3. Infrastructure

a) Transport

Total direct damages in the transport sector are summarised in Table 28. It encompasses damages to roads, ports, vehicles, airports and all means of transportation, including losses of aircraft and vessels. How these figures were calculated is detailed in this section, where the different components are analysed.

Table 28

BELIZE: TRANSPORT DIRECT COST OF DAMAGE

(Belize dollars)

Sub sector	Total damages	Total reconstruction costs	Labour	National	Foreign
Total	46,735,790	32,726,357	5,028,785	14,321,253	13,376,319
Infrastructure (public sector)	43,550,790	28,901,357	4,991,285	14,313,753	9,596,319
Roads network	23,154,392	25,804,990	4,273,806	12,938,160	8,593,024
Airports	75,000	115,000	66,000	27,500	21,500
Ports	516,747	678,857	190,977	196,838	291,042
Villages and town streets and urban infrastructure	19,804,651	2,302,510	460,502	1,151,255	690,753
Equipment (private operators & owners)	3,185,000	3,825,000	37,500	7,500	3,780,000
Vehicles (buses) a/	150,000	150,000	30,000	7,500	112,500
Aircraft	2,395,000	2,875,000	7,500	0	2,867,500
Vessels b/	640,000	800,000	0	0	800,000

Source: ECLAC, on the basis of official data.
a/ Ministry of Works (MOWTC&BI).
b/ Vessels rescued by the Port Authority only.

One of the persistent effects of hurricane Keith – more than the wind force and the severity of the rainfall – is the passive flooding. As the inland area effected by the storm is mainly flat, low terrain, with a very small gradient towards the sea, water remained on the ground and rivers persisted in above normal levels for a long time. This not only affected agricultural land and cattle pastures, but very significantly also caused a breakdown in communications by the interruption of many highways, secondary and feeder roads for an extended period. In fact water was deposited in Belize's flood plains during the storm at much above normal levels than

the terrain's absorption capacity. Clay-based soils were saturated by the rainfall registered (at Philip Goldson Intl. Airport rainfall registered reached 809.9 mm in four days, while September normally registers for the whole month 288.9 mm in spite of seasonally being the second most rainy month). The slow evaporation and filtration to the underground will take in total over 16 weeks by some estimates.

An illustration of the low elevations of the affected continental area is that in the country's western border at Blue Creek – located 40 miles form the coast line – altitude above sea level is of just over 2 meters. This has two effects: on one hand, the water accumulated does not drain and, on the other, water speed does not cause erosion. Thus it does not – per se – have a destructive effect over the road and highway infrastructure. This aspect is to be considered in the further analysis as an important fact.

Indirect costs to the transportation system are shown in Table 29. Given the indicated conditions of the roads and that repairs, once the flooding recedes, should not be very costly, indirect costs are substantially larger than direct ones. This is on account of the economic, social and operating costs increased due to the closing of roads to normal operation. It also bears mentioning that while direct cost are to be borne mainly by the public sector, indirect costs will reflect mainly in the users and operators, mostly private.

Table 29

BELIZE: TRANSPORTATION INDIRECT COSTS

(Belize dollars)

Sub sector	Total cost	Government	Private users & operators
Total indirect cost	33,633,646	859,115	32,774,531
Highways	32,240,193	4,025	32,236,168
Cut of roads	22,328,299	4,025	22,324,274
Use of alternative roads	527,612	0	527,612
Roads condition	9,384,282	0	9,384,282
Airport	1,393,453	855,090	538,363
Airport	893,453	855,090	38,363
Airlines lost of income	500,000	0	500,000
Port	0	0	0
Port facilities	0	0	0
Operators lost of income	n.a.	n.a	n.a.

Source: ECLAC.

i) Main highways direct damage. The storm affected the Western Highway and the Northern Highway. The Western Highway was affected by flooding in the initial section close to Belize City due to the Sibun river overflowing. The road was underwater for a number of days and due to the continuous passage of vehicles erosion loosened the pavement surface and affected the base course. Culverts overflow and blockage contributed to the slow dispersion of the waters. Most of the damage was done by heavy traffic passing over the soaked structure of the road. Additionally, at Roaring Creek Bridge, close to Belmopan, in the Belmopan-San Ignacio section, a major cut occurred due to the river's overflow, causing the road to remain under the water level for a number of days.

The Northern Highway was affected by flooding in the initial section close to Belize City and was under also. A similar situation was observed at Carmelita Toll, the New River overflowed and the highway was under water for some days. Culverts collapsed in many places along the lane buy no more damages were reported even the storm passed in the same direction along all the road in its rout to the Gulf. Less damage affected some culverts in the Hummingbird Highway was also reported and included in the account.

The total direct cost of damage in these main highways is shown in Table 30. Reconstruction estimated cost of BZ$2.8 million as shown in the same table. A breakdown in labour needs and national and foreign components is also included.

With regard to the secondary network (public feeder roads, as different from in-farm feeders that are accounted for in the agricultural sector), of a total of 1,515.8 miles of such roads, 740 of them were affected. Most damage occurred in culverts and fill erosion, with a total direct cost of damage of BZ$20.7 million, as shown in Table 31.

Two bridges collapsed in low standard feeder roads. Estimated damage and reconstruction costs appear in Table 32. Fortunately they were located in an area where many alternatives may be used if necessary.

Table 30

BELIZE: DIRECT DAMAGE TO MAIN HIGHWAYS a/

(Belize dollars)

Road N°	Road name	Length miles	Activity	Unit	Quantity	Unit price damage	Unit price reconstruc-tion	Value of damage	Value of reconstruc-tion	Labour	National	Foreign
	Total	219 4						1,676,274	2,801,704	519,167	818,608	1,463,929
AR1	Western Highway	73.7	Fill	yd^3	1,995	30	30	59,850	59,850	8,978	32,918	17,955
			Culvert	foot	5,000	94	134	469,000	670,000	234,500	134,000	301,500
			Base Course	yd^3	404	38	75	15,162	30,324	3,032	12,130	15,162
			Shoulder Rep	mile	3 0	11,730	58,650	35,190	175,950	21,114	105,570	49,266
			STD	yd^2	12,000	12	24	144,000	288,000	14,400	57,600	216,000
AR2	Northern Highway	90 9	Fill	yd^3	11,970	30	30	359,100	359,100	53,865	197,505	107,730
			Culvert	foot	1,200	94	134	112,560	160,800	56,280	32,160	72,360
			Base Course	yd^3	2,426	15	75	36,389	181,944	63,680	36,389	81,875
			Shoulder Rep	mile	3 0	29,325	58,650	87,975	175,950	17,595	70,380	87,975
			STD	yd^2	27,667	12	24	332,004	664,008	33,200	132,802	498,006
AR3	Hummingbird Highway	54 8	Fill	yd^3	0	30	30	0	0	0	0	0
			Culvert	foot	267	94	134	25,045	35,778	12,522	7,156	16,100
			Base Course	yd^3	0	15	75	0	0	0	0	0
			Shoulder Rep	mile	0	29,325	58,650	0	0	0	0	0
			STD	yd^2	0	12	24	0	0	0	0	0

Source ECLAC, based on data from the Ministry of Works (MOWTC&BI).

a/ Unit prices considered for the different activities were calculated by they specialist. Supplies such as culvert pipes, cement, equipment and fuel have to be imported, and were applied to calculate the reconstruction value To determine the destruction value, a percentage of the total value was applied, depending of the activity. For filling 100 per cent was applied, as earthmovings does not loose value along the service of a route; 70 per cent for culverts and bridges; 50 per cent for base course and STD and 20 per cent for shoulders

Table 31

BELIZE: DIRECT COST OF DAMAGE TO FEEDER ROADS

(Belize dollars)

	Length miles	Total destruction	Total reconstruction	Labour	National	Foreign
Total feeder affected roads and estimated cost	740.0	20,709,617	21,152,786	3,468,364	11,117,002	6,567,420

Source: ECLAC, based on data from the MWTC&BI

Table 32

BELIZE DIRECT COST OF DAMAGE
BRIDGES

(Belize dollars)

Road N°	Road name	Length miles	Activity	Unit	Quantity	Unit price destruct	Unit price reconstruction	Total destruc.	Total reconstruction	Labour	National	Foreign
	Total bridges				156			768,500	1,850,500	286,275	1,002,550	561,675
F3317	Cimaron Sugar Road # 1	3 1	Bridge	Foot	40	5,000	12,500	200,000	500,000	75,000	275,000	150,000
			Access Fill	yd^3	200	30	30	6,000	6,000	2,100	1,200	2,700
F3318	Nava Sugar Road	1 7	Bridge	Foot	45	5,000	12,500	225,000	562,500	84,375	309,375	168,750
			Access Fill	yd^3	250	30	30	7,500	7,500	2,625	1,500	3,375
D200	Hattieville Boom Road	8.2	Bridge	Foot	29	5,000	12,500	145,000	362,500	54,375	199,375	108,750
			Access Fill	yd^e	800	30	30	24,000	24,000	8,400	4,800	10,800
F9068	Billy White Road	8.2	Bridge	Foot	22	2,500	6,000	55,000	132,000	19,800	72,600	39,600
			Repairs	yd^e	0	30	30	0	0	0	0	0
F33100	Blue Creek Road		Bridge	Foot	20	5,000	12,500	100,000	250,000	37,500	137,500	75,000
			Access Fill	yd^3	200	30	30	6,000	6,000	2,100	1,200	2,700

Source. ECLAC, based on data from the MWTC&BI

Table 33 summarises direct damages to the highway system after Hurricane Keith in Belize.

Table 33

BELIZE: DIRECT COST OF DAMAGE TO THE ROAD NETWORK

(Thousand of Belize dollars)

N°	Type of road	Total country		Total affected		Total destruction cost	Total reconstruction	Labour	National	Foreign
		Unit	Qty	Unit	Qty					
	Total road network					23,154.4	25,805.0	4,273.2	12,938.2	8,593.0
1	Highways	mile	338.5	mile	164.6	1,676.3	2,801.7	519.2	818.6	1,463.9
2	Feeder Roads	mile	1515 8	mile	740	20,709.6	21,152 8	3,468.4	11,117.0	6,567.4
3	Bridges	foot	n.a.	foot	156	768.5	1,850.5	286.3	1,002.6	561.7

Source: ECLAC.

Additionally, streets in cities and villages suffered damage and interruptions that caused mostly damage to the surface and culverts. Table 34 shows the number of villages and towns areas affected with a total direct cost (estimated on the basis of repairs already completed or underway) of BZ$19.8 million.

With regard to transportation equipment, some buses reported mechanical damages, with an estimated cost of BZ$3.7 million.

ii) Highways indirect damages. Three sources were identified for indirect cost in ground transportation system due to damage in highways and roads. Account was made of user delays in buses and light vehicles users delays due to cut roads, increase of vehicle operation cost (VOC) and time expense due to make a trip by an alternative and longer itinerary and increase of VOC due to vehicles run over a poorer condition pavement.

Cost estimation for cut roads was calculated considering the average daily traffic (ADT) at the affected point: [14]

Vehicle type	Time cost per passenger (BZ$/hour)	Time cost per vehicle (BZ$/hour) a/
Cars	5.00	10.00
Pickup	3.20	9.60
Buses	1.40	56.00

a/ For all light vehicles, BZ$10.00 was adopted.

Additionally, lost income was estimated for the operators, i.e. buses and trucks owners. This indirect cost was calculated as the amount of the fare multiplied by number of passengers less the variable cost of operation, in this case, fuel consumption. An average loss of BZ$4.31 was adopted for buses (estimated as the fare per passenger less fuel consumption). For trucks, the income loss was estimated multiplying the average capacity of the truck estimated by an average transportation distance pondered by a factor of BZ$1.6 per trip, which is equivalent to transportation fare less fuel consumption.

At the beginning of the emergency service was provided by the government, by means of small motor boats operating at the interrupted points. This implies a cost that was estimated at BZ$140/boat/day. In relation to Government's costs and/or reduced income, the fares lost Carmelita Toll, the only in Belize, were estimated at a rate of BZ$400/day. Adding all the above-explained subtotals, the total indirect cost is shown in Table 34.

[14] Taken from *Western Highway Resealing Project,* 1997 by Roughton International Consultant, MWTC&BI and own calculation.

Table 34

BELIZE: DAMAGES TO STREETS

	Villages affected (No.)	Miles	Total rep. (BZ$)
Total	95	1,074	2,259,551
Corozal	20	226	454,916
Orange Walk	25	283	469,945
Belize	18	203	448,904
Belmopan	10	113	424,858
Cayo	22	249	460,928
Towns affected (acres)			
Total	19,941	657	17,545,100
Corozal	1,920	63	1,600,000
Orange Walk	4,480	148	2,400,000
Belize City	8,640	285	9,860,000
Belmopan	1,331	44	480,000
San Ignacio	1,305	43	880,000
Santa Elena	768	25	530,000
Benque Viejo	512	17	350,000
San Pedro	640	21	1,140,000
Caye Caulker	345	11	305,100

Source: ECLAC, on the basis of data from the MOW.

It bears emphasising that the Northern Highway, which shows the highest indirect cost is the most important route of the country. The Orange Walk and Corozal Districts that it serves are important sugar, cattle and other agriculture products areas and connects the Belizean-Mexican border where important trade is hold. On the other hand, an important traffic is observed between Belmopan, the Capital City and San Ignacio, where most of the government employees live, thus, the main impact in indirect cost is here at this point. Calculation of indirect cost was done determining the vehicle operating cost (VOC) and time expense by the comparison of both by the current rout and the alternative. [15] Another factor of indirect cost was estimated by the comparison of the VOC in the former condition of the road surface and the condition resulted after the damage, for the period of time that is expected to be in the poorer condition before

[15] Only one case was identified and is referred to the Burrel Boom Village. Current rout is 18 miles between Burrell Boom and Belize City, the mainly destination to be considered, by the Northern Highway while alternative is 36 miles, by the Western Highway.

reconstruction. [16] The affected length for the Western Road was estimated in 12 miles, while the same length for the Northern Road was 25 miles. For feeder roads, 740 miles were considered. Increase of time cost was not considered significant for this case.

Table 35

BELIZE: INDIRECT COSTS DUE OF ROAD INTERRUPTION

(Belize dollars)

Road N°	Place of interruption	ADT	Boats supply	Toll lost	Number of days	Total indirect costs (thousands)
	Total		3,625	400		22,328,299
AR1	Roaring Creek	2,494	725	0	3	1,290,174
AR2	Carmelita	3,694	725	400	7	12,954,609
D253	Crooked Tree	180	725	0	Undetermined	566,468
D250	Maskall	500	290	0	7	1,253,157
D362	Orange Walk	774	290	0	7	2,504,421
D334	San Felipe	500	290	0	7	1,253,157
D332	San Antonio	500	290	0	7	1,253,157
F3029	San Roman	500	290	0	7	1,253,157

Source: ECLAC

iii) Airports direct damages. The only airport that permits jetliners operation is the Philip Goldson (PG) International Airport located in Belize City. Other national airports feed local services and commute tourism. Of these the one with more commercial traffic is the San Pedro Airport at Ambergris Cay, which has a paved runway and has an intensive daily service of small aircraft. Of similar traffic is the Municipal Airfield of Belize where San Pedro service departs, (unpaved runway).

The PG International Airport reported few damages in buildings and equipment while San Pedro Airport reported some damages, which did not interfere with the provision of services once weather allowed for it. Such is the collapsing of part of the fence surrounding the field and installations. The value of these damages was estimated in BZ$75,000. Reconstruction of the fence in San Pedro is urgent because it is a safety hazard as the airstrip is in the midst of the city.

[16] Surface condition is characterized by the IRI, then an IRI = 3 was considered for the former condition and an IRI = 6 for the poorer condition. VOCs were determined by using the HDM III (Highway Design and Maintenance Model). This case is applied to the Northern and Western Highway, in those sections near Belize City where the STD wearing coarse was lost. It was applied to the public feeder roads affected by the storm, this mean a poorer gravel surface condition. The ADT for both highways was obtained from the Traffic Census, March 2000, MWTC&BI and an average of 500 was assumed for the feeder roads.

The value for installations and equipment at PG International Airport was valued too. Also considered are damages to aircraft affecting both commercial and private small planes. (See Table 36.)

Table 36

BELIZE DIRECT DAMAGE TO AIR TRANSPORTATION

(Belize dollars)

	Damage costs	Repair costs	Labour	National	Foreign
Philip Goldson International Airport	15,000	15,000	6,000	7,500	1,500
San Pedro Airport	60,000	100,000	60,000	20,000	20,000
Subtotal airports	75,000	115,000	66,000	27,500	21,500
Sub total aircraft for public transportation	1,095,000	1,575,000	7,500	0	1,567,500
Sub total private aircraft	1,300,000	1,300,000	0	0	1,300,000
Total aircraft	2,395,000	2,875,000	7,500	0	2,867,500

Source: Director of Civil Aviation, Tropic Air and own estimates.

iv) Indirect cost of airports. Two sources of indirect cost of damages were considered: passenger delays since the airport was closed for three days (with an estimated cost of BZ$855,090) and the loss of revenue of the local air services (valued at BZ$38,363).

v) Ports direct cost of damages. The most important damage at the Belize City Port is a breakwater under construction. Also reported were minor damages in lighthouses around the cayes:

Description of damage	Damage	Repairs or reconstruction	Labour	National	Foreign
	516,747	678,857	190,977	196,838	291,042
Breakwater under construction in Belize City Port	151,417	151,417	52,996	30,283	68,138
Equipment and vessels	26,002	32,503	-	-	32,503
Installations	19,865	33,109	13,244	16,555	3,311
Navigation buoys	70,512	88,140	-	-	88,140
Light, warehouse & installation	98,950	123,688	24,738	-	98,950
Miscellanies damage a/	150,000	250,000	100,000	150,000	-

a/ A lump sum estimation was placed for the small private piers wooden maid wide spread around the cays.

vi) Ports indirect cost of damages. The port was closed for three days but no indirect cost was assumed since the pier was in idle time. Loss of revenue of water taxis should also be considered, since their regular service was restarted quickly. The brief interruption was compensated by the increased traffic in the days immediately after the hurricane as more than the regular amount of trips were made on account of visits to the damaged areas, relatives visits and transportation of light cargo for the emergency.

There are no reliable figures of vessels lost; although the Port Authority recovered four private vessels which were completely destroyed, but there is no valuation of the numerous little leisure and transport boats destroyed in the cayes. [17]

b) Telecommunications

Telecommunications services suffered damages all over the country, however the most important failures are concentrated in San Pedro and Caye Caulker's village. In many localities failures were due not only to rain, flood and wind, but also to lightning storm and power failures. The total estimated cost of the damages on the telecommunication systems is show in Table 40.

In Belize City also some lines fell down while in Belize-Rural, power failure caused most of the service's interruption. Flooding caused a manual shutdown of the exchange in Ladyville and in Mile 32-Cell site, two racks and two batteries were lost. Damage in Orange Walk City was minor, as in Blue Creek and Sartaneja. In many instances, emergency generator sets were used to provide energy to restore the service.

In San Pedro the devastation caused by the hurricane damaged the BTL [18] infrastructure, affecting all the services provided by them, which include, local, long distance, international, data, paging, Internet, and mobile communication. The damages primarily were due to the collapse of a 37.5-m self-supporting tower, provoked by intensive wind. The rain and flood affected the Exchange and Transmission equipment, while, rain, wind and flood also affected the overhead network and distribution point cases. Additionally many ancillary equipments, such as, payphones, key systems, private automatic branch exchange, Wireless Local Loop, etc. also suffered intensive damage.

Temporary, BTL is using a BEL tower to support their telecommunication antennas and then to restore at least partially, the telecommunication services in San Pedro. The damaged self-supporting tower must be replaced as well as the external network and most of the electronic equipment, which was irreversible damaged by rain and flood.

In Caye Caulker the devastation caused by the hurricane damaged the BTL infrastructure, affecting all the services provided by BTL, which include, local, long distance, international, data, paging, internet, and mobile communication. The rain and flood affected the Exchange and

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[17] Fishing boats are accounted for in the fisheries valuation

[18] Belize Telecommunication Limited (BTL). A state owner company, which is in charge to provide local, long distance, international, data, paging, internet and mobile communication to the whole country.

Transmission equipment, while rain, wind and flood also affected the overhead network and distribution point cases. Additionally many ancillary equipment, such as payphones, key systems, etc. were damaged. The damaged external network must be replaced as well as the electronic equipment, which was irreversible damaged by rain and flood The replacement cost, for exchange, transmission, power and data equipment and customer lines, including some improvement to reduce vulnerability, as is also shown in Table 37.

Table 37

REPUBLIC OF BELIZE : ASSESSMENT OF DAMAGES ON TELECOMMUNICATION

(Thousands of Belize dollars)

	Total	Direct	Indirect a/ c/	Reconstruction b/	Foreign currency c/
Total	2,422.4	1,536.0	886.4	4,850.0	3,637.5
City					
Caye Caulker	614.4	614.4	-	1,940.0	1,455.0
San Pedro	921.6	921 6	-	2,910.0	2,182.5
Sales (Global)	886.4		886.4		

Source: BTL and own calculations.

a/ Indirect cost includes only the loss of profit from October to December 2000 and technical assistance received from CANTO.

b/ BTL consider to improve the communication networks, switching the actual over head lines to an underground network in both cities.

c/ BTL have an insurance policy which cover interruption business losses and equipment.

c) Energy

i) Electricity. The passage of Hurricane Keith resulted in excessive rainfall in the north and wind affecting mainly the eastern part of the country. The electrical system was affected as a whole, but in particular the transmission and distribution lines suffered cuts and loss of poles. Some damages affected the generating system. The most affected area is too concentrated in the island of San Pedro, Caye Caulker's village and in Belize City. Interruptions in the service occurred during the storm, affecting approximately 22,000 customers. The total estimated cost of the damages on the electrical system is show in Table 38.

The total generation capacity was severely affected only in San Pedro and Caye Caulker. Only minor damages affected Belize City. The total demand affected (3.7 MW) represents 7 per cent of the total national installed supply. San Pedro is fed through a submarine line of 34.5 kV interconnected to the Interconnected National System (INS). The power station in the island (2 MW) is a back up station, while the Caye Caulker power station (0.965 MW) is the only source for its inhabitants. The INS did not break down during and after the storm and submarine cable did not suffer any damage.

Table 38

BELIZE: SUMMARY ASSESSMENT ON THE ENERGY SECTOR

(Thousands of Belize dollars)

	Total	Direct	Indirect	Reconstruction	Foreign currency
Total	4,232.7	3,115.3	1,117.4	4,446.5	3,557.4
Electrical sub-sector					
Generation	823.60	823.60	-	1,420.00	1,136.00
Transmission and distribution	1,538.7	1,538.7	-	2,136.5	1,741.9
Sales	1,455.4	338.0	1,117.4	890.0	722.0
Clean up/Others	415.0	415.0	-	-	-

Source: ECLAC on the basis of official reports and figures from BEL.
Notes: 1) Hydrocarbon sub-sector reported no damages.

The installed generation capacity in the country is 53.1 MW [19] including the isolated systems. The installed capacity of the isolated systems is 5.98 MW and provides energy to Punta Gorda, Caye Caulker, Independence, Big Creek and Sartaneja. Most of the generating capacity is thermal and is owned by BEL, [20] a recently privatized company. A hydroelectric power station of 25 MW is also in service and there is an interconnection link with Mexico operating at 115 kV, also in service.

In San Pedro and Caye Caulker the entire main and secondary distribution lines were affected in some way and many poles fell down or were broken affecting 9.4 per cent of the 34.5 kV transmission lines, 43.2 per cent of the main fallen and 32.7 per cent of the secondary distribution network. In Caye Caulker the damages caused by poles were more severe, affecting 73 per cent of the main and 42 per cent of the secondary distribution networks respectively. The damages on the network were caused by the extreme winds and flooding, while the damage in the power stations was due to the excessive rain and flooding.

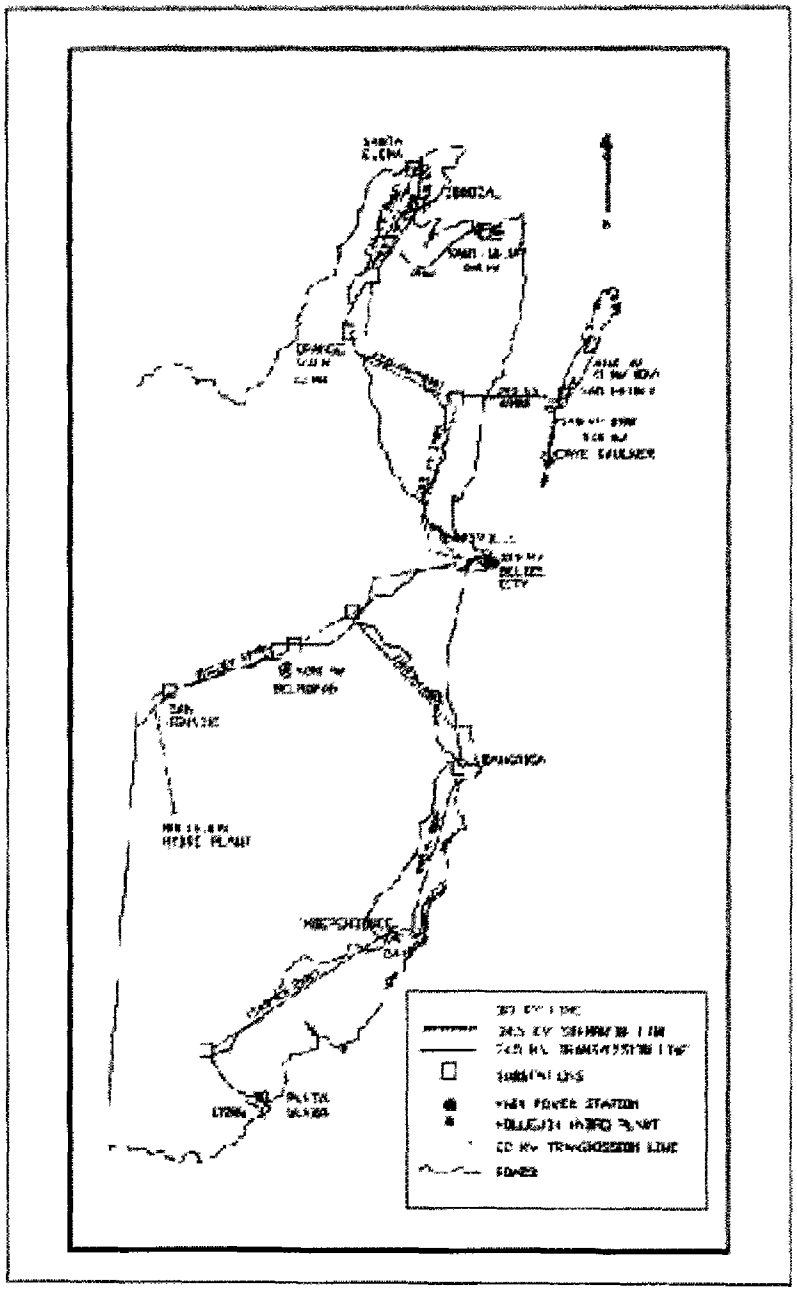
In San Pedro, energy supply was quickly restored using two trailer-mounted generator sets and by repairing the damages on the sub transmission and distribution networks. In the meantime, inspections and testing on the submarine cable were done in order to ensure the energy supply from INS. In Caye Caulker the priority was to recover the distribution network and then to connect emergency generator set.

[19] Information provided by BEL.

[20] Belize Electricity Limited (BEL). A private and state owned company, vertically integrated, providing the electricity supply to the whole country.

Graph 7

BELIZE: ELECTRIC SYSTEM



Source: BEL.
Note: This map does not ratify national and international boundaries. The only purpose is to show the locations of the electric infrastructure.

The estimated losses of profits are BZ$1.1 million till the end of the year. [21] These losses assume a gradual recovery of consumption once the rehabilitation and/or repair of the network is made, the power stations reach full capacity and the economic recovery gets demand to its normal levels.

As a part of the reconstruction/rehabilitation of the system, some of the generator sets must be replaced and the affected network repaired or rebuilt. Energy meters must be checked and replaced if necessary. The estimated costs are shown in Table 39.

Table 39

BELIZE· ASSESSMENT OF DAMAGES BY AFFECTED CITY ON THE ENERGY SECTOR a/

(Thousand of Belize dollars)

	Total	Direct	Indirect b/	Reconstruction c/	Foreign currency
BZ$		2,690.9	1,117.4	3,802.7	3,126.8
US$	4,158.2	3,115.3	1,042.8	4,446.5	3,577.7
City					
San Pedro	2,738.2	1,789.9	948.2	2,422.6	1,925.6
Generation	375.0	375.0	-	250.0	200.0
Transmission and distribution	1,112.0	1,112.0	-	1,482.6	1,186.1
Sales	1,086.2	138.0	948.2	690.0	552.0
Clean up/Others	165.0	165.0	-	-	-
Caye Caulker	1,037.9	975.5	62.4	2,023.8	1,651.8
Generation	408.6	408.6	-	1,170.0	936.0
Transmission and distribution	326.9	326.9	-	653.8	535.8
Sales	102.4	40.0	62 4	200.0	160.0
Clean up/Others	200.0	200.0	-	-	-
Belize City	382.1	349.8	32.2	-	-
Generation	40.0	40.0	-	-	-
Transmission and distribution	99.9	99.9	-	-	-
Sales	192.2	160.0	32.2	-	-
Clean up/Others	50.0	50.0	-	-	-

Source· ECLAC on the basis of information provided by BEL.
a/ Energy sector includes only the electric sub-sector. Hydrocarbon sub-sector did not report damages.
b/ Indirect cost includes only losses of profit from October to December 2000.
c/ BEL has an Insurance policy only for the generation equipment.

ii) Oil, gas and gasoline supply. Belize has no oil refining capacity and all the refined products are imported by ship or by truck. There seems to have been no disruption in this supply in spite of the hurricane closing the ports and the roads being interrupted through flooding. The

[21] BZ$1.08 million for San Pedro and BZ$0.12 million estimated for Caye Caulker. This amount claimable is under existing insurance, once generating expenses (estimated at BZ$0.20 million) are deducted.

The indirect cost due to income losses was estimated over the base of the number of inhabitants living in the affected cities and towns, the time the water supply was interrupted, and the percentage of the damaged systems. The indirect estimated cost does not include the cost associated to transportation, chemical treatment, emergency power supply, etc. The total estimated indirect value is show in Table 40.

According with a WASA [23] report dated on October 2000, the company produced an estimated 2,284 million US gallons of water in 1999, of which 1,181 million US gallons was sold. This figure reflects a very high rate of losses on the mains and secondary distribution lines (as much as 48.3 per cent of the average water production), which could be associated to lack of maintenance, non-paying connections and the age of the utility's network of supply. There are no reported additional losses after the hurricane, but if the losses are the same or higher, this figure reflect an already very difficult economical situation for the company.

It is worth noting that only three cities in the country have sewerage systems (Belize City, Belmopan and San Pedro). Lack of this basic service represent a potential health problem not only for those that don't have access to it but – in extreme circumstances like the one caused by Keith – will jeopardise the existing facilities capacity to cope and increase the vulnerability of the population at risk. This is certainly an area where mitigation seems to have a high degree of urgency for the inhabitants who have not this service.

Table 40

BELIZE: ASSESSMENT OF DAMAGES ON DRINKING WATER AND SANITATION NETWORKS a/

City	Total	Direct	Indirect b/	Reconstruction c/, d/	Foreign currency
Total	1,854.7	1,654.7	200.0	3,403.7	2,866.5
Belize	1,489.6	1,489.6	-	-	-
Belmopan c/	39.7	39.7	-	269.9	202.9
Orange Walk Town d/	140.4	140.4	-	1,371.1	1,165.4
Corozal Town d/	265.1	265.1	-	1,371.1	1,165.4
San Ignacio/Sta. Elena e/	15.1	15.1	-	391.6	332.8
San Pedro	635.6	635.6	-	-	-
Sales (global) f/	200.0		200.0		
Others f/	51.3	51.3	-	-	-

Source: ECLAC on the basis of WASA's data.

a/ Only three cities have sewer collection systems.

b/ Indirect cost associated to water transportation, increase of chemical treatment, emergency power supply, etc were not provided.

c/ Reconstruction include a new back up well, three genset and powerhouse for all of those three.

d/ The new storage tanks include some improvement in order to reduce vulnerability.

e/ Include only estimated loss of profit.

f/ Others include some small cities with minor damages.

[23] Water and Sewerage Authority (WASA). is the state owner company, which is in charge for the water supply and sewerage systems to the whole country.

4. Effects on the environment

Besides destroying or harmfully affecting human life, as Keith influenced natural assets and their productivity. It will affect the ability to provide or sustain environmental services and, additionally, it will increase the costs of enjoyment of services.

There is little doubt that natural disasters and the environment are linked. Environmental degradation intensifies disasters, thereby increasing the potential for secondary disasters. The recent ECLAC assessments [24] of the damages caused by Hurricane Mitch in Central America conclude that the already severe effects of the rains were aggravated by man's previous actions, such as deforestation, inappropriate land use, and settlements on hillsides or on riverbanks and lakeshores. Similarly, most of the damage by Hurricane Lenny in Anguilla was aggravated by the location of tourism infrastructure within a high-risk zone adjacent to the shoreline.

Recognition of the causal links is an important step towards mitigation of the negative consequences of disasters, but needs to be followed by a more detailed understanding of the underlying process and, eventually, a quantification of the impacts and an assessment of the subsequent economic implications. In fact, failure to account for the impact of disasters on environmental systems may seriously undermine the reliability of *ex ante* cost-benefit tests, or the reliability of post-disaster damage estimates.

a) Belize environment

Within the Meso-American region, Belize displays one of the most significant habitat diversity (see box 1), with such habitats ranging from coral reef, mangroves and coastal lagoons to savannahs, rainforest and pine forests. [25] Belize's coastal plains and marine zone (the area that was most impacted by Hurricane Keith) contain a wide diversity of ecosystems that are rich in plant and marine resources. This coastal area is a complex system comprising the 220-km barrier reef (one of the most significant ecosystems in the world, see box), three atolls, sea-grass beds, dense mangrove forest and numerous coral islands. Presently about 45.9 per cent of its territory is set aside in protected areas for the preservation and protection of highly important natural and cultural features. Marine reserves represent about 150,000 hectares (6.9 per cent of marine area).

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[24] ECLAC (1999 and 2000).

[25] Central Statistics Office; Ministry of Finance, Belize (2000).

Box 1

THE MESO-AMERICAN BARRIER REEF SYSTEM

The Meso-American Barrier Reef System (MBRS) is a unique and extensive coral reef system extending more than 1,000 km along Mexico, Belize, Guatemala and Honduras. In 1997 the Presidents of these four countries signed the Declaration of Tulum which recognised the shared resources and connections between each of the four country's coastal areas and agreed to work towards a regional conservation strategy to ensure the integrity and future management of this system. According to scientists of the four countries, the principal threats to the MBRS are:

Coastal/Island Development and Unsustainable Tourism, which includes urban, hotel and resort development and related infrastructure, together with all the direct and indirect impacts that these bring to bear on the MBRS (pollution/contamination, nitrification, sedimentation, physical reef damage, impacts to estuary and lagoons and

storage capacity was not affected, and gas stations reported no damages or losses. The only damage reported is two storage tanks located at Caye Caulker power station; however this damage has been included in the total damages corresponding to that power station in the electrical sector.

d) Water and sanitation

The Belize Water and Sewerage Authority (WASA) is responsible for all urban water supplies in the country and for the only three sewerage systems in the country – in Belize City, Belmopan and San Pedro, Ambergris Caye. However, many rural communities independently operate their own water system with technical support from WASA. [22]

Most damage to drinking water and sewerage systems is in the localities worst affected by the hurricane. One of the greatest challenges posed by the emergency was in reaching areas at the end of near-impassable roads. The short-term aims of the institutions involved were to re-establish damaged drinking water and sewerage systems, and to carry out health and education actions to prevent and reduce the risk of epidemics in affected areas. In the medium term, actions should focus on the total reconstruction and upgrading the now damaged systems. The total estimated cost of the damages on water and sewerage system is show in Table 39.

In Corozal Town the damages were concentrated on the overhead storage tank, pumping station and cover material for the main transmission lines. In San Pedro Town the damages affected the secondary distribution lines and sewer collection system. In Orange Walk Town, the intensive wind collapsed an overhead storage tank and flood affected the electrical system of the pumping station and main distribution lines.

In Belize City, damages were due to flood affecting the transmission lines and sewerage system. Belmopan and other five cities and town reported small damages on the distribution lines as a consequence of flooding.

Before the hurricane passed, some attempt was made at prevention measures were taken. In Corozal Town and Orange Walk City, the storage tanks were filled in order to prevent some water scarcity after the emergency. Unfortunately this measure was not successful because the water weight and intensive winds caused such stress on the structures that they collapsed in both towns. In San Ignacio/Santa Elena a ground storage tank also failed due to ground saturation and

certain sections it appeared that the Belize River and the Sibun River had joined and become one body of water.

Graph 7 summarises the environmental impacts and the environmental goods and services involved.

The following description of the environmental impacts has been made mainly from the Environment Committee of the NEMO and from observations of the ECLAC team. It is a preliminary assessment that demands a more in depth assessment (especially in relation to coral reef damages).

Coastal erosion

- Caye Chapel was severely impacted on its western coast as evidenced by the collapsing of almost its entire seawall. Specifically, the plastic sheet pile wall that has been used along the entire western length of this shoreline was destroyed. With this wall gone, the beach was severely eroded and the either carried offshore or up onto the golf course in the lee of the seawall. Observations made along this shoreline indicated that in some areas along this western coast, the shore had been eroded approximately 10-15 metres landward of the seawall. A total length of affected shoreline is estimated to be 2,800 metres.

- In Caye Caulker the greatest erosion occurred at the "Split", which had almost doubled in width, and had been deepened. In particular, the water depth is reported to have increased from 5 m to 8 m, while the width of this feature appeared to have been more than doubled. Inspection of aerial photographs taken both before and after hurricane Keith indicated that there was significant damage to the plastic sheet pile wall, which previously lined the southern bank of the "Split". A total shoreline loss of more than 11,000 m^2 has been estimated.

- At Ambergris Caye, shoreline erosion was limited to the south-eastern coastline, where water came overland from the west, and eroded the shoreline over a distance of approximately 300-500 m. This occurred at an area where the lagoon came inland, the width of the Caye was diminished and the buffering effect of the mangroves was reduced. A total affected area of approximately 600-1000 m^2 was estimated.

Damage to reef, mangrove and seagrass bed ecosystems

- The entire waterbody within the Reef Lagoon from Robinson Point to North Ambergris Caye was extremely turbid during and immediately following the hurricane. This turbidity was observed to extend beyond the Belize Barrier Reef (BBR), some 30 to 50 meters eastward. The impacts of this tremendous amount of silt on the sections of the BBR will need to be assessed in order to determine its immediate, medium and long-term impacts. [26] It is likely that sections of the BBR may suffer long-term damage from the smothering effect of the silt plume. The Coastal Zone Management Authority and Institute carried out an assessment of

[26] Diving operators observed mechanical damages in the coral reefs of Turneffe Cayes. Despite visibility is not being at 100 per cent, damages in other areas were reported as not being significant.

reef health following hurricane Keith. This was done on the back reef at Caye Caulker and

of the corals were observed to have been bleached.

- Seagrass beds within the Reef Lagoon in this area were also been impacted by wave action, due to Hurricane Keith. Observations show that a large fraction of the seagrass beds were

  smothering effects of the silt, as it is deposited on the seafloor. Many large mats of uprooted sea-grass were observed floating between Caye Chapel and San Pedro Town.

  Mangroves: all cayes suffered moderate to severe (40-80 per cent) mangrove leaf loss. Only few (about 5 per cent) mangrove trees were uprooted (most of these appeared to be isolated trees). Due to differences in species composition, mangroves at the water line of the cayes are expected to recover whereas less salt-tolerant mangroves landward of these, which were exposed to an overflow of sea water. In addition, the rich nutrients that were stored in the mangrove wetlands may have been released into the sea, with the potential medium or long-term negative impacts on the reef ecosystem. Additional sources of nutrients have also been contributed from the overflow of sewerage lagoons and septic tanks on these cayes.

Impacts to wildlife

- Birds appeared to be the wildlife that suffered the greatest impacts as reported by the number of dead birds. In addition, birds continue to be affected on these cayes due to the loss of their habitats and feeding grounds. It was reported that the nesting and roosting sites of some of these birds on the atolls were also severely affected. For example, the habitats for the frigate and boobies at Half Moon Caye were heavily impacted.

Impacts on water quality

- Contamination of coastal water with faecal coliform was believed to occur resulting from the overflow of sewage lagoons and the inundation of septic tanks.

Impacts on fisheries

- Damage to the fisheries sector is significant especially since the lobster season, which extends from 15 June to 15 February, was on its way to being one of the best in recent years. The conch season, scheduled to open on 1 October has been delayed for at least two months (the same will occur for shrimp and finfish).

- In the medium term fisheries could also be affected by the damages suffered by mangroves, sea-grass beds and coral reefs.

c) Economic valuation of environmental damages

Broadly speaking natural hazards may affect use values in two different ways: (i) by inducing temporary or permanent environmental changes thus altering a natural asset's "intrinsic

productivity"; (ii) by altering people's ability to use the environment (the economic costs people

environmental changes include soil erosion, losses of natural habitats, forest fires, etc. The second type of impacts arise from man-made capital's partial or total disruption which may

water-distribution networks or water-treatment facilities would harmfully affect water resources' use values (loss of agricultural or industrial production; increased health risks; increased

ECLAC's definition of *direct damage* the direct environmental damage

flows of capital. As a proxy of the welfare cost, the capital's *restoration cost* measure of damage, provided the analyst believes that the cost incurred in restoring the asset to its original state is not greater than the benefits the damaged/destroyed assets provide.

take into account the changes in the flows of marketable goods and services attributable to the disruption of physical assets, which occur until the assets'

taken into account that (i) the restoration of a natural asset's original productivity may be technically unfeasible; (ii) many environmental goods and services are not exchanged in normal

phase may last longer than the average time required to restore man-made capital.

In the case of hurricane Keith, resulted in environmental changes (loss of birds' habitats, beach erosion, changes in water quality, and damages to

recreation (tourism) and fisheries are impacted from (i) environmental changes described above and (ii) disruption of physical infrastructure such as buildings damages, boats and fishing gear, *indirect damages* and most of them have been already

double counting only direct damages will be considered (see Table 41). [27]

Valuation of the environmental services of coral reefs (Ruitenheek and Cartier, 1999) have been done for Montego Bay in Jamaica as a part of a World Bank project. Values range from

encompass recreation (linked to tourism), fisheries habitat, coastal protection, maintenance of biodiversity and source of sand for beaches and dunes. In the case of Belize Barrier Reef, a value of US$200,000 per

Caulker) and a plain area of 75 m (53 hectares). As several environmental services were already considered (recreation, fisheries) in different sectors, a percentage of 20 per cent of the value has been

Table 41

ENVIRONMENTAL DAMAGE ASSESSMENT

Direct damages	(Thousand BZ$)
Total	49,051
Property loss by beach erosion a/	3,240
Damage to mangroves b/	40,000
Beaches clean up (Caye Caulker and Ambergris Caye)	1,060
Damages to infrastructure of Lamanai (archaeological site) d/	500

Source: ECLAC on the basis of different sources.

a/ In San Pedro, 8 lots ([2] [2] Caye x

differences in room rates.

provide a good buffer against storm wave action. An area of 5,000 acres is estimated to be suffered Cayes. Of them, a replanting programme for 500 acres at most vulnerable sites

US$80,000 per acre Applying this factor and assuming that approximately 50 per cent of the

regeneration of mangroves on the
acre to BZ$8,821. The first task is to assess natural recovery capacity of mangroves and compare it

studied, in considering financing requirements. As indicated above, restoration cost only can be used

its original state is not greater than the benefits the damaged/destroyed assets provide. Taking into

this project have not been made yet, this figure must be taken with care.
Ruitenheek and

done for
per hectare up to as much as US$500,000 per hectare. Environmental services considered

biodiversity and source of sand for beaches and dunes. In the case of Belize Barrier Reef, a value of

Ambergris Caye
services were already considered (recreation, fisheries) in different sectors, a percentage of 20 per
biodiversity maintenance and

d/ Preliminary estimation.

d) Tourism and environment

Environmental damage assessment highlights the linkages between tourism and the environment. Most of the environmental services lost by Hurricane Keith are related to recreation and tourism. Belize is a country that is well positioned in the market of tourism based on natural resources endowment. As a first condition in order for Belize to continue attracting tourist, environment must be preserved. In addition, environmental reputation and environmental performance of the country are of growing importance to increase competitiveness.

Tourism can also become a serious threat in areas where there is insufficient infrastructure and planning to support a large number of visitors. Unregulated coastal building, poor sewage

habitats. Land clearing and construction activities for tourism in coastal areas involve removal of natural vegetation, dredging, water disposal and sand mining in mangroves, dune communities,

and hurricanes. A report of the Cayes states that "it was clearly visible that structurally sound (and even some that were not) buildings that were surrounded or located on the east side of

not, suffered tremendously".

Many tourist sites are over-saturated with visitors, beyond their carrying capacities, both from biophysical and management perspectives. Immigration induced by the growing tourism

planned residential neighbourhoods with inadequate basic human services (this can be the case of San
plans and zoning related to basic environmental and engineering principles must be strengthened (code/standards for land development, buildings and waste treatment and disposal, weakness in

The Environment Committee of the NEMO urges "planning authorities for San Pedro and Caye Caulker to ensure that the construction of piers and sea walls now occur in a planned

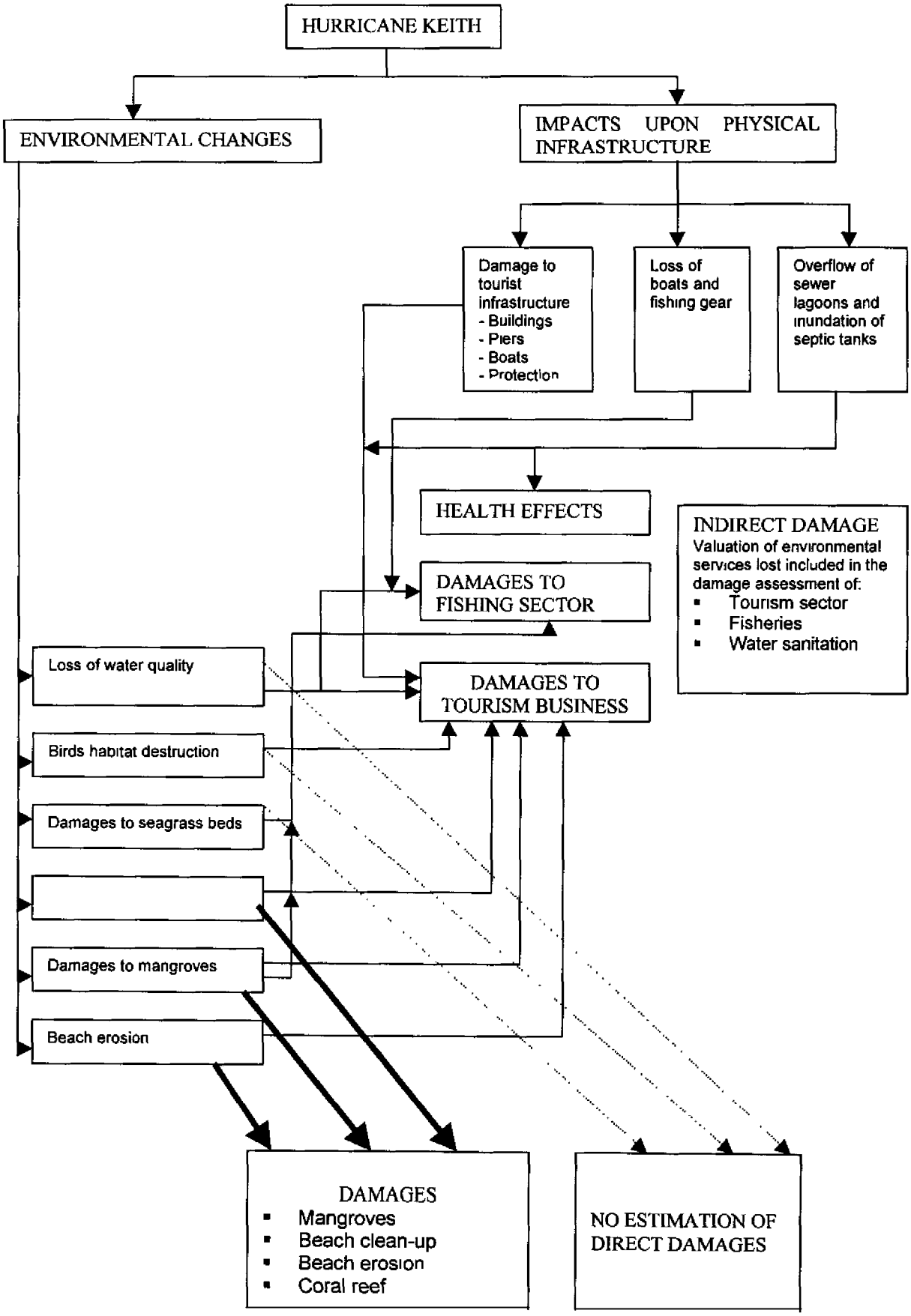
opportunity for reducing the number of piers now exists. The erection of new fuel dispensers on piers and on the islands should be given careful attention, to ensure that they meet new standards

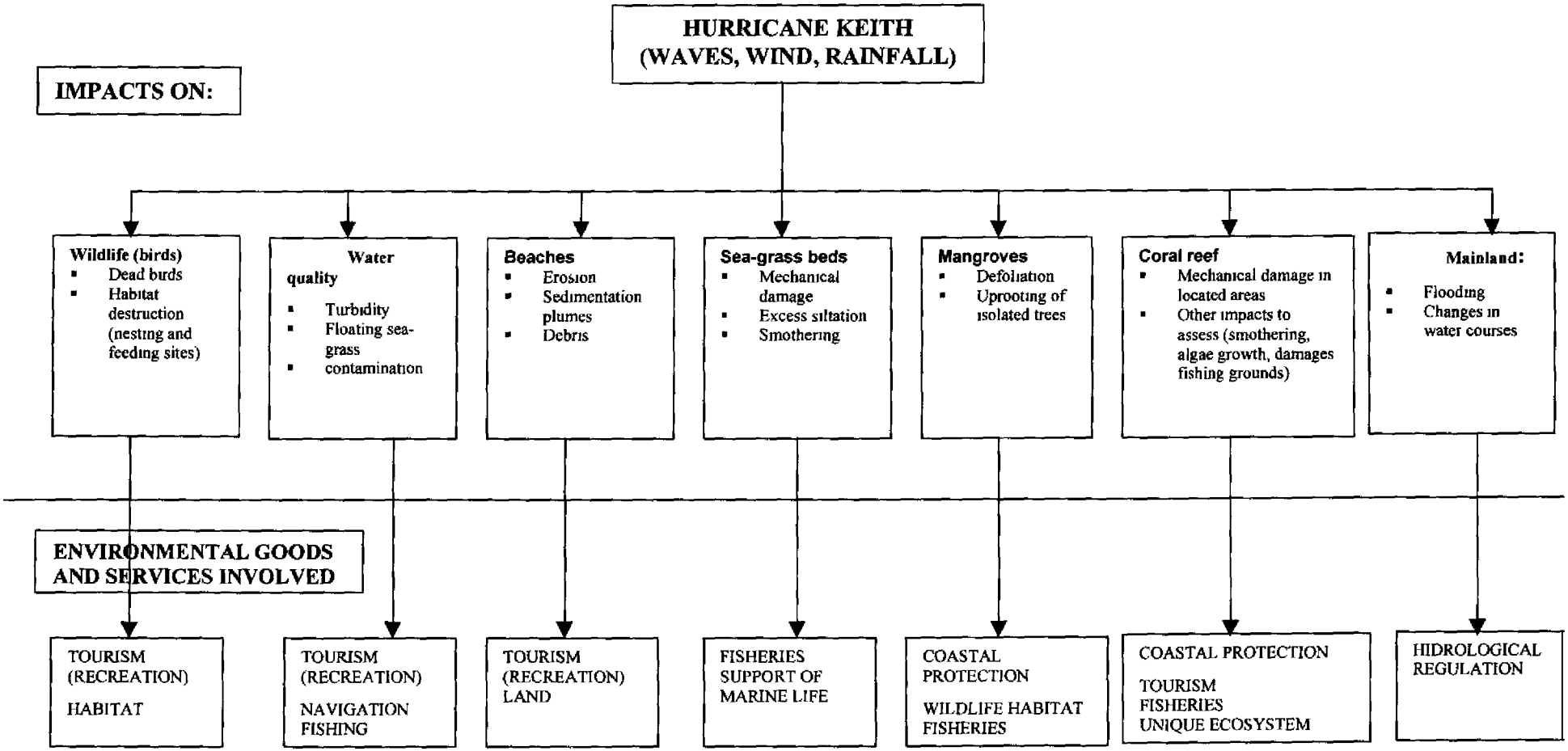
San Pedro and Caye Caulker". In addition, in most countries that border the Caribbean sea, a design condition of 1 in 50 year storm is recommended to be adopted.

Environment Committee (NEMO).

Graph 8

ENVIRONMENTAL DAMAGE ECONOMIC ASSESSMENT SCHEME




HURRICANE KEITH
(WAVES, WIND, RAINFALL)
IMPACTS ON:
Wildlife (birds)
Dead birds
Habitat destruction (nesting and feeding sites)
Water quality
Turbidity
Floating sea-grass
contamination
Beaches
Erosion
Sedimentation plumes
Debris
Sea-grass beds
Mechanical damage
Excess siltation
Smothering
Mangroves
Defoliation
Uprooting of isolated trees
Coral reef
Mechanical damage in located areas
Other impacts to assess (smothering, algae growth, damages fishing grounds)
Mainland:
Flooding
Changes in water courses
ENVIRONMENTAL GOODS AND SERVICES INVOLVED
TOURISM (RECREATION)
HABITAT
TOURISM (RECREATION)
NAVIGATION
FISHING
TOURISM (RECREATION)
LAND
FISHERIES
SUPPORT OF MARINE LIFE
COASTAL PROTECTION
WILDLIFE HABITAT
FISHERIES
COASTAL PROTECTION
TOURISM
FISHERIES
UNIQUE ECOSYSTEM
HIDROLOGICAL REGULATION