Financial Assessment for Wastewater Treatment and Disposal (WWTD) in the Caribbean

Prepared by
the Caribbean Environmental Health Institute
for
UNEP/CAR-RCU

Presentation outline

- Methodology
- Characterization of WWTD Needs
- WWTD Investment and Financial Requirements
- Estimating Financing in WWTD
  - Non-Pilot States
- Capacity Building for WWTD

Objective

- to provide background information to assist in evaluating the type of financing needed to address wastewater issues in the Wider Caribbean based on the needs and circumstances of Caribbean SIDS
  - Support to formulation of the CReW

Methodology

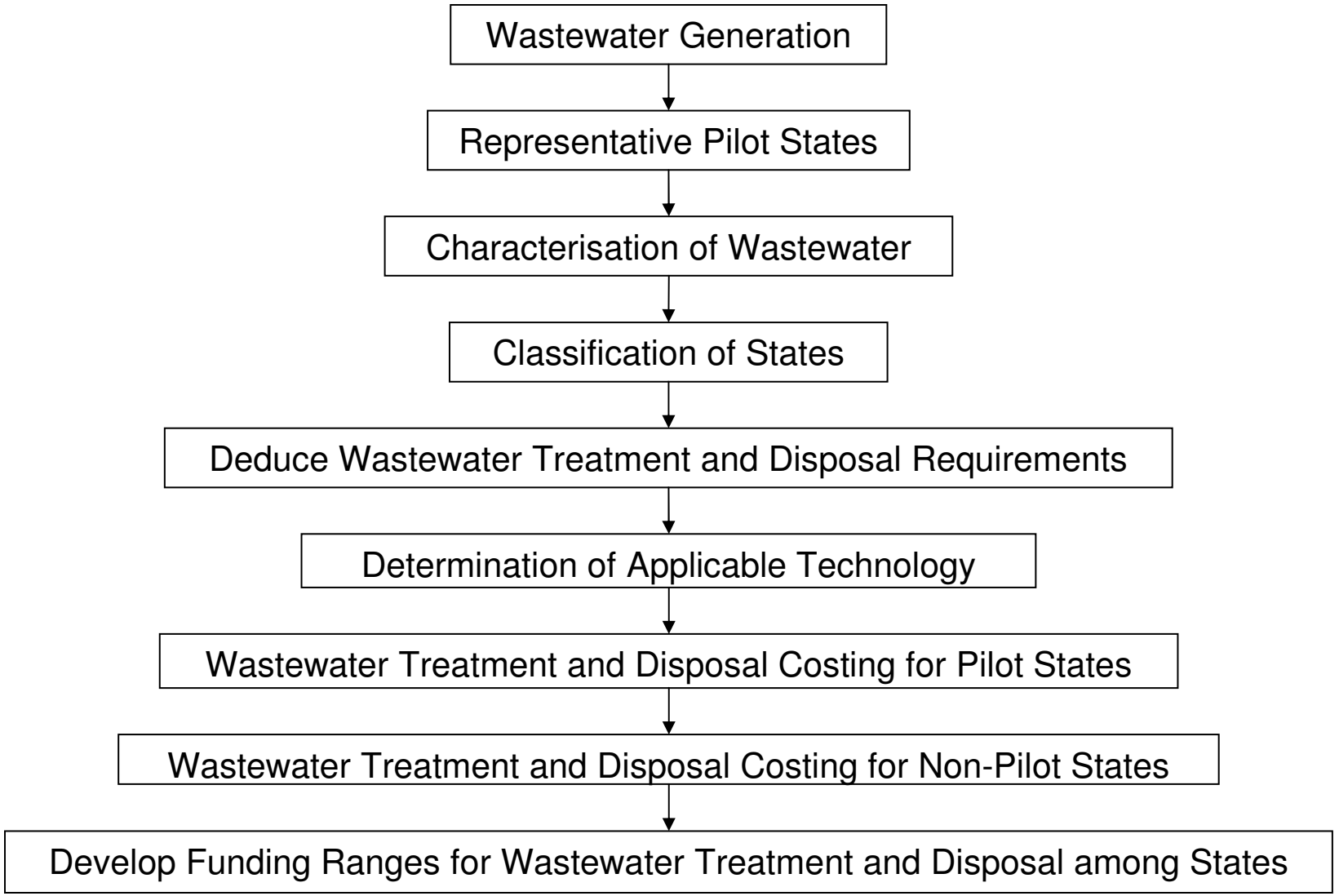
Methodology

- Assessment based on 4 wastewater generation categories:
  - Municipal, communal, residential and housing developments;
  - Tourism and institutions;
  - Ports and marinas;
  - Manufacturing and industry.

Methodology

- Assessment further defined by geographic (size, terrain) and demographic, socio-economic groupings into:
  - Continental landmass countries
    - Guyana, Suriname and Belize;
  - Larger Islands States
    - The Bahamas, Haiti, Jamaica, Trinidad and Tobago;
  - Smaller Island States (<1000 km^2), variable terrain and small populations <300,000)
    - Anguilla, Antigua, Barbados, British Virgin Islands, Dominica, Grenada, Montserrat, St. Kitts and Nevis, St. Vincent and the Grenadines, St. Lucia, Turks and Caicos Islands.

Assessment process



Methodology

- 3 pilot countries (limited due to resource constraints)
  - Jamaica, Guyana and St. Lucia
- representative of the range of demographic and environmental conditions found across the Caribbean
- Jamaica
  - Generally representative of larger island States; greater populations with manufacturing and heavy industry as significant components of economy
- Guyana
  - Generally representative of typical large flat continental landmass countries; large land expanses to allow for cost effective WWTD systems
- St. Lucia
  - Generally representative of other Eastern Caribbean States in. as its topography and demographic

Data Acquisition and Analyses

- Pilot Countries: in-country survey instrument administered - September to October 2008
  - water utilization/wastewater management agencies
    - Jamaica - National Water Commission (NWC)
    - Guyana - Guyana Water Incorporated (GWI)
    - St. Lucia - Water and Sewage Company (WASCO)
  - agencies possessing specific data of importance to the cost modelling
- Non-pilot countries: similar data collection instrument administered
  - Same as above

Data Acquisition and Analyses

Sectoral agencies surveyed:

- Tourism authorities:
  - water consumption, liquid waste generation, investment associated with ports and marina developments; investments in WWTD;
- Planning authorities, Ministries of Health, housing authorities, other private sector agencies
  - municipal and housing developments
- Private sector investment agencies, development corporations
  - Manufacturing and industrial

Data Acquisition and Analyses

- Regional and international technical and funding agencies
  - UNEP CAR/RCU and UNEP GPA
  - Economic Commission of Latin America and the Caribbean
  - Canadian International Development Agency
  - World Health Organization/Pan-American Health Organization
  - Caribbean Environmental Health Institute
  - Caribbean Water and Wastewater Association
  - Caribbean Basin Water Management Programme
  - Global Water Partnership – Caribbean
  - Caribbean Development Bank
  - Inter-American Development Bank
  - World Bank

Literature Review Findings

- No regional level assessment of sewage management needs in last 10 years
- Little data on wastewater management costs
  - financial costs associated with developing and implementing appropriate systems
  - social, economic and environmental costs of poor wastewater management
- Information is available on WWTD technologies appropriate for the Caribbean (for both centralized and decentralized systems)
- Some reports on implementation of WWTD technologies in the region
- Traditionally more focus on the quality and accessibility of drinking water versus wastewater management
  - Growing concern over the impact of wastewater on health, the sustainability of livelihoods and other socioeconomic issues

Cost estimate assumptions

Cost Category 1: Municipal, Communal, Individual and Residential Developments estimate assumptions

- Include urban centers, sub-urban areas, rural linear, clustered or dispersed communities
- WWTD system options:
  - Space availability unlimited: Waste Stabilization Ponds (WSP) - preferred option
    - cost effectiveness of development, operation and maintenance, and generation of an effluent that meet the stipulations of guideline and standards
  - Space availability limited: Small FootPrint (SFP)-type systems - Membrane Bioreactors (MBR), Biologically Engineered Single Sludge Treatment (BESST) - preferred options.
- Per-capita sewage generation rates (from in-country surveys)
  - 227.3 litres/day – island states
  - 135 litres/day - continental land masses (CLMs) represented by Guyana, Belize and Suriname

Category 2: Hotels and Institutions

- Include tourism accommodations, social service, health sector, educational institutions
  - WWTD options:
    - Inland locations: primary treatment with filtration and sub-surface disposal was the proposed option
    - Coastal settings (where municipal sewerage systems not available): technologically advanced package plants are preferred option (to meet effluent quality for LBS Class I receiving waters)
  - Costing assumptions: sewage generation rates for hotels and institutions can be X10 and X3 of residential generation respectively (based on Jamaica data)

Category 3: Ports and Marinas

- Includes cargo, cruise ships ports, marinas, airports
  - WWTD options:
    - Seaports: based on availability of municipal systems, which is the current case in the majority of Caribbean States.
    - Standalone systems for marinas, airports where municipal systems not available
  - Costing assumptions: Transient and resident population at ports were determined and per-capita sewage generation calculated (based on Jamaica data)

Category 4: Industry and Manufacturing

- Includes agro-processing, bottling and beverage production, canning and other similar wastewater generation activities
  - WWTD options:
    - Small footprint systems (SFPs): MBR and BESST preferred options for serving single companies.
    - Since most industries are located within the coastal zone, Class I discharge criteria guide the level of treatment and final disposal

Cost Estimates: Construction of WWT Plant/System – Pilot States

- Modelling data inputs:
  - Volume of wastewater generated by sectors;
  - Unit cost of equipment and installation
    - Obtained from studies and ongoing refurbishment works (Jamaica)
    - Cost of small footprint technology such as Membrane Bio-Reactors (MBR) and Biologically Engineered Single Sludge Treatment (BESST) obtained from suppliers;
  - Unit cost of pipe network required
  - Unit cost of auxiliary facilities such as lift stations (in countries with variable terrain);
  - Unit cost for operations and maintenance
  - Use of cost WWTD per defined representative number of population (population equivalent (PE)) to standardise the volumes and cost per unit volume for wastewater generators;

Cost assumptions

- Equipment and installation for WSP WWT: $1,100 per m^3
- Equipment and installation for SFP biomechanical WWT system: $7,829 per m^3
- Pipe network: $645 per m^3
- Lift stations: $165 per m^3
- Annual O&M WSP WWT: 10 -12 % of system cost
- Annual O&M SFP WWT: 30 - 40 % of system cost
- Construction of communal WWT systems: $1,805.4 / m^3
- Annual O&M for communal and individual WWT system: $73.5 / m^3
- Number of households: Population ÷ 5
- Average cost of housing: $30,000 - $100,000
- Individual WWT system: 10 % cost of the house
- Per capita water consumption for island States = 227.3 litres
- Per capita water consumption for continental States = 135 litres
- NOTE: all costs in US Dollars

Cost assumptions

- Population dispersion: estimated 60% living within 4 km of the coast and 40% inland
- Ratio of 1:1 for water consumption and wastewater generation: This rule is used in Jamaica and was deemed logical and appropriate

Cost calculations

Example: Jamaica - Residential and Hotels for illustration

Residential (Kingston-St. Andrew)

- Estimated population: 663,650
  - 30% of KSA population connected to sewerage collection and treatment system; remainder use on-site septic-soak away systems or direct to soak ways.
- Hence 199,095 persons connected to a sewerage system; need to increase coverage to 464,554 persons
  - WSP with adequate treatment and disposal proposed
- Daily flow rate:
  - 464,554 x 227.3 L/person = 105,593,124.2 L = 105,593 m^3
- Cost of equipment and installation:
  - \$1,100 x 105,593 m^3 = \$116,152,437
- Cost of pipe network: \$645 per m^3 x 105,593.1 m^3 = \$68,107,565
- Cost of Lift stations: 2 x \$165 /m^3 x 105,593.1 m^3 = \$34,845,731
- **Total cost System:**
  - \$116,152,437 + \$68,107,565 + \$34,845,731 = **\$219,105,733**
- **O&M WWT System:**
  - \$116,152,437 x 0.12 = **\$13,938,292 /annum**

Hotels

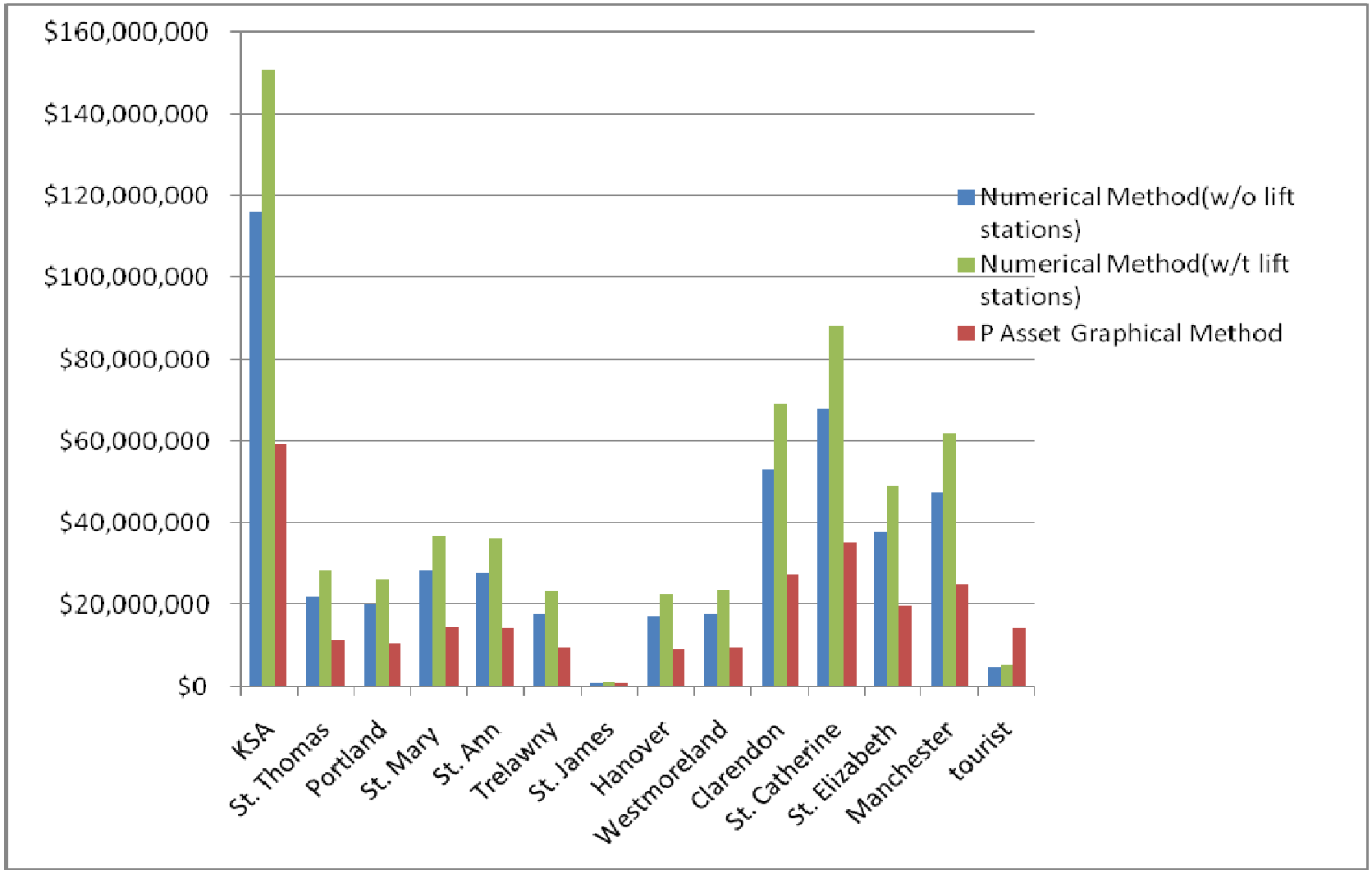
- Annual number of stay over visitors: 1,700,785
- Average length of stay per tourist: 10.2 days
- Visitor per capital generation of wastewater:
  - Per-capita WW generation: = X10 for residential
  - Typical water consumption: 286 gal/pers/day
- Annual wastewater generation:
  - 1,700,785 tourists / year x 10.2 days x 286 gal/pers/day x 0.85
- (Assume 85% of water consumption = waste water generation)
  - 4.22 billion imperial gallons = 19.17 million m^3
- Assume all hotels constructed in next 10 years: install SFP system.
  - 31% of the hotels have own private WW treatment systems.
  - 31% of 19.17 million m^3 = 5.94 million m^3 treated by package plants may need upgrade
  - 5.94 million m^3 x \$7,829.11/ m^3 = \$ 46.52 billion

Hotels

Additional capacity

- The tourism 10 year master plan indicates an increase in the number of hotel rooms from 30, 000 to 45,000 in the next ten years.
- 15,000 rooms in 10 years, or 15000 ÷ 10 = 1500 / year.
- Additional wastewater to be generated
  - 1,500 rooms x 243 gallons/guest/night x 2 guest per room x 1/220 gallon per cubic meter = 3,313.63 m^3
- Assume each hotel invests in a small foot print package plant
- installation/construction cost
  - 3,313.63 m^3 x \$7829.11 / m^3 = \$25.94 million/year.
- In ten years (ignoring inflation) the total installation cost = \$ 259.4 million
- The total O&M costs will be 30% of \$ 259.4 million = \$77.82 million

Total estimated costs by parish



Estimates of funding requirements - Using unit costs

treatment and disposal of 1 m^3 of wastewater

Country groups

Unit costs: Continental countries

- Guyana pilot
- Context: large expanse of flat marginal lands - cost effective WSPs preferred option; relatively low pop'n
  - Population: 750,000
  - Construction cost (80% of population) = $344,815,060
  - Annual O&M cost (80% of population) = $11,572,997
- Wastewater volume:
  - 600,000 persons x 135 litres/person/day = 81,000 m^3/day
- Cost of wastewater treatment:
  - $344,815,060 ÷ 81000 m^3 = 4,257 /m^3
- Annual cost of O&M:
  - $11,572,997 ÷ 81,000 m^3 = $143/$m^3$

Estimated costs: Continental countries

- **Unitary costs from Guyana applied:**
- **Belize**
  - Population 282,600
  - Cost of WWT needs:
    - 30,521 m^3 x \$4,257 / m^3 = \$129,930,000
    - Annual O&M = 30,521 m^3 x 143 / m^3 = \$4,364,503
- **Suriname**
  - Population 492,830
  - Cost of WWT needs
    - 53,227 m^3 x \$4,257 / m^3 = \$226,590,000
    - Annual O&M = 53,227 m^3 x \$143 / m^3 = \$7,611,461

Unit costs: Larger Islands

- Jamaica pilot
- Context: available lands for the construction of WSPs (except Bahamas – SF systems)
  - Population: 2,650,000
  - Total construction cost for WWTD: $1,273,321,085
  - Annual O&M cost for WWTD: $164,945,274
- Wastewater volume
  - 2,650,000 x 227.3 litres/person/day = 602,345 m^3/day
- Cost of wastewater treatment
  - $1,273,321,085 ÷ 602,345 m^3= 2,114 /m^3
- Annual cost of O&M for WWTD
  - $164,945,274 ÷ 602,345 m^3 = 274 /m^3

Estimated costs: Larger Islands

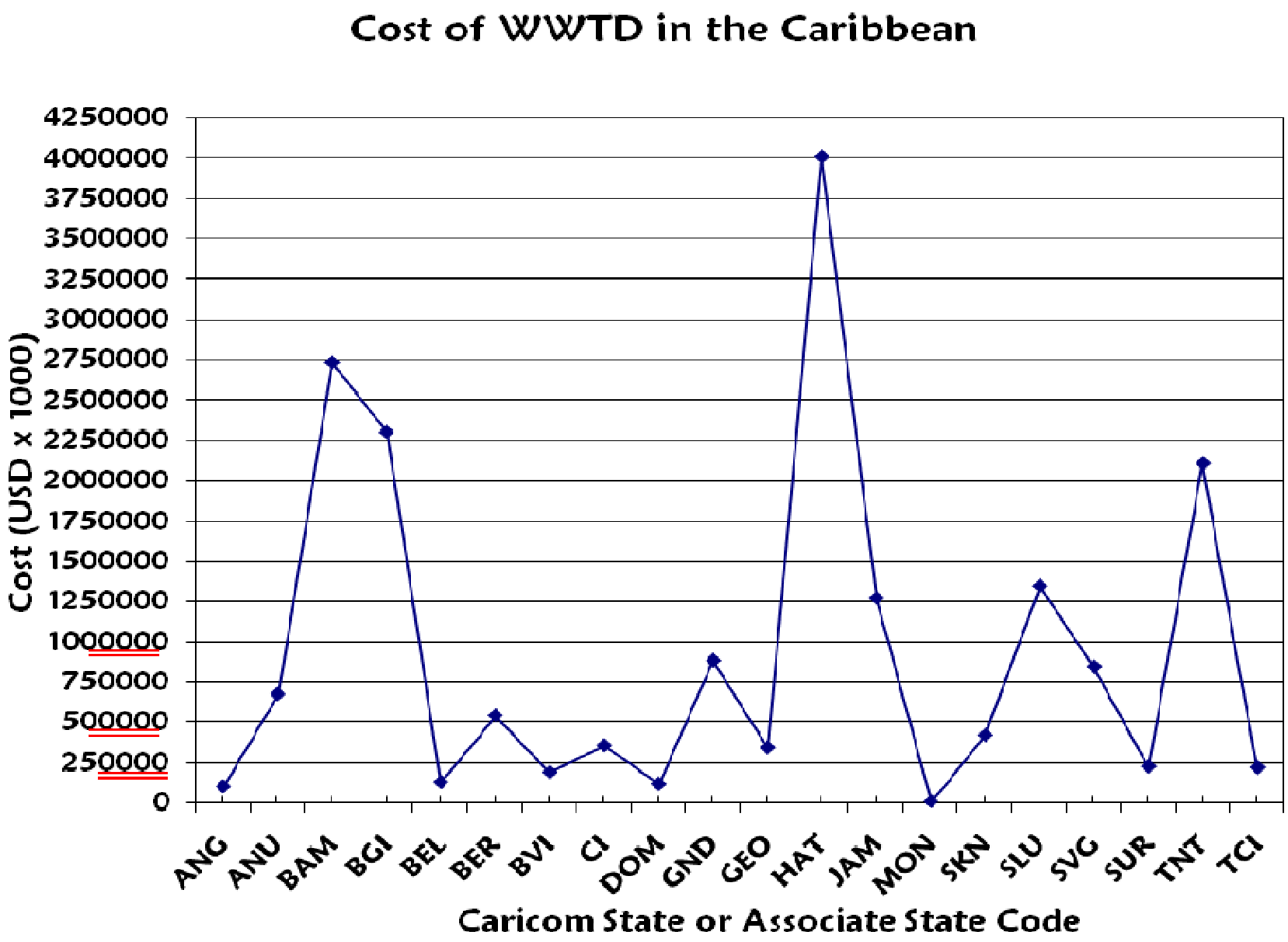
- The Bahamas
  - Population 324,800
  - Required cost = $2,739,498,489
  - Annual O&M cost = $703,349,829
- Trinidad and Tobago
  - Population 1,290,650
  - Required cost = $2,108,582,584
  - Annual O&M cost = $273,297,847
- Haiti
  - Population 8,351,000
  - Required cost = $4,012,757,382
  - Annual O&M cost = $520,101,950

Unit costs: Smaller Islands

- St. Lucia pilot
- Context: limited land space, variable terrain; SF systems
  - Population: 160,000
  - Total construction cost for WWTD $1,349,399,509
  - Annual O&M cost for WWTD $346 438 325
- Wastewater volume
  - 160,000 persons x 227.3 litres/person/day = 36,368 m^3/day
- Cost of wastewater treatment
  - $1,349,399,509 ÷ 36,368 m^3 = $37,107/$m^3$
- Annual cost of O&M for WWTD
  - $346,438,325 ÷ 36,368 m^3 = $9,527/$m^3$

Estimated costs: Smaller Islands

Smaller Islands	Cost WWTD (USD)	Cost O&M (USD)
Anguilla	102,901,422	26,418,492
Antigua and Barbuda	675,934,507	173,536,462
Barbados	2,304,285,329	591,592,827
Bermuda	544,022,017	139,669,966
British Virgin Islands	191,037,968	49,046,310
Cayman Islands	357,618,713	91,813,571
Dominica	118,081,895	50,528,032
Grenada	885,614,216	227,368,986
Montserrat	8,434,421	3,609,032
St. Kitts & Nevis	421,721,055	108,274,355
St. Lucia (**pilot**)	1,349,399,509	346,438,325
St. Vincent and the Grenadines	848,503,505	217,848,193
Turks and Caicos Islands	219,716,670	56,411,272


Cost of WWTD in the Caribbean
Cost (USD x 1000)
4250000
4000000
3750000
3500000
3250000
3000000
2750000
2500000
2250000
2000000
1750000
1500000
1250000
1000000
750000
500000
250000
0
ANG
ANU
BAM
BGI
BEL
BER
BVI
CI
DOM
GND
GEO
HAT
JAM
MON
SKN
SLU
SVG
SUR
TNT
TCI
Caricom State or Associate State Code

Limitations

- These are preliminary estimates; should be regarded with expected accuracy of between + 30% to – 15% based on estimates derived in other studies (Burnside and ENR)
- Numerous factors affect the cost of wastewater treatment, these include:
  - Type of plant;
  - Desired quality to effluent;
  - Local cost of materials
  - Local cost of labour;
  - Design criteria;
  - Geographical location;
  - Transportation;
  - Climatic conditions;
  - Level of competition among building contractors;
  - Delivery time of requisite equipment and materials;
  - Project schedule;
  - Importation cost for specific materials and equipment

Limitations

- Annual O&M costs are highly variable among WWT plants; much more difficult to estimate than construction costs.
- O&M costs depend on a number of factors including:
  - Labour cost;
  - Wastewater characteristics;
  - Extent of use of imported equipment and materials;
  - Sophistication of the plant;
  - Chemicals and energy costs;
  - Sensitivity to changing market price.

Capacity building recommendations

Recommendations: Regional-level capacity building

- The conduct of one annual training course in each of the States constituting the larger islands (Haiti, Jamaica, Trinidad and Tobago and The Bahamas) and the continental landmasses (Belize, Guyana and Suriname).
- In collaboration with the Environmental Health Units, water and wastewater utilities and the private sectors in particular tourism and manufacturing.
  - estimated cost - as much as $15,000 per annum, cost of participation, resource personnel and content delivery.
- The conduct of two training courses annually for States belonging to the category of the smaller islands.
  - The islands can be grouped together based on logistics of travel, ease of delivery and geographic factors.
  - One training course - target islands of the upper reaches of the Caribbean archipelago, such as British Virgin Islands, Turks and Caicos Islands, Bermuda, Antigua and Barbuda, Anguilla, St. Kitts and Nevis and Montserrat.
  - Second training course - target Windward Islands and Barbados.
  - Estimated $ 30,000 annually - facilitation, development and administration of each of these two training courses

Administration and Financing of Regional WWTD Training

- Joint development of the structure, content and method of delivery of the training courses in WWT
  - UNEP/CAR-RCU, CEHI, CBWMP and PAHO, in association with the national regional regulatory agencies and water wastewater utilities.
- Develop a structured financing programme (sustainability mechanism) by regional agencies. Options may include:
  - Annual allocation of funds under UNEP/CAR-RCU's programme for the promotion and institutionalisation of the *LBS Protocol*,
  - National allocations under the PAHO Biennial Programme Budget (BPB) for the under States.
  - Private sector investment in WWTD
  - NOTE: compliance requirements from EIA processes and environmental management plans should trigger greater mainstreaming of budgetary allocations for training in WWTD.

Summary

- Cost influenced significantly by volume of wastewater generated;
- Cost of small footprint biomechanical methods, e.g. membrane bioreactors or biologically engineered single sludge treatment - 5 to 7 times cost of waste stabilisation ponds for the same volume of wastewater, under similar environmental considerations;
- Annual O&M cost - up to 30% the cost of construction and installation of small foot print systems;
- Annual cost of O&M for waste stabilisation ponds - approximately 30% the annual operations and maintenance cost of small footprint systems;
- O&M cost - decisive factor influencing choice of system to be used;
- States with smaller populations, where waste stabilisation ponds are applicable have lower financial requirements for wastewater treatment and disposal;
- Small States with limited available land space, relatively higher populations, higher tourism, manufacturing investments - higher financial requirements;
- Larger states, where waste stabilisation ponds were deemed appropriate, cost for treatment and disposal of unit volume of WW per unit population - lower than for smaller islands using small footprint systems;

Thank You...Questions

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