
*Articles***Climate Change and Small Island Developing States:
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This paper reviews published work and projects on climate change and Small Island Developing States (SIDS), covering impacts, vulnerability, and adaptation. As a critical review, this paper does not seek to be comprehensive, but it extracts key ideas and discusses key material to evaluate the current state of knowledge on SIDS and climate change. Illustrative examples and references, rather than a full listing, are used to support points. The main way forward suggested for the future is better integration of top-down and bottom-up approaches to ensure that data and methods are based on local interests while acknowledging and integrating local and traditional knowledge with other forms of knowledge. Placing climate change into appropriate contexts is also important along with filling in prominent knowledge gaps, especially moving beyond the current focus on Caribbean and Pacific SIDS.

Keywords: small island developing states; SIDS; climate change

Introduction*Small Island Developing States (SIDS)*

In April 1994 in Barbados, the first *Global Conference on Sustainable Development of SIDS* adopted the *Barbados Programme of Action* (UN, 1994), updated a decade later in the *Mauritius Strategy* (UN, 2005). These documents consolidated the grouping of island countries and territories labelled SIDS: Small Island Developing States. The SIDS group now comprises 52 small countries and territories (Appendix 1) in the tropics and low-latitude sub-tropics.

The SIDS label displays inconsistencies in that not all descriptors are accurate for all SIDS. Papua New Guinea, with an area of 462,840 km² is almost twice New Zealand's size and could not be considered to be "small" compared to Tuvalu's 26 km². Belize and Guyana do not conform to the strict definition of "island" since they are not small pieces of land surrounded by water. With national economic data better than many European countries, Bahrain and the Cayman Islands could not necessarily be termed "developing". Finally, the Netherlands Antilles and Montserrat are territories, rather than states, which implies sovereignty.

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Yet UN (1994, 2005) describe how all SIDS display some level of similarity in terms of sustainable development, even though SIDS' physical and human geographies vary immensely. They have also formed a relatively cohesive group for addressing environmental issues, including climate change, in international fora.

Climate Change

Climate change has different meanings in different contexts. The Intergovernmental Panel on Climate Change (IPCC), defines climate change to be "any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC, 2007: 871). In contrast, the United Nations Framework Convention on Climate Change (UN, 1992: Article 1, Paragraph 2), defines climate change to be "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Therefore, scientific studies consider all climate trends irrespective of their origin whereas UNFCCC policy measures, most notably the *Kyoto Protocol* addressing greenhouse gas reduction, factor in only human-induced climate change. Since UNFCCC's definition is encompassed by IPCC's definition, this paper adopts IPCC's broader approach.

Significant challenges, however, exist in decoupling long-term climate trends from ongoing climate variability and climate cycles (e.g. Glantz, 2003a). Climate variability and cycles can occur annually, producing seasons, as well as decadal, producing phenomena such as the El Niño-Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), and the Pacific Decadal Oscillation (PDO). Climate also cycles on the order of centuries and millennia. The latter cycles are linked to connections amongst for example, ice ages and the Earth's position in space relative to the sun, the most prominent changes of which are referred to as Milankovitch Cycles. Human-caused climate change will affect many of these climate cycles, climate variations, climate trends, and climate extremes. Climatic variability and trends are also influenced by other phenomena such as meteorite strikes and volcanic eruptions.

SIDS and Climate Change

Even though SIDS are recognized as some of the most vulnerable places to climate change (e.g. IPCC, 2007; Kelman, 2006; Lewis, 1990 and 1999; Pelling and Uitto, 2001; UN, 1994 and 2005), they face many other ongoing concerns. Examples are rapid rural-to-urban migration, the potential loss of languages and cultures through emigration, gender inequities, pollution, and illegal resource extraction. Meanwhile, inherent SIDS characteristics of isolation, relatively small populations, and limited domestic land-based resources bring about their own environmental and social challenges.

Yet some characteristics of SIDS and SIDS populations also yield advantages and opportunities for addressing the challenges faced, including climate change. SIDS advantages include tight kinship networks, unique heritage, a strong sense of identity and community, creativity for sustainable livelihoods, remittances from islander diasporas supporting life on SIDS, and local knowledge and experience of dealing with environmental and social changes throughout history (Kelman, 2007).

This paper reviews published work and projects on climate change and SIDS, covering impacts, vulnerability, and adaptation. Although only climate change is considered, the wider context of climate variability, both natural and human-caused and including extreme events, cannot be entirely separated from climate change. As a critical review, this paper does not seek to be comprehensive or even to list the majority of all work on SIDS and climate change. That, in fact, would exceed the permissible length of this paper several times over. Instead, key ideas are extracted and key material is discussed to evaluate the current state of knowledge on SIDS and climate change. Deficiencies in the work on climate change in SIDS are discussed and recommendations are provided for filling those gaps. Illustrative examples and references are used to support points.

Despite the difficulties with defining both SIDS and climate change, SIDS' experiences with climate change are helping to frame discussions beyond SIDS. SIDS are seen as one of the globe's barometers of climate change, so plenty of attention is being focused on them, with the highest profile example being sea-level rise potentially making several countries, such as Tuvalu and the Maldives, uninhabitable. As such, a critical review of SIDS and climate change work can help to establish a base for continuing research, policy, and practice on dealing with SIDS, with climate change, with wider climate change issues, and with SIDS-related development other than climate change.

Impacts overview

For SIDS, sea level rise is arguably the most certain and potentially devastating climate change impact. According to IPCC (2007), during the 21st century, sea level will rise at least 0.18 m and perhaps as much as 0.59 m. IPCC (2007), though, explicitly does not provide an upper bound to the maximum possible sea level rise, stating that the final maximum rise by 2100 might exceed these projections, partly because of inputs from ice sheet break up in Greenland and Antarctica. In the small likelihood that the West Antarctic Ice Sheet collapses raising global mean sea level by approximately five meters (Vaughan and Spooage, 2002), the coastal zones of all SIDS would be entirely flooded, covering many entire SIDS and a significant proportion of most SIDS' capital cities and ports.

Even without that extreme scenario, under average IPCC (2007) scenarios, several SIDS are expected to lose significant proportions of their land due to sea level rise, including Tuvalu, Tonga, Kiribati, Marshall Islands, Tokelau, and the Maldives. Even larger SIDS with much land area well above potential sea level rise—such as Fiji, Puerto Rico, and Samoa—could have problems since most settlements and infrastructure are in the coastal zone while the hilly, inland regions would experience severe ecological changes in settling all the migrants.

Care must be taken before assuming island destruction due to sea-level rise, because the expected physical changes to low-lying islands under sea-level rise scenarios have not been well-studied. Significant geomorphological changes are likely, but complete inundation and loss of all land is not inevitable (e.g. Harvey and Mitchell, 2003; Kench and Cowell, 2002). Yet that does not necessarily imply that these islands will remain inhabitable over the long term.

An example of a significant geomorphological change occurred on Tuvalu, then the Ellice Islands, during Cyclone Bebe on 21 October 1972. The storm surge which inundated Funafuti Atoll created a coral rubble wall 18-19 km long and 30-40 m wide with a mean height of 3.5 m—larger than some of the atoll's islets (Baines and McLean, 1976; Maragos et al., 1973). Continual, similar events might increase island area but reduce island habitability.

Chemical, rather than geomorphological changes, could also reduce low-lying islands' inhabitability. Oceanic absorption of atmospheric carbon dioxide is leading to ocean acidification (Caldeira and Wickett, 2003; Royal Society, 2005) which is likely to harm coral reefs and to have detrimental effects on coral islands, including shingle beaches. These impacts are not well studied. Another significant ecological impact across all SIDS is likely to be invasive alien species (e.g. Wilkie, 2002).

Air temperatures are projected to increase between 1°C and 4°C by 2100 relative to 1961-1990 for all SIDS regions (Mimura et al., 2007). Sea surface temperature data are more limited, but also appear to be rising (IPCC, 2007). Warming oceans have depleted zooplankton and have resulted in considerable coral bleaching in some SIDS regions (UNFCCC, 2005, 2007). Coral bleaching occurs if coral cannot adapt fast enough to increasing sea surface temperatures. These events have the capacity to eliminate more than 90% of the corals on a reef, destroying the ecosystem, leaving islands exposed to ocean waves and storms, and eliminating many SIDS livelihoods.

As SIDS are generally situated in warmer climates they will be less likely to experience cold-related impacts. For example, changes to glaciers, frozen precipitation, first snowfall day, timing of the spring ice breakup, and days below freezing are important climate change impacts elsewhere, but few SIDS locations experience these phenomena. Similarly, although global increases in adverse heat-related health effects might be balanced by decreases in adverse cold-related health effects, most SIDS experience limited cold-related effects. Expected health impacts include increasing insect-borne diseases and ecosystem health suffering from invasive alien species, thereby affecting local food supplies and ecosystem-based livelihoods.

Precipitation changes over SIDS regions are subject to large relative uncertainties and even the direction of the change is not certain. For instance, across the whole of the Caribbean the projected change in precipitation by 2100 relative to 1961-1990 could range from -49.3% to +28.9% (Mimura et al., 2007). Downscaling such projections to a country level would not yield much confidence in the results.

Increases to, decreases to or changes in the nature of freshwater will affect SIDS too. These may occur through precipitation changes and sea water intrusion into freshwater lenses and aquifers. Examples of potentially affected SIDS are Aruba, Barbados, Kiribati, the Maldives, and Tokelau. Over the long-term, some SIDS receive up to 25% of their annual freshwater supply during tropical cyclones. If the cyclone regimes change to decrease the precipitation, then SIDS such as Puerto Rico and Jamaica might also experience freshwater shortages.

Projections regarding tropical cyclones are subject to intense debate across all SIDS regions, including the cyclones' frequencies, tracks (including durations), and

intensities. Increased sea surface temperatures appear to be leading to more intense storms once the storms form, but storm formation might be less likely due to wind changes at the tropopause. As well, changing storm tracks could lead to SIDS closer to the equator—such as Tokelau, Tuvalu, Aruba, Barbados, and Trinidad and Tobago—experiencing more storms. Because these SIDS have limited cyclone experience, the consequent events are liable to have a much greater impact than on more experienced SIDS until the newly-hit islands can adjust.

Vulnerability and Adaptation Overview

Vulnerability and adaptation information for SIDS is relatively extensive, often provided in the form of databases, data lists, and annual sector reports. The main caution with many of these sources is that data are not always disaggregated by country. SIDS are small compared to other countries, so reported trends and analyses might not reflect SIDS' experience.

Country profiles relevant to vulnerability and adaptation include SIDS and always incorporate climate change related material, with examples being the United Nations International Strategy for Disaster Reduction's (UNISDR) disaster-related profiles (see Cuba at <http://www.unisdr.org/eng/country-inform/cuba-hazard.htm>), Health Profiles for the Caribbean SIDS from the Pan-American Health Organization (<http://www.paho.org/english/country.htm>), and the Environmental Vulnerability Index (<http://www.vulnerabilityindex.net>).

Several SIDS-related centres dealing with climate change vulnerability and adaptation exist. The Caribbean Community Climate Change Center (CCCCC) was established in 2004 in Belize. The Caribbean Disaster Emergency Response Agency (CDERA) based in Barbados explicitly incorporates climate change adaptation as part of their Comprehensive Disaster Risk Management programme. For Pacific SIDS, the Pacific Regional Environment Programme (SPREP) is the focal point for climate change, focusing on strengthening meteorological services; understanding climate change, variability and sea level rise; understanding vulnerability, adaptation and mitigation; and supporting policy development on climate change. The Pacific Islands Applied Geoscience Commission (SOPAC) is also contributing to climate change knowledge, such as producing maps for sea level rise for several Pacific SIDS. The East-West Center in Honolulu Hawai'i (e.g. Shea, 2001, 2003) and the International Global Change Institute (IGCI) in Hamilton, New Zealand (e.g. Feresi et al., 2000; Kouwenhoven and Cheatham, 2006) have long been involved in all aspects of Pacific SIDS and climate change.

Climate change vulnerability and adaptation in the Caribbean and Pacific SIDS is not confined to regional organisations. Some examples are provided in Table 1.

Table 1: Examples of climate change vulnerability and adaptation work in Caribbean and Pacific SIDS.

Initiative Type	Caribbean SIDS Example	Pacific SIDS Example
National	St. Lucia has a <i>National Climate Change Policy and Adaptation Plan</i> (Government of Saint Lucia, 2003).	Fiji Ministry of Tourism (2006) reports on a workshop about how the country's tourism industry might adapt to climate change.
Consortium	The Caribbean Adaptation to Climate Change and Sea Level Rise project runs from 2003-2013 and involves more than two dozen partners	Koshy (2003) describes some approaches to assessing climate change vulnerability and adaptation for Pacific island coastal areas.
Scientific Study	Lewsey et al. (2004) examines impacts of climate change, urban development, and land use in Eastern Caribbean coastal zones, with recommendations on improving planning choices.	Gilman et al. (2006) details how mangroves on Pacific islands might be affected by climate change, especially sea-level rise.
Private Sector	UNDP (2003) details a SIDS insurance workshop, covering climate and weather and including insurance industry representatives.	The feasibility for a Pacific island catastrophe insurance pool has been investigated by a risk modelling company.
Non-profit Sector	The Island Resources Foundation has been involved in producing several Environmental Outlook and Environmental Profile reports for Caribbean SIDS.	The Environmental Education & Awareness Program, Conservation Society of Pohnpei, Federated States of Micronesia, has produced outreach material for climate change.

Regarding non-Caribbean, non-Pacific SIDS, regional organisations dealing with climate change do not exist, although many of these SIDS have national initiatives and other in-country and multilateral work. The most prominent material relates to Seychelles coral bleaching (e.g. Walther et al., 2002), tourism vulnerability and adaptation in Seychelles and Comoros (Maddison, 2001; Payet, 2003), and the Maldives' sea-level rise vulnerability and adaptation (e.g. Ghina, 2003; Hamilton, 2008). As well, Mauritius and Seychelles were the first and second countries respectively to ratify UNFCCC. In Bahrain, Alnaser and Merzaa (2003) described some climate change characteristics and a national climate change report is underway. Wasson (2001) is one of a handful of publications on climate change in Timor-Leste.

Many development projects link to or incorporate aspects of climate change vulnerability and adaptation, even if that is not the main focus. For example, Mauritius and Guinea-Bissau have received African Development Bank loans for projects on agricultural and economic development. The Asian Development Bank has funded an energy and water project in the Maldives, but climate change is not mentioned (ADB, 2007, although see also ADB, 2003a and 2003b).

One common adaptation document across many SIDS is a National Adaptation Programme of Action (NAPA). NAPAs provide a UNFCCC-endorsed process for least developed countries (LDCs) to identify priorities for addressing the most urgent needs for climate change adaptation by using existing information, to present suggestions in an easily-understood format and language. Table 2 shows the SIDS for which NAPAs had been produced as of December 2008.

Table 2: SIDS with NAPAs as of December 2008

(http://unfccc.int/national_reports/napa/items/2719.php)

SIDS	Date of NAPA submission
Cape Verde	December 2007
Comoros	November 2006
Guinea-Bissau	February 2008
Haïti	December 2006
Kiribati	January 2007
Maldives	March 2008
Samoa	December 2005
Sao Tome and Principe	November 2007
Tuvalu	May 2007
Vanuatu	December 2007

Critique of Impacts, Vulnerability, and Adaptation Work

The material available for climate change and SIDS has a significant component of top-down data collection and technocratic application, such as using remote sensing to monitor physical climate parameters, detailed mapping of topography and bathymetry, and running computer models with the data. Extensive effort is also placed into making significant amounts of data available online. Examples of free, online, robust data which are relevant to SIDS and climate change are the *International Water Management Institute World Water and Climate Atlas* (<http://www.iwmi.cgiar.org/WAtlas>) and marine species through *IOBIS -- Ocean Biogeographic Information* (<http://www.iobis.org>). The *Millennium Ecosystem Assessment* and striving to achieve the *Millennium Development Goals* also produce data pertinent to climate change.

Relevance, though, does not necessarily mean complete applicability. A challenge with such data sets is often the resolution in that the small size of many SIDS means that the data resolution is too coarse to meet their needs. Some data from the *Digitized River Networks*, as part of the *Indicators for World Water Assessment Programme* (<http://wwdrii.sr.unh.edu>), are at ½-degree resolution, far bigger than many SIDS. The one-tenth degree resolution data from that database are more helpful, but that distance is still larger than many SIDS islands.

Additionally, where data is aggregated by region, it can cover many SIDS, or the SIDS characteristics are buried by the characteristics of non-SIDS areas. Another common concern is that SIDS data are sometimes of less quality than other locations because data collection and storage infrastructure is often less adequate. Finally, differences across islands of a SIDS can be vast, such as amongst different islands of

Tonga and of St. Vincent and the Grenadines, but data might be focused on the capital city, main island, or the entire SIDS. Top-down information is frequently not downscalable to a useful accuracy or precision for the highly localised context of SIDS.

Similarly, the IPCC (2007) process is based on published, peer-reviewed literature, although references to other material do appear. Yet no formal method is included in the IPCC process to track other kinds of literature and knowledge, including reports, indigenous knowledge, or local understanding, which forms a large part of SIDS and climate change vulnerability and adaptation work. In contrast, Minority Rights Group International (2008) and IUCN (2008) highlight that although climate change is disproportionately affecting indigenous groups around the world, which includes those on SIDS, their capacities and demonstrated abilities for dealing with past environmental changes are resources that should be respected and used on the people's own terms.

There is doubt that that top-down data collection, technocratic application, and making those data available are essential tasks for addressing climate change. These endeavours should be neither criticised nor curtailed. A legitimate critique is that these initiatives should be better balanced with (i) bottom-up consultation to obtain local knowledge and (ii) the needs of SIDS residents in terms of the information that they would like to have in order to make decisions for themselves. The various knowledge bases should then be better integrated to ensure that top-down and bottom-up research, analysis, and application are balanced evenly that the communities who need to deal with climate change are involved from an early stage.

Nakalevu (2006) provides a method for involving local communities in Pacific SIDS in analysing their own situations and in making decisions regarding climate change, using both their own knowledge and top-down approaches and data. Mercer et al. (2007, 2008) describe this approach for disaster risk reduction including climate-related events in PNG. Haynes et al. (2007) detail how to make maps accessible to local populations for Montserrat. Participatory three-dimensional mapping for planning in the context of environmental change is another technique (Maceda et al., 2009) that could be applied more extensively to SIDS.

Initiatives are expanding to document and apply local knowledge relevant to climate change. UNESCO started *On the Frontlines of Climate Change*, a forum highlighting indigenous peoples and SIDS, for sharing observations, actions, and ideas regarding climate change. WWF, the World Wide Fund For Nature, runs a *Climate Witness* programme which scientifically reviews submissions of texts, photos, or videos describing individual observations of climate change, many from SIDS. As an example of single-country work, Lazrus (2005) outlines knowledge on Tuvalu relevant to climate change.

Another element is examining past climate-related changes on SIDS to see how that experience could assist the present. Nunn (2000), Nunn and Britton (2001), and Nunn et al. (2007) describe sea-level fall and regional changes in the Pacific climate approximately seven hundred years ago which altered the environment of Pacific islands and the culture of Pacific island communities. Lessons from this work related to islander migration as a response to contemporary changes, climate and others,

assist in understanding the options and challenges that SIDS face (Kelman, 2006). Conversely, IPCC (2007) amongst other studies of contemporary climate change tend to neglect the possible social lessons that could be learned from the past.

Community-based approaches and local knowledge should not be seen as a panacea or necessarily the dominating influence. They should be an important and essential component, but care is needed to avoid forcing participatory processes (Cooke and Kothari, 2001), to acknowledge lack of cohesiveness within most communities (Brint, 2001; Cannon, 2007), and to recognise when local knowledge is not accurate (Tibby et al., 2007).

In these techniques, the key is not to lose the remote sensing, computer models, and extensive data, but to better match them with local needs, local knowledge and social realities. For example, early warning systems may be regarded as “technical fixes” when they are not connected to local realities and needs even though warning system science and practice demonstrate the need and effectiveness of warning systems as social processes embedded in day-to-day life (e.g. Glantz, 2003b; Glantz, 2004; Lewis, 1999; Wisner et al., 2004). On the other hand, even amongst some SIDS communities, the value of their own knowledge is not often accepted or is actively devalued due to the perception of the superiority of Western science and technology. Local strategies for dealing with climate change are sometimes dismissed as ineffective due to a lack of relevant knowledge from which to work, even when they are actually hampered by a lack of supportive institutions and financial resources to implement adaptation activities. Although recent social and environmental changes have rendered some local and traditional knowledge less applicable to contemporary contexts, such knowledge not only provides a valuable baseline from which to start exploring changes and how to deal with those changes, but also serves as a needed entry point to communities on the communities’ own terms.

Rather than contrasting local and non-local knowledge or observations, ensuring that all knowledge bases and perspectives are working together, as much as feasible, would best address climate-related challenges (Lewis, 1999; Mercer, et al. 2007, 2008; Wisner, 1995; Wisner et al., 2004).

Conclusions: Balancing Contexts

Using different knowledge bases also means balancing contexts. As described at the beginning of this paper, climate change is only one change-related challenge and opportunity affecting SIDS. Any information on climate change and attempts to address vulnerability and adaptation to climate change need to be considered within the context of multiple stressors. That includes not attributing to climate change concerns that are due to other factors.

International perspectives for policy and action relevance need to be considered too. In addition to the SIDS strategies for sustainable development (UN, 1994, 2005), *The Johannesburg Plan of Implementation from the World Summit on Sustainable Development* held in 2002 in South Africa highlights SIDS and climate change as does the *Hyogo Framework for Action* agreed at the World Conference on Disaster Reduction in January 2005 in Japan.

Furthermore, balancing contexts means filling in gaps amongst SIDS. Pacific and Caribbean SIDS dominate climate change work, indicating a need for more detailed studies for African SIDS, Indian Ocean SIDS, Bahrain, and Timor-Leste, especially with regards to collecting local climate and environmental data by using all forms of knowledge. The similar characteristics amongst many SIDS can lead to fruitful exchange, avoiding duplication of efforts and ensuring that mistakes identified in one location are not repeated elsewhere—while not neglecting the different contexts in different SIDS and in different parts of a single SIDS. As such, the SIDS group is advantageous in bringing together people from around the world who otherwise might not have opportunities to interact.

Despite the sense of urgency in many SIDS for addressing climate change, islanders are aware that inappropriate actions can cause more harm than good, so the right choices must be made. The critical review in this paper of climate change and SIDS work will hopefully assist in focusing efforts to improve and properly apply knowledge. That will support policy processes at all governmental levels, thereby providing decision-makers—from individuals to governments and international organisations—with the knowledge and techniques needed to strengthen SIDS communities in dealing with climate change within the context of the many other challenges that they face.

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Appendix 1: SIDS List

From the official United Nations list: <http://www.un.org/esa/sustdev/sids/sidslist.htm>

American Samoa 1/ 4/
Anguilla 1/ 2/ 4/
Antigua and Barbuda
Aruba 1/ 2/ 4/
Bahrain 2/
Barbados
Belize
British Virgin Islands 1/ 2/ 4/
Cape Verde
Commonwealth of the Northern Marianas 1/ 2/
Comoros
Cook Islands 1/ 3/
Cuba
Dominica
Dominican Republic 2/
Federated State of Micronesia
Fiji

French Polynesia 1/ 2/ 4/
Grenada
Guam 1/ 4/
Guinea-Bissau
Guyana
Haiti
Jamaica
Kiribati
Maldives
Marshall Islands
Mauritius
Montserrat1/ 2/ 4/
Nauru
Netherlands Antilles 1/ 4/
New Caledonia 1/ 2/ 4/
Niue 1/ 3/
Palau
Papua New Guinea
Puerto Rico 1/ 4/
Saint Kitts and Nevis
Saint Lucia
Saint Vincent and the Grenadines
Samoa
Sao Tome and Principe
Seychelles
Singapore
Solomon Islands
Suriname
The Bahamas
Timor-Leste
Tonga
Trinidad & Tobago
Tuvalu
U.S. Virgin Islands 1/ 4/
Vanuatu

1/ Associate Member of a UN Regional Commission

2/ Not a Member or Observer of the Alliance of Small Island States (AOSIS)

3/ States non-Members of the United Nations

4/ Territories non-Members of the United Nations