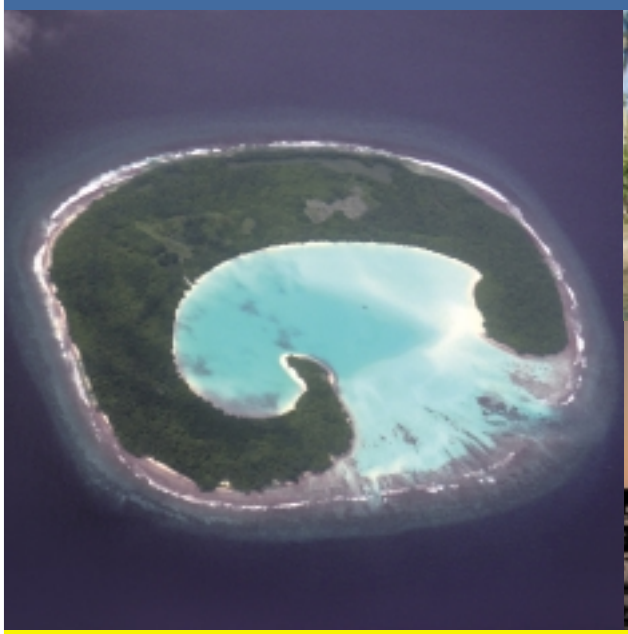
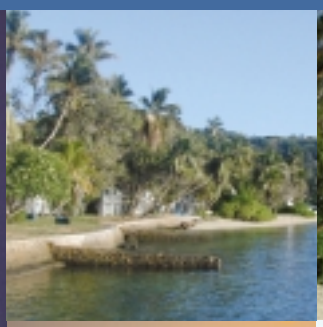
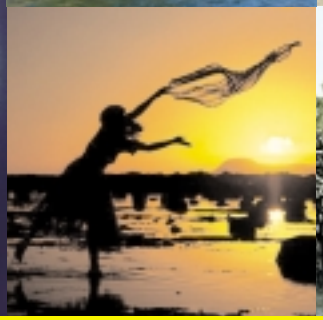
SIDS

Small Island Developing States

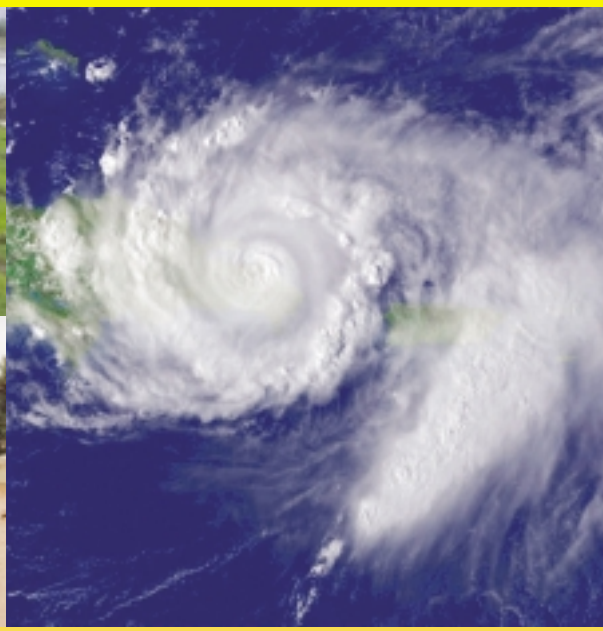
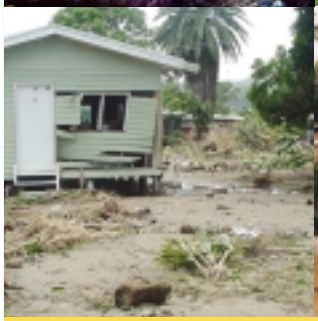
Saving paradise

Ensuring sustainable development






World Meteorological Organization
Weather • Climate • Water

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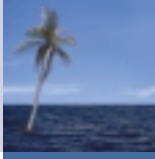


Saving paradise

Foreword

Since the adoption of the Barbados Programme of Action (BPoA) for the Small Island Developing States (SIDS) in 1994, considerable efforts have been deployed to implement the high-priority programme areas defined therein. Today, the achievements may seem meagre when compared to the objectives of the BPoA and the increasing challenges faced by SIDS in areas of trade, security and environment. This is true for most developing countries, but particularly so for SIDS.

The impediments are daunting, whether they be natural, indigenous or originate from global conditions. While the responsibility for meeting their socio-economic aspirations should rest primarily with the SIDS themselves, the world community, including strategic partners, UN system organizations and the private sector, have the duty to commit resources and means of support. The support should be based on the strategies and the Programme of Action that SIDS will evolve at the 2005 Mauritius International Meeting to Review the Implementation of the Programme of Action for the Sustainable Development of SIDS.

WMO has been at the forefront of collaboration with SIDS to ensure endogenous capacity building and the availability of some of the sophisticated products that recent advances in meteorology, hydrology, oceanography and related sciences can provide. These include observational data from all countries on weather, atmospheric composition, the ocean surface and surface and underground freshwater from a global network of in situ stations and satellite systems.

WMO ensures the availability around the clock of the most reliable weather forecasts and warnings with as much lead time as possible. Seasonal forecasts up to a year ahead are also being developed nationally or globally. The Organization gives particular importance to products that are essential for socio-economic sectors, including agriculture, water-resources management, energy and tourism and for environmental protection. It also promotes research and capacity building in these areas,

as well as in climate variability and change and their impacts on sea-level rise.

A unique feature of WMO is that its efforts are geared to supporting the activities of the National Meteorological and Hydrological Services of SIDS, while ensuring that the coordination mechanism and systems are developed and implemented by SIDS themselves. This booklet provides a brief overview of this distinctive global system in which each country contributes according to its means and benefits according to its needs in all socio-economic and environmental areas where weather, climate and water play a role.

This brochure aims to contribute to awareness of the potential contribution of weather, climate and water to sustainable development and thus to the formulation and implementation of the Mauritius Programme of Action for the sustainable development of SIDS and the well being of their populations now and in the future.

M. Jarraud
(Secretary-General)

Introduction

Small Island Developing States (SIDS) are highly vulnerable to natural disasters, as well as human-induced factors. These have been highlighted by the Alliance of Small Island Developing States (AOSIS), which has played a key role in drawing attention to the concerns of SIDS and calling for urgent action. Indeed, the threats can be mitigated through appropriate strategies that are based on the basic principles of sustainable development and the concerted efforts of the countries concerned, and with the support of the international community.

Photo: H. Kootval

Photo: Delphine Tailfer

From Barbados to Mauritius and beyond

As an outcome of the 1992 United Nations Conference on Environment and Development, the 1994 Barbados Conference on the Sustainable Development of Small Island Developing States not only recognized common environmental challenges facing SIDS, but also highlighted the meteorological, hydrological and oceanographic issues in many of these countries. The Barbados Programme of Action (BPoA), the principal output of the Conference, identified 14 issues and/or focal areas as urgent priorities. All these areas require inputs of varying degree from the National Meteorological and Hydrological Services (NMHSs) of SIDS and the global network of the NMHSs under the aegis of WMO.

SIDS Programme priority areas requiring significant inputs from National Meteorological and Hydrological Services (NMHSs)

- Climate change and sea-level rise
- Natural and environmental hazards
- Management of waste
- Coastal and marine resources
- Freshwater resources
- Land resources
- Energy resources
- Tourism resources
- Biodiversity resources
- National institutions and administrative capacity
- Regional institutions and technical cooperation
- Transport and communications
- Science and technology

The Mauritius International Meeting to Review the Implementation of the Programme of Action for the Suitable Development of SIDS will also build on the outcomes of the 2002 World Summit on Sustainable Development. It will review the achievements over the last 10 years and highlight areas of the BPoA requiring further implementation. Issues such as trade, good governance, security, health and other social issues should be seen as being holistically and intimately linked with environmental aspects of sustainable development.

Environmental security lays the foundation for sustainable development. Both the policy-makers and the public will need to ensure that advances in sciences such as meteorology, hydrology, oceanography and the environment are adequately understood and harnessed to address issues such as those related to climate change and sea-level rise, natural and environmental hazards, freshwater resources, energy, and coastal zone management. The National Meteorological and Hydrological Services in each of the countries should be able to provide related information, including forecasts and warnings of natural hazards and day-to-day variations in weather and climate, which affect all aspects of daily activities in agriculture, tourism, and other socio-economic activities.

As part of WMO's global network, the NMHSs of SIDS can access the most sophisticated products in near-real-time and advance forecasts of extreme weather events several days ahead, movement of atmospheric and oceanic pollutants, seasonal predictions and climate projections. In this way, the NMHSs are at the forefront of efforts to address some of the major challenges concerning weather, climate, water and the environment of the 21st century.

SIDS: some of the challenges

Tropical cyclones are among the major challenges facing SIDS in the Atlantic, Pacific and Indian Oceans. Because of their frequency and severity, they constitute some of the greatest threats to the socio-economic well-being of the populations. These tropical systems may also be beneficial, however, as they replenish the aquifers upon which most SIDS depend for their freshwater.

Longer-term climatic variations may be even more devastating to SIDS, since sea-level rise, resulting from climatic change, could permanently drown many of the low-lying islands of the Indian Ocean, the Caribbean and the Pacific. Sea-level rise would also affect the coastal areas and freshwater sources of all island States, as well as agriculture, fisheries, tourism and infrastructure.

Coastal zone management is therefore critical and requires data on tides, water levels, sea temperature, winds and coastal ocean circulation. Meteorological, hydrological and oceanographic information is essential for the design, construction, operation and management of infrastructure such as dams, roads, commercial and domestic buildings, harbours and bridges.

Meteorological and climatological information is vital for day-to-day agricultural operations, as well as for designing and construction purposes.

Photos: Y. Boodhoo

Weather and climate affect most sectors of the economy such as agriculture, transport, fishing and tourism, as well as leisure activities. The National Meteorological and Hydrological Services are responsible for monitoring weather, climate and water resources, for forecasting the weather, and disseminating the information to users. They also provide forecasts and early warnings to alert decision-makers and the population in a timely manner.

Addressing these issues requires action at national, regional and global levels. The priority areas listed in the BPoA require the application of meteorological, hydrological, oceanographic, and other environmental sciences to everyday life and decision-making.

They are crucial elements in the quest of SIDS to achieve sustainable development. While the support of the international community is necessary, it is the ownership and commitment of the States, individually and collectively, that will ensure a sustainable future for their populations. WMO's structure and operations enable each nation to build its sustainable development though its own NMHS, with WMO providing the overall framework for international cooperation.

Vulnerabilities of the Maldives to climate change

- **Land loss and beach erosion**
- **Damage to infrastructure**
- **Damage to coral reefs**
- **Impacts on the economy**
- **Food security**
- **Water resources**
- **Human health**

Source: First National Communication of the Republic of the Maldives to the United Nations Framework Convention on Climate Change

Photo: Fiji Meteorological Service

Weather and climate affect all sectors of the economy. For Small Island Developing States, fishing is an important export industry, while fish often form the basic form of sustenance for many.

Climate change and sea-level rise

Some island States, such as Kiribati, Tuvalu, the Marshall Islands and the Maldives, have their highest elevations only 4 metres above mean sea-level and are therefore highly vulnerable to projected sea-level rise.

The rise of sea-level globally is due primarily to the expansion of ocean water resulting from an increase in ocean temperature and, to a smaller extent, to the melting of glaciers. Since 1861, mean annual global surface temperature has increased by an average of 0.6°C and it is most likely that this increase will continue in the 21st century. The Inter-governmental Panel on Climate Change (IPCC), established by WMO and the United Nations Environment Programme (UNEP), in its Third Assessment Report, attributes this increase mainly to human activity.

In recognition of the potential adverse impacts of climate change resulting from the greenhouse effect, the United Nations Framework Convention on Climate Change (UNFCCC) set an objective of stabilizing "*greenhouse-gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate systems*".

Photo: NASA

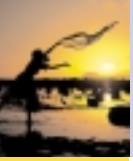
The classic atoll is composed of a coral reef encircling a shallow lagoon.

Photo: Martin Ferm, IVL Swedish Environmental Research Institute

Small low-lying islands are at particular risk from sea-level rise induced by climate warming.

It is estimated that SIDS contribute less than 1 per cent to global GHG emissions and they are not yet obligated to implement GHG mitigation measures. Nevertheless, many have shown a commitment to the objectives of the UNFCCC by completing inventories of GHG emissions as a step towards achieving greater energy independence and implementing GHG reduction for sustainable development.

According to the IPCC, during the last 100 years, sea-level has risen at a rate of 1-2 mm/yr and is projected to rise 9-88 cm by the end of the present century. Such a rise would pose grave problems for SIDS. A large part of the Majuro atoll, for example, which is home to 50 per cent of the population of the



Marshall Islands, and significant landmass in Kiribati would be lost. Some cays of the Bahamas, and the Turks and Caicos islands in the Caribbean might be inundated. Sea-level rise would lead to rapid land loss through submergence of lowlands, loss of wetlands and erosion of beaches in most SIDS.

As its contribution to mitigating the adverse effects of climate change, reducing vulnerability and identifying options for adaptation, WMO has been implementing numerous programmes worldwide, focused on promoting the collection and analysis of climate data, encouraging the development of capacities for the prediction of climate variability and for climate change projection.

Some of WMO's initiatives related to climate change and sea-level rise are:

- Ensuring the ready availability of high-quality data for climate research and climate change detection;
- Promoting research on reducing uncertainties in climate change projection and the potential impacts of human activities on climate, including:
  - Increased accuracy about the impact of climate change at the regional level and, as far as possible at local level, on socio-economic development;
  - Increased accuracy about the potential impacts of climate change on the occurrence and intensity of extreme weather and climate events;
- Supporting the assessment activities of the IPCC and encouraging the participation of developing countries in the process.
- Supporting the UNFCCC process, especially though the provision of scientific inputs.

Understanding climate variability is important for planning adaptation for climate change. The data collected, processed and exchanged by the NMHSs also form the basis on which vulnerability assessments, adaptation strategies and policy guidelines will be developed by SIDS.

Climate Information and Prediction Services (CLIPS)

The potential of using new knowledge of the El Niño/Southern Oscillation (ENSO) phenomenon for climate prediction on seasonal-to-interannual scales in some regions was identified some 10 years ago. Accordingly, WMO initiated CLIPS to assist countries, in particular SIDS, to access regional and global climate monitoring and prediction products and, with their local knowledge, provide users in sectors such as agriculture, disaster planning, tourism and water resources with a tool for planning.

Date rescue (DARE)

The Data Rescue (DARE) project was launched with the aim of assisting developing countries to manage, preserve and analyse their data efficiently. This project has allowed valuable data in manuscript form to be transferred to microfilm and computer-accessible format. In 1995, a DARE project commenced for the Caribbean. Recently, more advanced techniques, such as digital scanners and cameras, have enabled data on manuscript to be "captured".

Some NMHSs have lost data from damage by fire and water. The proper collection, processing and archival of data will lessen the risks of similar tragedies in the future. Rainfall data in the Caribbean and the South-West Pacific are available as of the mid-19th century. The Barbados monthly rainfall dataset dates from 1843 and climate observations for Apia, Samoa, go back to 1890.

Natural and environmental hazards

SIDS are highly vulnerable to weather- and climate-related natural and environmental hazards, such as tropical cyclones, floods and droughts, which cause death and injury and economic losses. During the 10-year period 1992-2001, about 90 per cent of all natural disasters worldwide were of meteorological or hydrological origin. Other events, which can be just as devastating, are storm surges and mudslides. Other catastrophic events are volcanoes, earthquakes and tsunamis.

Photo: Fiji Meteorological Service

The heavy rains associated with large tropical systems often trigger flooding.

Early warning systems

WMO supports the efforts of each affected SIDS to develop its own warning system which is scientifically proven and culturally based. Each cyclone basin has its own regional coordination mechanism for monitoring tropical cyclones, accessing the most sophisticated forecasts, capacity building, naming of cyclones, and issuing regional forecasts. Each Region has its own Regional Specialized Meteorological Centre for Cyclone Warnings—but the responsibility of issuing warnings for each nation rests with its National Meteorological Service.

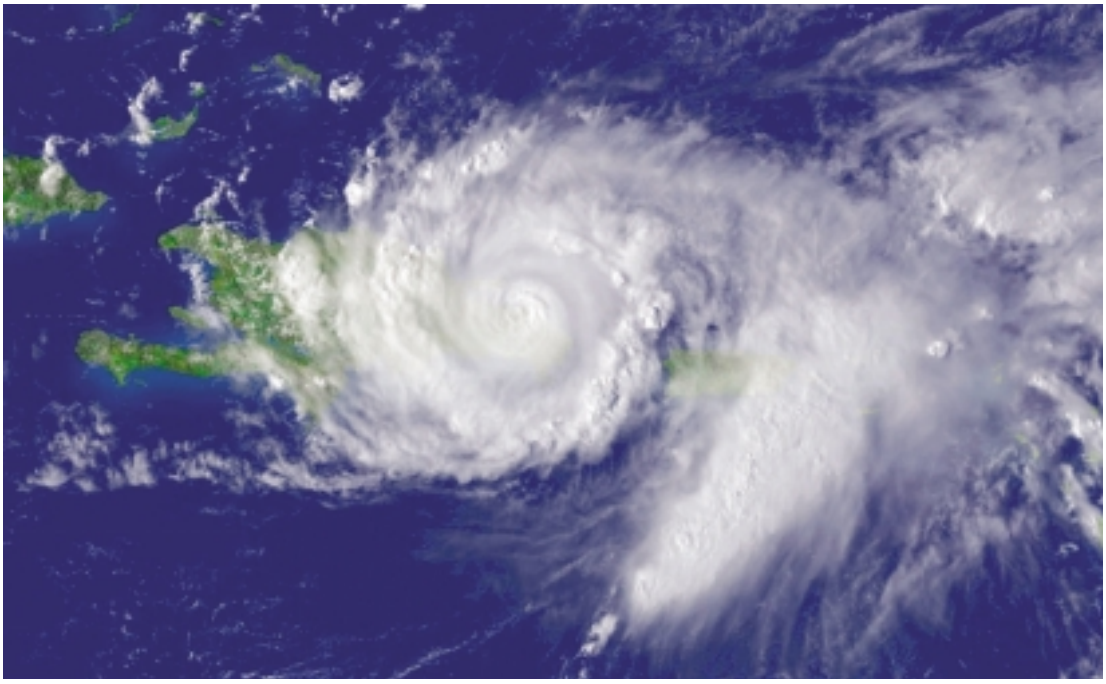


Image oh Hurricane *Jeanne*: NASA

SIDS and tropical cyclones in 2004

Caribbean

Ivan was one of the most powerful hurricanes of the century. It tore through the southern and western Caribbean in early September. On 7 September, it roared into Barbados, ripping off roofs and battering Bridgetown with waves as high as 2 m on top of a storm surge of about 1.5 m. The eye moved south of the island and intensified to a category 4 hurricane as it hit Grenada the next day, destroying some 90 per cent of the island's buildings. *Ivan* pounded the Cayman Islands as a category 5 hurricane (sustained winds of 256 km/h with much higher gusts. About half the island's 15 000 homes were damaged or lost, but the greatest impact was the storm surge and the high waves it generated. Houses were washed away and buildings were inundated by floodwaters. Many of the inhabitants sought refuge from the water by climbing on to rooftops.

Jeanne, in mid-September, affected the US Virgin Islands, Puerto Rico, the Dominican Republic, Haiti, the Bahamas, and the US state of Florida. The worst damage occurred in Haiti. Heavy rains totalling some 33 cm in the northern mountains caused severe flooding and mudslides, particularly in the coastal city of Gonaïves, where about 80 000 of the 100 000 residents were affected. Although the weakest of the four hurricanes to hit the area in rapid succession in two months, *Jeanne* left 3 006 people dead in Haiti, of whom 2 826 were in Gonaïves alone. Another 2 601 people were injured and an estimated 300 000 were left homeless.

Indian Ocean

Between 26 January and 4 February, tropical cyclone *Elita* hit Madagascar several times, causing widespread destruction and leaving thousands homeless. On 7 March, Tropical Cyclone *Gafilo* struck the island, killing 200 people and affecting the lives and livelihoods of some 800 000 others. The diameter of the area of impact was more than 400 km, with recorded wind gusts of over 250 km/h. *Gafilo* was the fiercest storm to have struck Madagascar in 20 years.

North Pacific

Ten tropical cyclones hit the Federated States of Micronesia between April and December: *Sudal, Omais, Tingting, Chaba, Songda, Sarika, Tokage, Nock-ten, Nanmadol* and *Talas. Sudal* was the first and the strongest. It struck the island group of Yap with winds of over 200 km/h, wreaking havoc. The main hospital was badly damaged and the airport and government buildings were affected. Many houses were completely destroyed. Water and electricity supplies and telecommunications to 99% of the population were disrupted.

South Pacific

In the first week of January, Tropical Cyclone *Heta* moved through the South Pacific islands of Tokelau, Samoa, American Samoa, Tonga, Niue and Cook Islands, leaving behind damage of various degrees. Niue was by far the worst affected to the extent that its future was in the balance for months afterwards. The worst storm in living memory in Niue, *Heta* caused damage amounting to an estimated US$ 24.6 million. The capital Alofi was flattened by 300 km/h winds. A storm surge and huge waves engulfed the 18 m cliffs which ring the island. In February, Tropical Cyclone *Ivy* cut through the centre of Vanuatu, tearing down homes, uprooting trees and cutting communications.

Damage inflicted on the infrastructure of Niue, South Pacific, by Tropical Cyclone Heta in January 2004: (above) the hospital; and (below, left) the Justice Department

Photo: Nation Publishing Company Ltd., Barbados

Hurricane Ivan in September 2004 destroyed 90 per cent of Grenada's buildings.

Other hazards

Floods

Floods are among the most disastrous events. Tropical cyclones can cause intense rainfall with accompanying floods especially in low-lying areas. Flooding is often aggravated by human interference with the runoff regime as a result of land use or blocked watercourses. Most flooding in the Caribbean has resulted from, or been exacerbated by, the removal of trees and other vegetation from hill-slopes and the dumping of waste in river channels. Haiti, for example, is vulnerable to floods and mudslides—problems often made worse by massive and continuing deforestation, wood being the basic domestic fuel.

Many SIDS lack a comprehensive flood-management plan, but some are putting plans in place. Floodplain mapping exercises are in progress as pilot projects in Barbados, Trinidad and St. Vincent, among others, with the aim of alleviating disastrous flooding of rivers.

The NMHSs are called upon to assist in conducting studies on frequency/intensity/duration curves of rainfall. Such information is used to calculate the flows for sizing culverts and storm-drainage works in densely populated urban areas where flooding frequently occurs. For this purpose, predictions of rainfall intensity and duration are essential. Long-term data on weather, climate and the hydrological regime are required for the design and planning of some of the infrastructural work in risk management and vulnerability reduction

Drought

For SIDS, drought conditions may arise relatively quickly when there is a marked reduction in the rainfall regime. Data collection, storage and analysis and the dissemination of related forecasts and warnings, as well as weather, climate and water information to the various end-users, are increasingly vital to many sectors of the economy in mitigating the impacts of drought.

Photo: WMO

Haiti is vulnerable to hurricanes, floods and mudslides.

Landslides

Landslides are caused by the saturation of soil and rocks such as clays, mudstones, and loose sandstones, during the heavy rains which normally accompany tropical cyclones. When these materials lie on steep slopes and saturation reduces the frictional forces, slip planes tend to develop, and the soil and rock masses begin to creep downhill. Some can move quickly, however, and even turn into avalanches, which can bury entire villages in the valleys below. Housing and infrastructure, such as roads and utility poles, can be destroyed, even by slow downhill movement.

In the year 2000, two cyclones struck the island of Madagascar within a two-week period, triggering 280 landslides that caused widespread socio-economic and environmental damage. There was considerable dislocation of human
settlements, as more than 100 000 people had to be evacuated and relocated away from the paths of the landslides. In addition, there was considerable damage to road, rail and other infrastructure.

Photo: International Committee of the Red Cross

Some island States are now undertaking flood-plain mapping exercises to avoid some of the damage caused by flooding

Pollution of groundwater, surface and marine water

SIDS have scarce surface freshwater aquifers and many rely on groundwater. Global warming leading to higher sea-level will also cause a higher incidence of flooding, with increased saltwater intrusion into surface and ground-water sources.

In the context of waste management in SIDS, protection of the environment from pollution is extremely important for sustainable development and in particular for the tourism and fishing industries.

The monitoring of air quality and the transport of transboundary air pollutants, as well as prediction of the movement and intensity of pollutants and toxic chemicals in the air and over the oceans, form essential information for taking suitable and timely measures to avert the impacts of the pollutants.

Coastal zone management

Beach and coastal erosion are problems shared by SIDS and low-lying countries.

Photos: Leslie Barker

Coastal and marine resources play a crucial role in the socio-economic development of all Small Island Developing States. These assets are exploited in a variety of ways and by a wide range of stakeholders. Coasts provide opportunities for, among others, housing and settlements, agriculture, tourism and recreation, fishing and mariculture, mining, transport and waste disposal. Through these activities, many SIDS are able to provide shelter, food, jobs and other forms of support for their populations.

Coastal and marine resources

The importance of coastal areas to the livelihood of island populations and the competition among stakeholders for access to them, cause resources to deteriorate rapidly. The damage manifests itself in many ways, including the loss of mangroves and other coastal ecosystems, mining of sand, accelerated beach erosion, degradation and destruction of marine ecosystems and vegetation (e.g. coral reefs and seagrasses), poor water quality due to pollution

(including that from external sources, such as hazardous waste which is transported across the oceans where many SIDS are located), and depletion of fish stocks. These effects are largely the outcomes of unsustainable practices which are often triggered by necessity and poverty.

Photo: Y. Boodhoo

Groynes properly installed help prevent beach erosion.

Coastal erosion

Intense tropical systems trigger floods but other hazards, also. The population of Dominica still remembers Hurricane *David* in 1979. Homes were destroyed and agriculture was severely affected, but the hurricane also caused massive coastal erosion. For example, several roads were cut off when mudslides and huge waves eroded beaches. Heavy seas exacerbated the erosion, which was estimated at 0.7 m/yr for the period 1970–1984.

Beach erosion

Beach erosion can be a disaster, especially if a hurricane induces storm surges. In all SIDS, beach erosion is a hazard which takes place year after year, in many cases unabated. In Grand Turk, Turks and Caicos Islands, it is estimated that the rate of erosion was 0.3-0.45 m/yr for the period 1906–1969. Winter storms with northerly swells play a highly significant role in beach erosion in the Caribbean. The mining of sand is another activity which destabilizes beaches, and the improper construction of groynes prevents the longshore movement of sand. Stable beaches have to be maintained if tourism is not to suffer.

The problem of coastal degradation in SIDS is exacerbated by the threat of global warming and rising sea-level, as the ecosystems will have to cope with the anthropogenic stresses identified above in combination with the negative effects of global warming.

The Intergovernmental Panel on Climate Change has indicated that projected climate change would lead to higher water levels and, consequently, a higher incidence of flooding and inundation in SIDS (most of which are low-lying), increased wave erosion and saltwater intrusion into coastal aquifers and loss of coastal infrastructure and will threaten the survival of key ecosystems. Specifically, the occurrence of coral bleaching, which is associated with elevated sea-surface temperatures, is already evident throughout SIDS in the Caribbean, Pacific Ocean and Indian Ocean. Episodes of bleaching are more intense, for example, during El Niño years when sea-surface temperatures are higher.

Ecosystems: protecting biodiversity

Mangroves are highly productive ecosystems and provide a valuable habitat for shrimps and other marine life, and birds. Their existence is threatened by sea-level rise, severe storms and pollution.

Integrated coastal area management

It is now widely acknowledged that integrated coastal area management (ICAM) is perhaps the most appropriate framework for looking after coastal and marine resources in a sustainable manner. ICAM is a dynamic process that seeks to achieve maximum economic and social benefits for all stakeholders without jeopardizing the coastal resource base. It is a tool that allows managers to plan for, and respond to, medium- and longer-term concerns (e.g. sea-level rise), as well as short-term, present-day needs. The process necessarily draws heavily upon a wide array of disciplines, including meteorology, hydrology and other Earth and biological sciences. Comprehensive ICAM programmes have been successfully implemented in a few SIDS at both the national level (e.g. Barbados) and the regional (Pacific island countries) level. While many other SIDS have implemented isolated projects, full national programmes with a long-term commitment for funding should be regarded as urgent priorities.

More specifically, the skills and expertise derived from training in fields such as meteorology, climatology, marine meteorology, oceanography and hydrology provide the scientific basis for understanding the dynamics of basic processes, such as coastal erosion and

Photo: V. Torres

A healthy mangrove (left) and the consequences of pollution after an oil spill at sea (right)

Photo: International Coral Reef Information Network

Coral reefs and fish stocks are at risk from rising sea-surface temperatures, with significant adverse consequences for biodiversity, tourism, recreation and fishing.

deposition. For example, the distribution of energy, sediment and even organisms (e.g. fish larvae) within the coastal and marine zones is driven largely by waves, tides and currents. Thus, the formation of beaches and dunes, the creation of natural inlets and bays for the construction of harbours and safe anchorage and of vital habitats and aggregation of fish populations (to name but a few) cannot be properly understood without reference to these disciplines.

Moreover, SIDS, with their life-sustaining coastal resources, are among the groups of countries most at risk from the projected impacts of global warming. SIDS have no option therefore but to decrease their vulnerability, build up resilience and implement appropriate adaptation options. Such strategies cannot be properly designed or implemented without an interdisciplinary approach that is strongly grounded in a combination of sciences that includes meteorology, hydrology and oceanography. Without doubt, the training and capacity building in these fields undertaken in many SIDS by the World Meteorological Organization, will be critical in preparing these countries to better manage these risks.

Freshwater

The Earth has abundant resources of water, but the amount that is easily accessible for sustaining human life is minute by comparison. The imbalance is further underscored when we consider the water resources available to SIDS. By definition, they have limited landmasses which do not allow for extensive surface waterbodies or for large underground sources of water. The restricted water resources of the SIDS are extremely vulnerable to both long-term climate change and to shorter-term climate variability, such as the series of drought and wet years induced in some countries by occurrences of El Niño and La Niña.

Resources and availability

On some of the islands, because of the small size of the watersheds and catchment areas, freshwater occurs either as thin groundwater lenses floating on saltwater, or as small rivers and lakes. The low-lying atolls of the Pacific and Indian Oceans, e.g. the Maldives, Tuvalu and the Cook Islands, and the Bahamas, together with other limestone islands such as Barbados and Antigua, are all dependent on groundwater, as well as on the direct use of rainwater.

Due to their limited land area, SIDS have restricted freshwater resources which are under threat from both pollution and climate variability.

The thin, underground freshwater lenses of these islands are at risk from sea-level rise, which would significantly reduce their extent and thus the volume of available freshwater. Reduced precipitation would also reduce replenishment of the lenses. Increased demand, resulting in overpumping, causes both saltwater intrusion and the reduction of freshwater.

SIDS must have more efficient water-resources management if they are to sustain and improve the living standards of their populations. Efficient management requires rainfall, river and and underground flow data collection over sufficiently long time periods, rigorous analysis of these data and rainfall and flood forecasts—and this means that SIDS must have efficient national meteorological and hydrological institutions. Collaboration among the various States in sharing scant technical and financial resources is also a prerequisite.

Island drought

Mediterranean droughts impact the islands of Cyprus and Malta to the extent that they have serious sea-water intrusion problems. The demand for potable water in Barbados has doubled from 90 million litres per day in the 1960s to over 180 million litres today. Barbados also has increased salinity problems.

Islands like Dominica and St. Vincent in the Caribbean are largely dependent on small surface-water sources. Their relatively small rivers can be affected by reduced rainfall in the watershed, or be easily polluted by upstream anthropogenic activity. Dominica has already been recording reduced flows from lower rainfall, in the last few decades.

World Hydrological Cycle Observing System

The water resources of some SIDS have been developed effectively but in most, however, no agency can be considered a complete National Hydrological Service (NHS) which makes hydrological observations, collects, analyses and archives these data and publishes the results. Some governments have appointed lead agencies in water but, for the vast majority, their main task is distribution for public supply.

In most SIDS, hydrological data collection and processing and rainfall prediction are not adequate. WMO's World Hydrological Cycle Observing System (WHYCOS), launched about 10 years ago, is intended to build capacity of the National Hydrological Services (NHSs) of a region by strengthening the observation networks, improving the data-management systems (thus allowing the Services to provide products specific to end-user needs) and promoting the free international exchange of these data.

CARIB-HYCOS and SOUTH-WEST PACIFIC HYCOS, which are regional components of HYCOS currently being developed, will mean that integrated water-resource management will become a reality for SIDS in the Caribbean and the South-West Pacific regions.

Photo: FAO

Access to freshwater for human and livestock consumption, as well as for domestic and agricultural use is a prerequisite for sustainable development. The situation is critical in all developing countries and SIDS in particular.

Energy

Energy is one of the most critical factors in sustainable development, yet energy generation from fossil fuel is held responsible for some of the environmental problems facing society today. Some of the most critical technologies for sustainable development are energy technologies.

Towards sustainability

Increased greenhouse-gas emissions are considered to be the major contributors to climate change and sea-level rise, which, as we have already seen, can lead to significant loss of the coastal lands that constitute a significant proportion of the valuable land areas of many low-lying SIDS, with ensuing and severe socio-economic disruption. In addition, SIDS have the very real problem of the negative impact of high energy prices on their already fragile economies.

SIDS therefore need to move to a more sustainable energy system, which will not only have a lesser impact on their economies, but will also be more environmentally friendly. Renewable forms of energy must play a more significant role in the energy mix of these States.

Photo: Eugene Water and Electric Board

Despite certain difficulties, renewable energy is a viable option for SIDS.

Renewable energy

Renewables refer to energy sources which can be sustained indefinitely. Renewable **energy flow** includes insolation, wind, biomass production, flowing water, geothermal, or ocean thermal, tides). All these flows, except for geothermal flow, can be said to be derived from the Sun, and they can be converted into useful power.

Other key technologies, which do not produce energy directly but can integrate renewable technologies into energy supply systems, are also available to assist in optimizing global energy use.

These are **storage technologies** (e.g. batteries, seasonal thermal storage, pumped hydropower), which allow energy flows to be used when and where needed; **high power semi-conductors** allow efficient integration into the grid; **energy conversion technologies** (gasification of biomass) may expand options for renewable energy; **fuel cells** can produce electricity from hydro-carbons more efficiently than direct combustion.

Adapted from *A New Power Base,* by K.L. Kozlof and R.C. Dower (1993)

The renewables

The renewables that are currently available to most SIDS are wind, solar, biomass and, to a lesser extent, ocean thermal energy conversion , and mini-hydropower. These options are not all equally exploitable or economically viable, but they are, generally, more environmentally friendly and economically sustainable than hydrocarbons.

While there are a few exceptional cases of developing countries achieving a contribution of renewable energy greater than 50 per cent to their total energy supply, in Latin America and the Caribbean, for example, a figure between 10 per cent and 20 per cent is currently more realistic and achievable. Curaçao, a small Caribbean island, produces more than 50 per cent of its total energy demand from wind. It is estimated that Barbados could produce 33 per cent of its total energy demand by 2010 from renewable sources; and this does not take into account the 36 000 solar heaters currently in use.

Photo: Leslie Barker

Solar panels on the roof provide power for a large building complex.

Most of these energy forms depend very much on reliable meteorological and hydrological information and forecasts for their design, siting and efficient operation:

- Ocean thermal energy conversion requires oceanographic data, including, but not limited to, current sea temperatures and sea-bed morphology;
- Wind and solar energy, which are already being used extensively worldwide, require considerable meteorological data collection and analysis;
- (Mini-)hydropower, which could be important to SIDS, requires careful hydrological monitoring, data collection and analysis, as well as projection.

The contribution of NMHSs is vital if SIDS are to utilize renewable forms of energy more extensively. Despite some difficulties, appropriately chosen renewable energy is still a viable option for SIDS.

Tourism

Tourism is one of the largest economic activities in the world today and has become one of the largest earners of foreign currency for SIDS. Tourists' expenditure can account for as much as 95 per cent of the Gross National Product of some countries such as the Maldives, and as much as 75 per cent of export earnings in the case of the Bahamas.

Tourism is also a significant contributor to employment in SIDS, providing jobs for between 20 and 70 per cent of the labour force. It is clear, therefore, that any threat to the viability of this industry in these States is of major concern. These threats can be both short- and long-term. The annual storm season can pose problems for beach stability, the structural integrity of the hotel plant, with the need for constant repairs owing to hurricane damage and, indeed, the very safety and comfort of the tourists.

There is therefore the need for maintenance of the beaches and for the proper design of hotel structures. Day-to-day weather forecasting is also essential for tourism. In the longer term, impacts of sea-level rise could have adverse consequences for the industry. Meteorological and oceanographic data, particularly concerning the coastal zone are of prime value for tourism in SIDS.

WMO, in collaboration with the World Tourism Organization, has produced the *Handbook on Natural Disaster Reduction in Tourist Areas*. This publication provides technical guidance on how risk assessments using climatological and hydrological data provided by NMHSs can be used to reduce the vulnerability of tourists and tourist facilities and exploit existing natural resources in an optimal, yet environmentally friendly, fashion.

SIDS have also been assisted by WMO in the areas of maritime and air transport, both areas being of critical importance to the tourist industry. The World Area Forecast System (WAFS) enables SIDS to use accurate weather information in a cost effective manner to assist national and international aviation operations. Marine meteorological forecasts are similarly vital for safe maritime activities.

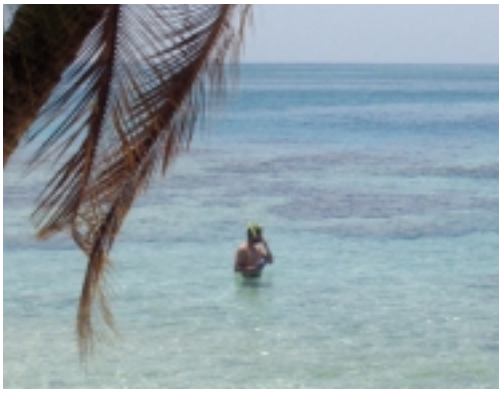


Photo: Delphine Tailfer

A paradise for tourists—but for how much longer?

Photo: Leslie Barker

Tourism is a major earner of foreign currency for SIDS and a significant employer.

National Meteorological and Hydrological Services and regional cooperation

In view of the importance of the work of National Meteorological and Hydrological Services (NMHSs) to the sustainable socio-economic development of SIDS, the World Meteorological Organization supports its Members in developing adequate structures and building capacity to ensure that relevant and the most sophisticated information is available in a timely manner to address issues of concern to them. These include natural hazards, climate change and sea-level rise and their impacts, including environmental degradation, and provide support to agricultural production, fishing and mariculture, freshwater resources, coastal zone management, transport by sea and air, energy and tourism.

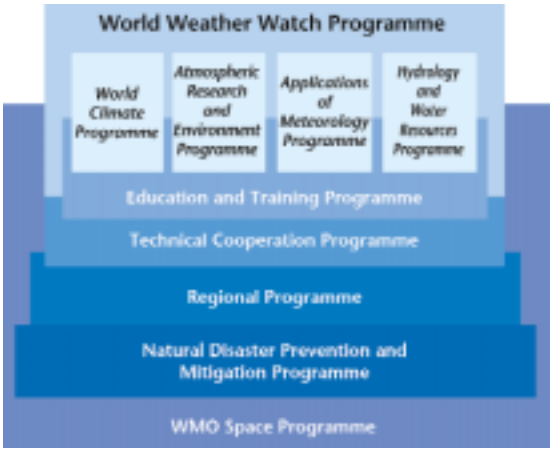
For this purpose, the World Meteorological Organization coordinates global meteorological and hydrological activities of its 187 Members and conducts its work through technical commissions, scientific and technical programmes and in collaboration with regional groupings. Most of WMO's efforts are directed towards supporting NMHSs. In particular, WMO encourages the transfer of technology, cooperation and capacity building.

Regional cooperation

Regional cooperation forms a cornerstone of WMO's strategy in supporting the NMHSs. The examples below shows the range and nature of activities that WMO supports in this context.

SIDS-Caribbean Project

An example of regional cooperation in the implementation of the Declaration of Barbados and the Programme of Action is the regional project "Preparedness to Climate Variability and Global Change in Small Island Developing States, Caribbean Region: the SIDS-Caribbean Project".



WMO programmes

The Project involves the following countries: Guyana, Trinidad and Tobago, Grenada, St. Vincent and the Grenadines, Barbados, St. Lucia, the Commonwealth of Dominica, Montserrat, Antigua and Barbuda, St. Christopher and Nevis, Anguilla, Dominican Republic, Haiti, Jamaica, Cuba, Turks and Caicos Islands, Bahamas, and the Netherlands Antilles.

The Project ensures enhanced meteorological and climatological knowledge and improved scientific capacities, allowing better planning for sustainable development in the Caribbean region. In particular, the countries concerned will have greater capability to monitor and predict weather and climate phenomena. They will also have access to up-to-date information for policy formulation, strategic planning and improved awareness and delivery of such information to decision-makers and the public to ensure preparedness against the adverse impacts of climate variability and global change.

The Caribbean Institute for Meteorology and Hydrology (CIMH)

Located in Barbados, the CIMH is a designated WMO Regional Meteorological Training Centre (RMTC) and, since 1968, when it was established as the Caribbean Meteorology Institute (CMI), has trained technicians at entry, middle and senior level in meteorology.

The CIMH is an arm of the Caribbean Meteorological Organization (CMO), which comprises 16 governments in the English-speaking Caribbean.

The CIMH provides seasonal climate prediction for the Caribbean based on information from several international prediction centres and serves as an archival centre for climate and hydrological data. It conducts research in areas such as agrometeorology, biometeorology, the climatology of small islands, tropical meteorology, satellite cloud climatology; floodplain hazard mapping, hydrology of extreme events and effects of saltwater intrusion on coastal aquifers.

South-West Indian Ocean

In the face of recurring hydrometeorological disasters in islands of the South-West Indian Ocean (Comoros, Madagascar, Mauritius, La Réunion (France) and Seychelles), systems are being put into place to provide for accurate and timely meteorological information and products in support of early warning and disaster mitigation.

Improvement of meteorological infrastructure in the countries of the Indian Ocean Commission (InOC) is important, not only from the standpoint of preparing for, and minimizing the damage caused by, severe weather events but also for climate-change impacts, including sea-level rise. WMO has therefore been working closely with the InOC Secretariat with a view to enhancing capacity to monitor and predict weather and climate phenomena for improved awareness, policy formulation and strategic planning. This will enable decision-makers and the public to access information to ensure preparedness against the adverse impacts of climate variability and global change for long-term sustainable development.

Photo: FAO

WMO provides support to the work of National Meteorological and Hydrological Services of SIDS in all economic sectors, including agricultural production.

South-West Pacific Ocean and North Indian Ocean

Climate variability and change are part of a set of local and global environmental changes that are being addressed in the Pacific and North Indian Ocean regions as in other parts of the world. Human health is one specific aspect of global change that impacts on sustainable development. Effects on health, either in the short or long term, are expected to increase the vulnerability of Small Island Developing States. Some aspects of concern are vector-borne and diarrhoeal diseases, acute respiratory infections, malnutrition and injuries caused by weather extremes.

Applications of forecast information in mitigating negative health impacts of climate variability and extreme events, and on assessing vulnerability and adaptive capability in Small Island Developing States remain a priority. WMO maintains close working relationships with regional organizations such as the South Pacific Regional Environment Programme and the South Pacific Applied Geoscience Commission.

Photo: Delphine Tailfer

Towards strengthened future cooperation

The Nassau Ministerial Declaration on SIDS and the AOSIS Strategy Paper have noted the wide-ranging problems facing Small Island Develop-ing States and how they impinge on their development agenda. They recognize weather, climate and water as playing critical roles in human welfare and the environment.

The conclusion is that it is of utmost importance to protect life and property and to make optimum use of resources.

Photo: G. Tortoli/FAO

WMO helps Small Island Developing States protect their natural resources and infrastructure by reducing vulnerability to natural and environmental hazards.

WMO and the SIDS Programme of Action:

- Enhancement of national, regional and international capacity to monitor the Earth's atmosphere, land and oceans, including strategies for integrated global observations, including improved products, analysis and applications to sustainable development;
- Development of the regional components of the World Hydrological Cycle Observing System, in particular, the Carib-HYCOS and South-West Pacific-HYCOS projects for sustained freshwater availability;
- Strengthen disaster-management capacity at national and regional levels and vulnerability assessment (an important factor in determining the adequacy of early warning systems, as well as to understand and prevent disasters);
- Strengthening of institutional, scientific and technical capacity at national and regional levels and building effective response measures to cope with the effects of climate change and sea-level rise; support initiatives to assess the consequences of climate change;
- Risk-management applications, such as hazard mapping, suitable agro-climatic zoning and the establishment of partnerships as essential tools for land-use and preparedness planning;
- Ensuring that SIDS develop and utilize their climate databases for various sectors of the economy, including climate predictions;
- Transfer of appropriate technologies; assistance in the establishment of regional centres for capacity building and training; establishment and maintenance of information and databases on new and innovative technologies; and
- Development of a strong and effective human resource base in all fields and across all sectors; greater regional and subregional cooperation for the joint sharing of resources, technologies and expertise, as well as at bilateral and multilateral levels.

Conclusion

The 10-year review in Mauritius is a landmark event that will generate renewed political commitment by all stakeholders on practical actions in support of SIDS.

Meteorology, hydrology, oceanography and related sciences and the National Meteorological and Hydrological Services are vital in the implementation of all the areas addressed by the Barbados Programme of Action. The role of those Services will be increasingly important in the implementation of the Programme of Action on the road beyond Mauritius.

WMO pledges continued support for initiatives in favour of sustainable development and the implementation of the United Nations Millennium Development Goals in areas that include climate change and sea-level rise, natural and environmental disasters, integrated coastal area management, freshwater resources, protection of land resources, and new and renewable energy. WMO remains firmly committed to the BPoA and will continue to support SIDS in achieving sustainable development for the welfare of their populations now and in the future .

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