)

Major crops include cabbage, peanuts, yams and carrots, which accounted for 53% of total production in 1986/87, 65.7% in 1987/88 and 52.5% in 1988/89.

Most of the produce is consumed locally. The local market will expand with the continued growth of tourism. However, because part of the dry season (January – April) coincides with the peak tourist season (December-April) the ability of farmers to supply quality produce to hotels will be constrained by moisture deficiencies, which limit plant growth and yield at this time of year.

d) Tree Crops

Tree crops are less susceptible to extended periods of dry weather due to deeper root systems. Unfortunately, 90% of fruit trees were either damaged or destroyed by Hurricane Hugo in 1989 and full recovery has not been possible because of subsequent hurricanes.

Most fruit trees are grown on household lots. One advantage is that plants like bananas, which require a lot of water, can be fed by household gray water without adverse health effects once the necessary precautions are taken in installing the waste systems.

Coconut trees still exist but by 1990 the Department of Agriculture had stopped encouraging the use of coconuts in copra production. The potential for bottling coconut water for use as a nutritional drink in homes and for cocktails could be explored.

The tree's tolerance to salinity allows it to make adaptations to drought conditions if planted near the shoreline. Extensive fibrous roots and its copious demand for water help it to mitigate drainage problems in low lying coastal areas during periods of heavy showers.

e) Farmers

Farmers in Nevis work full or part time in agriculture. Most full time (commercial) farmers work plots 0.75 to two acres in size, while part-time farmers work plots 0.5 to 0.75 acres in size.

Many farmers work areas that are generally low in fertility or otherwise inhospitable to productive farming. This is because of shallow and stony soils, clayey conditions and poor water infiltration hence rapid run-off. Difficulties are compounded in dry months when water becomes perhaps the most limiting factor to crop yield.

Such conditions can be mitigated by improved farming methods such as:

- Terracing to slow run-off and aid infiltration
- Strategic timing of inputs (fertilizers, pesticides, etc.)
- Measures to aid moisture retention (such as mulching and wind breaks) and hence slow moisture loss
- Use of organic amendments in soil to modify soil structure for better aeration and infiltration
- Crop selectivity; ensuring the crops are suited to plot conditions, including exposure to wind, clay, shallowness

Farmers are usually reluctant to change habits or may not have the resources to make changes even when they are willing.

2.3.2 Livestock Farming

a) Constraints and Problems

Livestock grazing presents a challenge to land management in Nevis. Two major constraints with which farmers must content are:

- Ownership of land large enough to sustain grazing; many livestock owners are landless or own plots not large enough for grazing.
- Poor quality of grazing lands; this is partly linked to lack of ownership, which eliminates any chance of improving pastures unless under lease arrangements with provisions that do not discourage long term investment.

Because livestock ownership remains a strong tradition in Nevis, farmers continue to raise stock not withstanding the difficulties posed by the above constraints. A large percentage of the livestock population is therefore poorly managed and creates problems for the country as a whole, namely:

- Damage to commercial crops and household gardens. Such damage increases during drought because of a decline in the quality of rangeland.
- Widespread damage to habitats (forest and scrub) by goats in particular. This makes such areas more vulnerable to the effects of drought.
- Erosion due to overgrazing.
- Poor water infiltration and increased run-off due to soil compaction.

b) Livestock Population

The total livestock population (cattle, sheep, goats, pigs) for Nevis in 1975, 1985 and 1986 is given in Table 3. The current population of cattle, sheep and goats is shown in Table 4.

Table 3 Livestock Population for Nevis 1975, 1985 and 1986

Year	Population
1975	17,877
1985	23,900
1986	10,815

(Source: IRF 1991, after Department of Agriculture)

The goat population showed a major increase from 5,869 in 1975 to 9,000 in 1985 but declined to 3,521 in 1987 (IRF, 1991). Such rapid decline in two years was not explained but would appear to be unusual.

Table 4 Current Livestock Population by Species, Nevis

Livestock	Population
Cattle	904
Sheep	10,060
Goats	18,000
Pigs	na

(Source: Department of Agriculture, January, 2001)

There has been a marked increase in livestock population between 1975 and 2001, with goats alone numbering more than the figure for 1975. The larger livestock population increases the pressure on the landscape given the nature of grazing practices.

c) Grazing Practices

Grazing and rough grazing areas have been delineated on the land use data map for Nevis. The term *grazing* as used for mapping refers to grassland or bushed grassland areas where cattle and small ruminants are able to move freely in the absence of vegetative cover that restricts movement.

The term *rough grazing* refers to bush land or cactus scrub areas where livestock movement is more restricted due to plant density. Grazing also occurs in some of the settlement areas identified on the Land Use data map.

There are two major issues associated with grazing practices on Nevis. One is excessive livestock population density. The other is limited control over the movement of livestock. These combine to create a landscape highly vulnerable to drought.

2.3.3 Settlements and Communities

Distribution

The distribution of settlements is shown on the Land Use data map for Nevis. Settlement population and location with respect to elevation are provided in Appendix 4. The elevation of settlements in relation to the elevation of storage reservoirs is critical to water pressure experienced from distribution lines.

Settlements that encounter water pressure problems due to their elevation in relation to water storage reservoirs are:

- Fountain/Westbury
- Brown Hill.

A number of homes in Zetlands are above the elevation that allows for mains water distribution and therefore rely on roof catchment and cistern storage.

Water pressure problems are more severe during droughts when water rationing becomes necessary.

2.3.4 Hotels and Tourist Zones

Major hotel locations are north of Charlestown, south of Nevis Peak at middle elevations and the Nevis north coast. None of these areas have the density or cluster of properties that warrant the definition of a tourism resort area as used in other destinations with hotel clusters.

However, a land-use zoning map used by the Physical Planning Office in making planning decisions on development applications has identified several coastal areas for tourism development.

2.4 Water Resources and Water Supply

Effective water resources management is critical to achieving reasonable success in mitigating the impacts of drought. For this reason, this part of the report examines water resources and water supply on Nevis. The review of supply covers demand for water.

2.4.1 Water Resources

a) Watersheds

The watershed as a hydrological unit is not as readily defined in Nevis as it is in other islands where slopes and valleys feature prominently in the landscape. Rather than using the watershed as a unit for management, water resource planners have divided the island into water demand zones.

The island is divided into two (2) main zones (north and south) and nine secondary zones (see Water Resources and Supply data map). The 1990 population and demand by zone are given in Table 5.

This zonal classification, while convenient for water demand management may need to be complemented by a corresponding supply management system, whose primary goal would be to manage watersheds, catchments and watercourses to sustain run-off and soil quality.

b) Aquifers

Aquifers for Nevis were defined and mapped in 1986. They are coastal and extend along almost the entire length of the west coast (north to south) and almost the length of the east and north coast. In effect, the aquifers sit at the edge of a fresh water lens lying underneath the island.

Table 5 Nevis Domestic Water Zones by Demand, 1990

Zone	Population	Demand (@ 65gpd)
Newcastle	250	16,250
Westbury	95	6,175
Cotton Ground/ Jessup	1,247	81,055
Charlestown	2,392	155,480
Morning Star	1,010	65,650
Stoney Hill	1,767	114,855
Hardtimes	1,241	80,665
Butlers	344	22,360
Brick Kiln	362	23,530
Camps	407	26,455
Mt. Lily	303	21,645
Total	**9,448**	**614,120**

(Source: Nevis Water Department, IRF,1990)

c) Springs

A number of springs form part of the water resources profile of the country, namely:

- Camps springs
- Maddens spring
- Jessup spring
- Nevis spring
- New River spring

2.4.2 Water Demand

Water needs of Nevis, domestic, agricultural and industrial, are met by combined surface rain and ground water sources. From January to November 2000, water demand, based on metered supply averaged less than 700,000 gpd. Total water consumed from metered supply for the period was 230,066,000 gallons. Total water produced was 253,774,000 gallons.

Consumption by user group is given in Table 6. The data provided by the Nevis Water Department did not contain water used for agriculture. Water sold to the Four Seasons Resort to irrigate its golf course accounted for 21% of total water consumed during the period.

Table 6 Metered Water Supply, January to November, 2000, Nevis

User	Total ('000 gals)	Cost (EC$)
Hotels	42,686	1,068,050
Irrigation (FSR)*	49,263	988,660
Domestic	135,003	1,251,063
Non-Domestic	11,545	230,009
Total billed	215,515	3,604,556
Government	14,551	no charge
Total Consumed	230,066	
Total Produced	253,774	

(Source: Nevis Water Department)
** Supplied to Four Season's Resort*

The data also showed that water production remained around 27 million gallons each month, except for September, when production was zero and October when production was just over seven million gallons.

Monthly average consumption from January to May was about 17.5 million gallons and for June to November 23.9 million gallons. During the months of low consumption, water production remained above the 27 million gallons level, so that between January and May only 51 to 69% of monthly water produced was accounted for according to the data provided by the Nevis Water Department.

2.4.3 Water Supply

a) Wells

In 1990, the well system accounted for 721,440 imperial gallons per day (igpd), as against demand at the time of 614,120 gpd. Today 16 wells, 14 of which are commissioned, account for 1,236,960 IGPD.

It is significant that 94.8% of the actual yield from the wells is pumped from wells in three zones as shown in Table 7.

Table 7 Water Production by Zones, Nevis

Zone	# Wells	Total Actual Yield (IGPD)
Maddens/Butlers	5	547,200
Padlock/Hickmans	5	378,720
Charlestown	4	247,680
Sub Total	14	1,173,600
Zion	1	63,360
Paradise	1	-
Total	16	1,236,960

(Source: Nevis Water Department)
Note: Padlock/Hickmans well is not Commissioned but has 115,200 IGPD Yield capacity. The Paradise well is not Commissioned but has a yield capacity of 17,280 IGPD.

East-coast aquifers are critical to the water needs of the island, supplying 74.8% of daily yield. The well zones drawing on east-coast aquifers are Maddens/Butlers, in the Parish of St. James and Padlock/Hickmans in the Parish of St. George.

b) Storage Reservoirs

The current municipal or domestic water storage capacity in Nevis is 3,125,500 imperial gallons. The water is stored in 23 reservoirs ranging in capacity from 2,000 gallons at Spring Hill to 560,000 gallons at Stoney Hill.

The island has no municipal surface storage reservoir for potable water. A summary of the location, type of construction, capacity and elevation of the reservoirs is provided in Appendix 3 (a). Their locations are given on the Water Resources and Supply data map.

Reduction in loss by evaporation normally experienced with surface reservoirs is a major benefit of enclosed water storage as provided by the tanks.

According to the Nevis Water Department all settlements below 1200 ft. are served by water in its distribution system. A review of the location of the reservoirs, whose elevations range from 185 ft. AMSL to 1120 ft. AMSL would suggest that most settlements are adequately served.

c) Booster Pumps

The island uses five (5) booster pumps (Appendix 3 (b)) to move water from well fields to storage tanks. Gravity then feeds the water distribution network. The total yield of the pumps is 931,200 IGPD. (See Water Resources and Supply data map for pump locations).

The Fothergills pump is located at about 500 ft AMSL, approximately 1 ½ mile above the Padlock/Hickman's wells. The Camps pump is about 200 ft AMSL near Scarborough; the Springhill pump about 500 ft ASML between Westbury and Fountain.

d) Springs

Five (5) springs yield 135, 360 IPGD (see Appendix 3 (d)). Several dams and ponds are located in different parts of the island. Their capacities were not determined.

e) Roof Catchment and Storage

Planning guidelines encourage the construction of cisterns for houses and other buildings. However there are no required standards for water catchment and storage for residential buildings or hotels.

f) Dams/ponds

Several dams and ponds located in different parts of the country provide water for agricultural uses. These were mapped using available information (see Water Resources and Supply data map).

Because of their importance to agriculture, a thorough inventory of the dams and ponds should be done and the results used to update the data maps. Water storage capacities should be determined and recorded as part of the drought management database.

Publicly owned dams and ponds are managed by the Department of Agriculture.

3.0 IMPACT AND VULNERABILITY

3.1 Historic Drought

This section of the report reviews the impacts of past droughts on the islands and the response to the adverse effects experienced.

3.1.1 Description of Drought Events

Based on rainfall records obtained from the Department of Agriculture, three (3) periods of drought have been identified for the last decade, namely:

1990 – 1991
1993
1997

The year 2000 may also turn out to be one of below average rainfall –the average rainfall from January to November being 32.51 inches.

In 1990, average rainfall was 46.77 inches but 15.11 inches was recorded for the month of October. For the rest of the year rainfall was 31.66 inches and for the months of January to September only 24.37 (See Appendix 2). Even with the 15.11 inches of rain recorded for October 1990, the average rainfall for the two-year period was 37.07.

In 1993, average rainfall was 37.10 inches and in 1997, 34.06 inches.

Actual yearly rainfall figures before 1990 were not obtained but 1974 was said to be perhaps the worst period of drought in recent times (Richard Lupinacci, Hermitage Hotel, pers. comm.) Lupinacci said that the dryness and wilting of vegetation in 1974 was the most severe experienced in recent times even in higher elevations such as Hermitage where average rainfall is about 55 inches/year.

3.1.2 Drought Impacts

3.1.2.1 Environmental Impacts

a) Vegetation and Landscape

Drought impacts were particularly severe in watersheds where plants with shallow root systems on shallow soils were among the first to be affected by deficiencies in soil water.

Significant losses in biomass productivity were experienced for undeveloped areas of such watersheds seeking to re-establish an ecosystem integrity after years of cultivation and charcoal burning,

No studies were made of soil conditions during the 1990-91 drought. However, it is assumed that moisture deficiencies during this and other droughts gradually led to the reduction in soil fertility. Plant growth and crop yield is affected as a result.

Leaf and stem loss in herbaceous and woody plants were followed by plant mortality in certain species in the 1974 drought (R. Lupinacci, pers. comm.). As plants wilted and died, canopy cover decreased in wooded areas and the landscape generally became visibly brown, dusty and harsh looking.

In Nevis, prolonged periods in which the landscape is visibly stressed are perceived as hard times. This perception is a carry over from times when rain fed agriculture provided the major source of income and livelihood for rural families.

The reduction and, in some cases, disappearance of plant cover exposed soils to the erosive force of winds and water when it eventually rained. Under such conditions, soil loss can be severe.

Atkins reported in 1983 (see IRF, 1991) over 50% topsoil loss for lands on the east and north coast of Nevis and the total loss of topsoil in an area between Indian Castle and Whitehall Estate.

Soil exposure due to overgrazing makes more land vulnerable to accelerated erosion with each drought. Soil loss is therefore a major environmental impact from drought particularly on the east, northeast and southeast coastal areas that are very exposed to wind.

Accelerated soil loss is assumed to affect soil fertility, which in turn impacts on agriculture.

b) Habitat

In Nevis, wildlife habitats are sometimes also used for grazing by livestock. Such areas may have a combination of scrub, grass and woody plants with sufficient canopy cover to attract different species of birds.

Ideal ecosystem conditions require adequate moisture. Inadequate moisture during the droughts created conditions that were stressful to bird, reptile (lizards) and amphibian (frogs) species.

Stressful conditions are exacerbated by competition for resources and space from goats and other livestock. Population densities in some areas are in excess of what are considered sustainable for such ecosystems.

One constraint in assessing habitat impacts is the absence of detailed listings of plant species preferred by goats. Unlike cattle and sheep, goats browse (rather than graze) normally on various herbaceous plants and woody shrubs as well as on ornamental plants if they get access to household gardens.

Since biomass production of grass used by livestock in Nevis declines faster relative to many species used by goats, grazing livestock are likely to reach the critical threshold of nutritional stress earlier than goats.

3.1.2.2 Economic Impacts

a) Agriculture

Agricultural Landuse

The Department of Agriculture was not able to provide an up-to-date agricultural land use map. The information used for mapping agricultural uses was therefore taken from the various other sources that are credited on the drought hazard Land Use data map.

The Preliminary findings of the 2000 agricultural and fisheries census provide a summary of the location and acreage of agricultural holdings in Nevis (Table 8).

The 3,278.5 acres of land in agricultural holdings represent 14% of total land area in Nevis. It is instructive however that only 5% of the land is devoted to what the census terms “agricultural purposes.” What is termed “common grazing lands” is not included in this calculation by the census.

Table 8 Number of Agricultural Holdings by Parish, Nevis

Parish	Holdings Land-less	Holdings With land	Total	Acres
St. Paul	4	163	167	160.3
St. Thomas	8	156	164	1,261.3
St. James	19	209	228	515.6
St. George	23	369	392	734.5
St. John	9	311	320	606.8
Total	63	1,208	1,271	3,278.5

(Source: St. Kitts and Nevis 2000 Agriculture and Fisheries Census)

It is assumed that the distribution of the 5% of land devoted to agriculture will be presented by parish in the final census report so that geo-referencing of land under production could be done with the location of critical water resources (e.g. aquifers) and water infrastructure (wells, dams or reservoirs, booster pumps).

Such relationships are helpful in making assumptions about past impacts of droughts geographically or spatially where data is lacking and more important, in trying to determine agricultural areas vulnerable to future droughts.

For example, the parish of St. George has five (5) reservoirs with total capacity of 1,155,500 imperial gallons located at various areas within its borders that could allow for gravity flow to farm areas. It also has six (6) wells with total yield of 442,080 IGPD.

However, farming in the parish remains mainly rain fed because of the cost of domestic water. Here vulnerability to drought could be reduced if a way could be devised to subsidize the purchase of water.

Farmers in the Cades area of St. Thomas, on the other hand, benefit from free (subsidized) water supplied by government dams located in the spring Hill/Westbury area. These farmers remain vulnerable to drought since they use irrigated water from dams totally dependent on rainfall.

In response to request for information, a written summary was received on the impact of drought on the agricultural sector. This summary is provided below as given, namely:

a) The period of time water is available in open dams becomes limited.
b) Farmers have to reduce their scale of operations as a direct result.
c) Farmers use more domestic water, which is at a higher cost.
d) Due to a decrease in local production, more vegetables and fruits are imported – loss of revenue to farmers and loss of foreign exchange.
e) The quality of certain vegetables, for example lettuce, watermelon and cucumber, is severely affected.
f) Smaller and poorer quality feed for livestock.
g) Poorer quality meats.
h) Deterioration of conditions of animals resulting in fewer returns.
i) Overgrazing, which impacts on agriculture and the environment.
j) Increase in the mortality rate of animals.

Dams

The location and capacity of agricultural dams in Nevis are shown in Table 9.

Table 9 Location and Capacity of Agricultural Dams, Nevis

Designated Location	Dam#	Capacity (gallons)
Cades Bay	1	1,000,000
	2	600,000
	3	700,000
	4	400,000
	5	800,000-1,000,000
New River	1	15,000
	2	1,000
Potworks	1	600,000
Matters		n/a

(Source: Department of Agriculture)
Note: The Matters dam leaks because of insufficient clay lining

The Cades Bay dams are actually located in the Spring Hill area at >500 ft amsl. They fall within the 50-inch average per year rainfall zone, based on average rainfall isohyets developed by Atkins, 1983 and IRF, 1991. However, the closest rainfall station to the dams is at Cades Bay at 90 ft amsl (see Table 10).

Table 10 Location and Elevation of Rainfall Stations, Nevis

Station/Location	Elevation (ft amsl)
Bellevue	70
Prospect Agri. Station	280
Indian Castle Estate	30
New River Estate	200
Hardtimes Estate	800
Eden Brown	120
Maddens Estate	270
Potsworks	59
Cades Bay Estate	90
Hamiltons	510

(Source: Department of Agriculture, 2001 and IRF, 1991)

Farms in the Cades Bay area are gravity fed from the dams at higher elevation with a total capacity of 3.5 million gallons. Potsworks farms benefit from a dam with the storage capacity of 600,000 gallons, while dams supplying farms at New River have a total capacity of only 16,000 gallons.

According to the Department of Agriculture, drip irrigation is the most common method of irrigation in these areas but sprinkler systems are also used.

The initial impact on farmers during times of drought is monetary. When dam sources dwindle or dry up farmers are forced to use domestic water bought at the cost of EC$5 per 1000 gallons. Water costs then become a major factor in the ability of farmers to keep crops supplied with the level of moisture required to achieve normal yields. This is particularly so where drought conditions result in higher temperatures and evaporation rates.

The quantification of effects from drought relative to the availability of water and the understanding of future vulnerability are hindered by:

- Absence of rainfall stations at dam locations; rainfall stations exist at estates fed by the dams (Cades, Potsworks, New River) but the stations at Cades Bay and Potsworks Estate are not routinely monitored, hence regular monthly data is not available.

- Absence of reliable evaporation records from the dams.

- Failure to meter dam water supply to farms.

Reduction in Farm Operations

The Department of Agriculture's conclusion that farmers reduce the scale of their operations when water in dams becomes limited is understandable. There is however no data readily available to determine quantitatively:

- Reduced acreage of land farmed in any of the drought periods and for what period of time.

- Reduced crop yield per acre.

- Reduction in volume of crop produce.

- Cost to farmers.

Use of Domestic Water

A monetary impact on the use of domestic water by farmers as a substitute for dam water could easily be determined if supply from dams was metered. Metered dam water supply would also allow authorities to estimate additional demands for water from farms during drought periods.

Increased Importation of Vegetables and Fruits

Based on number of holdings and acreage under cultivation, sweet peppers, sweet potatoes, tomato, cabbages, pumpkins, carrots, chive, tannia, yams and cucumber are major annual crops on Nevis.

Among permanent crops, bananas, mango and coconuts have relatively large holdings (between 355 and 461 acres), while breadfruit, sugar apple, soursop, avocado pears, limes, golden apple, guava and guinep have holdings ranging between 150 and 200 acres.

Bananas are moisture-loving plants with growth and yield adversely affected by extended periods of dry weather. Coconuts on the other hand use a lot of water but are less vulnerable to drought particularly where located in areas with high water table.

Thus, rarely would there be a need to import coconuts, while the tendency is to import bananas at the first indication that local production is down.

The same is true for vegetables in relatively high demand such as carrots, tomatoes and sweet peppers.

Quality of Vegetables

Water-loving vegetables such as lettuce, cucumber and watermelon and fruits such as bananas, decline in quality when they experience moisture stress. The impact is most severe for farms without access to dam or domestic water.

Impact is also relative to space requirements of crops. For example, lettuce can be intensely grown in small parcels thus moisture requirements are more easily managed than for plants requiring more space per plant.

Quality of Livestock Feed

When there is a deficit of rainfall biomass productivity among species of grass used by grazing livestock drops relatively quickly. This is true for managed livestock ranges (labeled grazing on the land use data map) and unmanaged livestock ranges (labeled rough grazing).

Managed livestock areas that are fenced with extensive grass cover require contingency measures (securing hay) to ensure that adequate feed is available. This is costly in time and/or cash for farmers.

In rough grazing areas, with a dominance of cactus/scrub vegetation and low percentage of grass cover, small ruminants (particularly goats) are better able to endure drought conditions even when biomass production in grass drops significantly.

The cost to livestock owners may be less but goats and sheep will graze or browse beyond their normal ranges to the detriment of vegetable farmers. Crop damage from uncontrolled grazing livestock during extended periods of dry weather carries a major cost that is not normally quantified.

Animal Health

The droughts affected the health, weight (hence marketability) and productivity of livestock. Hot weather caused heat stress, which is said to reduce fertility through sperm damage. Hot weather also affects libido in male animals, decreases milk production in cows and kills chickens (Dr. Paul Cadogan, 2000).

Animals also suffered from dehydration caused by shortages of water.

Livestock Mortality

Death of livestock caused by drought was confirmed by the Department of Agriculture after consultation with the Veterinary Division. However, drought related mortality figures were not available.

In the Annual Report of the Veterinary Division, 1999, livestock losses attributable to hurricanes Jose and Lenny in 1999 were given along with the dollar value linked to such losses.

That such records are not available for drought related deaths suggest that there might be difficulties in getting reports on losses from farmers. It could also be that losses from drought occur over a period of time and the impact is less pronounced than the damage caused by a hurricane.

Economic Impacts

The economic impacts could therefore be summarized as:

- Setbacks to the development of small and large herds due to drought effects on the productive capacities of animals.
- Reduction in weight and hence marketable volume of meat because of undernourishment.
- Reduced marketability of animals and their products due to the mal-nourished appearance of animals and the feeling (real or imagined) that they were afflicted by disease brought on by the drought.
- Reduction in the supply of local meats, creating more dependency on imported meat products.
- Significant income loss to livestock farmers.

Many farms in Nevis are still rain dependent despite a growing trend towards drip irrigation.

As a result, widespread crop failure continues during extended dry periods or droughts. Even farms with access to potable water may be affected if reduced water supplies lead to water rationing.

Absence of Drought Insurance

The economic impacts on agriculture from drought were compounded by the absence of drought insurance for crops and livestock. Insurance is lacking for three key reasons:

- Insurers do not perceive this as a feasibly investment of resources, given the relatively small sizes of farms and livestock herds.
- Even if crop and livestock insurance for drought was available, small farmers most likely would not have seen the need. With the small size and subsistence nature of many operations, paying insurance premiums would have been considered an additional financial burden.
- Crop insurance is not integral to the small farm culture in Nevis.

In the absence of being able to file claims for crop damages and/or loss, farmers had to absorb their own financial losses. The experience was difficult and stressful for many farmers and, in some cases, dampened the enthusiasm for future investment in agriculture.

b) Tourism

Accommodation and Location

Nevis has 478 rooms divided between hotels/resorts, condominiums/villas, plantation inns and guesthouses as indicated in Table 11.

Table 11 Nevis Tourism Accommodation

Type	No. Rooms
Hotels/resorts	258
Condos/villas	12
Plantation inns	96
Guest houses	16
Total	478

(Source: St. Kitts & Nevis Visitor, Vol. 5, 2000-2001)

A number of the plantation inns and guest houses are located south of Nevis Peak within the rainfall "shadow" where temperatures are relatively more comfortable and conditions for plant growth better.

Most of the hotel rooms are on the west coast. A few of the plantation inns and guesthouses are located on the relatively exposed north coast. Fortunately, none are sited on the lower elevations of the east coast where exposure and dryness in periods of drought make vacations less comfortable.

Tourist Arrivals

Nevis' economy is tourist dependent. Since 1994 when the total number of tourist arrivals was 45,686, the worst year for tourism was 1995, when 39,459 tourists visited. Since then arrivals peaked at 49,812 in 1997 and declined to 47,032 in 1999 (see Table 12).

Table 12 Tourist Arrivals, Nevis 1996-1999

Type	1996	1997	1998	1999
Stay over	30,020	33,014	31,798	31,534
Excursionist	1,063	1,251	867	1,027
Yacht pass.	5,567	5,252	5,512	4,993
Sub Total	36,650	39,517	38,177	37,554
Cruise pass.	9,142	10,295	11,061	9,478
Total	45,792	49,812	49,238	47,032

(Source: St. Kitts & Nevis Department of Tourism)

Landscape, Product and Climate

Nevis' tourism is promoted on the strength of its climate, sea and beaches. Numerous ground tours are designed around its ecology and scenic landscape.

Drought adversely affects the quality of the biological landscape (that is the living landscape of plants and animals) and the physical (non-living) landscape. The latter is due mainly to the heat and dust associated with extended periods of low precipitation.

During the droughts the general quality of the visitor experience was affected by relatively hotter and drier conditions and a landscape stressed from heat and moisture deficiencies.

The extent to which such conditions affected eco-tours is not known. Reason suggests that drought would adversely impact on how the visitor perceives the natural landscape if not on the understanding of the landscape's ecology.

While these impacts may not have caused tourists to shorten their vacations, they could possibly have impacted negatively on decisions to make return visits. The potential future income lost from return visits or from potential visits from friends who might have been influenced to visit if their experiences were more positive, cannot be determined.

Failure to quantify economic loss in this case, however, should not reduce the significance of drought effects on the tourist product.

Property Landscape

One impact from droughts was the loss of plants on hotel property. Hotels did not have to purchase water from other than normal sources but indications were that some rationing of water occurred on properties.

At an average cost of EC$25 per 1000 gallons, some hoteliers view water as expensive. Consequently, although water was available from the local water authority, water was sparingly used on plants. As a result, properties such as Hermitage reported a loss of plants.

Local Produce

Hotels had difficulties securing local fresh fruits and vegetables. Hermitage reported difficulties in purchasing local bananas, melons and other fruits, lettuce and various other vegetables.

Effects on Workers

Unlike Antigua, where workers were laid off due to a decline in tourism, none of the hotels interviewed reported laying off workers as a direct consequence of the droughts.

Impact on Natural Attractions

Natural attractions of vegetation and scenic interests lose their visual appeal due to moisture deficiency.

The Nevis Island Development Plan 1996-2005, Volume 1, Island Profile Survey lists the following natural attractions:

- Nevis Peak National Park
- Gallows Bay Bog
- Saddle Hill
- Round Hill/Hurricane Hill
- Nelson Spring
- Pinney's Beach and Wetland
- New Castle Bay
- Indian Castle.

It is not known if any of these were affected by drought conditions to the point where visitors' trips were reduced. Even if this were the case, it would have been difficult to obtain supporting data because the infrastructure to record such trips to most, if not all, of these attractions does not exist.

c) Settlements

The Nevis Island Development Plan 1996 – 2005 identifies 25 "defined" settlements but actually listed 24. The 24 settlements are grouped by location in order of relative exposure to normal trade winds, east, west, north and south and presented in Appendix 4.

The elevations of the 24 settlements were taken from a Directorate of Overseas Surveys (DOS) map, Series E803 (D.O.S 343), Edition 5 O.S.D. 1984 and are also given in Appendix 4.

A summary of the location of inhabitants based on the grouping of settlements is provided in Table 13.

Nevis' population by parish is given in Table 14. This is provided for reference, particularly for entities where the parish boundary is still considered an important delineation for management purposes.

Table 13 Inhabitants by Settlement Grouping

Location	#Settlements	Pop.
West, NW, SW	7	4201
East, NE, SE	10	2909
North	1	210
South	7	1494
Total	24	8804

Table 14 Parish Populations, Acreage and Number of Settlements

Parish	Area(acres)	# Settlements	Pop.
St. Paul	858	1	1,414
St. John	5,146	7	2,189
St. George	4,545	8	2,079
St. James	7,671	4	1,499
St. Thomas	4,405	5	1,623
Total		25	8,804

(Source: NIA & UNCHS/UNDP, 199?)

3.2 Future Vulnerability

This section of the report seeks to identify areas where the potential adverse effects of droughts combined with the vulnerability of the population of the area would constitute risk.

Factors contributing to drought risk have been identified as listed below:

- Low rainfall.
- Exposure to wind and marine influences.
- Exposure to excessive sunlight based on orientation to sun.
- Problem soils, defined as soils that are either shallow, stony, erosion prone, soils with poor infiltration, heavily leached soils, or soils known to be lacking in nutrients.
- Areas with high-density livestock populations or grazing wildlife (monkeys).
- Areas considered disadvantaged in regard to their location to water resources, including, key watersheds, catchments, aquifers, springs, dams and ponds.
- Areas disadvantaged in regard to location to water supply infrastructure or network, including, storage reservoirs, water mains, pumping stations.

3.2.1 Agriculture

The agricultural sector remains highly vulnerable to future droughts for several reasons, namely:

Location of crops. Crops located in areas where rainfall is below the national yearly average will remain vulnerable to drought if rain continues to be the sole source of water for plants. Vulnerability can be reduced if water for irrigation is made available at reduced or subsidized rates.

Vegetable crops grown in shallow soils on relatively steep slopes will also remain vulnerable unless water and soil conservation measures are applied. Depending on the level of constraints posed by shallow soils and steep slopes, soil and water conservation measures could be very costly and may prove uneconomical in some applications. Cultivation practices that cannot be sustained can be considered economically vulnerable.

Cost of water. Although the number of farms with access to water for irrigation is increasing, irrigation remains uneconomical for most small farmers because of the cost of water. As a result, even if farms have access to potable water, cost could prove a deterrent to its use in meeting irrigation requirements.

Overgrazing. High livestock population density will continue to adversely affect the landscape, soil, habitat and plant growth unless radical policy interventions are made to mitigate these impacts. If mitigation does not occur, large sections of the island's landscape will remain vulnerable to drought.

Better control of livestock populations will be necessary to reduce and eventually eliminate crop damage from goats and sheep, which increases during periods of drought.

3.2.2 Tourism

Recent increases in water supply will reduce the impacts of meteorological drought on the hotel sector. Where dry weather conditions persist long enough to drastically reduce ground water yield, water rationing would be required and this would affect hotels.

Growth in the hotel sector, along with the construction of any additional golf courses, would significantly increase demand to the point where supply could become inadequate. For this reason, growth in water demand should be anticipated and investment made to increase supply to reduce vulnerability to drought.

3.2.3 Settlements

Settlements have become less vulnerable to droughts because water supply and distribution have improved in recent years. A few settlements are affected by low water pressure because of water transmission and water supply problems.

The majority of settlements are not expected to suffer major water shortages for household use unless rainfall deficiencies persist long enough to affect ground water yields. However, households headed by farmers that are dependent on agriculture for all or part of their incomes will remain vulnerable to meteorological droughts, where costs prohibit irrigation of crops.

Certain characteristics that may suggest the need for mitigating the vulnerability of settlements to drought can be identified, namely:

- Residential areas without potable water supply.
- Villages or areas where household connections to potable water are below the national average.
- Areas in high elevations relative to storage reservoirs, susceptible to periodic low pressure water problems.

- Areas supplied by inadequate storage, pumping or distribution infrastructure, resulting in periodic water shortage problems.

- Villages overly dependent on subsistence farming.

3.3 Institutional Arrangements

3.3.1 Key Agencies

Institutional capacity to manage drought is a critical factor in reducing vulnerability to drought events. Key agencies dealing with drought include the Nevis Water Department, Department of Agriculture, the National Disaster Emergency Management Agency (NEMA), Department of Tourism and the Development Planning and Development.

The approach to planning, research and data management with respect to drought is ad hoc. The correct orientation and a commitment to drought impact mitigation, including adequate resource allocation and training of selected staff, are required.

3.3.2 Procedures and Information

It is recognized that drought is a recurring event in Nevis. However, apart from actions being taken to reduce problems related to potable water, there are no clear procedures in place to mitigate drought impacts and drought information management is disorganized.

To improve the capacity for drought management, drought effects must be documented and a database to assist with decision making is needed. Also, procedures for drought awareness and building of public support for drought mitigation are critical measures to be considered.

4.0 ANALYSIS OF AREAS AT RISK

4.1 Understanding and Applying the Concept of Risk

Drought risk for the purposes of this analysis is considered as having two (2) contributing factors, namely:

- Recurring environmental or meteorological events or natural physical characteristics beyond the control of man.

- Human practices (policy or land use) that make the population vulnerable to natural events and characteristics.

a) Natural risk factors

- Variable climate (periodic low rainfall).
- Exposure to wind and marine influences.
- Exposure to excessive sunlight based on orientation to sun.
- Problem soils resulting from geological history that may be soils that are shallow, stony, erosion prone, have poor infiltration, heavily leached or lacking in nutrients.

b) Land use practices leading to vulnerability

- Removal of forest cover, for agriculture, housing or other needs.
- Overgrazing (high density livestock populations).
- Cultivation on steep slopes.
- Disregard for water and soil conservation practices.
- High per capita water consumption.

c) Policy

- Cost of water for irrigation.
- Inadequate regulation of livestock grazing and livestock population densities.
- Absence of incentives for water and soil conservation practices.
- Lack of drought insurance.
- Lack of drought relief programs.

4.2 Areas At Risk to Drought

4.2.1 Drought Risk Criteria for Mapping

Mapping of areas on the basis of their risk to drought, namely, low, moderate, high and very high is based on a set of criteria. Each criterion is given a value of one (1) and the total value of an area determines its rank:

Low drought risk	1-5
Moderate drought risk	6-8
High drought risk	9-10
Low drought risk	11-12

The listing of drought risk criteria is shown in Table 15. A description of the criteria follows:

a) Meteorological/Environmental

< ***45 inches Rainfall***. Areas that experience < 45 inches of rain annually fall just below average annual precipitation of 46 inches. Average rainfall for the dry season (January to June) is considerably lower in these areas. Therefore for extended periods during the year, plants and crops in such areas are affected by inadequate soil or foliage moisture.

Exposure to wind. Areas with excessive exposure to wind are determined by location, topography and slope type. Exposure to wind adversely affects evapo-transpiration and soil erosion rates, the latter where natural vegetation cover has been lost.

Table 15 Drought Risk Criteria

Environmental Meteorological	
• Rainfall < 45 inches	1
• Exposure (wind)	1
• Strong marine influence	1
• Shallow soils	1
• Slopes >10 degrees	1
• Cactus scrub and agricultural vegetation	1
• Absence of moist forest	1
• Absence of dry evergreen forest	1
• Absence of dry woodland forest	1
Hydrological/Infrastructural	
• Absence of wells, springs	1
• Absence of storage reservoirs (ponds, dams)	1
Human/Landuse	
• Grazing	1
• Cultivated crops	1
• Settlements	1

An area's position in relation to the direction of prevailing winds will determine its level of exposure. As such, sites on the east, southeast and northeast coasts of Nevis are more likely to be affected.

Exposure to marine influences. Areas affected by marine influences are often those affected by exposure to wind. Such areas are therefore found on the east, southeast and northeast coasts. Many plant species have low levels of tolerance to salt in the air. Crops and ornamental plants with low salt tolerance perform poorly in such areas and are particularly vulnerable in periods of drought.

Established plant communities in areas of strong marine influence evolve from tolerance or adaptation to salt spray. When ecosystem balance is disrupted by human influences, habitat recovery is slow, particularly for areas affected by overgrazing and when soil loss from erosion is accelerated. Drought exacerbates such problems.

Shallow Soils. Shallow soils have limited moisture retention capacity and are often lacking in nutrients. Root development is often retarded because of inadequate soil depth.

Where vegetation is well established on such soils without recent disturbance vulnerability to drought is low. Vulnerability increases when cutting, grazing and other forms of land use, disturbs vegetation.

Two soil groups mapped in this project (see soil data map) are used in this criterion. One is soil group # 3, described as Shallow Hilltop Sandy Loam and found northeast and east below the summit of Nevis Peak. The other is soil group # 4, of the middle and lower elevations. This group is included because of relatively high rates of topsoil loss (over 50% topsoil loss on the east, northern and southeastern parts of the island) and up to 50% topsoil loss on the west and southwest parts of the island.

Slopes > 10 degrees. Where such slopes have retained forest cover, particularly in the forests at higher elevations, they are less prone to erosion and better able to retain moisture than slopes that have lost natural vegetation cover. Habitat degradation from drought is less severe on slopes in the former category.

Cactus Scrub and Agricultural Vegetation. These refer to two vegetation categories used on the Vegetation data map, namely Cactus Scrub and Agriculture and Settlements. The cactus scrub designation includes areas that are subjected to extensive livestock grazing.

The lack of dense vegetation cover in many parts of this vegetation zone encourages grazing and browsing by sheep and goats – major factors contributing to the vulnerability of the landscape to drought. Such areas visually exemplify the brown, harsh and oftentimes depressing conditions of droughts.

The Cactus Scrub designation, as used on the vegetation map for Nevis, includes remnants of naturalized vegetation. Such vegetation evolved on account of meteorological and other environmental influences, along with vegetation in various stages of succession after being cleared or cultivated.

The former may include combinations of Acacia spp, lucaena and other legumes, agaves, cactus and other xerophitic species, all well adjusted to drought conditions. This type of association is considerably less vulnerable to drought except where coverage is sparse enough to allow overgrazing or browsing of the under storey. Where this happens, soil erosion or compaction can adversely affect soil fertility or otherwise retard plant growth.

Vulnerability is therefore more associated with Cactus Scrub areas, where vegetative associations are less agreeable to drought conditions or where land uses create imbalances in the landscape that may lead to severe erosion or flooding.

Areas designated settlement on the vegetation map are also subject to grazing in rural areas and to building practices that increase the rate of soil erosion. Where soil and water conservation is not practiced vulnerability to drought increases in agricultural ecosystems and crop yield decreases.

A weakness in using this criterion is the lack of adequate vegetation information that would allow a more detailed classification of the various types of vegetation associations found within the Cactus Scrub designation. Work is therefore needed to update, detail and more comprehensively map vegetation for the island.

Notwithstanding the weakness in vegetation data and the drought resistant nature of many plant species found in the Cactus Scrub vegetation zone, such areas remain vulnerable to drought for several reasons:

- Goats appear to like the general dryness of this type of landscape and appear to favor a number of herbaceous plants and other shrubs found in it.

- Where drought resistant species exist but with sparse vegetative wood cover, over grazing of under storey vegetation leads to erosion and slower plant re-growth.

- Where grass offers adequate cover for soil and moisture during normal conditions rapid loss of biomass due to water deficiencies in the soil and from grazing leaves the soil exposed.

- Extensive grazing in Cactus Scrub areas adversely affect plant diversity and the ecology of some areas. Species liked by goats and sheep have difficulties surviving;

- Ornamental plants introduced in gardens falling in this general vegetation category are often not suited to local conditions – for example, water loving plants cultivated in areas with low precipitation. Such plants die quickly where water is not available for extended periods.

Absence of moist forest. Moist forests of Nevis (Montane forest, Palm Break forest and Elfin Woodland forest) represent areas of high rainfall and limited disturbance. Because vegetative cover is well maintained such areas are less vulnerable to rapid moisture loss and erosion. Conversely, areas without moist forests are relatively more at risk to drought.

Absence of dry Evergreen forest. Good land cover is maintained in Dry Evergreen forests. Such areas are less vulnerable to drought than areas that have been disturbed or otherwise affected by human uses.

Absence of dry woodland forest. As with moist and dry evergreen forests, dry woodland forest (designated dry scrub woodland on the vegetation data map) provides protection against erosion that places areas with sparse vegetation cover at risk to drought.

b) Hydrological/Infrastructure

Limited water resources (wells, springs). These are areas where wells or springs are absent or limited or where ground water deposits are absent. Where such resources exist, provisions for water relief to local areas can be made even where pumping from wells or springs is tied into the national water distribution grid.

Local areas without these resources do not have options for tapping into local springs or wells when water shortages occur on the national distribution lines.

Absence of Dams/ponds. Areas with no agricultural dams or ponds create difficulties for crop and livestock farmers in periods of drought. During droughts, water levels drop in ponds and dams, or these reservoirs may even run dry. Nevertheless, some level of replenishment may result from periodic rainfall, which places areas with water storage facilities at an advantage over areas without such facilities.

c) Human/Landuse

Grazing. Grazing densities of > 6 goats or sheep per hectare or 1.5 cattle per hectare for pasture areas without irrigation is considered not sustainable.

Grazing densities were not available but it is common knowledge that there are areas in the island that are excessively grazed.

Where livestock densities are in excess of sustainable limits in improved (managed) pastures, impacts are mostly felt within the boundaries of the fenced pasture. Vulnerability from grazing is therefore due mainly to the threats to crops, gardens and habitats posed by un-tethered livestock found in Grazing and Rough Grazing categories on the Land Use data map.

Livestock population and grazing density data by area is required to strengthen vulnerability and impact analysis.

Settlements. Nevis' settlements are generally small but scattered over relatively large areas. Settlement development from Charlestown on the west and New River on the east of the island provides an example of ribbon type growth that occurs along most of the island's ring road.

Low-density development is associated with higher per capita cost for water supply infrastructure that makes it difficult to recover investment and operating costs from revenue.

Housing development trends suggest the continuation of low-density settlements and possibly the continuation of a policy to subsidize water supplied to homes.

This is not a sustainable policy and could limit the development of water production to keep pace with demand and increase vulnerability to drought over the long term.

Because the raising of small ruminants (goats and sheep) is associated more with households and less with livestock farms, settlement patterns to a large extent determine the impact of livestock on the landscape.

Cultivated Crops. This criterion is used for two main reasons. One is that the relative position of cultivated crops to agricultural reservoirs or domestic water mains supply determines to some degree the vulnerability of farms during periods of low rainfall. Information to map water distribution infrastructure was not acquired in this assessment but should be used to update drought hazard mapping in the future. For this assessment, it is assumed that water mains are buried alongside main and secondary roads.

The second reason for using cultivated crops is the threat posed by sheep and goats to farms particularly when drought reduces the amount and quality of forage plants preferred by these animals. Crops located close to un-tethered livestock are most vulnerable in this respect.

4.2.2 Areas

The assessment confirms, what perhaps is already known, that the central mountain area of moist forest has the lowest risk to drought. Moderate risk areas include the northwest and north of the island.

High-risk areas include the Charlestown water zone and the Butlers/Mannings water zone on the east of the island. The south and southeast section of the island is considered to be of very high risk to drought.

It is suggested that additional work be undertaken to confirm these drought risk designations. The work should include field observations to update the data maps where necessary.

Emphasis should also be placed on identifying more appropriate boundaries for water resources and drought management. A thorough analysis of drainage basins on the island could provide the basis for the delineation of the management boundaries.

Follow-up should also involve the refinement of the methodology used for drought risk ranking. Selective merging of drainage basins into units for managing drought would require re-evaluation and adjustment to the drought risk zones.

5.0 DROUGHT MAPPING

5.1 Data Collection and Sources

Data for drought hazard mapping were obtained from:

- Past projects and project reports, e.g. USAID funded Country Environmental Profile, prepared by the Island Resources Foundation, the St. Christopher Heritage Society and the Nevis Historical and Conservation Society, and the Land Resources Development Centre, Overseas Development Administration maps on land use, and soils.

- Government agencies, such as the Nevis Water Department, Department of Agriculture and Planning Department.

- Field observations.

Relevant sources are credited on individual maps.

5.2 Structure and Content of Maps

The drought hazard map for Nevis were produced by analyzing ArcView GIS generated data maps with the following titles:

- Mean Rainfall Isohyets
- Vegetation
- Slope
- Water Resources and Supply
- Soils
- Land Use

The structure (content) of the each data map is given in Appendix 5.

5.3 Analysis of Data

Data was analyzed using ArcView. The Risk Criteria identified in Section 4.0, were used as vulnerability themes and spatially manipulated by:

(i) Analyzing the spatial occurrence of vulnerability themes in the various water zones. This was used to rank the water zones in relation to drought risk based on numerical scores given in Appendix 6. Acreage data for land covered by relevant themes, e.g. grazing, was not calculated but could be done in the future when vegetation and other data are updated.

(ii) Overlaying (intersecting, as opposed to merging in ArcView GIS terminology) the themes to determine areas of critical risk.

In relation to (i) water zones were given drought risk ranks as shown in Table 16. Water zones were used because they are the geographic units used for water management on the island.

Table 16 Drought Risk Ranking of Nevis Water Zones

Level of Risk	**Water zones**
Low	5, 7
Moderate	8, 9
High	6, 10
Very High	2, 3, 4

By overlaying themes from data maps, critical areas within the water zones that require remedial policy and land management actions can be identified.

5.4 Map Use and Limitations

a) Map Use

The maps can be used for sector, strategic or development planning, disaster mitigation planning and drought management. The watershed, as a hydrological unit, with a common drainage basin is considered the most appropriate physical space for managing drought.

However, watershed boundaries for Nevis are not distinct because of the island's cone shaped topography and are not used by the Water Department to differentiate areas for management.

The Water Department uses Water Zones instead. These can be considered water supply management zones. They are not drainage basins but are used to rank areas according to level of drought risk.

These zones are numbered 1 to 9 for identification and reference in this drought hazard assessment.

Ranking of water zones in relation to drought risk provides the necessary background for further investigation and mitigation of drought impacts.

For any given water zone, themes from data sets (maps) can be overlaid or merged to highlight actual or potential impacts from drought, as shown in the following examples:

a) ***Overlay*: Cactus Scrub vegetation + Grazing and Rough Grazing.** Result: Tells the extent to which grazing impacts on this vegetation zone. Acacia and other woody or thorny species, dense enough to discourage foraging by goats and sheep, often characterize areas that fall outside of where the two themes intersect.

Defining mitigation strategies to protect such areas, which may be the least degraded of the Cactus Scrub associations, will require the updating of field data for more accurate mapping and/or detailed reclassification of the Cactus Scrub vegetation zone.

b) ***Overlay*. Grazing + > 10° slopes + exposed slopes (east coast) + < 45 inches rainfall**. Result: Indicates areas of actual or potential landscape degradation, where vegetation re-growth is retarded; also indicates actual and potential areas of soil erosion from wind and rain;

c) ***Merge*. Cultivated crops + grazing and rough grazing.** Result: actual or potential threats to crops from livestock.

Limitations in Use of Maps

The maps can be used as references to drought mitigation planning and drought impact assessment. Data inadequacies however may prevent their use for certain types of decision making without the benefit of additional research and field observations.

In this regard, weaknesses of various maps are pointed out, namely:

- **Nevis, Average Annual Rainfall Isohyets (Inches).** Eleven (11) rainfall stations are identified on this map. The stations are located between 30 ft and 800 AMSL. Rainfall at higher elevations is therefore based on estimates and not on actual recordings. This means that while the rainfall map provides an approximation of rainfall distribution on the island, additional rainfall stations should be erected and monitored regularly for better accuracy.

- **Vegetation Map.** The main source of the vegetation map is IRF (1991), based on work by Rodriques (1990). Nevis does not have a Forestry Department so changes to vegetation are not monitored continuously. Not much change is assumed to have occurred to forests at the higher elevations but land use impacts on cactus scrub areas and riparian forests may have created changes that can be corrected with adequate fieldwork.

- **Slope.** The slope map provides general rather than detailed slope categorization. GIS can generate detailed slope analysis from the PGDM contour map. This should be done where site specific assessment of drought impact and mitigation is required;

- **Water Resources and Supply.** This map shows boundaries for water zones of Nevis rather than watershed boundaries. Watershed boundaries represent natural geographic divisions useful in the management of water resources, land use and drought. Water zones facilitate the management of water supply, which is critical to drought management. However they do not provide a hydrological reference that would be more effective in managing key water resources, e.g., aquifers and well fields.

- **Soils.** The soil classification used is general but adequate for this assessment. Digitization of more detailed soil types can be done in the future using the work done by the Land resources Development Centre (1987).

- **Land Use.** Time was not available under this project to adequately review and verify land use data sources. There is no ongoing project in the Physical Planning Unit on land use mapping for the entire island. Since land use is undergoing continuous change in Nevis the map should be updated as significant changes are observed, particularly where practices could lead to increased vulnerability to drought.

6.0 INDICATORS FOR FUTURE IDENTIFICATION OF DROUGHTS

This section summarizes and describes indicators that suggest approaching or actual drought conditions. These indicators are discussed under the following categories:

- Meteorological/Environmental
- Hydrological
- Agricultural
- Socio-economic

a) Environmental Indicators

- ***Reduction in biomass production of common grass species.*** Early warning is wilting, as grass roots become progressively damaged by lack of soil water; grass cover becomes patchier as fallen leaf debris is blown away by wind in exposed areas. Homeowners find no need to use lawn mowers.

- ***Leaf fall and litter in forests***. Leaf fall and litter (detritus) on the forest floor is another indicator of drought. Measurement of volume or weight of detritus would be required if this indicator is to be reliably used. Since leaf fall varies between species, measurement would need to be correlated with plant associations.

  In Cactus Scrub forests, xerophytes (plants growing in dry areas), such as those with small hard leaves can use measures to decrease water loss when the area begins to get drier, such as dropping their leaves in prolonged drought.

- ***Damage to "indicator" plant species***. Some types of xerophytes, (succulents, such as cacti and agaves) utilize stored water in dry periods without noticeable damage. In fact, such plants can survive for weeks when uprooted, so that signs of damage (dried leaves or broken stems) may be an indication of negative water balance resulted from extended drought.

b) Hydrological

Reduction in Ground Water levels. The Nevis Water Department uses ground water levels at various well fields in as an indicator of hydrological drought.

There is a time lapse between meteorological and agricultural drought conditions and hydrological drought as indicated by ground water levels. The latter occurs later but the time lag cannot accurately be predicted in the absence of more complete rainfall data that could be correlated with rates of pumping and recharge for the drainage areas in which the well fields occur.

Recovery from meteorological and agriculture droughts occurs in advance of the replenishment of ground water to average levels. Again, the data does not exist to accurately predict the gap in time between these events.

Reduction of Water Levels at Dams and Ponds. Receding water levels at dams and ponds is another drought indicator observed but not measured in Nevis. Indicator levels at selected dams could be established over a period of time by consistent monitoring of meteorological and hydrological data, including, rainfall, temperature, wind speed, evaporation and seepage.

Drying of wetlands. Drying of fresh water wetlands is also an indication that

that ground water levels have receded to critical levels.

Water Rationing. Improvement in water supply has reduced the frequency and the length of time water needs to be rationed during droughts. However, when necessary, the Nevis Water Department begins to ration water before ground water levels recede to critical points.

In fact, the decision to begin rationing water appears to be influenced by perceived meteorological and agricultural drought conditions and is taken before water reaches critically low levels in aquifers (hydrological drought).

Rationing encourages a form of water conservation. Therefore, the practice to begin rationing before the situation becomes critical is good. However, better coordination between key government agencies to reach consensus on when to begin rationing is required. Once the decision is made, adequate public awareness should follow to build public support for the rationing program and conservation measures required as a result.

c) Agricultural

Livestock

Livestock gain water from drinking water, foraging plants and water molecules produced in the breakdown of food. They lose water through urine, feces and water evaporated through the skin and lungs.

Some livestock can reabsorb water into their intestines to produce dryer feces and can reduce water used to excrete nitrogenous wastes of the urine (Brewer, 1994).

Goats are animals adapted to drought conditions and are presumed to use similar physiological measures to conserve water. However, despite being able to adapt to drought conditions, they and other livestock will show signs of stress during extended drought:

- ***Weight loss***. Symptoms are reduced muscle density and visible ribs. Effects are more associated with tethered livestock. However, untethered animals foraging larger areas for food use more energy and may suffer similar weight loss;

- Higher incidence of disease.

- Unusual high incidence of miscarriage among pregnant females.

Crops

Indicators may include:

- Negative water balance, as evidenced from wilting and ultimately death of plants in extended droughts.

- Unusually high incidence of disease as plants are unable to obtain needed moisture and nutrients from the soil.

d) Socio-economic

Socio-economic indicators include changes in water use practices by households and businesses:

- Storage of water in existing or temporary storage facilities as a result of water rationing.

- Reduction of water used for landscaping of household and hotel gardens.

- Regular trucking of water to meet water deficit due to rationing.

- Higher incidence of respiratory ailments due to excessive dust in a very dry landscape. Respiratory ailments related to drought are not recorded for Nevis but are generally considered a drought related health impact.

References

Brewer. Richard. 1994. *The Science of Ecology. Second Edition.*

Cadogan, Paul. Dr. 2000. *Quoted in article, Extreme Weather Distresses Regional Farmers. Caribbean Edition, Executive Time, page 13.*

Government of St. Kitts/Nevis and FAO. 2001. *St. Kitts and Nevis 2000 Agricultural and Fisheries Census. Preliminary Findings.*

Island Resources Foundation. 1991. *Nevis Environmental Profile.*

National Drought Mitigation Center. 1995. *Categories of Drought Definitions.*

Nevis Island Administration and UNCHS/UNDP. 1996. *Nevis Island Development Plan 1996-2005 (Volume 1: Island Profile, The Survey)*

Nevis Island Administration. 1999. *Annual Report Veterinary Division 1999.* (Prepared by Dr. Patricia Bartlette-Powell, Veterinary Officer.

OAS. 1991. *Desertification Hazard Assessment (Chapter 9).*

APPENDICES

Appendix 1 Tasks Outlined in Terms of Reference

Under this contract, the consultant will undertake the following activities for Nevis:

a) Meet with the relevant agencies and individual… to collect reports and data on drought hazards. These are to include both agencies that collect information on drought and those representing sectors affected by drought (e.g. tourism, agriculture, water authorities, economic and physical planning.) …Document current information and procedures regarding drought, existing definitions of drought, designated lead agencies and existing policies and plans.

b) Undertake a drought hazard vulnerability assessment for Nevis. The assessment is to be consistent with current drought hazard assessment methodologies and with reporting needs for St. Kitts/Nevis under the Convention to Combat Desertification. Activities under the hazard assessment include:

   i) Compile historic evidence of drought effects on critical sectors. To the extent possible, the social, economic and environmental impacts of these events are to be described. From this information, develop a working definition of drought and indicators for future identification of future drought events.

   ii) Compile information on and assess causes of drought. Included in this investigation are the contributions of precipitation patterns, controlled and uncontrolled grazing, soil types and development.

   iii) Identify the sectors most at risk to the effects of drought. Assess the vulnerability of these sectors to drought and determine the level of preparedness for future events. Meet with representatives of these sectors to determine appropriate responses to any gaps in preparedness.

   iv) Produce island-wide geographic information system (GIS) data layers depicting drought hazard risk zones in Nevis. These data are to be in an Arc/Info or ArcView-compatible format, geo-referenced to the common mapping standard for the islands, and accompanied by appropriate GIS metadata.

   v) Using the GIS data described above, produce island-wide drought hazard maps for Nevis. These maps will depict areas of high, medium and low-risk to drought. All maps are to include a common set of reference features (e.g. roads, settlement areas), to be provided by the PDGM for this purpose, and will conform to the PDGM hazard map layout, as defined by GS/OAS. Where appropriate, information on vulnerable sectors is to be included on these maps.

c) Produce a technical report of the drought hazard assessment. This report should include a proposed definition of drought in the context of the islands and indicators for future identification of drought events. This technical report should also identify key contacts on each island for drought hazards.
d) Produce non-technical summaries of the drought hazard assessment. This summary should be suitable for distribution independent of the technical summary and should be approximately 2,500 words in length.

Appendix 2 Mean Monthly and Annual Rainfall Data for Nevis up to 1985

DATA TYPE	STATIONS 1	2	3	4	5	6	7	8	9
Period of Record (yrs)	23	42	31	36	28	36	42	43	17
Elevation (ft.)	30	800	200	270	60	50	510	280	725
Monthly Data (inches)									
January	1.70	3.34	2.01	2.40	2.14	2.51	3.84	3.74	2.81
February	1.23	1.92	1.36	1.49	1.27	1.42	2.29	2.38	1.52
March	1.19	1.64	1.18	1.42	1.17	1.50	2.28	1.80	1.09
April	2.48	2.30	1.45	2.35	2.47	2.41	3.06	2.19	2.64
May	1.67	3.42	2.08	2.57	3.14	3.46	3.88	3.23	2.58
June	1.26	2.25	1.99	2.17	1.95	2.72	2.76	2.70	1.79
July	2.75	3.72	2.83	3.69	3.54	3.96	4.56	3.98	2.84
August	3.42	4.51	3.46	4.46	3.82	5.09	5.21	5.23	3.31
September	2.92	5.23	3.92	4.76	3.68	5.51	6.09	4.78	4.34
October	3.72	4.73	4.11	4.20	4.57	5.08	4.62	4.56	5.27
November	2.50	4.52	3.76	4.49	4.53	4.84	5.02	4.55	6.22
December	2.55	3.88	2.57	3.08	2.76	3.24	4.57	3.90	3.85
Annual Data (in.)	**33.30**	**45.38**	**29.66**	**43.08**	**39.80**	**45.98**	**51.60**	**46.98**	**44.83**

Note on Stations:

1 Indian Castle 6 Cades bay
2 Hard Times 7 Hamiltons
3 New River 8 Prospect
0 Maddens 9 Prison Farm (privately operated)
1 Potworks

(Source: IRF, 1991 after Kennedy and Robins, 1988).

Appendix 3 (a) Municipal Storage Reservoirs, Nevis

Location	**Type**	**Capacity Imperial Gals**	**Elevation (ft. AMSL)**
Stoney Hill	Reinforced concrete	560,000	1120
Stoney Hill	Glass reinforced plastic	270,000	1120
Morning Star	Glass reinforced plastic	200,000	660
Hamilton	Reinforced concrete	366,000	345
Hamilton	Glass reinforced plastic	200,000	345
Hardtimes	Reinforced concrete	45,500	800
Cox	Reinforced concrete	30,000	690
Burden Pasture	Reinforced concrete	25,000	830
Old Manor	Reinforced concrete	10,000	760
Maddens	Reinforced concrete	50,000	525
Maddens	Glass reinforced plastic	200,000	530
Brick Kiln	Reinforced concrete	100,000	295
Camps	Reinforced concrete	50,000	185
Mount Lily	Reinforced concrete	40,000	600
Mount Lily	Glass reinforced plastic	200,000	610
Cotton Ground	Reinforced concrete	45,000	200
Jessups Upper	Reinforced concrete	100,000	650
Jessups Lower 1	Reinforced concrete	62,000	420
Jessups Lower 2	Fused glass/steel	200,000	430
Fothergills	Glass reinforced plastic	270,000	640
Spring Hill	Fused glass/steel	80,000	750
Land Development Hamilton	Reinforced concrete	20,000	410
Spring Hill	Reinforced concrete	2,000	525
Total Gallons		**3,125,500**	

Appendix 3 (b) Booster Pumps, Nevis

Booster Pumps	**Theoretical Safe Yield (IGPD)**	**Actual Yield (IGPD)**	**Horse Power**
Fothergills	504,000	336,000	100
Camps	504,000	336,000	110
Springhill	96,000	48,000	20
Trech Wells	316,800	211,200	40
Totals	**1,420,800**	**931,200**	**270**

(Source: Nevis Water Department, 2001)

Appendix 3 (c) Yield of Wells, Nevis

Wells	Theoretical Safe Yield (IGPD)	Actual Yield (IGPD)	Horse Power
Maddens 1	180,000	227,520	40
Maddens 2	72,000	72,000	20
Maddens 3*	72,000	72,000	20
Butlers 1	100,800	92,160	25
Butlers 2	86,400	83,520	20
Paradise*	17,280	0	6
Hospital	64,800	74,880	15
Government Road	72,000	57,600	15
Charlestown school	64,800	64,800	15
Stoney Ground	57,600	50,400	15
Zion	72,000	63,360	15
Padlock 1	115,200	115,200	40
Padlock 2	151,200	151,200	40
Padlock 3*	115,200	0	30
Hickmans 1	36,000	40,320	11
Hickmans 2	72,000	72,000	23
Totals	**1,349,280**	**1,236,960**	**350**

* *not in commission*

Appendix 3 (d) Yield of Springs, Nevis

Springs	Theoretical Safe Yield (IGPD)	Actual Yield (IGPD)
Nevis Source	43,200	43,200
Camps Springs	72,000	72,000
Maddens	20,160	20,160
Jessups	0	0
Totals	**135,360**	**135,360**

(Source: Nevis Water Department, 2001)

Appendix 4 Nevis Settlements Population, Location and Elevation

Settlement Grouping	Population	Elevation (ft AMSL)
West, Southwest and Northwest		
1. Charelestown, Hamilton/upper Gov't Road,Craddock Road /Pinneys	1921	<10 - 450
2. Bath Village, Bath, Stoney Ground	709	<50 – 300
3. Brown Hill/Prospect, Low Ground/Pembroke	455	250 - 400
4. Jessups	438	50 - 350
5. Barnes Ghaut	168	350 - 450
6. Cotton Ground	373	<50 - 250
7. Westbury	137	250 - 400
Sub Total	**4201**	
North		
8. New Castle	210	<50 - 150
East, Northeast and Southeast		
9. Brick Kiln	277	100 - 250
10. Butlers	306	50 - 500
11. Camps, Liburd's Hill/Barnaby/Scarborough	420	<50 - 200
12. Fountain, Mount Lily	286	250 - 600
13. Bucks Hill	190	400 - 500
14. Hanley's Road	398	300 - 400
15. Hardtimes	336	750 - 950
16. Rawlins/Hull Ground	222	900 – 1100
17. Hickman's/River Path	203	250 - 500
18. Zion/Harris	271	200 - 650
Sub Total	**2603**	
South		
19. Cole Hill/Morning Star	248	400 - 600
20. Brown Pasture	242	500 - 800
21. Church Ground	174	500 - 800
22. Hermitage	79	500 – 1000
23. Cox/Pond Hill	282	750 - 850
24. Maynard Ground/Zetland	209	500 - 1000
25. Clay Ghaut	250	650 – 800
Sub Total	**1484**	

(Source: Nevis Island Administration (NIA) and UNCHS/UNDP, 1996? For Settlements and Population)

Appendix 5 Structure (Content) of Mapped Data Sets, Nevis

Data Set Map Title	**Content (Legend)**
Nevis, Average Annual Rainfall Isohyets (inches)	Rainfall isohyets; Rainfall stations
Nevis, Vegetation	Dry "Evergreen" Woodland; Montane Forest; Palm Break; Elfin Woodla Woodland; Cactus Scrub; Littoral Woodland; Coconut Plantation; Ripar Woodland
Nevis, Slopes	0-2°, 3-11°, 11-20° and 21-30° slopes
Nevis Water Resources and Supply	Water Zone boundaries; Storage reservoirs; Dams/ponds; Wells; Springs
Nevis Soils	Deep, course-textured Rawlin's Gravelly Loam; Nevis Peak Silty Clay; Loam; Montmorillonitic Clay with silica pan: Charlestown Loam
Nevis Land Use	Cultivated crops; Tree crops; Coconut plantation; Grazing; Rough grazir Settlement

Appendix 6 Drought Risk Totals by Water Zones

Water Zones

Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Cactus scrub agricultural vegetation	1	1	1	1	0	0	0	0	0
> 10° slopes	1	1	1	1	1	1	1	1	1
Shallow soils	1	1	1	1	1	1	1	1	
Grazing	1	1	1	1	0	1	0	1	1
Rainfall < 45 inches/yr	1	1	1	1	0	1	0	0	0
Settlements	1	1	1	1	0	1	1	1	1
Cultivated crops	1	1	0	1	0	1	0	0	1
Absence of Wells, Springs	0	1	1	0	1	0	0	0	0
Absence of Storage Reservoirs, Ponds/Dams	0	0	0	0	1	0	1	0	0
Exposure to marine influences			1	1		1			1
Exposure to winds			1	1		1			1
Absence of moist forests	1	1	1	1		1		1	
Absence of dry evergreen forest	1	1	1	1					
Absence of Dry woodland forest	1	1	1	1	1		1	1	
Total	**10**	**11**	**12**	**12**	**5**	**9**	**5**	**6**	**6**

Appendix 7 Map References For Nevis, St. Kitts and Nevis Country Environmental Profile, IRF, 1991

Appendix 8 Drought Contacts

1. Mr. Llewellyn Newton, Nevis Coordinator, National Emergency Management Agency (NEMA)
2. Mrs. Esternella West, Director (Ag.) Department of Planning and Development
3. Ms. Berneece Herbert, Economic Development Officer, Department of Planning and Development
4. Mr. Kiethly Amory, Ag. Director, Department of Agriculture
5. Mr. Eric Evelyn, Communications Officer, Department of Agriculture
6. Hon. Lauhton Brandy, Jr. Minister, Planning and Development, Trade, Industry, Labour, Youth and S
7. Ms. Elmeade Brooks, Director of Tourism
8. Mr. Floyd Robinson, Manager, Nevis Water Department

Appendix 5 Structure (Content) of Mapped Data Sets, Nevis

Data Set Map Title	**Content (Legend)**
Nevis, Average Annual Rainfall Isohyets (inches)	Rainfall isohyets; Rainfall stations
Nevis, Vegetation	Dry "Evergreen" Woodland; Montane Forest; Palm Break; Elfin Woodland; Dry Scrub Woodland; Cactus Scrub; Littoral Woodland; Coconut Plantation; Riparian Woodland; Mangrove Woodland
Nevis, Slopes	0-2°, 3-11°, 11-20° and 21-30° slopes
Nevis Water Resources and Supply	Water Zone boundaries; Storage reservoirs; Dams/ponds; Wells; Springs; Booster pumps;
Nevis Soils	Deep, course-textured Rawlin's Gravelly Loam; Nevis Peak Silty Clay; Shallow Hilltop Sandy Loam; Montmorillonitic Clay with silica pan: Charlestown Loam
Nevis Land Use	Cultivated crops; Tree crops; Coconut plantation; Grazing; Rough grazing; Forested area; Settlement

Appendix 6 Drought Risk Totals by Water Zones

Water Zones

Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Cactus scrub agricultural vegetation	1	1	1	1	0	0	0	0	0
> 10° slopes	1	1	1	1	1	1	1	1	1
Shallow soils	1	1	1	1	1	1	1	1	
Grazing	1	1	1	1	0	1	0	1	1
Rainfall < 45 inches/yr	1	1	1	1	0	1	0	0	0
Settlements	1	1	1	1	0	1	1	1	1
Cultivated crops	1	1	0	1	0	1	0	0	1
Absence of Wells, Springs	0	1	1	0	1	0	0	0	0
Absence of Storage Reservoirs, Ponds/Dams	0	0	0	0	1	0	1	0	0
Exposure to marine influences			1	1		1			1
Exposure to winds			1	1		1			1
Absence of moist forests	1	1	1	1		1		1	
Absence of dry evergreen forest	1	1	1	1					
Absence of Dry woodland forest	1	1	1	1	1		1	1	
Total	**10**	**11**	**12**	**12**	**5**	**9**	**5**	**6**	**6**

Appendix 7 Map References For Nevis, St. Kitts and Nevis Country Environmental Profile, IRF, 1991

Appendix 8 Drought Contacts

1. Mr. Llewellyn Newton, Nevis Coordinator, National Emergency Management Agency (NEMA)
2. Mrs. Esternella West, Director (Ag.) Department of Planning and Development
3. Ms. Berneece Herbert, Economic Development Officer, Department of Planning and Development
4. Mr. Kiethly Amory, Ag. Director, Department of Agriculture
5. Mr. Eric Evelyn, Communications Officer, Department of Agriculture
6. Hon. Lauhton Brandy, Jr. Minister, Planning and Development, Trade, Industry, Labour, Youth and Sports
7. Ms. Elmeade Brooks, Director of Tourism
8. Mr. Floyd Robinson, Manager, Nevis Water Department