WORLD ENVIRONMENT DAY
JUNE 2014

on the theme of

"Effects of Climate Change on Small Island Developing States (SIDS) and its Mitigation"

Celebrated by

PAKISTAN ENGINEERING CONGRESS

PAKISTAN ENGINEERING CONGRESS

(4th Floor) Pakistan Engineering Congress Building,
97-A/D-1, Liberty Market Gulberg-III, Lahore 54660
(Near Liberty Roundabout)
Phone: (042) 35784238, (042) 35784235 Fax: (042) 35784236
Web-site: www.pecongress.org.pk
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Engr. Iftikhar-ul-Haq

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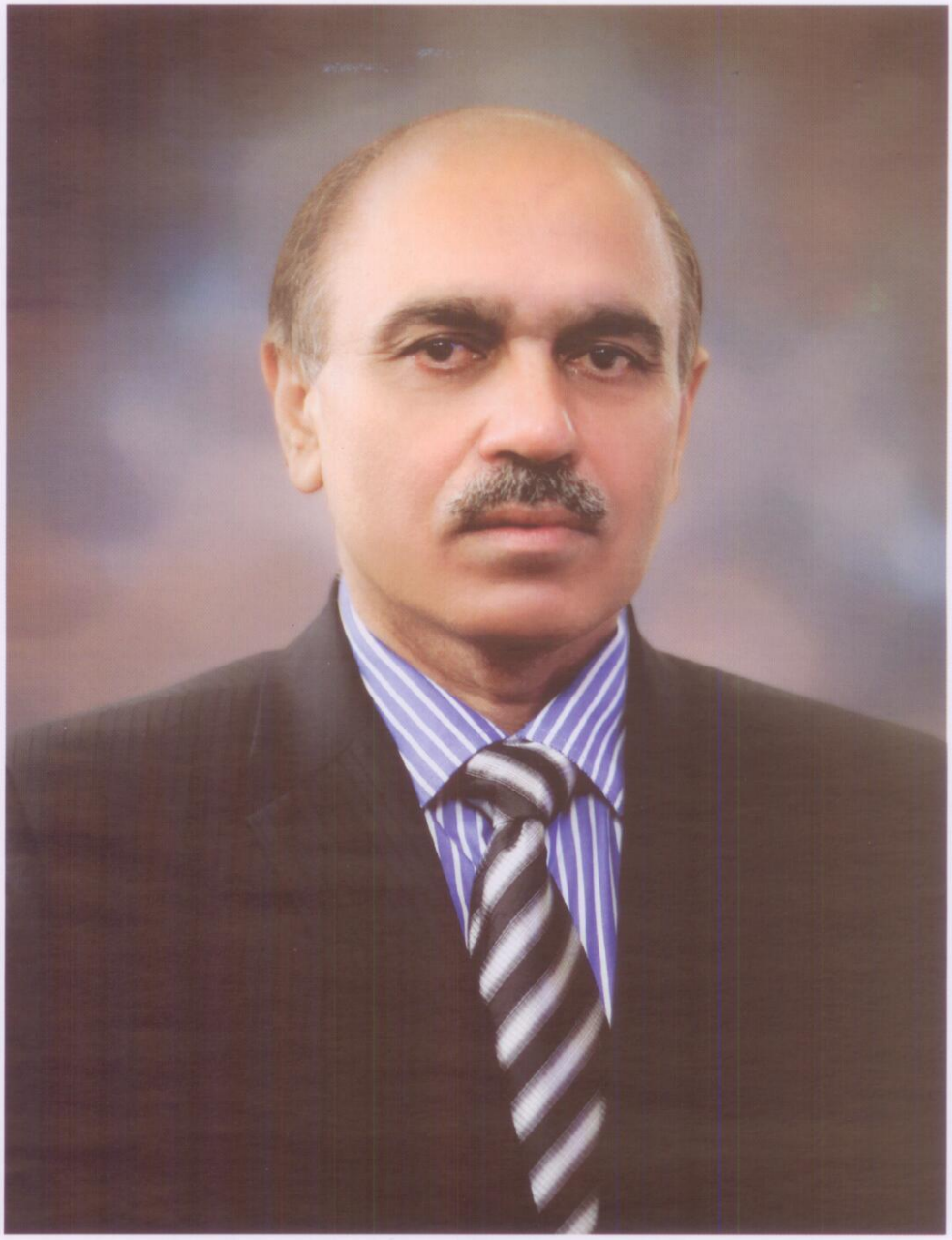
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ADDRESS OF WELCOME

By

Engr. Iftikhar Ahmad

President

PAKISTAN ENGINEERING CONGRESS

on

WORLD ENVIRONMENT DAY

(Thursday, 5th June, 2014)

at

Pakistan Engineering Congress

The Honourable Mr. Shuja Khanzada
Minister for Environment, Govt. of Punjab
Distinguished Delegates
Members of Pakistan Engineering Congress
Ladies and Gentlemen

اَلسَّلَامُ عَلَيْكُمْ وَرَحْمَةُ اللّٰهِ وَبَرَكَاتُه

I take this opportunity on behalf of Pakistan Engineering Congress in general and on my own in particular to welcome you all to this gathering for observing World Environment Day on the theme of:

"Effects of Climate Change on Small Island Developing States (SIDS) and its Mitigation"

Ladies & Gentlemen!

Small Island Developing States which are commonly called SIDS are the most affected places by the environmental and natural disasters. The total number of SIDS is 52 out of which 38 are on the approved list of United Nations. Some of the prominent small islands are Cuba, Singapore, Mauritius, Maldives, Bahrain, Bahamas etc. Singapore has been transformed in a highly economically and commercially developed country. Mauritius and Maldives are tourist attraction for its beautiful location. However, they can be easily hurt by the rising sea levels and global warming. The United Nations has been making continued efforts to help the small islands in their financial, social, food security problems.

Ladies & Gentlemen!

The UN General Assembly declared 2014 as the international year of Small Island Developing States with the objective of ***raising awareness*** of their special development challenges, achievements in solving environmental problems, climate change, waste management, excessive consumption, degradation of natural resources, natural disasters etc.

Ladies & Gentlemen!

It is our responsibility that we should join hands with other countries of the world for a greater understanding to help protect these Small Islands from the ever increasing risks

of effects of climate change and the resulting rise in sea levels. An overwhelming number of countries have come to the conclusion that the average world temperature should not be more than 2-degrees Celsius (3.6 degree Fahrenheit) to safeguard from the killing effects of global warming. However, the increase in temperature far exceeds this limit. This is resulting in fast melting of glaciers and snows, expansion of sea water, floods and increased number of storms. Hence, the very lives of the people living in these small islands / coastal areas are exposed to greater risks. This is necessary because approximately 50-million of the world's population live in the SIDS and they are faced with the problem of growing population with limited resources at their disposal. Problem of shortage of fresh water, remote location, adverse effects on their fisheries, decreasing mangrove forests. With the sea level rising by 3 to 4 mm per year there is a danger of alarming adverse effects on their fruit, Agriculture and Tourism industry and above all their very survival. The rise in global warming is due to excessive emissions of Greenhouse Gases (GHG's) due to burning of fossll fuels by the advanced countries of the world (America, China, Russia, Japan etc.). However, the amusing / strange happening is that the bad effects of Glboal Warming are being borne by countries like Pakistan (with 0.2%) and Small Islands (0.5%) of world emissions.

With this prologue, I would like to conclude my address of welcome by once again thanking you all, for granting me a patient hearing.

Pakistan Paindabad

ADDRESS BY THE CHIEF GUEST

The Honourable Mr. Shuja Khanzada
Minister for Environment, Govt. of Punjab
on
WORLD ENVIRONMENT DAY
(Thursday, 5th June, 2014)
at
Pakistan Engineering Congress, Lahore

Engr. Iftikhar Ahmad
President Pakistan Engineering Congress
Distinguished Delegates
Members of Pakistan Engineering Congress

Ladies & Gentlemen!
I feel extremely privileged for presiding over the august gathering of engineers, environmentalists, water resources experts, meteorologists. Pakistan Engineering Congress deserves high appreciation for assembling such a galaxy of experts to apprise us about the phenomenon of Green House Gas Emissions, Global Warming, Rising Sea Levels and the Consequent adverse effects on various countries especially the Small Island Countries commonly called SIDs. The theme is very relevant as almost 50-Million people inhabit in these Small Islands.

Ladies & Gentlemen!
The nature has bestowed on mankind the free gifts of ECO-System and Bio-diversity on which balanced economic development and wellbeing of human race depends. However, due to ever increasing population, over exploitation of resources, over consumption, commercialization, human avarice and over dependence and over playing of the value of higher and higher Gross Domestic Product (GDP) instead of welfare and wellbeing of common man the balance of ECO-System has been badly impaired resulting in horrific damages.

Ladies & Gentlemen!
The rich nations and the fast developing countries using huge quantities of fuel, coal and gas are responsible for the excessive emissions of Greenhouse Gases; Carbon Dioxide (CO_2), Methane (CH_4) etc. These gases trap heat in the atmosphere and raise the temperature of the earth. It is this ever increasing rise in temperature that is catalyst of accelerated melting of glaciers, floods, droughts, hurricanes, rising sea levels. Here I quote the following extract from a United Nations Report;

"The rate of decline in emissions was too slow to limit average World Temperature rises to 2 degree Celsius (3.6 degree Fahrenheit) above pre-industrial times, a ceiling set by almost 200 Nations to avert droughts, heat waves and rising seas".

The irony is that for no mistake on their part, Nations like Pakistan which is amongst 12 countries most at risk (on the list of most vulnerable countries) contribute only 3% per capita GHG's which comes to 0.2% of world average. Similarly all the 52 SIDs (38 on UN list and 14 protectorates of other countries) contribute 2% GHG's per capita which comes to only 0.5% of world emissions. These SIDs which are remotely located, with limited resources, limited export potential are the worst sufferers of global warming. Not only their economies but their very survival is at stake. No doubt some of these (Cuba, Singapore, Bahrain, Maldives, Mauritius) have shown remarkable economic achievements nevertheless their fragile economies cannot bear the onslaught of 3 to 4 millimeter a year rising sea levels and the consequent inherent devastation. The coastal zones will also surely be affected.

- Tens of millions of people in low-lying coastal areas of south and Southeast Asia affected by sea level rise and an increase in the intensity of tropical cyclones.
- Coastal inundation is likely to seriously affect the aquaculture, industry and infrastructure particularly in heavily-populated mega deltas.
- Stability of wetlands, mangroves, and coral reefs increasingly threatened.

The United Nations has been making efforts to economically help these small island countries and bolster their economies and has rightly chosen SIDs for the environmental discussion in 2014 to focus the global attention to their problems, short-term / long-term steps for mitigation of adverse effects of global warming, rising sea levels, tsunami's etc. as well as to generate financial resources for implementation of these resources.

Ladies & Gentlemen!

In the end, I congratulate Pakistan Engineering Congress for organizing the seminar on such an important subject. I hope the recommendations of the seminar would provide us with least carbon emission economy.

Pakistan Paindabad

MITIGATION OF ADVERSE IMPACTS OF CLIMATE CHANGE IN SMALL ISLANDS DEVELOPING STATES

By

Dr. Muhammad Afzal Chaudhry[1]

ABSTRACT

There are around 20,000 small islands in various seas and oceans of the earth but 52 of them are of the size that Small Island Developing States (SIDS) could be established there. Of these 38 are members of the United Nations while 14 are not. In the Earth Conference 1992 at Rio De Janeiro, at the initiative of the United Nations (UN), it was realized that due to consistent and ever increasing emission of Green House Gas (GHGs) the earth warming process had accelerated over past 150 year, ever since the advent of Industrial revolution in Europe followed by ramp industrial development in U.S.A and China. The earth warming has caused climate change which in turn has resulted in a number of adverse impacts on global level such as melting of polar ice caps, rise in sea level, threat to biodiversity, loss of marine resources, triggering natural disasters, damage to renewable energy resources like forests, damage to transport and communication, loss in trade and finances, adverse impacts on waste management, loss of fresh water resources, loss of land resources, loss of tourism and loss of food resources and damage to agriculture. The SIDS being of small in size, low in height above mean sea level and completely surrounded by sea or ocean waters have proved to be more vulnerable to the adverse impacts of the climate change. Ironically the SIDS are worst hit by adverse impacts of the climate change without causing any global scale contribution in GHG emission and thus the global warming. The climate change is threatening the economy of SIDS by causing major upsets in sustainable development and endurance balance of SIDS. The U.N. has been making efforts to muster help from industrialized GHG emitting member countries starting with 1992 Climate Change Conference followed by Kyoto Conference, Barbados action programme, Bonn Conference and Copenhagen Conference. Not much success has been seen so far. The best course for SIDS so far suggested is that they should readjust with the changes which have been caused in the climate. Keeping in view that trend, this paper suggests mitigation measures for most obvious adverse impacts on SIDS.

Keywords: SIDS, Kyoto Protocols, GHGs, Global Warming, Adverse Impacts, Mitigation.

1. Introduction

1.1. Small Island Developing States (SIDS) are the states located on small coastal and non-coastal Islands or groups of Islands. Although there are some 20,000 small Islands located in various seas and oceans of the world, only 52 of them are recognized as SIDS and have been facilitated to form an alliance for sustainable development. (See Table 1 and Figure 1 for list of SIDS).

[1] Chief Engineer Environment, Neelum Jhelum Hydropower Project, Muzaffarabad (AJK)

Of these 38 SIDS are members of the United Nations (UN) while 14, being protectorates of some developed countries, are not considered as independent members of the UN. However all 52 SIDS face specific social, economic and environmental vulnerabilities due to climate change. The SIDS share similar sustainable development challenges including small but multiplying population, limited resources, remoteness, susceptibility to natural disasters, vulnerability to external shocks, excessive dependence on international trade and fragile environments. In addition, high costs of communication, energy and transportation also hold back their economic growth and development. Their economies of scale are further subjected to limitations because of small size of SIDS via-a-via their irregular international traffic volumes, disproportionately expensive public administration and poorly developed infrastructure. The SIDS were identified as a special case by the U.N. at the conference on Environment and Development (UNCED), also called as the Earth Summit, held at Rio De Janeiro (Brazil) on 13-14 June, 1992. This recognition was a targeted action in the light of Agenda 21 (Chapter 17G). It was followed by the Barbados Programme of Action in 1994 aiming at providing assistance to SIDS for their sustainable development.

1.2. This desk study takes into account the location of SIDS, causes and effects global warming, the GHG emissions, the adverse impacts of climate change on SIDS and some suggested mitigation measures for most obvious adverse impacts of the climate change. It has been kept in view that any reversals in the changes are not possible and any suggested mitigation will consist of an advice to readjust with the irreversible upsets caused due to climate change. The UN has been trying ever since 1992 to muster the assistance of the industrialized countries, basically considered as responsible for emitting GHGs and thus the global warming, but a proportionate response has not been received. Therefore the agencies/development partners suggested along with proposed mitigation measures are also illustrative.

Table 1
List of Small Island Developing States

Caribbean	Pacific	Africa, Indian Ocean, Mediterranean and South China Sea (AIMS)
Anguilla (NM)	American Samoa (NM)	Bahrain
Antigua and Barbuda	Cook Islands (NM)	Cape Verde
Aruba (NM)	Federated States of Micronesia	Comoros
Bahamas	Fiji	Guinea-Bissau
Barbados	French Polynesia (NM)	Maldives

Caribbean	Pacific	Africa, Indian Ocean, Mediterranean and South China Sea (AIMS)
Belize	Guam (NM)	Mauritius
British Virgin Islands (NM)	Kiribatihttp://en.wikipedia.org/wiki/Small_Island_Developing_States-cite note-note1-12	São Tomé and Príncipe
Cuba	Marshall Islands	Seychelles
Dominica	Nauru (NM)	Singapore
Dominican Republic	New Caledonia (NM)	
Grenada	Niue (NM)	
Guyana	Northern Mariana Islands (NM)	
Haiti	Palau	
Jamaica	Papua New Guinea	
Montserrat (NM)http://en.wikipedia.org/wiki/Small_Island_Developing_States-cite note-note7-8	Samoa	
Netherl ands Antilles	Solomon Islands	
Puerto Rico (NM)	Timor-Leste	
Saint Kitts and Nevis	Tonga	
Saint Lucia	Tuvalu	
Saint Vincent and the Grenadines	Vanuatu	
Suriname		
Trinidad and Tobago		
United States Virgin Islands (NM)		

UN Members	38
Non- Members (NM)	14

- (Source: U.N. OHRLSS 1994)

1.3. Special body created at UN to spearhead this programme was the Office of High Representatives for the Least Developed Countries, Land Locked Countries and SIDS.

As the list in Table 1 and Figure 1 show the SIDS are located in following regions:-

1) Atlantic Ocean, Caribbean zone
2) Pacific Ocean
3) Indian Ocean, Mediterranean and South China Sea (Aims)

Of these the SIDS in Pacific Ocean are the worst affected by the climate changes taking place due to global warming. A case study in the worst scenario of Pacific SIDS shall also comprehend the factor affecting less sensitive SIDS located in Atlantic Ocean and Indian Oceans and Mediterranean Sea. The list in Table 1 shows the SIDS in three different zones, including Pacific zone. Of Pacific SIDS, the UN member states are Federated States of Micronesia, Fiji, Kiribati, Marshal Islands, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor Leste, Tonga, Tuvalu and Vanuatu. (See Figures 2 & 3 showing maps of location of SIDS in Pacific Ocean). In Pacific Ocean the SIDS can be divided into three groups as per their origin. (See Figure 4, map showing the three groups).

1) **Melanesia:** or black group. This group is of volcanic origin and consists of fertile islands like New Guinea, Solomon Island, Fiji and Newzealand and it is highly populated.

2) **Micronesia:** This group consists of small islands built by coral reefs. These SIDS are comparatively drier and infertile and less populated. Examples are Marshall Islands, Palau Island and Kiribati Island.

3) **Polynesia:** This group consists of groups of very small Islands built on coral reefs. These are comparatively drier with poor and infertile soil and are very thinly populated. Examples are Tuvalu, Samoa and Cook Islands.



Figure 1: SIDS of Atlantic and Caribbean regions.

UN Members

- Antigua and Dominican
- Fiji
- Grenada
- Guinea-Bissau*
- Guyana
- Haiti*
- Jamaica
- Kiribati*
- Maldives
- Marshall Islands
- Federated States of Mauritius
- Nauru
- Palau
- Papua New Guinea
- Samoa*
- São Tomé and Singapore
- St. Kitts and Nevis
- St. Lucia

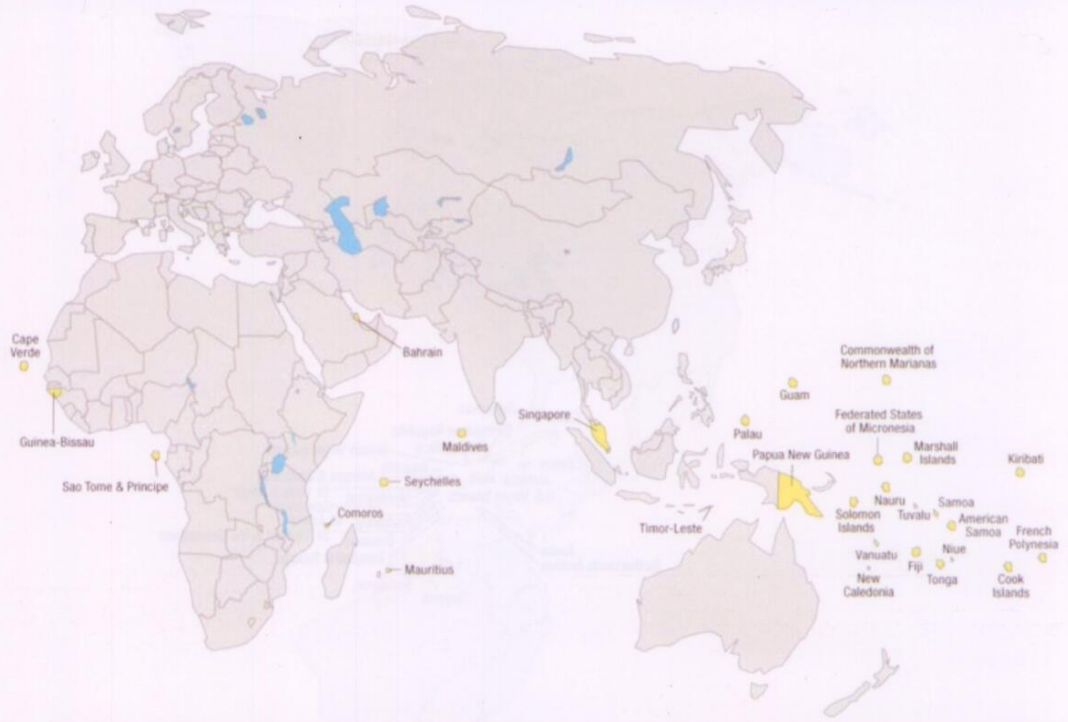


Figure 2: SIDS of Pacific Ocean, Indian Ocean and those of Atlantic Ocean near West African coast.

» St. Vincent and the Grenadines	**Non-UN Members / Associate Members of the Regional Commissions**	» Guam
» Seychelles	» American Samoa	» Montserrat
» Solomon Islands*	» Anguilla	» Netherlands Antilles
» Suriname	» Aruba	» New Caledonia
» Timor-Leste*	» British Virgin Islands	» Niue
» Tonga	» Commonwealth of Northern Marianas	» Puerto Rico
» Trinidad and Tobago	» Cook Islands	» U.S. Virgin Islands
» Tuvalu*	» French Polynesia	
» Vanuatu*		

* Also Least Developed Countries



Figure 3: Location of SIDS in Pacific Ocean.

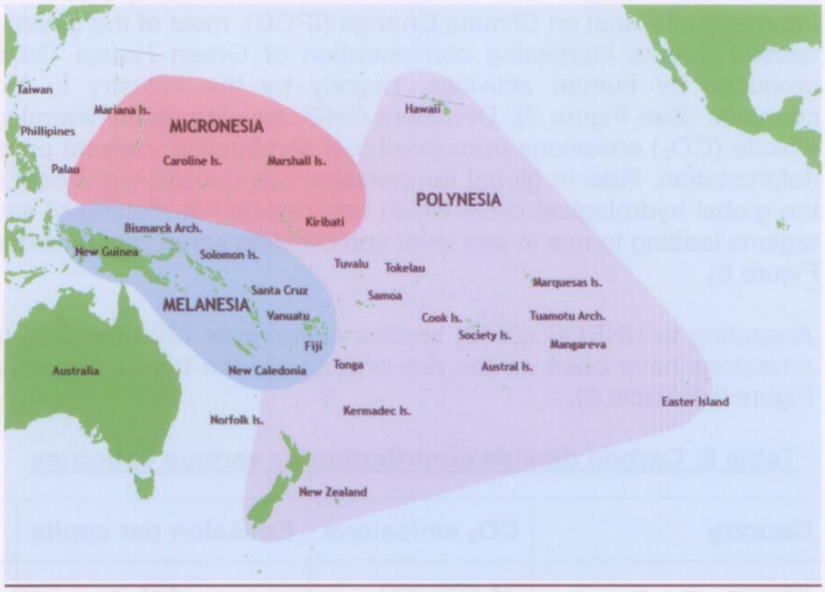


Figure 4: Map showing three groups of Islands in Pacific Ocean, Melanesia, Micronesia and Polynesia.

1.4. The United Nations has been assisting the SIDS under Barbados Programme of Action for Sustainable Development (BAPDA). This programme was further fine tuned and revamped at 5 year review held at twenty second session of General Assembly of UN in 1999 and the 10 years review held in Mauritius (10-14 January, 2005). The later was named as

Manritius Strategy under which Programme of Action for SIDS for their Sustainable Development called MSI. The UN General Assembly then decided to hold a high level reviews on 24th and 25th September, 2010. Yet another focused at SIDS was the Millenium Development Programme (MDP) of the U.N. In their report of 2009 the MDP reported that not much success had been achieved to address the financial, economic, food, security crises prevailing in SIDS. These challenges still prevail in almost all SIDS particularly in the Pacific region. And due to adverse impact of the global climate change the economies of SIDS are moving from bad to worse.

2. Global Warming

2.1. Global Warming means a continuing rise in the average temperature of Earth's Climate System. Studies show that 93% of the warming has occurred in oceans including the ice caps in Polar Regions of the Earth(See Figure 5). In addition, the impact of global warming is also measurable in Earth's surface and its atmosphere(See Figure 6). Over 20th century the global air and sea surface has increased, on an average, by 0.8 °C (1.4 °F). Of that 66% took place after 1980. Since then, every successive decade has been warmer than the previous decade. The trend is still upwards. According to International Panel on Climate Change (IPCC), most of the global warming is caused due to increasing concentration of Green House Gases (GHGs) produced by human activities, majorly by the industry in industrialized countries (See Figure 7). Dominant GHG, causing global warming is carbon dioxide (CO_2) emissions from fossil fuel combustion, cement production and deforestation. Rise in global temperature has caused significant changes in the global hydrological cycle which has resulted in melting of snow in polar regions leading to rise in sea level and creating some climate extremes. (See Figure 8)

According to UNECC (2012) studies experience 1990 the CO_2 (equivalent) emissions have been on the rise and as per the trends are still rising (See Figure 9 & Table 2).

Table 2: Carbon dioxide contribution by various countries

S.No	Country	CO_2 emissions	Emission per capita	%age
1	*World*	34,500,000	4.9	100%
2	China	9,860,000	7.1	26%
3	United States	5,190,000	16.4	17%
4	India	1,970,000	1.6	6%

S.No	Country	CO_2 emissions	Emission per capita	%age
5	Russia	1,770,000	12.4	6%
6	Japan	1,320,000	10.4	4%
	International Transport	1,060,000	-	3%
7	Germany	810,000	9.7	2%
8	South Korea	640,000	13.0	2%
9	Canada	560,000	16.0	2%
10	United Kingdom	490,000	7.7	2%
11	Mexico	490,000	4.0	1%
12	Indonesia	490,000	2.0	1%
13	Saudi Arabia	460,000	16.2	1%
14	Brazil	460,000	2.3	1%
15	Australia	430,000	18.8	1%
16	Iran	410,000	5.3	2%
17	Italy	390,000	6.3	1%
18	France	370,000	5.8	1%
19	South Africa	330,000	6.3	1%
20	Poland	320,000	8.4	1%
21	Pakistan	161,396	3.0	0.2%
22	52 SIDS	258,000	2.0	0.5%

Source: (EDGAR: Body created by European Commission and the Netherland Environmental Agency, 2012).

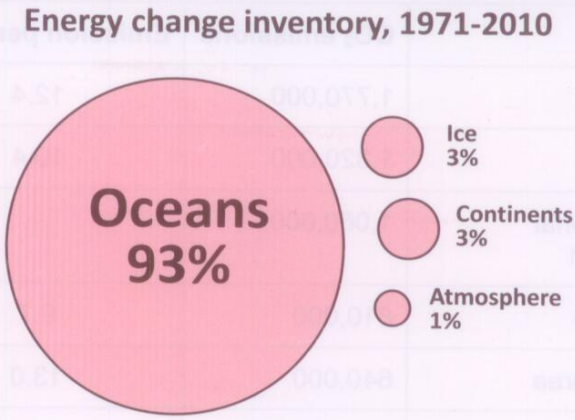


Figure 5: Earth has been in radiative imbalance since at least the 1970s, where less energy leaves the atmosphere than enters it. Most of this extra energy has been absorbed by the oceans. It is very likely that human activities substantially contributed to this increase in ocean heat content.

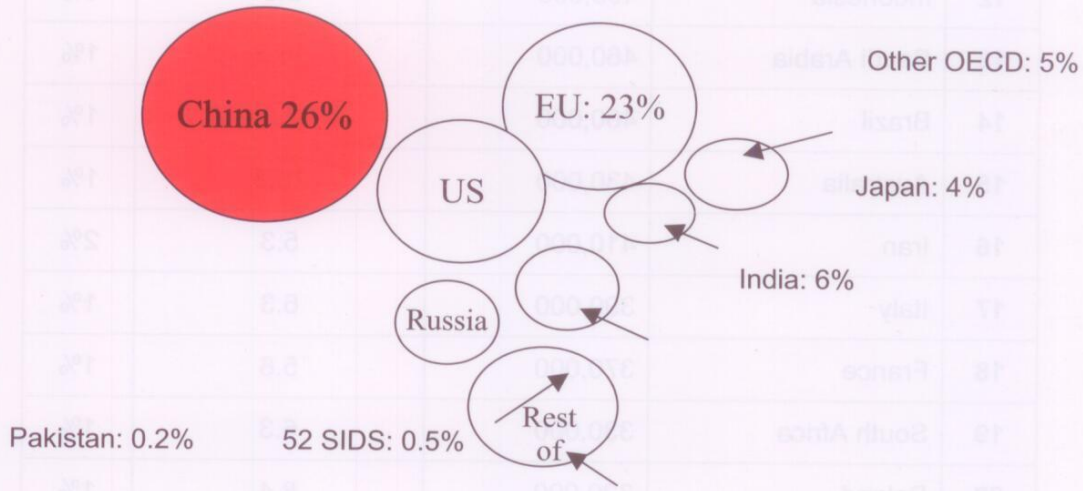


Figure 6: Bubble diagram showing the share of global cumulative energy-related carbon dioxide emissions for major emitters between 1890-2007.

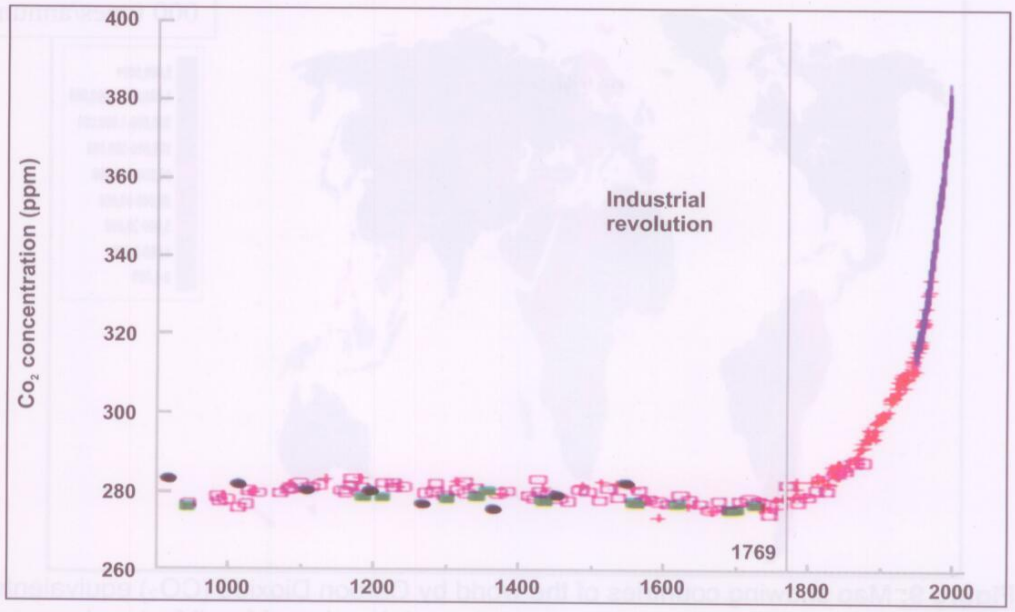


Figure 7: Carbon dioxide emission in nature and its comparison with Industrial area. This comparison also shows a comparison between SIDS and Industrial Countries.

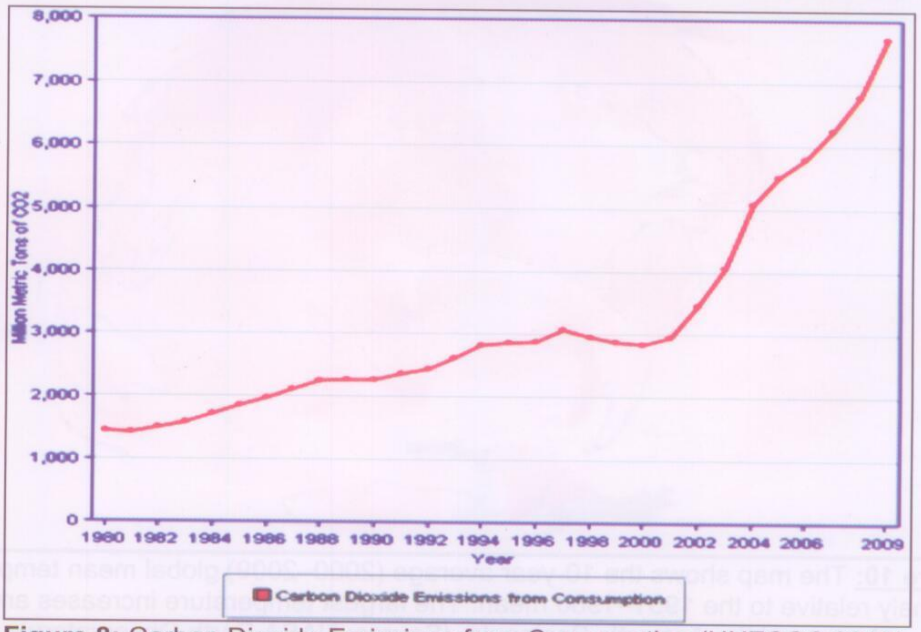


Figure 8: Carbon Dioxide Emissions from Consumption (UNFCCC 2010).

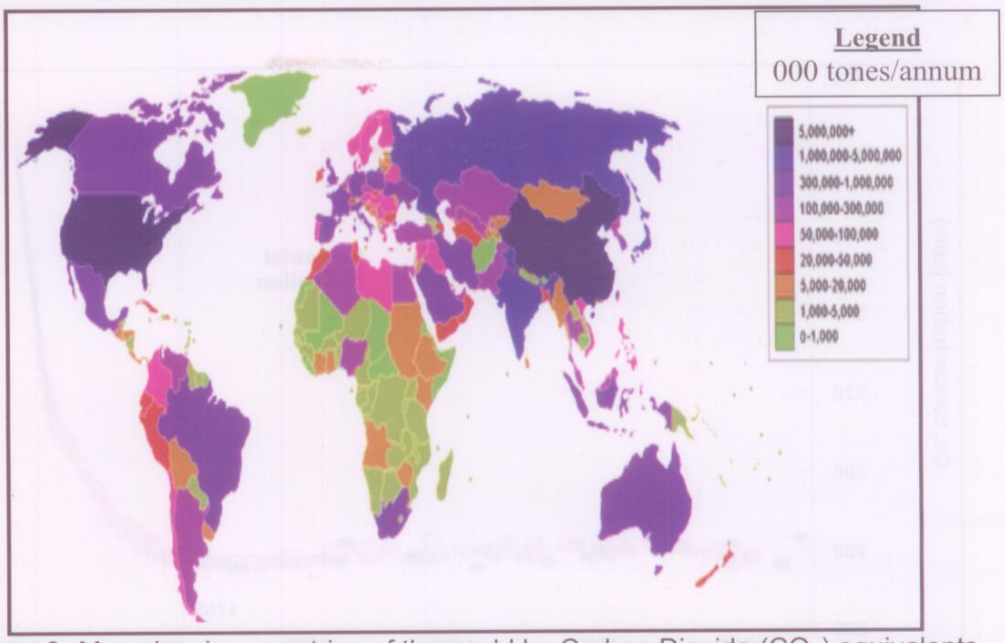


Figure 9: Map showing countries of the world by Carbon Dioxide (CO_2) equivalents emissions in thousands of tons per annum through burning of fossil fuel and cement manufacture (UNFCC 2012).

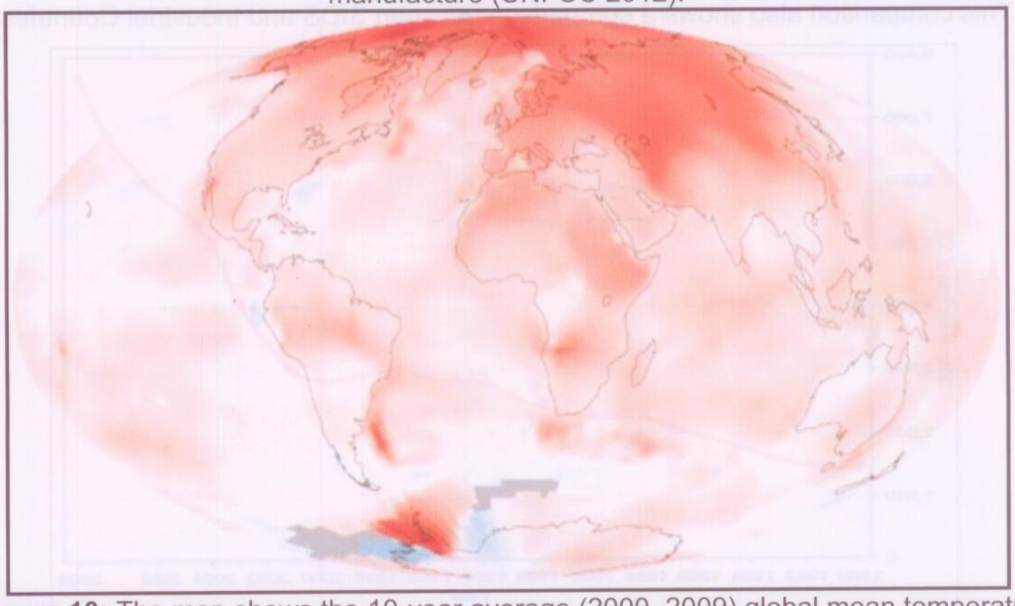


Figure 10: The map shows the 10-year average (2000–2009) global mean temperature anomaly relative to the 1951–1980 mean. The largest temperature increases are in the Arctic and the Antarctic Peninsula. (Source: NASA Earth Observatory).

2.2. According to CO2 equivalent emissions figure 9&10 shows various countries of the world. The total aggregated emissions of CO2 equivalents from 52 SIDS are extremely low; 258 million tones of CO2 equivalent per annum as compared to 17 billion tones of CO2 equivalents emitted by industrialized countries which are parties to UNFCCC(See Table 2). Considering the 52 SIDS as individual countries the emission becomes negligible. Considering the sectoral contribution of GHG emissions of SIDS, 90% come from agriculture & energy sectors. Emissions from the waste water and industrial sectors are almost insignificant. Of the emissions present 47% is Nitrous Oxide (NO2), 41% Carbon Dioxide (CO2) and 12% Methane (CH4). In contrast to that, the dominant emission in industrialized countries is carbon dioxide (CO2) (See Fig.11)

2.3. In addition in industrialized countries the ratio of Chloro Fluoro-Carbons (CFCs) is significant whereas in SIDS these are negligible in overall global assessment of emissions. It is a paradoxical fact that the SIDS play very insignificant or no role in causing GHG emissions and thus do not contribute to global warming but because of their geographical location and small land area surrounded by sea water would receive maximum adverse impacts of the global warming caused by the industrialized countries. Global warming cause's irreversible changes in the global climate which in turn has threatened the economy of SIDS and at places even their very existence. (See figure 11).

2.4.

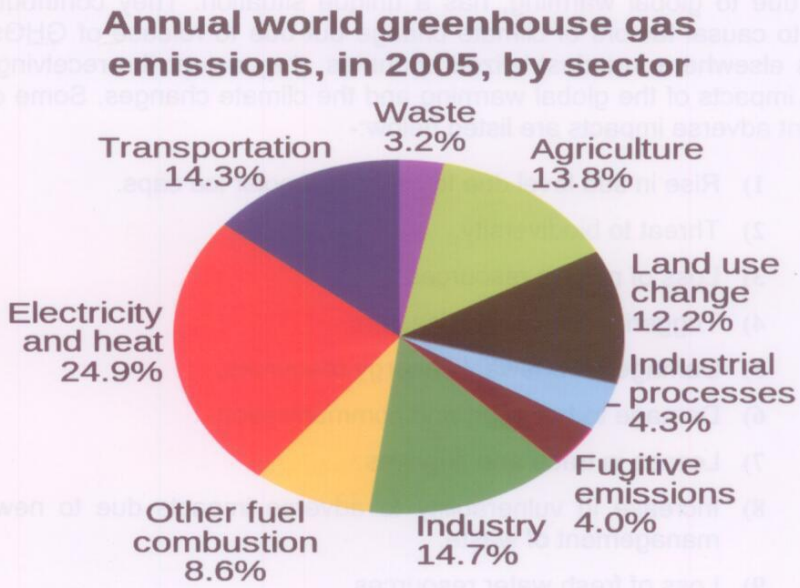


Figure 11: Annual world greenhouse gas emissions, by sector.

3. **Climate Change**

3.1. Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It results in more or fewer extreme weather events.

Historically, as per data gathered from borehole temperature profiles, flora and fauna records particularly of fossils, glacial and periglacial process, stable isotopes and other analysis, the earth climate has been undergoing changes ever since its creation e.g. warm periods alternating with ice ages. But an accelerated change over relatively short periods causes a major and mostly an unmanageable upset in physical, biotic and socio-economic balance in earth's ecosystems. Major factors believed to be causing climate change are:-

1) Variation in solar radiation
2) Biotic processes
3) Plate tectonics
4) Volcanic eruptions
5) Magnetic field strength
6) Human activities leading to release of GHGs and causing global warming.

In past 30 years or so, it is the human activity generated GHGs which have triggered the accelerated climate change. The SIDS, with respect to accelerated climate change due to global warming, has a unique situation. They contribute a little or nothing to causal factors of climate change but due to release of GHGs by human activities elsewhere in industrialized countries, they are at the receiving end of the adverse impacts of the global warming and the climate changes. Some obvious and significant adverse impacts are listed below:-

1) Rise in sea level due to melting of polar ice caps.
2) Threat to biodiversity.
3) Loss of marine resources.
4) Triggering of natural disasters.
5) Damage to renewable energy resources.
6) Damage to transport and communication.
7) Losses in trade and finances.
8) Increase in vulnerability to adverse impacts due to new hurdles in management of waste.
9) Loss of fresh water resources.
10) Loss of land resources.
11) Loss of Tourism.
12) Loss of Food resources and damage to agriculture.

All the above adverse impacts have begun to severely erode the economy and social sustainability of the SIDS. In ultimate analysis a scenario is being set in where the climate change may lead to annihilation of some of the SIDS.

3.2. It is noteworthy that in the global ecosystem is a complex scenario. If an activity or project is run at one place, its action, reaction and coaction trigger as a chain reaction (See Figure 12). The damage caused to SIDS due to GHGs contributed by industrialized countries is irreversible.

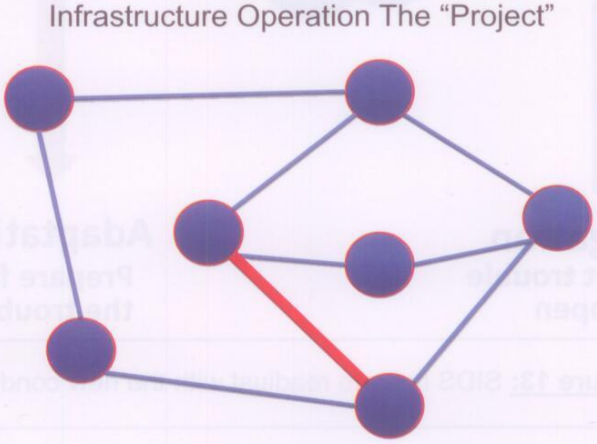


Figure 12: The development projects are a small part in a whole with its actions, reactions and coactions. No simplistic solution can be offered to SIDS as mitigation for adverse impacts of climate change.

4. Mitigation of adverse impacts

As seen in Figure 13, mitigation of adverse factors, at the prevailing international scenario is almost impossible. No industrialized country is ready to close their industry and the emission of GHGs. So it is not possible to stop the trouble before it happens. In a series of annual meetings the United Nations and the industrialized countries are proposing to SIDS that they may adapt to new situation for their survival. They should prepare themselves to withstand the trouble and adapt ways and means to adjust with climate change. Table 3 takes cognizance of the adverse impacts and their possible mitigation which by and large is readjustment. Even on that position, except the UN, none, particularly the industrialized countries, have made any solid commitment to the cause. In table 4, mitigation by way of adaptations has been suggested. Even to make these massive adaptations, the SIDS shall require funding and technical assistance for which the developed countries shall have to come forward for assistance through U.N. the SIDS on their own have too meager an economic base to afford the mitigation expenses. (See Table 4). It must however be borne in mind that the problem of SIDS is a global adversity. Unless all stakeholders join, it is not

possible to save SIDS. The approach and strategy to help SIDS has to be wholistic. All of us have a part to play (See Figure 14).

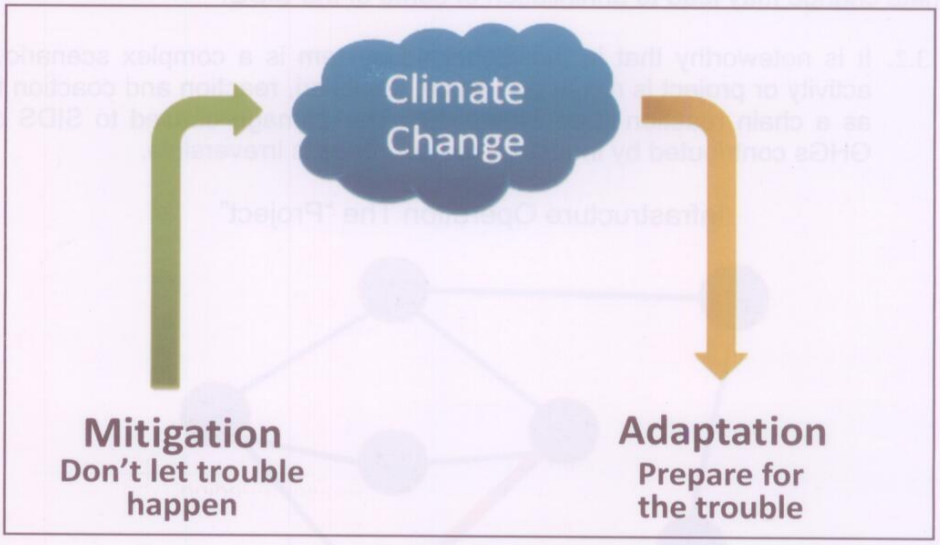


Figure 13: SIDS have to readjust with the new conditions.

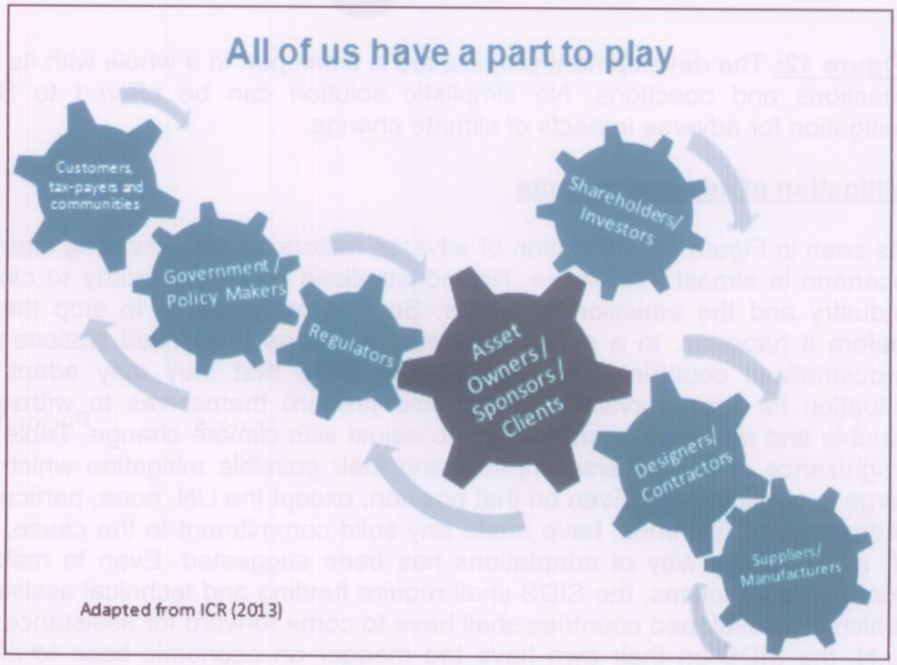


Figure 14: In a wholistic solution all stakeholders have to work in collaboration.

4. Adverse Impacts Due To Climate Change And Their Mitigation

4.1 RISE IN SEA LEVEL

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.1.1.	Coastal Agriculture Threatened	● Mitigation Policy formulation ● New Cultivars ● Integrated Agriculture	● Provide Funds ● Training & Capacity Building	● F.A.O. & UNFCCC Local Departments
4.1.2.	Coastal Infrastructure Threatened	● Modify Design ● Modify Construction Techniques ● Modify Maintenance	● Provide Funds ● Training & Capacity Building	● World Bank
4.1.3.	Existence of low lying SIDS Threatened	● Consistent Monitoring ● Resettlement Plan ● Awareness	● Provide Funding ● Write Resettlement Action Plans ● Develop capacity to monitor	● Donors as U.S AID JICA
4.1.4.	Coral Reefs and other Coastal Ecosystems Threatened or Damaged	● Research ● Monitoring System ● Change Management System	● Provide Funding ● Technical Assistance ● Collaboration with Research Institutions in Industrial World	● Global Environment Facility (GEF) of the World Bank

4.2. THREAT TO BIODIVERSITY

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.2.1.	Endonism of Biodiversity in SIDS seriously threatened & liable to unfavorable changes leading to chain reactions. This threatens sustainability.	● Formulate & Implement Integrated Biodiversity ● Promote Community Support	● Develop Capacity ● Promote Indigenous Techniques & Knowledge ● Build Effective Regional Partnership ● Funding	● World Bank ● UN

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.2.2.	Marine Coastal Resources, precious to Islands environmentally, economically & culturally, can be destroyed.	• Monitoring System • Research in biological, social & economical aspects of changes in Biodiversity	• Change of species • Develop Mangroves • Encourage Coastal Palm Plantation • Funding	• World Bank • AUS AID • JICA
4.2.3.	Biodiversity protection programmes, Bio-Reserves & Protected Areas, developed under existing conditions shall be reversed.	• Involvement of Social Communities in managing the changes in Protected areas • Training & Capacity Building	• Provide Funding • Collaborate International Coastal Management Activities • Funding	• World Bank • WWF • World Bank
4.2.4.	Studies & Surveys already done shall require to be revised and new system shall have to be developed.	• Fresh studies & Surveys • Training & Capacity Building	• Research • Training • Funding	• World Bank • WWF • World Bank
4.2.5.	Existing legal framework focusing on development & maintenance of existing Biodiversity will become redundant & shall require change.	• Revise legal framework(LF) where necessary • Adjust LF in Biodiversity Conservation Policy	• Provide improved access to financial & technical resources • Support National & Regional Programmes to evolve workable legal framework • Funding	• US Aid • World Bank

4.3. LOSS OF MARINE RESOURCES

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.3.1.	Massive loss of marine resources due to national disasters.	• More effective disaster management system • Build Capacity	• Provide Financing • Share Technical Information	• World Bank • UN

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
		to cope up with post disaster situation	• Awareness	
4.3.2.	Intensity & Frequency of storm surges, landslides & droughts has increased & thus damage to marine resources.	• Develop fore-warning system • Develop local broadcasting system • Awareness in Public	• Provide Finance • Provide Technical Assistance	• World Bank • UN
4.3.3.	Loss of marine resources leads to economic, social & environmental losses with high cost of rehabilitation.	• Provide & build alternate resources • Keep a workable working plan ready for rehabilitation	• Strengthen Regional Institution	• World Bank • UN
4.3.4.	Damage from Oil & Diesel spills	• Awareness • Physical elimination of Oil & Diesel from land & water	• Special recognition to SIDS • Technical Assistance • Financing	• World Bank • UN

4.4. TRIGGERING OF NATURAL DISASTERS

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.4.1.	Increased vulnerability to natural disasters.	• Awareness • Build preparedness for disaster management	• Share Technical Knowledge • Provide Finances	• World Bank • UN
4.4.2.	Increased intensity of storms & surges.	• Develop good forecast system • Develop good broadcast system • Awareness	• Training & Capacity Building • Financing	• World Bank • UN
4.4.3.	Triggering of economic, social &	• Solidify Institutions dealing with	• Help prepare a Rehabilitation Plan	• World Bank • UN

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
	environmental degradation.	rehabilitation • Keep Rehabilitation Plan ready	• Help Institution Building • Financing	
4.4.4.	Can cause greater distribution of injurious pollutants e.g. Oil & Diesel spills.	• Control Oil & Diesel spills & other pollutants on soil and water • Awareness	• Financing • Skills Training	• NUEP • US AID • JICA

4.5. DAMAGE TO RENEWABLE ENERGY RESOURCES (FORESTS)

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.5.1.	Due to damage to local Biomass Energy resources, dependence on imported fossil fuels increased.	• Build alternate technology e.g. Wind, Solar, Geothermal, Biomass, & Ocean energy	• Share research & development dividends with SIDS • Financing	• EC • US AID
4.5.2.	Some SIDS, due to physical changes because of climate change, fail to get endowment of renewable energy resources	• Promote efficient use of existing energy sources, by using proper instructions & incentives	• Formulate & ratify international agreements covering carbon credits & Transport of Petroleum • Financing	• World Bank • UN
4.5.3.	Absence of adequate finances limits the capacity of SIDS to make commercial use of their renewable energy resources.	• Take assistance for developing capability to make commercial use of renewable energy sources	• Transfer Energy Technology & develop database for SIDS • Provide Financing	• World Bank • UN
4.5.4.	Dependence, for developing appropriate technology for use of renewable sources, on developed countries increases.	• Take assistance for developing appropriate technology	• Give assistance for development of appropriate technology • Provide Financing	• World Bank • UN

4.6. DAMAGE TO TRANSPORT AND COMMUNICATION (LIFELINE WITH OUTSIDE WORLD)

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.6.1.	Physical damage to Transport & Communication aggravates the distance, remoteness & loneliness of SIDS resulting in high costs & poor economy.	• Plans to build safer transport & communication means & infrastructure	• Assist in re-building the transport & communication infrastructure on a safer design • Financing	• World Bank • UN
4.6.2.	Environmental degradation associated with transport and communication development accelerates.	• Develop an affective quarantine system • Get the Environmental safe designs	• Assist in development of an effective quarantine system • Assist in preparing environment friendly designs	• World Bank • UN
4.6.3.	Management and improvement of existing infrastructure for transport and communication is threatened and challenged.	• Prepare plan for effective management & improvement of existing infrastructure	• Assist in preparation of effective plans for management & maintenance of existing infrastructure	• World Bank • UN
4.6.4.	Economy sectors linked with Transport & communication suffer from high losses & results in increase in-unemployment poor distribution of food & poor health facilities.	• Prepare sound economy development plans • Get Research & Development support	• Assist in development of a balanced economic development plan	• World Bank • UN

4.7. LOSSES IN TRADE AND FINANCES (HIGHLY VULNERABLE SECTOR)

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.7.1.	Exclusion from the world Economy because of SIDS smallness persistent	• Seek to get integrated into global economy on	• Reaffirm commitment for development of SIDS by	• WTO • World Bank • UN

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
	structural disadvantages and vulnerabilities.	preferential basis	admitting them to global trade system	
4.7.2.	Deprivation from trade liberalization and globalization opportunities and trade references.	• Seek to be benefitted from World Trade System	• Strengthen country-driven donor coordination & active transport for regional cooperation	• WTO • World Bank • UN
4.7.3.	Further deprivation of representation at the World trade organization (WTO).	• Seek to be represented on WTO by relaxations in pre-conditions	• Strongly support the SIDS to be represented on WTO so as to balance their losses due to climate change	• WTO • World Bank • UN
4.7.4.	Further decline in capacity to meet WTO obligations and limitation on foreign trade.	• Seek to build capacity & manage resources at WTO standards	• Assist SIDS in building their capacity and manage their resources to meet WTO standards	• WTO • World Bank • UN

4.8. WASTE MANAGEMENT (A SERIOUS CONSTRAINT TO SUSTAINABLE DEVELOPMENT)

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.8.1.	Waste disposal problem particularly that generated by urbanization, further aggravates & threatens sustainable development.	• Develop fiscal & policy incentives & take other measures to make local products & imported material environment friendly	• Support national policies & enhance capacity for environmental monitoring	• World Bank • UN
4.8.2.	Reduction in land area makes the option of landfills causes' sustainability problem in long terms.	• Select waste dumping sites carefully assuming that after the landfill the site	• Help in building capacity for environmentally friendly land use • Arrange finances	• World Bank • UN

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
		can be reused for other purposes.		
4.8.3.	Threat, from passing ships carrying oil, toxic chemicals & radio-active materials, for sustainable development further increases.	• Develop the capacity for emergency response to marine accidents and incidences and to control the pollutant spills	• Assist in capacity building the Emergency response of SIDS • Assist in changing SIDS attitude towards sewage disposal	• World Bank • UN
4.8.4.	Threat from non-biodegradable imported materials increases and it further reduces the land productivity.	• Make policy not to allow non-biodegradable products to be produced locally or imported	• Get recommendation of London Conference 1972 implemented in SIDS • Training & capacity building	• World Bank • UN • WTO

4.9. LOSS OF FRESH WATER RESOURCES

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.9.1.	Increase in health hazards due to reduction in clean drinking water resources and use of polluted or poor quality for drinking.	• Adapt appropriate Water Quality Standards • Arrange effective monitoring	• Assist in access to environmentally sound and low energy sources of water	• World Bank • WHO
4.9.2.	Access to sources of clean drinking water gets further limited because of damage to water sources, storage capacity and water-supply system	• Develop technology to develop low energy water supply and sewage system • Use of rain water for drinking	• Assist in developing technology for low energy water supply and sewage system • Financing	• World Bank • WHO
4.9.3.	Watershed, already being poorly managed, and the ground water	• Watershed management • Ground water conservation	• Assist in water conservation and watershed management	• World Bank • WHO

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
	resources already under stress, is under further threat 9of extinction.	• Water conservation through good practice in use	• Assist in developing good water supply system • Financing	
4.9.4.	Fresh water sources, already under threat from human and animal waste and chemicals from agriculture, will be polluted at a faster rate.	• Effluents from agriculture must not be mixed with drinking water reservoir • A good water testing lab for all	• Assist in keeping fresh water reservoir unpolluted from agricultural effluents • Assist in water conservation through good practices • Financing	• US AID • JICA • UN

4.10. LOSS OF LAND RESOURCES (Exclusion from Global Economy)

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.10.1.	Already small land resources shrinks further. Most SIDS not part of global economy because of smallness.	• Seek to be recognized as full and effective participants, even as small economies in deliberation and decision making of WTO	• Help SIDS in getting recognized as full participants in deliberations & decision making of WTO	• WTO • UN
4.10.2.	SIDS are further pushed away from world trade and their capability to avail trade and opportunities and trade liberalization further are eroded.	• Seek to overcome issues like trade, food security, capacity constraints, structural handicaps & vulnerabilities	• Assist financially and technically to overcome issues like trade, food security, capacity constraints, structural handicaps and vulnerabilities	• WTO • UN • World Bank
4.10.3.	Most SIDS face serious difficulties in building capacity	• Seek WTO commitment for trade	• Assist in WTO's commitment for trade	• WTO • UN • World Bank

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
	to meet WTO requirements.	liberalization, for sustainable development of SIDS	liberalization leading to sustainable development of SIDS	
4.10.4.	SIDS are getting subjected to discrimination in global economic affairs.	• Seek to build up a universal rule based, open non-discriminatory and equitable multilateral trading system	• Help in building up a universal rule based, open non discriminatory & equitable multilateral trading system	• UN • WTO

4.11. LOSS OF TOURISM (CATALYST FOR SIDS ECONOMY)

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.11.1.	Threat to economy in turn threatens culture which is main tourist attraction in SIDS.	• Seek to same culture as main attraction in attracting tourists	• Assist and support in saving culture of SIDS to save tourism	• UNICEF • GEF
4.11.2.	Adverse impacts upset the planning and management of tourism which in turn can destroy the environment of SIDS leading to degradation of Tourism.	• Seek to save the environment in its original shape so as to help tourism	• Assist and support in conversation of environment in SIDS to save tourism base	• UNEP • GEF • World Bank
4.11.3.	Threats to land, water and biotic resources particularly in coastal areas, protected areas, parks and bio-reserves causing major failures in planning for tourism industry.	• Seek to develop specific tourism nitches and involve local communities to manage tourism	• Assist and support in development of specific ecotourism areas and involve local communities in managing ecotourism	• UNICEF • GEF • US AID
4.11.4.	Threat to environment and culture making it	• Seek to invite international support to	• Assist and support SIDS in getting	• US AID • JICA

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
	difficult to develop integrated tourism, especially on long term basis.	mitigate over-all adverse impacts and develop integrated Tourism model as per new conditions	international to mitigate over-all adverse impacts and develop integrated Tourism model as per new conditions	• UNICEF

4.12. LOSS OF FOOD RESOURCES AND DAMAGE TO AGRICULTURE (KING PIN OF SURVIVAL FOR SIDS)

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
4.12.1.	Reduction of agricultural land leading to food shortages.	• Seek to get food grants and subsidies till the pressure stays	• Assist and support in making food grants and subsidies proportionate to the losses due to climate change	• FAO of U.N. • U.S AID • JICA
4.12.2.	Food shortages leading to Hunger, Disease Work output and poverty.	• Seek to develop alternate sources of food • Possible change in food habits	• Research and knowledge should be transferred to SIDS • Finance the change management in food	• FAO of UN • U.S. AID • JICA
4.12.3.	Crops adjusted to precious climate becoming redundant and productivity falling.	• Research • Awareness & Extension Programmes • Local news	• Assist in Research • Assist in awareness and extension campaigns • Provide required Funds	• World Bank • U.N.
4.12.4.	New crops inviting new pests which can have sweeping effect on the existing as well as future crops.	• Research • Awareness & extension programmes • Radio & TV programmes	• Assist in applied research • Assist in funding awareness and extension programmes	• U.N. • U.S. AID • JICA

S.No	Adverse Impacts	Mitigation		Suggested Development Partner/Agency
		BY SIDS	By Development Partners	
			• Assist in designing and running Radio & TV programmes	

5. Case for SIDS

The United Nations Office of the High Representatives for the Least Developed Countries. Landlocked Developing Countries and Small Islands Developing Countries (UN-OHRLLS) in collaboration with a number of other UN bodies and the UN member SIDS are making efforts to help SIDS to readjust to their new conditions. Major issues being projected at OHRLLS are coastal and marine resources, biodiversity, energy, transportation and communication, land resources shrinkage, food security and loss of trade.

The UN-OHRLLS collects all required data from SIDS and projects various issues to developed industrialized countries, other U.N. agencies U.S. AID, JICA and the World Bank, UN-OHRLLS also promotes public private partnership in finding solution to the problems caused to SIDS due to various activities undertaken by industrialized countries. In response various agencies have committed to take up SIDS projects for funding and technical assistance. The UN-OHRLLS platform can be used by SIDS to seek technical assistance and funding from donor agencies which can become partners in development of SIDS. Attention of industrialized countries can be drawn that the SIDS are facing problems because of their activities and therefore they ought to compensate SIDS by funding, sharing their research dividends and extending necessary technical assistance. SIDS can also use this platform for alerting various international agencies about their priority issues faced by them.

The response to UN-OHRLLS appeals have been rather limited have not matched with the size of the problem. The issues of SIDS have been projected in the light of the UN Framework for climate change in following conventions and protocols:-

1) **1992:** Earth Conference or UN Conference on Climate Change.
2) **1995:** The Berlin Mandate
3) **1996:** Geneva, Switzerland, Conference.
4) **1997:** Kyoto Protocol came up as an international agreement linked to the U.N. Framework linked with Climate Change which expressed a commitment by the parties for emission reduction.
5) **1998:** Buenos Aires Conference (Argentina).
6) **1999:** Bonn Conference (Germany).

7) **2000:** The Hagne Conference (Netherlands).
8) **2001:** Bonn Conference (Germany).
9) **2001:** Marrakech Conference (Morocco).
10) **2002:** New Delhi Conference (India).
11) **2003:** Milan Conference (Italy).
12) **2004:** Buenos Aires Conference (Argentina).
13) **2005:** Montreal Conference (Canada).
14) **2006:** Nairobi Conference (Kenya).
15) **2007:** Bali Conference (Indonesia).
16) **2008:** Poznan Conference (Poland).
17) **2009:** Copenhagen (Denmark).
18) **2010:** Cancun (Mexico).
19) **2011:** Durbin (South Africa).
20) **2012:** Doha (Qatar).
21) **2013:** Warsaw Conference (Poland).

- **Future UN Conferences have been scheduled as follows:-**

22) **2014:** Lima Conference (Peru).
23) **2015:** Paris Conference (France).

Noteworthy points emanating from these conferences and protocols are as follows:-

1. U.S.A. along with some other developed/Industrialized countries participated in the conferences but abstained grows signing any protocol, resolution or commitment.
2. In Kyoto Conference under Kyoto Protocols UNFCCC was launched. It brought in concepts like Carbon Credits, Carbon sequestration and Carbon reduction programmes. The U.S.A. did not sign any of the protocols.
3. In Copenhagen Conference, the developing countries including SIDS declined from any further undertakings in such a UN Climate Change Framework where major industrialized countries led by U.S.A. were consistently defying from signing. That, to a large extent, broke the momentum of the programmes which were initiated under Kyoto Protocols. By the same corollary, the mitigation of adverse impacts of climate change, even by way of adaptation, is in the dole drums nowadays. They may have to develop an alliance of their own and look for some non-conventional donors.

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A REVIEW OF SIDS: CHARACTERISTICS, EFFECT OF CLIMATE CHANGE AND ITS MITIGATION

Sidra Siddique, Asifa Alam, Dr. Engr. Abdullah Yasar and Dr. Amtul Bari Tabinda[1]

Abstract: SIDS mainly consist of low-lying coastal countries and small islands that face the development limits of a small population, susceptibility to natural disasters, lack of resources, remoteness, and receptiveness to external shocks. There are total 51 Small Island Developing States. They have common characteristics such as limited physical size, limited natural resources, high susceptibility, thin water lenses, extreme openness of small economies, high population densities and poorly developed infrastructure. These features make them extremely susceptible to sea level rise and other consequences of climate change. Climate change greatly affects the development process in SIDS and it also affects the economic and social infrastructure in small islands which damages the fundamental sectors like tourism, biodiversity, fisheries and agriculture, and placing infrastructure at high risk. Studies illustrate that sea surface temperatures have been increasing by 0.1ºC per decade in the oceans where majority of small islands are situated. It has been anticipated that a 10 % decrease in annual rainfall by the year 2050 may produce a 20 % decrease in the size of the freshwater lens on Tarawa Atoll, Kiribati. It can be concluded that a natural disaster in SIDS can cause extreme environmental damage, extensive disruption in the economic process and complete breakdown of the social fabric of the island states.

Introduction

Small Island Developing States (SIDS)

SIDS mainly consist of low-lying coastal countries and small islands that face the development limits of a small population, susceptibility to natural disasters, lack of resources, remoteness, and receptiveness to external shocks (Nurse and Sem, 2001).

The development of SIDS is frequently impeded by communication costs and high transportation, excessively expensive public administration and infrastructural restrictions due to their small size, and no opportunity to create large economies (Nurse and Sem, 2001).

There is total 51 Small Island Developing States; 14 of which are non-UN members or are associate members of UN regional commissions (Table 1). Small Island Developing States are situated across the Pacific, Indian and Atlantic Oceans. The southwest Pacific and Caribbean have a large number of SIDS, whereas those SIDS, which are found in

[1] Sustainable Development Study Center

the Indian and Atlantic Ocean are located primarily around the African continent (Buko et al. 2007).

Table 1: List of small developing States

Antigua and Barbuda	Cuba	Guyana	Federated States of Micronesia	Sao Tome and Principe*	Solomon Islands*	Vanuatu	Cook Islands+	Niue+
Bahamas	Dominica	Haiti*	Mauritius	Singapore	Suriname	American Samoa*	French Polynesia+	Puerto Rico+
Barnados	Dominican Republic	Jamaica	Nauru	St. Kitts and Nevis	Timor-Leste*	Anguilla+	Guam+	U.S. Virgin Islands+
Belize	Fiji	Kiribati*	Palau	St. Lucia	Tonga	Aruba+	Montserrat+	
Cape Verde	Grenada	Maldives*	Papua New Guinea	St. Vincent and the Grendines	Trinded and Tobaga		Netherlands Antilles+	
Comotos*	Guinea-Bissau*	Marshall Islands	Samoa*	Seychelles	Tuvalu*	Commonwealth of Northern Marianas	New Calendonia+	

+Non UN Member/Associate Members of Regional Commissions
*Also a Least Developed Country

Source (Buko et al. 2007)

Characteristics of Small Island Developing States

Small Island Developing States have many common properties which dominate their vulnerability, specifically climate change and sustainable development, although they vary in their culture, climate, geography and stage of economic development (Buko et al. 2007). Sea-level rise is the key climate change threat to SIDS. These characteristics comprise:

- **Limited physical size:** SIDS has limited physical size, which successfully decreases some adaptation opportunities of climate change and sea-level rise;
- **Limited natural resources:** They have limited natural resources, which are greatly stressed from unsustainable human actions;
- **High susceptibility:** They have a high vulnerability to natural hazards such as tropical cyclones (hurricanes), volcanic eruptions, droughts and tsunamis;
- **Thin water lenses**: Generally SIDS have thin water lenses which are extremely sensitive to the sea-level variations;
- **Extreme openness of small economies:** SIDS has a tremendous openness of small economies and great susceptibility to external market shocks;

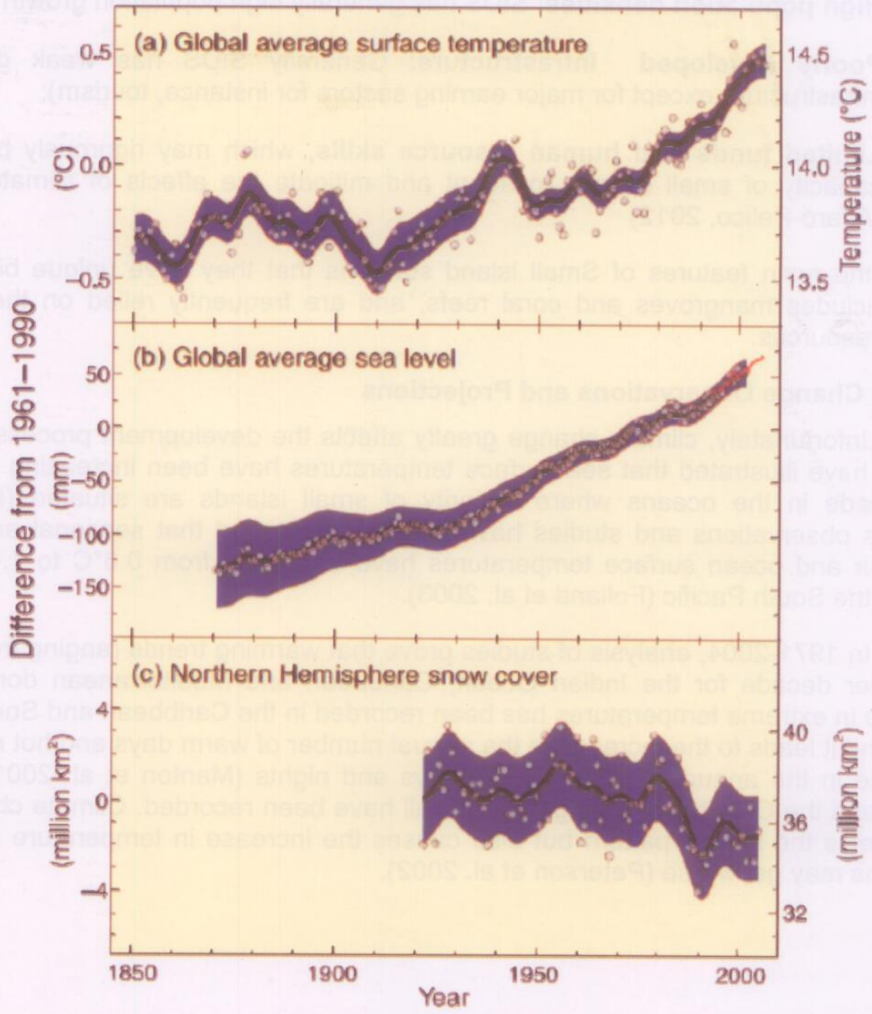
- **High population densities**: SIDS has generally high population growth rates;
- **Poorly developed infrastructure**: Generally SIDS has weak developed infrastructure except for major earning sectors for instance, tourism);
- **Limited funds and human resource skills,** which may rigorously bound the capacity of small islands to adapt and mitigate the effects of climate change (Alfaro-Pelico, 2012)

One of the main features of Small island states is that they have unique biodiversity which includes mangroves and coral reefs, and are frequently relied on their limited natural resources.

Climate Change Observations and Projections

Unfortunately, climate change greatly affects the development process in SIDS. Studies have illustrated that sea surface temperatures have been increasing by 0.1° C per decade in the oceans where majority of small islands are situated (Figure 1). Previous observations and studies have also demonstrated that seasonal and annual inland air and ocean surface temperatures have increased from 0.6°C to 1.0°C since 1910 in the South Pacific (Folland et al. 2003).

In 1971-2004, analysis of studies prove that warming trends ranging from 0°C to 0.5°C per decade for the Indian Ocean, Caribbean and Mediterranean domains. An increase in extreme temperatures has been recorded in the Caribbean and South Pacific areas and it leads to the increase in the annual number of warm days and hot nights and decrease in the annual number of cool days and nights (Manton et al. 2001). In the Pacific and the Caribbean, changes in rainfall have been recorded. Climate change not only affects the rainfall pattern but also causes the increase in temperature and these situations may get worse (Peterson et al. 2002).



Source: IPCC,http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

Figure 1: Changes in Temperature, Sea Level and Snow Cover (Source: IPCC, 2007)

Due to rise in sea level, it causes dominating **damage to coastal zone as well as on the economic infrastructure** of Small Island Developing States such as tourism (Church et al, 2006). Climate change also causes the destruction of infrastructure and economic gains because of **heavy tropical cyclones**, like those in 2004 (Haiti, Grenada and Niue), 2005 (the Cook Islands) and 2008 (Fiji, Cuba and Haiti). For example, Hurricane Ivan damaged 90% of the housing stock of the island of Grenada (World Bank, 2000).

Ocean atmospheric interactions greatly influenced the climatic atmosphere of SIDS. Storm surges and sea level rise may result into inundation and flooding whereas an increase in surface temperature will contribute to coral bleaching which is a crucial economic source of many islands (Sem, 2007) .

Islands are enormously vulnerable to cyclones and hurricanes that affects culture and socio-economic infrastructure. From 1950-2004, it was reported that cyclones accounted for 76% of the total disasters in the Pacific island regions having an average estimated cost of US$75. 7 million per cyclone (Khan et al. 2002).

SIDS is greatly dependent on fossil fuel based energy for their social and economic development, although the quantity of fossil fuels they used is rather small as compared to several developing and developed countries. SIDS contribute about less than 1% of global greenhouse gas (GHG) emissions (Table 2). For instance, the average per capita emissions are 0.96 tonnes of carbon dioxide (CO_2) per year; this consider to be equal to only 25 % of the CO_2 emissions imputable to the average person throughout the world in the Pacific islands. Similarly, the LDCs contribution to GHG emissions is quite low (Arnell, 2004).

Country	Mega Tonnes Carbon	World Rank	Percent of World Total
USA	1,576.90	1	22.27
China	1,227/40	2	17.34
European Union	1,092.60	-	15.43
India	313.4	6	4.43
Brazil	90.7	19	1.28
Least Developed Countries	38.1	-	0.54
Alliance of Small Island Developing States[14]	37.7	-	0.53

Table 2: Total Greenhouse Gas Emissions 2003- Selected Countries (Source: Arnell 2004)

The effects of environmental change can possibly make atoll islands, for example, Kiribati, Tuvalu and the Maldives dreadful owing to changes in precipitation, which might prompt dry seasons that influence the supplies of drinking water and nourishment security as a rule. Environmental change has additionally cultivated an ascent in ocean surface temperatures. This reasons coral blanching that influences artisanal fisheries and diminishes storm surge insurance (Church et al, 2006).

Effects and Vulnerabilities facing by SIDS

Water Resources

One of the major problems faced by small islands is **water pollution**. **Water stress** is already experienced by several SIDS. SIDS has such factors (geography, limited natural resource, etc.) which are severely susceptible to variations and changes in climate especially rainfall levels. There is a **need for expansion of existing water resources and effective** management system due to the rapid growth of tourism (Kabat et al. 2002).

Tuvalu in the Pacific and Cook Islands in the northern atolls usually used rain water as the main source of fresh water. Some **SIDS is completely dependent on surface water from steams such as Seychelles in the Indian Ocean and Dominica, in the Caribbean**. **Groundwater is the main water source for various small coral islands such as the Maldives and Barbados** and raised atolls such as Nauru, where freshwater lenses can vary in quality and thickness, depending on the extraction rates and rainfall recharge (Christensen et al. 2007).

In view of the fact that several islands are greatly dependent upon surface water catchments for their main water supply and this demand may not be met for the duration of low rainfall. On the other hand, significant surface and stream water losses happens during rainy season due to the lack of appropriate land areas for dams (e.g. in the Seychelles) and high runoff during stormy seasons (e.g. in Fiji). It has been anticipated that a 10 % decrease in annual rainfall by the year 2050 may produce a 20 % decrease in the size of the freshwater lens on Tarawa Atoll, Kiribati (Christensen et al. 2007).

Coastal Zones

Generally, coastal zones are of extreme importance on the islands as they are the center of economic activity because major settlements are situated in these areas and sometimes, vital infrastructure, like schools, hospitals and electricity generation plants are also located in coastal domains. Tourism is a crucial economic activity which also takes place in coastal zones.

Villages are situated on the beach itself or on the sand terrace in the Pacific and Indian Ocean atolls and almost more than half of the population are located within 1.5 km of the shoreline. In several small islands, continuous corridors of development now inhabit practically all of the major coastal lands such as along the north coast of Jamaica and the west and south coasts of Barbados (Alfaro-Pelico, 2012).

Biodiversity

Small Islands are home to a noteworthy piece of the world's biodiversity having a few geologically exceptional species. The biodiversity of coral and upland forests such as mangroves, are greatly threatened by both worldwide change and nearby elements. For instance, more than a quarter of the small island states have an extraordinarily lessened backwoods blanket as an after effect of the infringement of infrastructural improvement or farming (Alfaro-Pelico, 2012).

A storm in the Seychelles brought about the misfortune of in excess of 1,000 indigenous palms in 2001. Coral reefs are ceaselessly debilitated by ascents in ocean surface temperatures, which prompt coral fading. An ocean surface temperature ascent of nearly 1ºC over the ordinary greatest summer temperature has caused bleaching agents in the previous 20 years (Kurukulasuriya and Mendelsohn, 2006). In most tropical oceans, bleaching event might be occurred annually as predicted by scientists. The rise in the oceans' CO_2 concentration levels is an important threat to coral reefs (Nurse, 2001). Significance of coral reefs might not be overstated for several SIDS. Coral reefs are not only the source of prime nurseries for several important fish species but also play an essential role in beach protection and it also provides a great source for tourism industry.

Agriculture and Fisheries

In several SIDS, the agriculture sector is the basic source for economic development and survival for a long time. Cash crops of SIDS greatly participate in world trade and export revenue, whereas subsistence agriculture is a source of local food security in SIDS. Sea level rise is the main threat for the agriculture of SIDS because majority of agricultural lands is mainly located on the coastal plains. Extreme weather events in small islands greatly damage the food crops and other livelihood resources and populations of small islands greatly depend on it. Agricultural crops are damaged by extensive droughts which results into low exports and high imports. High imports add the burden on foreign exchange earnings (Alfaro-Pelico, 2012).

Change in climate affects the agriculture and it leads to economic loss and it varies between island states. Studies demonstrated that the cost might be in the range of US$23-52 million per year in 2050 in the absence of adaptation on a high island like Viti Levu in Fiji. (Kurukulasuriya and Mendelsohn, 2006)

Human Health

In Small Island Developing States, climate change could have an undesirable health impact on human populations. Rise in temperature leads to the increase in heat stress and at the same time, in the Caribbean, reduced rainfall reduces the fresh water amount for human utilization which leads to the increased risk of diseases.

During 1980-2000, several events of dengue have been accounted in Trinidad, Barbados, and, Tobago due to the change in temperature and precipitation. Dengue epidemics appeared mainly due to reduce rainfall and warmer temperatures (Alfaro-Pelico, 2012).

Policies, Strategies and Response Measures Undertaken by SIDS

Specific national priorities directly influenced the response of Small Island Developing States climate change threats. Though, using the framework of the Bali Roadmap, there are common domains of interference recognized in their measures for mitigation, adaptation, technology and financing. These four main pillars of the Bali Roadmap appeared from the 13th session of the Conference of the Parties (COP-13) to

the United Nations Framework Convention on Climate Change (UNFCCC)/Third session of the COP serving as the Meeting of the Parties (CMP-3) to the Kyoto Protocol, which was apprehended in December 2007 in Bali (Indonesia) (Alfaro-Pelico, 2010). Climate architecture finance greatly depends on government budgets and capital markets (Figure 2). Development cooperation agencies, UNFCCC and financial institutions are responsible for mitigation and adaptation measures (Figure 2) (Atteridge et al, (2009), Glemarec, (2001) .

Mitigation

Similar to many developing countries, SIDS view their very low greenhouse gas (GHG) emissions, estimated at less than 0.05% compared with global emissions (AOSIS, 2011a), and it is the prime reason for not undertaking climate change mitigation measures. Though, their heavy dependence on costly transport has become a driver for the conversion of ineffective fossil-fuel dependent industries into low-carbon economic domains. (Brooks et al. 2005)

It is reported that SIDS consume more than 220 million barrels of petroleum fuel per year to fulfill their energy needs. With the exemption of oil nations such as Trinidad and Tobago, Belize, Barbados, Suriname and Papua New Guinea, 90% of the industrial and commercial demand of SIDS is to rely on fossil-fuel imports. In some cases, electricity costs are reportedly 500% higher than in the US (AOSIS, 2011b). Therefore, there is higher realization between SIDS that a cleaner energy-supply mix, with increased renewable resource input, would result in important savings on fuel imports (Adaptation Fund, 2011).

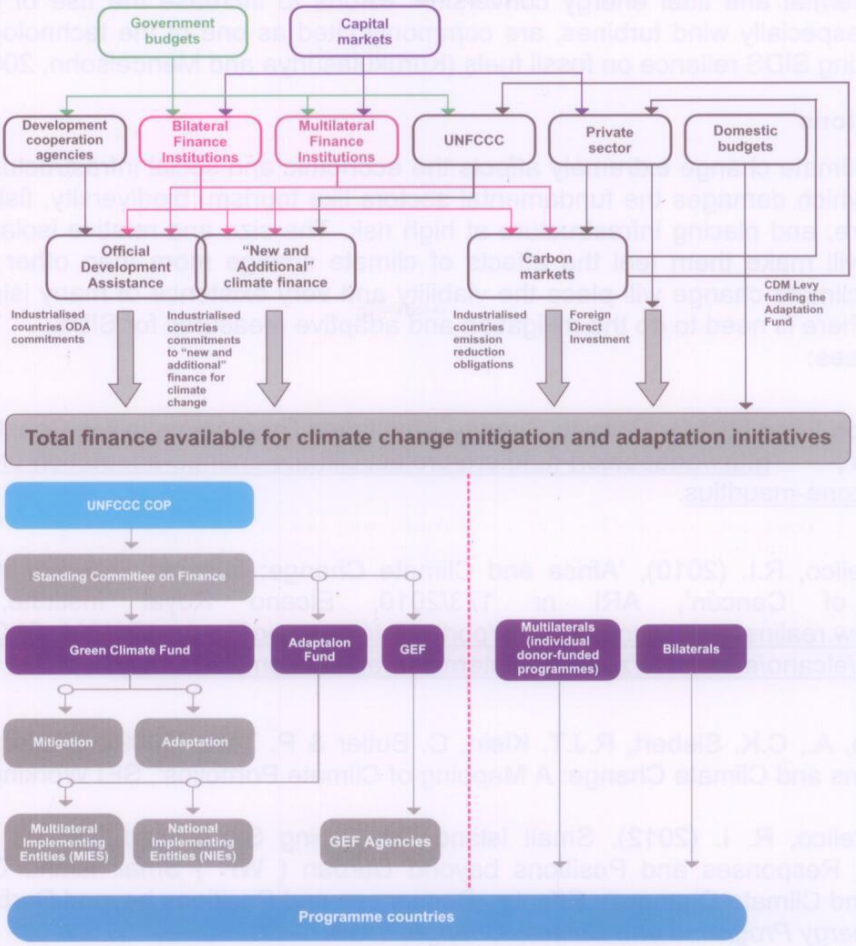


Figure 2: Climate finance architecture (Source: Atteridge et al, (2009), Glemarec, (2001))

SIDS benefit in various ways from a close relationship with the oceans. Singapore, for example, makes use of its tactical geographic position within the global trading system. Other countries such as the Marshall Islands and Tuvalu, greatly depend on their fish resources. And for several SIDS, sea-related tourism has become a foundation of the economy (AOSIS, 2009). Some SIDS, for instance, Bahrain and Trinidad and Tobago, also produce and export fossil fuels. (Khan et al. 2002)

Many SIDS have substantial potential for further development of renewable energy by the asset of their location, a plenty of sunshine that gives rise to the wind, and adequate rain and plant life that can be tapped for energy. In addition, the presence of geothermal springs, vents and other geo- and hydrothermal resources on land as well as in the ocean increases the potential sources of energy production in most SIDS. Future developments may include the high use of solar, wind and geothermal power as well as

ocean thermal and tidal energy conversion. Efforts to increase the use of renewable energy, especially wind turbines, are commonly cited as one of the technology options for breaking SIDS reliance on fossil fuels (Kurukulasuriya and Mendelsohn, 2006).

Conclusions

Climate change extremely affects the economic and social infrastructure in small islands which damages the fundamental sectors like tourism, biodiversity, fisheries and agriculture, and placing infrastructure at high risk. The size and relative isolation of the islands will make them feel the effects of climate change more than other countries. Indeed, climate change will place the viability and very existence of many island states at risk. There is need to do the mitigation and adaptive measures for SIDS.

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ENVIRONMENTAL CHANGE DETECTION OF URBAN LAND COVER, AGRICULTURE, FOREST AND SEA SURFACE TEMPERATURES USING SATELLITE DATA

Dr. Badar Ghauri[1]

Rapid development over the last few decades and ever rising demand for food and shelter have created a number of environmental problems such as ill managed urban expansion, deteriorating local and regional depleting productive resources, depleting snow and glaciers as well as water resources, ever increasing events of extreme climate etc. These problems have also been aggravated due to changes that occurred in land use without any environmental consideration. Climate change is another driving factor for, extreme weather events such as tropical cyclones, heavy downpour, heat waves etc. The rate of glacial melt in the major rivers of the country could have a heavy toll on downstream impacts and may result into water shortage for agriculture, industry and for human consumption. This could also increase the flood risks and water scarcity at later stage creating issues like food security. Some of the devastating disasters in the country were drought of 1999.The most severe was in the provinces of Balochistan and Sindh. The country has also experienced severe earth quakes. The earthquake which occurred on 8th October 2005 was one of the worst natural disasters, causing around 78,000 human casualties and damage to the property. The country also underwent deadly floods during July-September 2010 caused by intense rain systems on in late July and early August 2010, affecting about 20 million people, approximately 0.9 million households and 2.3 million hectares of cultivated land. Pakistan lacks in sufficient scientific and technological capability for the collection of environmental data required to monitor and predict the associated environmental changes. The traditional methods of measuring landuse and landcover are labor and cost intensive, requires good amount of time and thus are not practiced much these days. These informations become out-dated especially in the fast changing world. Temporal change monitoring and analysis are therefore not easy with conventional methods (Olorunfemi, 1983). High spatial resolution satellite data are needed to gather information of the changes underway in the glaciated areas of the country. In situ data capabilities are required to developing regional scenarios with high certainties.

The overall objective of this study was to add to sustainable development through enhancing of national capacity in utilizing environmental information for planning and

[1]*Institute of Space Technology, Former Director SUPARCO & Project Incharge E-mail: b_ghauri@yahoo.com*

decision-making.. The current status of environment could facilitate the time and extent of remedial measures required to be taken necessary for the long term sustainability of environment.This study included the development of temporal environmental monitoring applications. Analysis of dominant environmental changes over a span of one decade at national level covering different parameters such as; agriculture, forest, desertification, sea surface temperatures, snow and glacier extent, water bodies and settlements.

Methodology

This study mainly focused on detection of change using acquisition of environmental data at national level for the years 2000 and 2010 based on Geographic Information System (GIS) database employing satellite imagery. For this purpose, the Lands at TM satellite data of the years 2000 and 2010 were downloaded from satellite website, geo-referenced and image enhanced, digitized, validated with error removing processed, and analyzed for agriculture land, forest and desertification, settlements, rocky areas and water bodies.

To get spectral change detection, satellite images of year 2000 and 2010 were merged into a single-band or multi-band image. The final image was assigned the changes to specific land cover type {Wessels, K.J., et at 2004}. Medium resolution MODIS data were acquired for the study of Aerosol Optical Depth (AOD), Green House Gases (GHG), Snow Cover of Northern Areas, Natural Hazards events of 2010 and 2011 including temporal changes in sea surface temperatures (2001 to 2010) and cloud cover (from 1990 to 2002). Change detection in landuse/landcover was done on a temporal scale such as a decade to assess landscape change caused due to anthropogenic activities on the land. Satellite remote sensing is a tool which is extensively used to investigate land use/ land cover and change. This information, in turn, facilitates planning and policy decision making from local to regional scale. Change detection techniques on these data were applied using customized GIS application to detect changes in different attributes of landuse/ landcover in varying environmental regimes.

Satellite data for the year 2010 received from MODIS (AQUA and TERRA) through their Website https://earth**data**.nasa.gov/**data**/near-real-time-**data** to determine temporal changes over different areas. In view that scarce ground based aerosol data is available. MODIS data was acquired for studying the temporal changes in Sea Surface Temperatures (SST). It is worth mentioning here that SST variations are needed to study ocean behavior; its relationship with regional climate.

Results & Discussion

The process of change detection is identification of difference in the state of an object, area or phenomenon by observing over a varying time frame (Singh, 1989). This

technique is vital when it comes to monitoring and managing a development process and managing resources. It helps in assessing and analyzing spatial distribution of a changing phenomenon. Remote Sensing (RS) and Geographic Information System (GIS) are frequently being used for regular environmental monitoring and management. Change detection in given ecosystem can easily be determined through an intelligent application of remotely sensed data. In order to develop and maintain the adequate deployment of the earth's resources, it is imperative to maintain up to date information of landuse/landcover conditions over a period of time for achieving sustainability and devising strategies for conservation of natural resources.

Besides natural geomorphologic changes, landuse/landcover patterns of a country reflect socio-economic activities of that country. Depending upon these multiple factors various phenomena are taking place on the earth surface showing dynamic behavior. For generating landuse thematic layers, Landsat TM data of spatial of 30 meter resolution pertaining to the years 2000 and 2010 were selected. The selected data were of good quality with bare minimum cloud coverage. The main landuse themes considered in this study were agriculture, forest, natural vegetation, rocky area, salinity, sand, settlement, waterlogged, water bodies and snow.

Table 1 shows landuse/landcover themes with a real extent during the years 2000 and 2010 as well changes that occurred over in a decade. The agriculture land as calculated from the landuse/landcover data in the year 2000 is about 199513.764 km^2. The recent statistics from landuse/landcover data of the year 2010 shows that the existing agriculture land is about 201562.447 km^2 with an increase of 2048.683 km^2. The probable reasons for the increase in agriculture may be conversion of Kacho area forest to agriculture landuse, increased agriculture activities in Thal desert due to the canal network particularly on left side of River Indus and lower part of Chitral and Upper Dir districts. A maximum increase in agriculture land is found in the Bhakkar and Khushab districts and some increase in the Sargodha, Layyah and Muzaffargarh districts of the Punjab province. Similarly a maximum increase is observed in the Buner and Dera Ismail Khan districts of Khyber Pakhtunkhwa province. This increase is also found in the Kachhi, Washuk and Nasirabad districts of Balochistan province where most of the sand class is converted into agriculture land. In the Sindh province, the maximum increase is observed in the Qambar Shahdadkot and Khairpur districts due to conversion of sandy land into agriculture land.

Table 1: Showing landuse/landcover classifications during the years 2000 and 2010

LANDUSE	YEAR 2000 km^2	YEAR 2010 km^2	CHANGE
Agricultural Land	199513.764	201562.447	2048.683
Forest	32876.971	28405.948	-4471.023
Natural Vegetation	20123.753	13500.131	-6623.622
Sand and Desert	191414.186	200068.806	8654.62
Water bodies (River & Lakes)	5909.504	5767.043	-142.461
Settlement	3100.063	3870.747	770.684
Snow / Glaciers	60519.394	46719.201	-13800.193

The forest cover as determined from the landuse/landcover data in the year 2000 is about 32876.970 km^2. The recent statistics from the year 2010 shows that the existing forest cover is about 28405.947 km^2 with a decrease of 4471.023 km^2. Changes in rates of glacial melt in the Indus basin may have tremendous downstream impacts and may cause severe water shortage for agriculture and human consumption on one hand and increased risks of floods on the other. Climate change also affects the food security issue which in turn could spark internal and external security problems. For this Pakistan should be completely prepared with appropriate adaptation strategies. The glaciated cover of Pakistan is around 2,250 km^2 which produces much of country's water. Approx. 70% of country's water needs are met through snow and glacier melts. The snow/glaciers covered area as calculated from the landuse/landcover data in the year 2000 is about 60519.394 km^2 of the country's total area. The recent statistics from the year 2010 show that the covered area of the existing snow/glaciers is about 46719.201 km^2 of the total area of the country with a decrease of 13800.193 km^2.

Satellite remote (RS) sensing data has long been employed to study drought conditions. Prediction and intensity of upcoming drought could also be done using RS data. Satellite sensor measures radiations, reflected or emitted radiation from the earth surface are picked up by the satellite sensors and the nature of reflectance of vegetation in the visible and near-infrared spectral regions are then converted into qualitative assessment of state of vegetation cover. In Pakistan, many parts (southern parts) of the country depend on rainfall for land cultivation. These parts are often affected by drought due to less rainfall affecting the agriculture crops growth which consequently influences the national economy and causes the shortage of food. The country experienced severe droughts in years 1899, 1920 and 1935 in the Punjab, 1902 and 1951, in KPK and in 1899, 1931, 1947 and 1998 in Sindh province. A glimpse of recent short term drought as given in fig. 1 where effect of a winter drought in barani area (rain fed) has been shown through comparison of two years 2009-2010 satellite images.

Fig 1: Monthly mean Sea Surface Temperatures (SST) maps

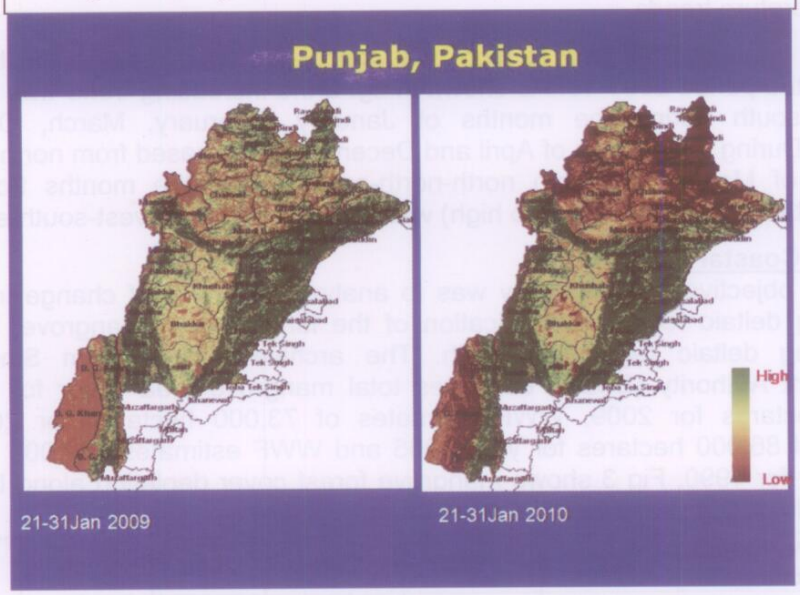
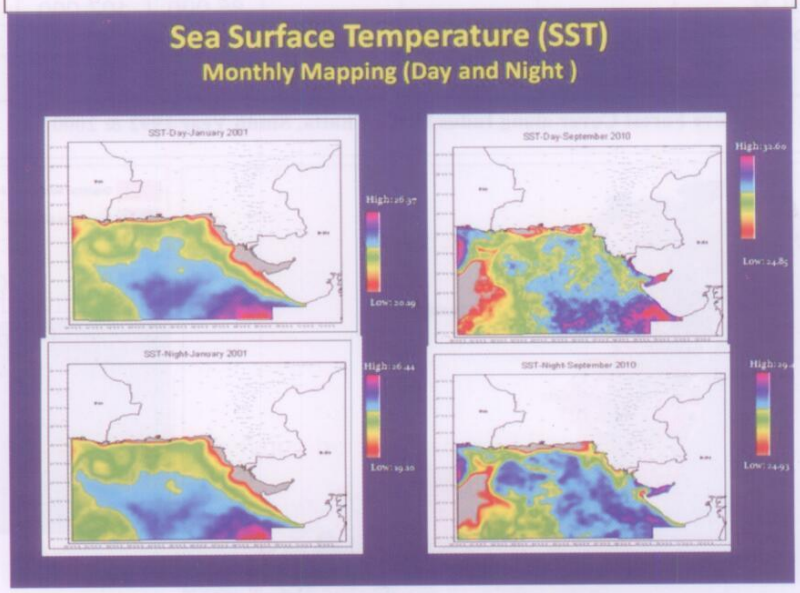


Fig 2: Monthly mean Sea Surface Temperatures (SST) maps



Sea Surface Temperatures

Sea Surface Temperatures (SST) affect the ocean- atmosphere linkage on global climate and ocean behavior in general. Further ocean flora and fauna are also linked to

SST. Large scale oceanic anomalies such as El Nino and La Nina are dependent on these temperature trends.

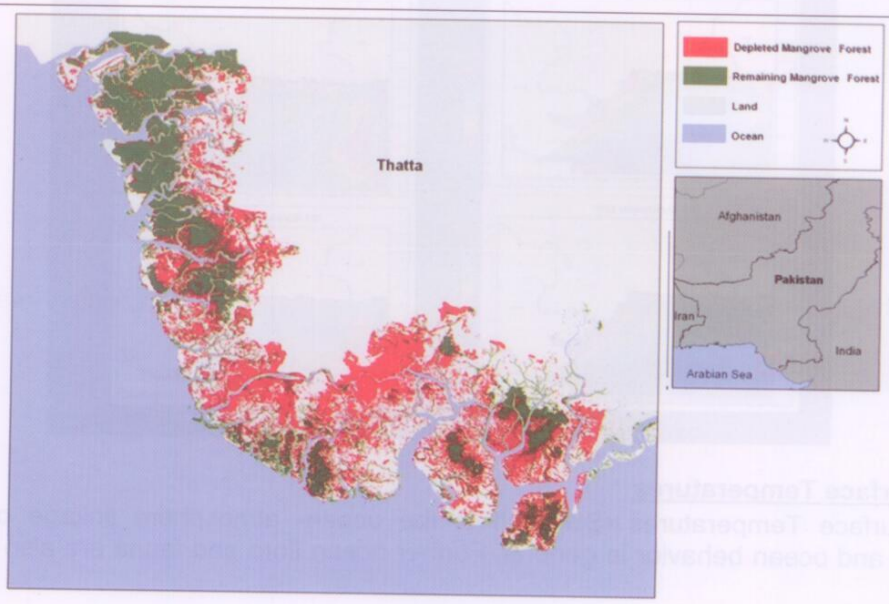
The spatial trend of SST (low to high) was calculated by averaging the trends of all months for the period 2001-10. As shown in fig. 2 the increasing trend was almost from north-north-south during the months of January, February, March, October and November. During the months of April and December it increased from north to south. In the month of May it was from north-north-east. During the months from June to September the trend of SST (low to high) was in the direction of west-south-east.

Mangrove- Coastal Forests

One of the objectives of this study was to analyze the trend of change in mangrove cover along deltaic region. Classification of the land covers (mangrove, sand, mud, water) along deltaic region of Sindh. The archive records from Sindh Coastal Development Authority (SCDA) estimates total mangrove area cover for delta to be 107,000 hectares for 2009, WWF estimates of 73,000 hectares for 2006, SCDA estimates of 86,000 hectares for year 2005 and WWF estimates 160,000 hectares of forest cover for 1990. Fig 3 shows mangrove forest cover depletion along Indus Delta, Thatta, Sindh during year 1992 & 2000.

Mangrove Extent in Hectares	1990	1992	2000	2006	2009	2011
WWF	160,000		73,000	73,000		
CSF	160,000					
SCDA/ IUCN				86,000	107,000	
This Report		123,247	73,057			106,018

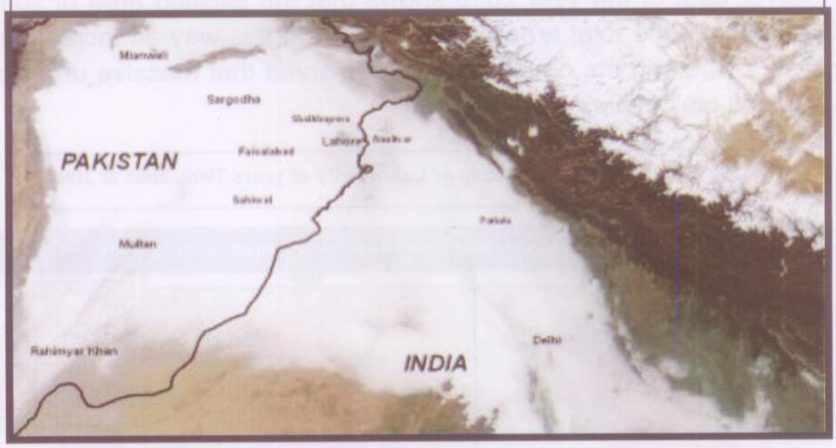
Fig 3: Mangrove Forest Cover along Indus Delta, Thatta, Sindh Year 1992 & 2000



Aerosols are micron sized particles suspended in the air. They are emitted into the atmosphere naturally i.e. volcanoes, dust storms, forest fires, sea spray etc. and through anthropogenic activities. Aerosols are believed to cause negative radiative forcing (cooling); since aerosols reflect sunlight back into space. Aerosol Optical Depth (AOD) is used as a unit of extinction of solar radiation by aerosol scattering and absorption between the point of observation on the earth surface and at the top of the atmosphere. During winter especially from December to February each year high aerosol load has been observed in eastern part of the country along the Indian Boarder.

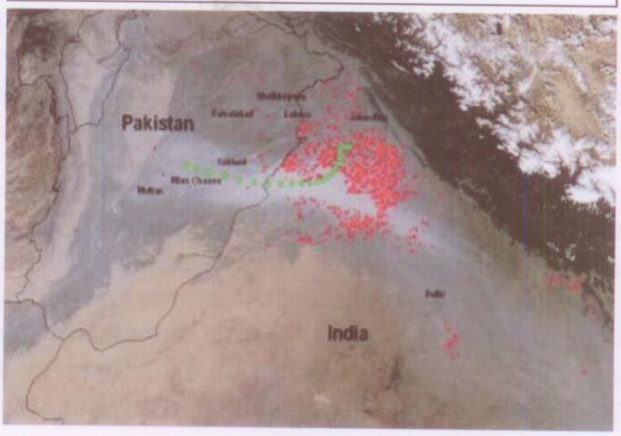
In this area the occurrence of aerosol related dimming events such as fog/haze are also frequent in winter, thereby, the distribution pattern drastically changes. The AOD values during December 2007 to December 2011 show a considerable variability of aerosols. Comparatively dense fog was observed in India and area covered by haze and fog was also larger. The maximum winter fog-affected area was determined as deduced from MODIS satellite images for the years between 2000 and 2010 (Fig: 4). For Pakistan this area varied from 136,000 km^2 to 381,000 km^2 and for India from 300,000 km^2 to 560,000 km^2.

Fig 4: Dense high level haze (fog) observed by MODIS satellite



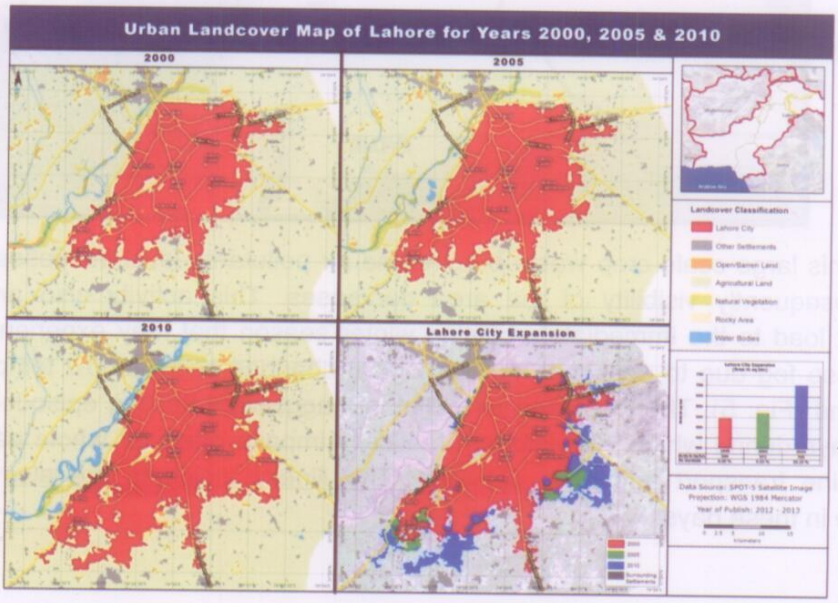
During this large scale crop waste burning the air pollutants level increases many folds and subsequently visibility of the area decreases. This activity also provides high pollutant load to the immediately coming winter season that may experience inversion and dense fog due to seasonal meteorological changes such as low temperature and calm wind (Fig: 5). The haze and air pollutants aggravate the fog episode hanging for many days during which the visibility drastically impairs often for whole day disturbing the routine transport and daily activities. The illness incidents are also reported to increase in these days.

Fig 5: MODIS Image (01 Nov 2010) showing biomass burning in India near Pakistani Border (Red) and green dot line show air trajectory (HYSPLIT4 modeled) representing haze transport from India to Pakistan



The settlement area as calculated from the landuse/landcover data pertaining to the year 2000 is about 3100.063 km^2 of the country's total area. The recent statistics from landuse/landcover data of the year 2010 shows that the existing area of settlements is about 3870.747 km^2 of the total area of the country. In this way an increase of 770.684 km^2 is found as a whole in the country. It was observed that massive urban sprawl has occurred around all major cities (Fig: 6).

Fig 6: Urban land cover map of Lahore city of years 2000, 2005 & 2005



Conclusion:

The process of change detection has played a key role in monitoring, assessment and management of resources and in overall development planning of a country. Such studies also facilitate quantitative assessment of various environmental impacts and help devise remedial strategies. Despite some increase in cultivated area, some of the alarming changes noticed in this study are rapid depletion of forested areas including coastal forests, increase in drought affected areas, rapid urban sprawl, deteriorating regional and air quality, and information on sea surface temperatures. Such studies provide a real linkage to the precursors of such changes and would enable the relevant agencies to take notice of these adverse changes and suggest remedial measures in future planning.

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EFFECTS OF CLIMATE CHANGE ON SMALL ISLAND DEVELOPING STATES (SIDS) AND THEIR MITIGATION

By

Engr. Riaz Nazir Tarar*

1 SMALL ISLAND DEVELOPING STATES (SIDS) AND CLIMATE CHANGE

1.1 LOCATION

Small Island Developing States (SIDS) are generally recognized as low-lying coastal countries (refer to map in Annex-01). These tend to share similar sustainable development challenges, including small but growing populations, limited resources, remoteness, susceptibility to natural disasters, vulnerability to external shocks, excessive dependence on international trade and fragile environments. Their growth and development is also held back by high communication, energy and transportation costs, irregular international transport volumes, disproportionately expensive public administration and infrastructure due to their small size and little to no opportunity to create economies of scale.

1.2 RECOGNITION AS DISTINCT GROUP

SIDS were first recognized as a distinct group of developing countries at the United Nations Conference on Environment and Development in June 1992. Barbados Programme of Action was produced in 1994 to assist SIDS in their sustainable development efforts. United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States represents this group of states.

1.3 LIST OF SIDS

Currently, the United Nations Department of Economic and Social Affairs lists 52 SIDS. These are broken down into three geographic regions: Caribbean; Pacific; Africa, Indian Ocean, Mediterranean and South China Sea. While the individual list is shown in Annex-02, a region-wise summary is as below:-

- Caribbean Sea (23 members): Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, British Virgin Islands, Cuba, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Montserrat, Netherlands Antilles, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, US Virgin Islands.

* Associate NDC & Project Manager, Diamer Basha Consultants, WAPDA, Lahore

- Pacific Ocean (20 members): American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, Vanuatu.
- Africa and the Indian Ocean (nine members): Bahrain, Cape Verde, Comoros, Guinea-Bissau, Maldives, Mauritius, São Tomé and Príncipe, Seychelles, Singapore.

Each of these has a regional cooperation body: the Caribbean Community; the Pacific Islands Forum; and the Indian Ocean Commission. Many SIDS are members or associate members of these regional cooperation bodies. In addition, most (but not all) SIDS are members of the Alliance of Small Island States, which performs lobbying and negotiating functions for SIDS within the United Nations System.

2 CLIMATE CHANGE IMPACTS ON SIDS

2.1 IMPORTANCE OF CLIMATE CHANGE

A key factor contributing to this phenomena of climate change is the green house gas (GHG) emissions by the industrialized countries. Estimated 2003 contributors of GHG for selected countries are listed in Annex-03. It will be noted that SIDS are nominal contributors to GHG emissions. Unfortunately, however, they are most vulnerable to the climate changes.

Why is climate change so important to SIDS? The answer is simple: these small nations are among the most vulnerable to climate change impacts, which will become critical if no appropriate action is taken. Many islands are threatened by rising sea levels. Another growing concern is the increasing number and severity of extreme weather events—with all they entail in terms of loss of life and damage to property and infrastructure that can easily cripple small economies. On the other hand, SIDS are among the party least responsible for climate change (refer Annex-03). Ironically, they are dependent on others to ensure that significant actions are taken to support their endeavours for coping with the adverse impacts of climate change. Consequently, they strive not only to support the process directly but also expect that proper international action is taken to limit emissions of GHG and to adapt to climate change.

2.2 VULNERABILITY

In spite of variations in geographical, physical, climatic, social, political, cultural and ethnic features and economic development, SIDS share certain characteristics that underscore their overall vulnerability to climate change, climate variability and sea-level rise in the form of:

- Generally limited natural resources, with many already heavily stressed from unsustainable human activities.
- A concentration of population, socio-economic activities, and infrastructure along the coastal zone.

- High susceptibility to frequent and more intense tropical cyclones (hurricanes) and to associated storm surges, droughts, tsunamis and volcanic eruptions.
- Dependence on water resources for freshwater supply that are highly sensitive to sea-level changes.
- Relative isolation and great distance to major markets, affecting competitiveness in trade.
- Extreme openness of small economies and high sensitivity to external shocks.
- Generally high population densities and in some cases high population growth rates.
- Inadequate infrastructure in most sectors.
- Limited physical size, effectively eliminating some adaptation options to climate change and sea-level rise.
- Insufficient financial, technical and institutional capacities, seriously limiting their capacity to mitigate and adapt to any adverse impacts of climate change.

Following few examples of the vulnerabilities in specific islands illustrate well this high level of susceptibility to the adverse impacts of climate change:

- In Barbados and many other islands, almost all foods, fuels, construction materials and other goods are imported.
- In Maldives and Papua New Guinea, some 50–80 per cent of the land area is less than 1 metre above mean sea level.
- In Seychelles, about 80 per cent of the infrastructure and population are found along the coast.
- Critically limited resources are required to address pressing short-term environmental problems in Grenada.
- In Palau, prolonged droughts are experienced during El Niño Southern Oscillation (ENSO) events.
- Throughout the South Pacific Region, frequent and more intense tropical cyclones, as well as climate-related and other extreme events, were experienced during the 1990s.

Due to the geographic location of SIDS and the profound influences of oceanic circulation systems, natural precipitation varies from one year to the next much more than in other countries. This can lead to various forms of extreme events, such as droughts and floods, that have a wide range of adverse impacts including some catastrophic damages to natural and human systems.

Climate projections suggest that significant climate change and sea-level rise are expected in all regions during 21st century. Increases in atmospheric concentrations of GHGs due to human activities over the past 100 years will continue to alter the climate and related systems on Earth during 21st century. Regional projections of the two key climate change parameters of temperature (^{o}C) and precipitation (%) over the 21st century are shown in Annex-04. These projections show the average global trends, as indicated below: -

Period	Projected Change in Global Trends			
	Temperature (°C)		Precipitation (%)	
	Range	Mean	Range	Mean
2010-2039	+0.51 to 1.24	0.87	-13.1 to +17.5	+4.4
2040-2069	+0.81 to 2.53	1.67	-24.65 to +22.6	-2.07
2070-2099	+1.03 to 4.46	2.75	-27.36 to +18.04	-9.32

2.3 IMPACT OF CLIMATE CHANGE

Climate change will impact the social and economic fabric of life in SIDS, affecting key sectors such as: water resources; agriculture; tourism; and coastal zones placing critical infrastructure at risk. The size and relative isolation of the islands will make them feel the effects of climate change more than other countries. Indeed, climate change will place the viability and very existence of many island states at risk.

As an illustration modeling has been conducted for several SIDS in the Caribbean to estimate impact of climate change on: water resources; and coastal zones.

With regard to impact on water resources, the modeling results are: -

i. Many SIDS already experience water stress at current levels of rainfall input and extraction of groundwater. Water pollution is one of the major problems facing small islands and poor water quality affects human health and the incidence of water-borne diseases. Owing to factors such as limited size, geology and topography, water resources in small islands are extremely vulnerable to changes and variations in climate, especially in rainfall. With the rapid growth of tourism and service industries in many small islands, there is a need for both augmentation of the existing water resources and more efficient management of those resources that already exist.

ii. Taking into account their size and topography, SIDS tend to rely on any one or all of the three main natural sources of water: surface water (rivers, small lakes); rainwater; and groundwater. Dominica in the Caribbean and Seychelles in the Indian Ocean, for example, are almost entirely dependent on surface water from ephemeral and perennial streams. Rainwater is the primary source of freshwater in several countries in the Pacific (e.g. Tuvalu and the northern atolls of Cook Islands). Groundwater is the major source of water on many low-lying coral islands such as Maldives and raised atolls such as Nauru, where the freshwater lens can vary in thickness and quality, depending on the rates of extraction and recharge from rainfall.

iii. This dependency on rainfall increases the vulnerability of small islands to future changes and distribution of rainfall. Low rainfall can lead to a reduction in the amount of water that can be physically harvested, a reduction in river flow, and a slower rate of recharge of the freshwater lens, which can result in prolonged droughts. Since

most of the islands are dependent upon surface water catchments for their water supply, it is likely that demand cannot be met during periods of low rainfall. On the other hand, during the rainy season, lack of suitable land areas for dams (e.g. in the Seychelles) and high runoff during storms (e.g. in Fiji) result in significant loss of surface and stream water to the sea.

iv. Wet and dry cycles associated with El Niño Southern Oscillation (ENSO) episodes can have serious impacts on water supply and island economies, highlighting the vulnerability water supplies to changes in the climate. For instance, the strong El Niño of 1998–2000 was responsible for acute water shortages in many islands in the Indian and Pacific oceans. In Fiji and Mauritius, borehole yields decreased by 40 per cent during the dry periods, and export crops including sugarcane were also severely affected. The situation was exacerbated by the lack of adequate infrastructure such as reservoirs and water distribution networks in most islands.

v. It has been estimated that a 10 per cent reduction in average rainfall by 2050 could produce a 20 per cent reduction in the size of the freshwater lens on Tarawa Atoll, Kiribati. Moreover, the thickness of the freshwater lens on atolls could be reduced by as much as 29 per cent. In addition, freshwater lenses are threatened by sea-level rise.

With regard to impact on coastal zones, the modeling results are: -

i. On Pacific and Indian Ocean atolls, villages are located on the sand terrace or on the beach itself, and in Caribbean more than half of the population lives within 1.5 km of the shoreline. In many small islands such as along the north coast of Jamaica and the west and south coasts of Barbados, continuous corridors of development now occupy practically all of the prime coastal lands. Such land is also occupied by a range of other settlements, such as fishing villages, and on many small islands government buildings and important facilities such as hospitals are frequently located close to the shore.

ii. Population growth and inward migration of people is putting additional pressure on coastal settlements, utilities and resources and creating a series of problems in terms of pollution, waste disposal and housing. In many parts of the Pacific, traditional housing styles, techniques and materials ensured that islanders were resistant to damage or could be repair buildings quickly. Many of these traditional practices are being abandoned today, increasing the vulnerability of coastal settlements.

iii. Coastal erosion is a major problem in small island states. It is a natural process which redistributes sediments but it can be accelerated by both natural and anthropogenic causes. Natural causes include hurricanes and storms. Anthropogenic activities which accelerate erosion include beach mining for building materials, unwise building practices on the coast and activities leading to the destruction of the coral reefs.

iv. For a one (1) metre rise in sea level, 98 coastal settlements in Cuba would be inundated affecting a population of over 50,000.

v. A 50 cm in sea level could lead to 60 per cent of beaches in some areas of Grenada being lost. For Maldives, however, a one (1) meter rise in sea level amounts to the complete disappearance of the nation.

The coastal zones of other littoral countries would be also impacted, particularly due to sea level rise which may cause inundation of low level areas and settlements. For instance, in Bangladesh climate change vulnerabilities for coastal area are surfacing in form of: salt water intrusion into agricultural lands due to sea level rise; and increased frequency of storms and floods. A few adaptation actions in this regard area already in hand at governmental and community levels with some international support.

Similarly, though to a lesser extent lands and fishermen's settlements along coastal areas of Pakistan in Thatta and Badin districts of Sindh may be impacted by these phenomena. This requires monitoring for timely planning / implementation of appropriate mitigation and adaptation measures.

3 MAJOR ISSUES RELATED TO ADAPTATION AND SUSTAINABLE DEVELOPMENT

3.1 ADAPTATION MEASURES

3.1.1 Need

With the major greenhouse gas emitters failing to curb emissions, it is clear that CO_2 levels will continue to rise. Even if emission reductions that would limit carbon dioxide levels to their 1990 levels were enacted today, climate change would continue to occur, and further warming would be unavoidable. Adaptation is thus the only option for SIDS.

3.1.2 Adaptation Measures in SIDS

3.1.2.1 Strategies

Many SIDS have already started to implement adaptation strategies on a local scale, often in an ad-hoc manner. For example, placing concrete blocks on the top of zinc roofs to prevent the roofs from being blown away during hurricanes has become common practice in Jamaica since Hurricane Ivan.

3.1.2.2 Physical Adaptation Measures

In Vanuatu, the South Pacific Regional Environmental Programme, with funding from Canadian Government, has moved 100 villagers living in the Lateu settlement to higher ground 600m from the coast and 15m above current sea level as frequent flooding and erosion made the original location of the settlement uninhabitable.

Using traditional knowledge is key in many SIDS for enhancing resilience and finding strategies to cope with the changing climate. For example, on Timor Island, farmers have developed their own varieties of major staple crops to adapt to erratic rainfall and cyclones and to ensure food security.

3.1.2.3 Coastal Erosion

Practices for coping with coastal erosion can be useful in adapting to rising sea level. For example, at Playa Rosaria, Havana Province, Cuba, the community has been relocated five kilometers inland as a result of coastal erosion. Other less disruptive activities such as reconstructing groynes, building sand dune fences, and planting trees along the coast can also reduce the impact of coastal erosion on communities.

3.1.2.4 Water Resources

With the predicted decrease in water resources, island specific actions for adaptation to enhance water resources should include: incentives to encourage the use of water saving devices; selecting appropriate drought tolerant vegetation; establishing river buffer zones to enhance the resilience of the river and catchments area; updating national water policies; and improving water resources management.

In the area of water resource management, revising building codes to increase opportunities for rainwater catchments and storage would be advantageous. A few other profitable water resource management options could include; preparing water resource master plans for the islands; assessing and improving the water supply systems; rainwater harvesting; water demand management; provision of water storage and water efficient household appliances; flood risk analyses with land zoning; and flood mitigation actions.

3.1.2.5 Bio-diversity

Biodiversity-centered frameworks also need to be established in order to promote less destructive environmental practices. Training fishermen and women in sustainable fishing practices is another possible adaptation strategy.

3.1.2.6 Land Management

As far as land management is concerned, creating land use plans and corresponding enforcement strategies, strengthening institutional capacity to enforce land zoning restrictions and the application of beach setbacks for construction are all viable adaptation strategies.

3.1.2.7 Controlling Maladaptive Practices

Adaptation can also occur through the prevention and removal of maladaptive practices. Maladaptation has been defined by Inter-govermental Panel for Climate Change (IPCC) as “any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli.” An alternate definition for maladaptation is “an adaptation that does not succeed in reducing vulnerability but increases it instead.” Examples of laws and practices that can inadvertently increase vulnerability include: policies that lead to the

destruction of mangroves; the relaxation of coastal setback regulations; laws preventing the use of recycled water by hotels; and an absence of comprehensive coastal zone management and planning. Individuals can carry out maladaptive practices by deliberately ignoring the risks posed by climate change (such as repeatedly rebuilding property in a vulnerable zone).

3.2 SUSTAINABLE DEVELOPMENT

For sustainable development in SIDS, adaptation measures should be integrated into the main stream planning activities. Furthermore, adaptation options must be selected carefully, depending on the uniqueness and the specificity of the issue which is to be addressed. In most cases, however, SIDS lack the capacity and resources to integrate climate change concerns in development activities and to undertake the adaptation actions required.

In SIDS, a number of projects have been developed to build adaptive capacities and provide further options for adaptation. These projects not only involve strengthening institutions, policies and regulations, but also ground-level tasks such as water storage and drought resistant crops. Many are acting in synergy with projects on the mainstreaming of adaptation.

These programmes are being implemented within United Nations Framework Convention on Climate Change (UNFCCC). A number of country groups are part of UNFCCC (refer Annex-05). This is being accomplished with the support of bilateral development assistance agencies, multilateral financial institutions and UN agencies, especially those that serve as Global Environment Facility (GEF) implementing agencies.

Adaptation programmes vary in scope. Some projects provide support for multiple countries, including GEF-UNDP project 'Piloting Climate Change Adaptation to Protect Human Health' and GEF-World Bank project on 'Mainstreaming Adaptation to Climate Change (MACC) in the Caribbean Region'.

Many of the adaptation projects and programmes have assisted in the enhancement of national and regional capacity as it relates to climate change adaptation. This has been demonstrated in the Caribbean where the 'Caribbean Planning for Adaptation to Climate Change Project' has led to the establishment of the Caribbean Climate Change Centre to help address climate change concerns within the region.

Despite such projects, the need to develop adaptation capacity of SIDS remains high specially in the context of sustainable development. Adaptation to climate change cannot be addressed in isolation but needs to be incorporated into developmental activities. Enhancing adaptive capacity will only be successful when it is integrated with other policies such as disaster preparedness, land-use planning, environmental conservation, coastal planning and national plans for sustainable development.

4 INTERNATIONAL COOPERATION

4.1 MITIGATION

Climate change is a matter of future viability or even survival for many SIDS. While GHG emission levels by SIDS are insignificant, emissions by other countries have a disproportionate effect on them as discussed earlier. Furthermore, getting other countries to reduce their GHG emissions is a priority for SIDS.

At the international level Least Developed Countries (LDCs) and SIDS are members of the Group of 77 and China (G77/China), a negotiating bloc of developing countries within UNFCC (refer Annex-05). However, G77/China also has some of largest greenhouse gas emitters among developing countries.

Dilemma for LDCs and SIDS is that they are members of the same negotiating group with countries whose emissions levels are continuously increasing. These same countries are reluctant to reduce greenhouse gas emissions because of their development objectives.

Members of the Organization of Petroleum Exporting Countries (OPEC) are also G77/China constituents (refer Annex-05). Burning fossil fuels is one of the main contributors to GHG emissions. Cutting of emissions may not be in their short-term economic interests.

Large developing country emitters, who are members of G77/China, often refer to the principle of common but differentiated responsibilities, as a justification for not taking action to reduce their respective GHG emissions.

As a consequence, SIDS and LDCs are at variance with their developing country negotiating partners with regard to greenhouse gas emission reductions. SIDS and LDCs will need to convince their partners to take on the responsibility of reducing their greenhouse gas emissions.

4.2 ADAPTATION

Given that the emission levels of SIDS and LDCs are extremely low, their policy actions are largely restricted to adaptation. On their own, SIDS and LDCs cannot afford the costs of adaptation. Studies have estimated the cost of protecting the coasts of Jamaica from a sea-level rise of one metre at US$462 million. Adaptation costs have been estimated at US$71 million in Antigua and US$50 million in St Kitts and Nevis.

World Bank has estimated that between US$10 to 40 billion will be required for adaptation in developing countries. At the global level, some funds have been established to assist groups of countries such as SIDS and LDCs with the costs associated with adaptation. These include: -

i. **Global Environment Facility (GEF) Trust Fund**
   GEF, as an entity entrusted to operate the financial mechanism of the UNFCCC has established the Strategic Priority on Adaptation (SPA) under its Trust Fund. The

objective of SPA is to reduce vulnerability to and increase adaptive capacity to the adverse effects of climate change in the focal areas in which the GEF works. SPA supports pilot and demonstration projects that address local adaptation and at the same time generate global environmental benefits.

ii. **Special Climate Change Fund (SCCF)**
SCCF aims at supporting activities in the areas of: (a) adaptation; (b) technology transfer; (c) energy, transport, industry, agriculture, forestry and waste management; and (d) economic diversification. Adaptation activities to address the adverse effects of climate change have top priority for funding under the SCCF.

iii. **Least Developed Countries Fund (LDCF)**
LDCF was established to support a work programme to assist LDC Parties carry out, inter alia, the preparation and implementation of National Adaptation Programmes (NAPAs).

iv. **Adaptation Fund Under Kyoto Protocol**
Adaptation Fund was established to finance concrete adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol and will be financed from the share of proceeds of the clean development mechanism (CDM) and other sources. A two (2) percent levy on Clean Development Mechanism (CDM) projects is mandated by Kyoto Protocol. Some estimates have established that the fund could provide between US $270 to 600 million for adaptation projects. Clearly, this is not enough to meet even just the current adaptation needs.

In addition, some funding is also available under other multilateral environmental agreements whose areas of work could be synergetic with adaptation, including the Convention on Biological Diversity, the United Nations Convention to Combat Desertification and the Ramsar Convention on the Conservation of Wetlands.

There is no specific fund which addresses the concerns of SIDS, yet SIDS, along with LDCs, are the most vulnerable to climate change. In the context of the current negotiations on climate change, special consideration needs to be given to funding adaptation needs in SIDS. Priority access for SIDS to the current Adaptation Fund is one element, whereas the establishment of a special fund to address the adaptation needs of SIDS should be considered an option. In the meantime, there are some opportunities for cooperation within: -

i. Regional organizations, groups and networks.

ii. Programmes for SIDS within inter and non-governmental organizations.

iii. University and Think-Tank Programmes of Importance to SIDS.

The supporting details are in Annex-06.

In addition to the aforementioned international efforts for coping with climate change, there is a need to integrate climate change concerns in other development programmes at the global level.

5 UN INITIATIVES

5.1 DURBAN CONFERENCE OF UNFCCC

Calling on interconnectedness of the world philosophy, SIDS have long reminded us that forgetting their cause could amount to 'atmospheric apartheid'. To review the progress of Kyoto Protocol during 2011, a session of UNFCCC was held in Durban (South Africa). This conference of the parties served as 7th session to review the progress on Kyoto Protocol. This will be remembered in terms of important discussions, leading to continued faith in the multilateral system to come up with a climate deal. The relevance of the outcomes may not be known until 2020, by which time some islands would need to deal with the prospect of their disappearance. SIDS face an unparalleled challenge given their inherent vulnerability of territories regularly impacted by the severity of hurricanes or earthquakes, further exacerbated by climate change. With sea level rise slowly manifesting itself, some are progressively taking steps to access cleaner sources of energy in an effort to use the long-term savings from reduced reliance on fuel imports to shore up coastal protection measures. But the large amounts of finance required (and insurance premiums) cannot be underestimated, and might quadruple if the increased temperature target is not kept below 2°C (seems to be exceed in later part of 21st century as projected in Annex-04).

5.2 DECLARATION OF 2014 AS YEAR OF SIDS

UN has declared 2014 as the international year of Small Island Developing States (SIDS). In support of this UN designation, World Environment Day (WED) 2014 will adopt SIDS in the broader context of climate change as its theme. This will be an excellent opportunity to raise a call for global unity with the islands.

5.3 DOHA MOOT (2014)

This will also help build momentum towards the 'Third International Conference' at Doha in September 2014. The objective will be to encourage a greater understanding of the importance of SIDS and of the urgency to help protect the islands in the face of grooming risks and vulnerabilities, particularly as a result of climate change. Doha may not just be the next stop in the negotiating process, but the last chance for the world to give SIDS the post-Kyoto regime they need.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

SIDS and LDCs are at the frontline of climate change effects, but they remain on the margins of the current debate on climate change. It is ironical that whereas their contribution to GHG emissions is insignificant, climate change would continue even with the most optimistic global reductions in this respect. Therefore, the priority focus is rightly on adaptation. On the other hand: -

i. Adaptation to climate change is not only a sustainable development challenge but also, in some cases, a survival issue. For adaptation to be successful, a number of actions are required at both national and international levels.

ii. In order to make better and informed, decisions about climate change impacts, it is important to improve the understanding of multiple stresses at all levels – local, national and global. Thus more research is needed to understand the impact of climate change on LDCs and SIDS and options for adaptation in view of their structural weaknesses.

iii. National Adaptation Programmes of Action (NAPA) prepared by the LDCs / SIDS are an important step in enhancing adaptive capacity. However, most of the current adaptation programmes focus on one or two sectors. There is need for such programmes to be more comprehensive. Indeed, adaptation needs should be mainstreamed in national development plans and strategies.

6.2 RECOMMENDATIONS

6.2.1 General

i. These countries have neither the financial resources nor the technical capacities to meet their adaptation needs. Therefore, the international community should provide stronger financial and technical support to both through the special funds such as the Least Developed Countries Fund and other international frameworks, including the Brussels Programme of Action for the LDCs and the Barbados Programme of Action for SIDS. In case of SIDS, consideration should be given to establishing a special fund for them along the lines of the LDC fund.

ii. These countries should significantly enhance their adaptation capacity through regional arrangements and pooling of resources. For example, it might be more efficient to establish and manage early warning systems at regional rather than national levels.

iii. These countries need to bring their influence to bear within the G77/China to gain support for significant reductions in global GHG emissions.

6.2.2 Agenda For Doha

In comparison with other regions of the world, SIDS have a high awareness of the impacts of climate change and the need to adapt, and are advanced in mainstreaming adaptation into their policy frameworks and development efforts. There are many adaptation projects on the ground with more projects in the pipeline but there are still barriers to adaptation that need to be removed.

Avenues for regional cooperation and sharing of traditional knowledge, project outcomes and technical data are extensive and should be exploited to help identify and remove barriers to adaptation. In addition to this, the following issues should be included in the agenda of Doha: -

i. How can outcomes of completed projects be disseminated effectively so that the information can be used by others?

ii. Decline in the use of local coping strategies and traditional knowledge is suggested as one reason for increased vulnerability of SIDS to climate change. However, does the reverse occur? Are some local coping strategies outdated and perhaps maladaptive? How can a balance be reached between modern technologies and traditional strategies in adapting to climate change?

iii. Is insurance the most suitable mechanism for risk transfer? What needs to be done first in order for insurance schemes to be successful (e.g. comprehensive risk assessment)?

iv. With adaptation being carried out by many different organizations, how can future adaptation projects be coordinated so that it is ensured that vulnerable sectors, areas or communities are not overlooked?

v. International migration from island countries to other island countries or larger states; or the internal migration of islanders between different islands poses political, socio-economic and ethical questions. How will climate change impact on this issue?

vi. How are the policies of other countries likely to affect adaptation to climate change in SIDS, for example, in terms of immigration and foreign trade policies?

vii. How can existing networks and organizations be better used to improve cooperation on adaptation and increase adaptation activities?

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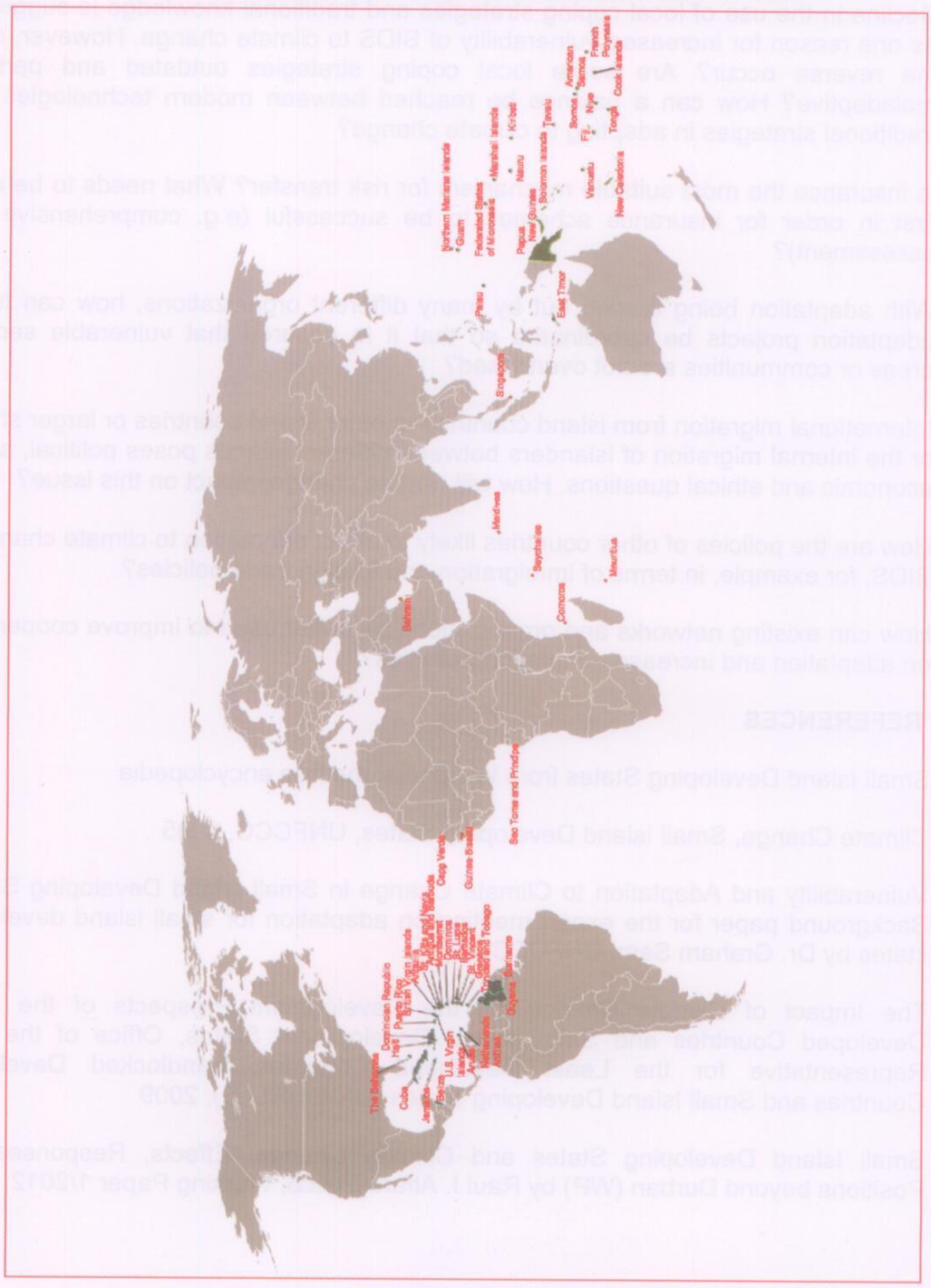
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ANNEX-01

MAP OF THE SMALL ISLAND DEVELOPING STATES



ANNEX-02

LIST OF SMALL ISLAND DEVELOPING STATES BY REGIONS

Caribbean (23)	Pacific (20)	Africa, Indian Ocean, Mediterranean and South China Sea (AIMS) (9)
Anguilla	American Samoa	Bahrain
Antigua and Barbuda	Cook Islands	Cape Verde
Aruba	Federated States of Micronesia	Comoros
Bahamas	Fiji	Guinea-Bissau
Barbados	French Polynesia	Maldives
Belize	Guam	Mauritius
British Virgin Islands	Kiribati	São Tomé and Príncipe
Cuba	Marshall Islands	Seychelles
Dominica	Nauru	Singapore
Dominican Republic	New Caledonia	
Grenada	Niue	
Guyana	Northern Mariana Islands	
Haiti	Palau	
Jamaica	Papua New Guinea	
Montserrat	Samoa	
Netherlands Antilles	Solomon Islands	
Puerto Rico	Timor-Lestehttp://en.wikipedia.org/wiki/Small_Island_Developing_States-cite_note-note1-12	

Caribbean (23)	Pacific (20)	Africa, Indian Ocean, Mediterranean and South China Sea (AIMS) (9)
Saint Kitts and Nevis	Tonga	
Saint Lucia	Tuvalu	
Saint Vincent and the Grenadines	Vanuatu	
Suriname		
Trinidad and Tobago		
United States Virgin Islands		

ANNEX-03

TOTAL GREENHOUSE GAS EMISSIONS 2003 – SELECTED COUNTRIES

Country	Mega Tonnes Carbon	World Rank	Percent of World Total
USA	1,576.90	1	22.27
China	1,227/40	2	17.34
European Union	1,092.60	-	15.43
India	313.4	6	4.43
Brazil	90.7	19	1.28
Least Developed Countries	38.1	-	0.54
Alliance of Small Island Developing States	37.7	-	0.53

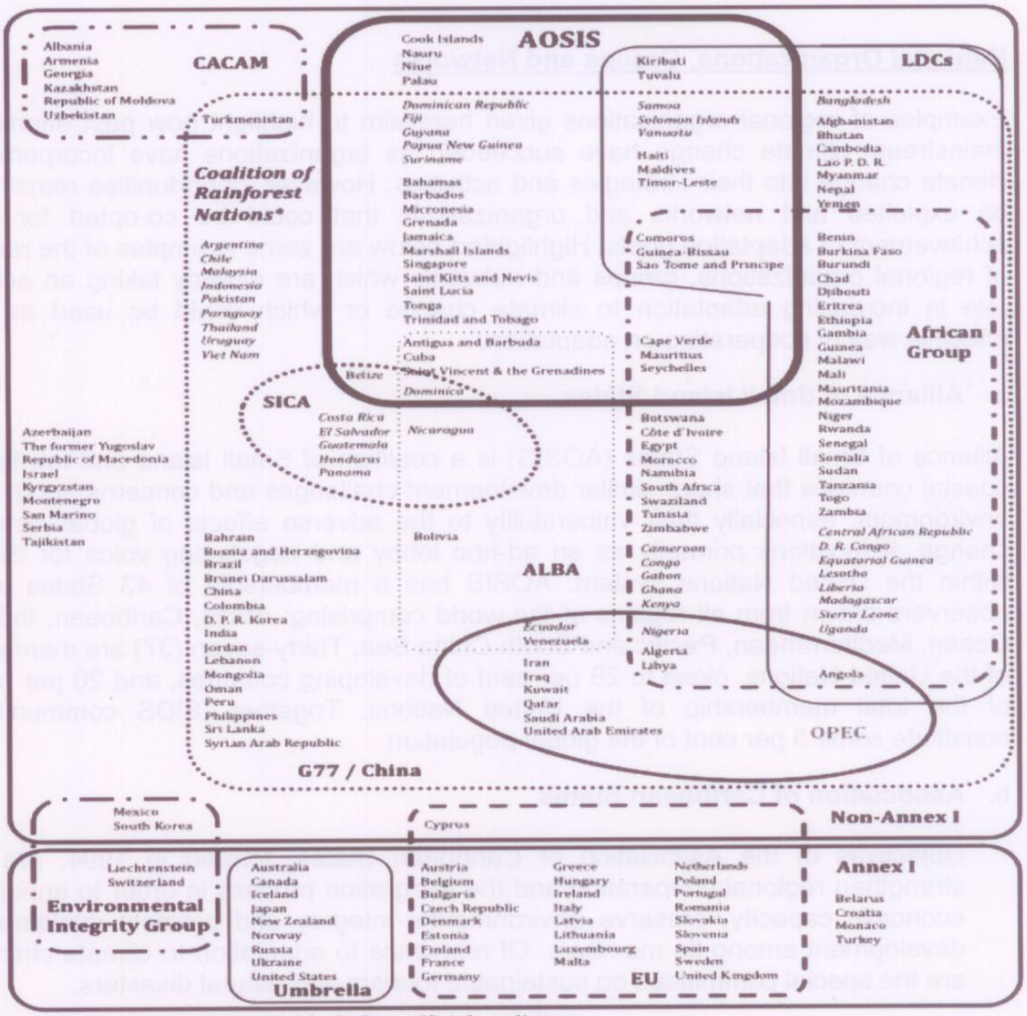
ANNEX-04

PROJECTED INCREASES IN AIR TEMPERATURE (°C) AND PRECIPITATION (%) BY REGION, RELATIVE TO THE 1961-1990 PERIOD

Region	2010–2039	2040–2069	2070–2099
I. Temperature Changes (°C)			
Mediterranean	0.60 to 2.19	0.81 to 3.85	1.20 to 7.07
Caribbean	0.48 to 1.06	0.79 to 2.45	0.94 to 4.18
Indian Ocean	0.51 to 0.98	0.84 to 2.10	1.05 to 3.77
Northern Pacific	0.49 to 1.13	0.81 to 2.48	1.00 to 4.17
Southern Pacific	0.45 to 0.82	0.80 to 1.79	0.99 to 3.11
Average Variation	**0.506 to 1.236**	**0.810 to 2.534**	**1.036 to 4.460**
Mean	**0.87**	**1.672**	**2.748**
II. Precipitation Changes (%)			
Mediterranean	−35.6 to +55.1	−52.6 to +38.3	−61.0 to +6.2
Caribbean	−14.2 to +13.7	−36.3 to +34.2	−49.3 to +28.9
Indian Ocean	−5.4 to +6.0	−6.9 to +12.4	−9.8 to +14.7
Northern Pacific	−6.3 to +9.1	−19.2 to +21.3	−2.7 to +25.8
Southern Pacific	−3.9 to +3.4	−8.23 to +6.7	−14.0 to +14.6
Average Variation	**−13.080 to +17.460**	**−24.646 to +22.580**	**−27.360 to +18.040**
Mean	**+4.38**	**−2.07**	**−9.32**

ANNEX-05

UNFCCC COUNTRY GROUPS



** countries in italics form part of the Coalition of Rainforest Nations.*

Source: Betzold *et al.* (2011), as adapted from Castro *et al.* (2011).

ANNEX-06

OPPORTUNITIES FOR COOPERATION

1. Regional Organizations, Groups and Networks

Examples of regional organizations given here aim to highlight how past efforts to mainstream climate change have succeeded as organizations have incorporated climate change into their strategies and activities. However, opportunities remain to be exploited and networks and organizations that could be co-opted for the achievement of adaptation goals. Highlighted below are some examples of the range of regional organizations, groups and networks which are already taking an active role in increasing adaptation to climate change or which could be used as an effective way of cooperating on adaptation.

a. Alliance of Small Island States

Alliance of Small Island States (AOSIS) is a coalition of Small Island and low-lying coastal countries that share similar development challenges and concerns about the environment, especially their vulnerability to the adverse effects of global climate change. It functions primarily as an ad-hoc lobby and negotiating voice for SIDS within the United Nations system. AOSIS has a membership of 43 States with observers drawn from all regions of the world comprising: Africa, Caribbean, Indian Ocean, Mediterranean, Pacific and South China Sea. Thirty-seven (37) are members of the United Nations, close to 28 per cent of developing countries, and 20 per cent of the total membership of the United Nations. Together, SIDS communities constitute some 5 per cent of the global population.

b. Association of Caribbean States

Objectives of the Association of Caribbean States, formed in 1994, are to strengthen regional cooperation and the integration process in order to enhance economic capacity, preserve environmental integrity and promote sustainable development among its members. Of relevance to adaptation to climate change are the special committees on sustainable tourism and natural disasters.

c. CARICOM

CARICOM was established in 1972 to improve standards of living and work; the full employment of labour and other factors of production; accelerated, coordinated and sustained economic development and convergence; expansion of trade and economic relations with third States; enhanced levels of international competitiveness; organization for increased production and productivity; achievement of a greater measure of economic leverage and effectiveness of

Member States in dealing with third States, groups of States and entities of any description and the enhanced coordination of Member States' foreign and foreign economic policies and enhanced functional cooperation. All objectives of CARICOM are threatened by the impacts of climate change. It provides an important framework through which adaptation to climate change can take place. In 2000, CARICOM established the Caribbean Community Climate Change Centre, which aims to protect the climate system in the region, enhance capacity of member governments to coordinate national responses to climate change, provide policy and technical support on climate change issues and act as an executing agency for regional projects relating to climate change. In December 2006, the Caribbean Community Climate Change Centre hosted a workshop on regional downscaling in Havana, Cuba.

Global Islands Network

The Global Islands Network (GIN) aims to serve as a hub that connects and coordinates efforts to help ensure a healthy and productive future for islanders. GIN brings together islanders and partner organizations, borrowing as well as replicating best practices to tackle sustainable development problems, and problems such as sea-level rise, the cause of which is beyond the control of small island states.

d. Indian Ocean Commission (Commission de l'Océan Indien)

Indian Ocean Commission (IOC) is an inter-governmental organization that brings together the Comoros, France (Réunion Island), Madagascar, Mauritius and Seychelles, with the objective of promoting sustainable development in the Western Indian Ocean Islands. IOC also represents the island states in international forums and defends their interest with regard to specific environmental and economic issues. It also facilitates regional cooperation and integration.

e. Organization of Eastern Caribbean States

Environment and Sustainable Development Unit of Organization of Eastern Caribbean States (OECS) has brought the member governments together to create the St. Georges' Declaration of Principles for Environmental Sustainability in the OECS. The Declaration contains 21 principles that were formed by peoples and governments of member states as a guide for environment management within their countries. Importantly, principle eight is called Preparation for Climate Change and states that: "Governments will enact laws, create organizations and institutions and provide money to assist people and communities to adapt to the impact of climate change".

f. Pacific Islands Forum

Pacific Islands Forum, founded in August 1971, comprises 16 independent and selfgoverning states in the Pacific. The Forum is the region's premier political and economic policy organization. Forum Leaders meet annually to develop collective responses to regional issues.

g. Pacific Regional Environment Programme

Pacific Regional Environmental Programme (PREP) has the mandate to promote cooperation in the Pacific Islands region and to provide assistance to protect and preserve the environment while ensuring sustainable development. It is highly active in terms of climate change, for example through initiatives such as the Pacific Islands Framework for Action on Climate Change 2006–2015 and Capacity Building for the Development of Adaptation Measures in Pacific island countries (CBDAMPIC).

h. Secretariat of the Pacific Community

The Secretariat of Pacific Community (SPC) cooperates with member countries, donors and other organizations to deliver work programmes to members that aim to develop technical assistance, professional, scientific and research support, and planning and management capability. During thirty-sixth Meeting of the Committee of Representatives of Governments and Administrations (CRGA) from 13 to 17 November, 2006, policy agenda item 3.1 addressed Key issues affecting Pacific Island countries and territories under which the issue of climate change was highlighted. Specific problems highlighted were alteration and possible irreversible damage to biodiversity, changed and unpredictable weather patterns, sea-level rise and reduced food security.

i. SIDSnet

SIDSnet was created in 1998 as a way of facilitating communication among SIDS to assist them in the implementation of the sustainable development goals embedded in the Barbados Programme of Action. It aims to form partnerships through the internet and other information and communication technologies.

j. South Pacific Applied Geoscience Commission

South Pacific Applied Geoscience Commission (SOPAC) is an intergovernmental regional organization which provides services to aid sustainable development in the Pacific countries it serves. It is introducing adaptation mechanisms to climate change, climate variability and sea-level rise as part of its Oceans and Islands programme.

2. Programmes for SIDS within inter and non-governmental organizations

Many organizations have environmental programmes specifically for SIDS are: -

a. Caribbean Environment Programme

The Caribbean Environment Programme (CEP) is a conglomerate of legislative, programmatic and institutional frameworks and entities working together to assist the nations and territories of the Wider Caribbean Region to protect their marine and coastal environment and promote sustainable development. The work of the CEP is based around the Caribbean Action Plan and is funded through the Caribbean Trust Fund. Although none of the CEP sub-programmes specifically target climate change, the work of CEP will be threatened by climate change, and adaptation should be a key concern.

b. Coastal Regions and Small Islands Platform of UNESCO

Concentrating on the mitigation and management of conflicts over coastal resources and values, the Coastal Regions and Small Islands Platform (CRSIP) works through field based projects, UNESCO Chairs and university twinning and a multi-lingual internet-based forum. With regard to small island states, it focuses mainly on helping implementation of the Barbados Programme of Action. Climate change and sea-level rise is one of the domains of the 1994 Barbados Programme of Action, the implementation of which has now been reinforced through the Mauritius Strategy.

c. Regional Offices (UNEP)

UNEP has a regional office for Latin America and the Caribbean (ROLAC), for Africa (ROA) and for Asia and the Pacific (ROAP). These offices are carrying out many initiatives which contribute towards sustainable development of the region.

d. Small States Forum (World Bank)

At the Small States Forum of the Work Bank, representatives of the 45 small developing countries that are members of the World Bank meet to discuss issues of particular interest to them.

3. University and Think-tank Programmes of Importance to SIDS

These comprise: -

a. Pacific Islands Development Program (East-West Centre), United States.

b. International Global Change Institute at the University of Waikato, New Zealand.

c. University of Malta - Islands and Small States Institute, Malta.

d. Universities Consortium of Small Island States, (UCSIS), multi-country.

e. Tyndall Centre for Climate Change Research, United Kingdom of Great Britain and Northern Ireland.

DISASTER VULNERABILITY, RISK REDUCTION AND MITIGATION IN SMALL ISLAND DEVELOPING STATES

Saba Dar, Ali Hasnain Sayed, Sohail Ali Naqvi

Introduction:

Small Island Developing States (SIDS) are a distinct group of developing countries facing specific social, economic and environmental vulnerabilities. SIDS were recognized as a special case both for their environment and development at the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, held in Rio de Janeiro, Brazil (3–14 June 1992). This recognition was made specifically in the context of Agenda 21.

SIDS are spread over three geographical regions namely, the Caribbean, the Pacific and the Atlantic, Indian Ocean, Mediterranean and South China Sea (AIMS). Small Island Developing States (SIDS) represent less than one per cent of the world's total population. SIDS are a highly diverse group both in terms of their unique social and cultural identity but equally in their economic and political development. Despite this, all SIDS share a common reality. SIDS are located among the most vulnerable regions in the world in relation to the intensity and frequency of natural hazards. SIDS face high levels of disaster risk, have comparatively low economic resilience and have high or extreme levels of environmental vulnerability.

Background:

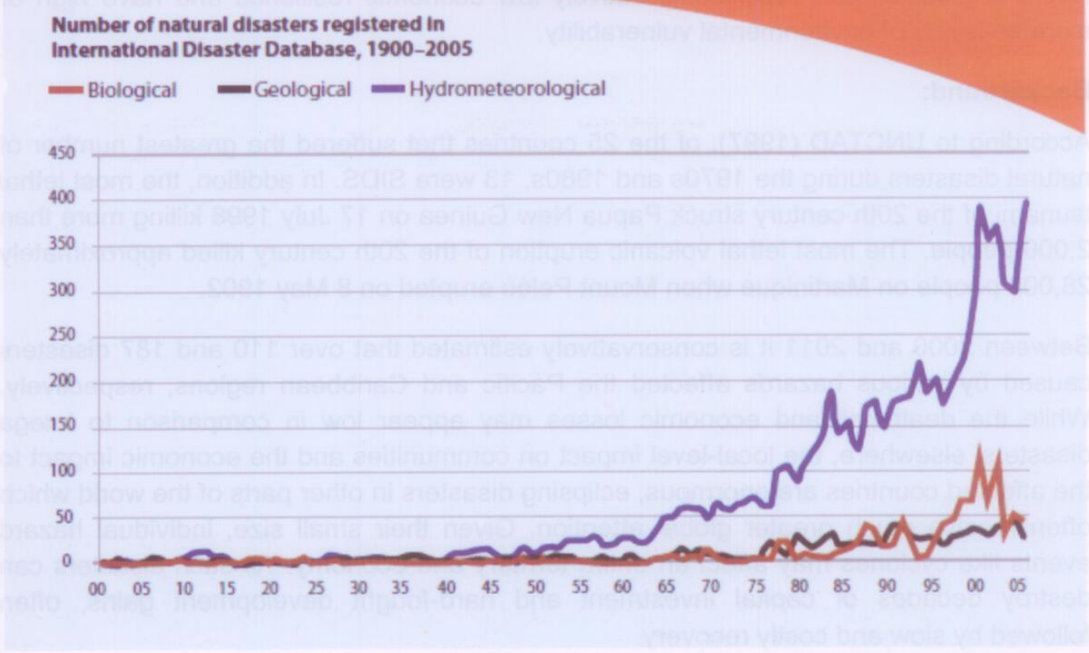
According to UNCTAD (1997), of the 25 countries that suffered the greatest number of natural disasters during the 1970s and 1980s, 13 were SIDS. In addition, the most lethal tsunami of the 20th century struck Papua New Guinea on 17 July 1998 killing more than 2,000 people. The most lethal volcanic eruption of the 20th century killed approximately 28,000 people on Martinique when Mount Pelée erupted on 8 May 1902.

Between 2000 and 2011 it is conservatively estimated that over 110 and 187 disasters caused by various hazards affected the Pacific and Caribbean regions, respectively. While the death toll and economic losses may appear low in comparison to 'mega disasters' elsewhere, the local-level impact on communities and the economic impact to the affected countries are enormous, eclipsing disasters in other parts of the world which often receive much greater global attention. Given their small size, individual hazard events like cyclones may affect an entire territory and economy. As such disasters can destroy decades of capital investment and hard-fought development gains, often followed by slow and costly recovery.

Scaling the economic impact of disasters provides a clearer picture on how development in SIDS is affected by disasters. For example Cyclone Ivan in 2004 resulted in estimated direct losses of $900 million in Grenada, more than twice the country's GDP. Cyclone Evan, which hit the South Pacific in 2012, resulted in total losses equivalent to one third of Samoa's annual economic output. Similarly, losses associated with the 2010 earthquake in Haiti are estimated to have exceeded 15 per cent of GDP. The increased indebtedness and constrained fiscal space can have long-term developmental consequences.

SIDS are located mainly in tropical and sub-tropical oceans. Their climate is influenced strongly by ocean-atmosphere interactions which often manifest themselves in extreme weather events such as hurricanes and cyclones. These events are associated with storm surges, coral bleaching, inundation of land, and erosion (with resulting high-cost damages to socio-economic and cultural infrastructure). In the Pacific islands region cyclones accounted for 76 per cent of the reported disasters from 1950 to 2004 with the average costs relating to damage caused per cyclone standing at USD 75.7 million in real 2004 value.

Figure 1: The rise of global disasters



Definitions:

Disaster: A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources. (UN/ISDAR, 2009)

Vulnerability: a human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard. (UNDP, 2004: 11).

Risk: The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period. (UN/ISDAR, 2009)

Mitigation: The lessening or limitation of the adverse impacts of hazards and related disasters. (UN/ISDAR, 2009)

Why SIDS are more vulnerable to disasters?

Small Island Developing States (SIDS) are 'undersized' in terms of land mass, population, and economic weight, but 'oversized' with respect to endemic biodiversity and indigenous bio-cultural heritage, economic and social features that makes them vulnerable to natural hazards, external economic shocks, and climate change. These include:

- **small size and endowment with natural resources**; high intensity of land use and concentration of industrial assets, critical infrastructure and urban areas in low laying coastal zones (LCZ) prone to elevated risk;
- **insularity and remoteness** implying sizeable costs for international trade, dependence on few commodities as sources of foreign exchange earnings, small internal market, low economic diversification, barriers to innovation and technology transfer, low investment in research and technology with subsequent impacts on employment and economic growth, dependency on fossil fuel imports;
- **limited capacity** to cope with natural hazards and adapt to the likely impact of climate change, weak institutional capacity and environment, under-developed skills and know-how to deploy and service new technologies, and limited domestic financial resources.

Factors of Increased Vulnerability:

a. Urbanisation

The Caribbean is the most urbanised island region. Here the urban population has been growing at 2.4 per cent per annum between 1990 and 1995. In the Pacific Islands region, Fiji is the most urbanised with 41.2 per cent of its population being urban in 1997. Similar rates of urbanisation can also be observed in the West African coast (Cape

Verde at 57.7 per cent urbanised in 1997) and Indian Ocean (Seychelles at 56.1 per cent urbanised in 1997) (UNDP, 1999). Many islands, especially the smaller islands in the Pacific, Indian Ocean and Caribbean regions continue to be dominated by rural populations but the overall trend is towards urbanisation and this brings with it a shift in the nature and focus of vulnerability to natural hazard.

Urbanisation and attendant industrial development concentrate risk. Rapid and unplanned nature of urban expansion in the Caribbean and Pacific islands means that growing numbers of residents are denied access to urban services and basic needs and exposed to industrial hazards. Inadequately constructed and dense dwelling forms, and the growth of informal settlements in vulnerable locations on steep hill-slopes or adjacent to hazardous industry similarly generate risk and were principal reasons for the large losses experienced in urban fringe settlements following Hurricane Mitch that devastated large tracts of the Caribbean coast in 1999.

b. Local environmental degradation

Local development activities are the cause of much environmental change and associated human vulnerability in small islands. Many local pressures combine with global environmental change to place additional stress on local ecologies. Examples include, serious water resource problems due to salt intrusion, coral bleaching and mangrove loss, both increasing the exposure of coastlines to flooding (IPCC; 2001). Cutting of forests for local consumption and associated changes in micro-climate and slope instability have resulted in landslide hazards in the Caribbean islands, especially Haiti and the Lesser Antilles and drought in the West African islands. Similar environmental changes have been experienced in the Pacific islands. Do many of the islands not have a serious water problem due to salt intrusion?

c. Climate Change

SIDS are among the countries that contribute least to climate change, with less than one per cent of total carbon dioxide emissions, yet stand to suffer most from its negative impacts. Climate change is likely to disproportionately magnify disaster risk in SIDS, due to sea level rise and associated flood and storm surge hazard, increasing cyclonic wind intensity, coastal erosion, saltwater intrusion into coastal aquifers and worsening water scarcity and drought. In the Caribbean, changes in annual hurricane frequency and intensity could result in additional annual losses of $446 million by 2080, incurred mainly from business interruption to the tourism sector.

SIDS are already experiencing the adverse effects of climate change. Sea-level rise has been negatively impacting the national economies of SIDS and the potential to cause further damage. Significant socio-economic impacts of climate change which are

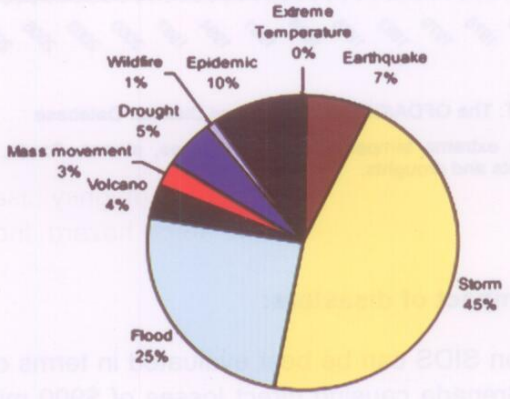
distinctive to many SIDS relate to equity and sovereignty. The impacts of climate change have the potential to make some atoll islands such as Kiribati, Tuvalu and the Maldives uninhabitable through changes in precipitation (causing drought which affects drinking water directly and food security through agriculture), sea surface temperatures (causing coral bleaching which affects artisanal fisheries and reduces storm surge protection) and extreme events (which impact infrastructure, agriculture and cause salt water intrusion into the freshwater lens). If societies, or even communities, are forced to leave because of these impacts, some nations may lose their sovereignty.

Disaster Vulnerability:

SIDS are located mainly in tropical and sub-tropical oceans. Their climate is influenced strongly by ocean-atmosphere interactions which often manifest themselves in extreme weather events such as hurricanes and cyclones. Natural disasters in many SIDS have undone the development achievements of years, even decades. Of the 25 countries that suffered the greatest number of natural disasters during the 1970s and 1980s, 13 were SIDS. Between 2000 and 2011, over 110 and 187 disasters caused by various hazards affected the Pacific and Caribbean regions, respectively.

SIDS are most commonly vulnerable to hydro-meteorological disasters such as cyclones, tropical storms, windstorm related events, accounting for an estimated **45%** of all natural disasters in SIDS. The share of the damage impact is even larger. Significant flooding is one of the after-effects of cyclones, estimated to cause 25% of the disasters.

Total number of disasters affecting SIDS by type of disaster: 1990 - 2009

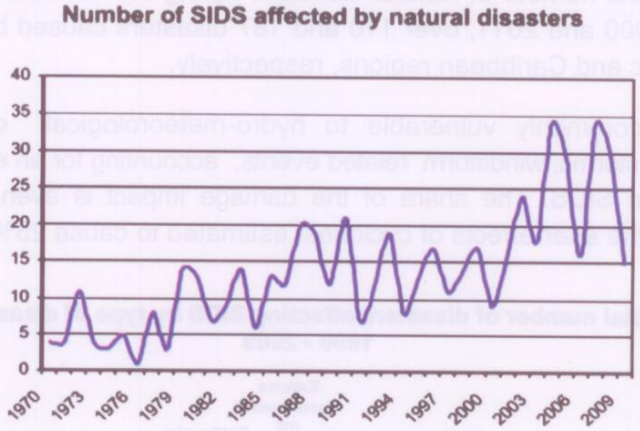


Source: **EMDAT: The OFDA/CRED International Disaster Database**

Disaster Impacts:

Given the small size of SIDS, individual hazard events may affect an entire territory and economy. Whether measured in terms of *area affected, population affected, houses destroyed,* or as *economic loss,* the highest proportional impacts are upon the island states (in contrast to other countries). For example, even the most catastrophic continental country earthquakes (eg: Guatemala; Algeria; Mexico City; Turkey; Gujarat) equate often to less than one percent of homeless of national populations than the homelessness repeatedly caused by tropical cyclones in islands states. Some of the disaster impacts on SIDS include;

- The devastation of the agricultural sector
- The wiping out of entire village settlements,
- The disruption of a high proportion of communication services.
- Injury or death of a relatively high percentage of inhabitants.



Source: EMDAT: The OFDA/CRED International Disaster Database

Note: Including extreme temperatures, earthquakes, storms, floods, volcanoes, mass movements and droughts.

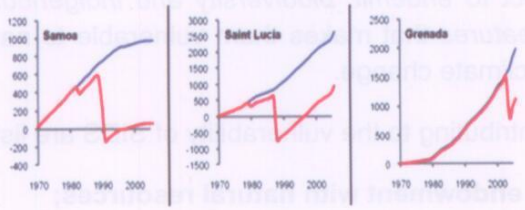
Fig. 2

Scaling the Economic Impact of disasters:

The impact of disasters on SIDS can be best evaluated in terms of economic losses. In 2004, Cyclone Ivan hit Grenada causing direct losses of $900 million, more than twice the country's GDP. Cyclone Evan, 2012 in South Pacific resulted in total losses equivalent to one third of Samoa's annual economic output and the earthquake that rocked Haiti in 2010 caused losses exceeding 15 per cent of GDP. According to a study,

Samoa, Saint Lucia, Grenada, Vanuatu, Tonga and Maldives suffered highest economic losses on capital stock due to natural disasters from 1970 to 2006.

Capital accumulation in Samoa, Saint Lucia and Grenada from 1970 to 2006, in relative terms. Red: actual, blue: time trend.



Source: Baritto, 2008

Fig. 3

Scale of Vulnerability:

A study conducted by Global Environment Facility and University of Liverpool ranked SIDs according to their vulnerability to natural disasters. The following table shows the ranking:

Group	Island	Number of disasters during 1900-1997
Greater Antilles	Cuba	47
	Haiti	48
	Jamaica	44
South Pacific	Papua New Ginuea	47
Small Pacific Islands	Fiji	41
	Tonga	55
	Vanautu	32

The highest number of disasters, took place in Tonga located in Small Pacific Islands followed Haiti, Cuba, Papua New Ginuea and Jamaica. Lesser Antilles, most of the Pacific islands, Indian and West African islands have mid to low intensities of disaster whereas Singapore is an exceptional case, being the only island not to record a disaster.

Why SIDS are more vulnerable to disasters?

After having established that SIDS are most vulnerable to disaster, the question now arises why is it so? There are many factors that contribute to their vulnerability. SIDS maybe 'undersized' in terms of *land mass, population, and economic weight,* but are **'oversized'** with respect to *endemic biodiversity and indigenous bio-cultural heritage, economic and social features* that makes them vulnerable to natural hazards, external economic shocks, and climate change.

Some of the factors contributing to the vulnerability of SIDS are listed as follows:

1. **Small size and endowment with natural resources;**
    - high intensity of land use and concentration of industrial assets
    - critical infrastructure and urban areas in low laying coastal zones (LCZ) prone to elevated risk;
2. **Geography and remoteness**
    - dependence on few commodities as sources of foreign exchange earnings,
    - low economic diversification
    - Fragile ecosystems
    - barriers to innovation and technology transfer,
    - low investment in research and technology with subsequent impacts on employment and economic growth,
    - dependency on fossil fuel imports;
3. **Limited capacity to cope** with natural hazards and adapt to the likely impact of climate change,
    - weak institutional capacity and environment,
    - under-developed skills
    - limited domestic financial resources

Key Vulnerabilities to Climate Change:

The vulnerability of SIDS to disasters has been exacerbated by climate change. With an increase in the temperature and shifting patterns of rainfall, SIDS are suffering from many economic, environmental and social consequences. A few of these are listed as follows:

- Sea surface temperatures have been risen by 0.1°C per decade in the oceans where SIDS are located. In the Caribbean, analysis of data from the late 1950s to 2000 has shown that the number of very warm days and nights is increasing

dramatically. The Caribbean Sea has warmed by 1.5ºC over the last century. A warming trend ranging from an annual mean change of 1.98 ° C in the Pacific Ocean to a change of 2.10 ° C in the Indian Ocean has been predicted by the 2050s. A decrease in the precipitation level in SIDS has also been predicted with prolonged dry spells.

- Sea-level rise is a major concern for SIDS. Major population of many SIDS lives in the low elevation coastal zone (LECZ), only less than 10 metres above sea level. These settlements are extremely vulnerable to sea-level rise, storm surges, floods and other climate change-induced hazards. For example, the islands of Maldives, with all of their land area 5m above Sea-level, are extremely vulnerable to even a minor rise in sea-level. The IPCC report published in 2007 estimated that by 2100, global warming will lead to a sea-level rise of 180 to 590 mm, while more recent research suggests a rise of up to about two meters.

- With climate change, Tropical cyclone intensities could increase 5 to 10 per cent by about 2020 whereas the peak precipitation rates are likely to increase by 25 per cent. For the Caribbean, extreme events (e.g. drought) may become more frequent and hurricane intensity could increase.

- The prospect of land loss and salinization due to climate change and sea-level rise will threaten the sustainability of both subsistence and commercial agriculture causing irreparable damage to food crops and other livelihood material on which small island populations depend. Extended droughts, triggered by climate change, often result in low exports and high imports.

- Fisheries contribute up to 10 per cent of the GDP in many SIDS. It is expected that changes in climate may cause migratory shifts in tuna aggregations to other locations.

- SIDS are home to an important proportion of the world's biodiversity. However, mangroves may not be able to keep pace with rising sea level depending on the composition of the forest, tidal range and sediment supply. Studies have projected that 3 per cent of Cuba's mangrove forests will be lost with a one meter rise in sea level and a complete collapse of the Port Royal mangrove wetland in Jamaica will occur. Coral reefs have also been threatened by rises in sea surface temperatures which lead to coral bleaching.

- In the next 30 to 50 years, bleaching events could occur every year in most tropical oceans. Another threat to coral reefs is that of rising CO_2 concentrations

in the oceans. Calcification rate of corals could decrease by about 14 to 30 per cent by 2050.

- The primary source of water in low-lying SIDS such as Maldives is groundwater while rainwater is also very important for most of the SIDS in Pacific. Many of the SIDS already fall under the category of 'water scarce nations' and climate change has exacerbated the issue. The dependency on rainfall increases the vulnerability of small islands to future changes and distribution of rainfall. Low rainfall can lead to a physical scarcity of water. It has been estimated that a 10 per cent reduction in average rainfall by 2050 could produce a 20 per cent reduction in the size of the freshwater lens on Tarawa Atoll, Kiribati. The wet and dry cycles associated with ENSO episodes can also have serious impacts on water supply and island economies.

Reducing Vulnerabilities through Disaster Risk Reduction:

Disaster risk reduction is the concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment and the improved preparedness for adverse events (UNISDR 2008). Many international efforts have been directed towards drafting a disaster risk reduction framework in order to reduce the risks associated with vulnerable nations.

In 1994, the "Yokohama Strategy and Plan for Action for a Safer Word", was endorsed at the First World Conference on Natural Disaster Reduction. This plan acknowledged social liability of rising risk and vulnerability. In 2004, Second World Conference on Natural Disaster Reduction was held in order to track the progress made since Yokohama and define the subsequent steps for the years 2005 to 2015.

Hyogo Framework for Action 2005-2015 (HFA):

The first internationally accepted framework for DRR is Hyogo Framework for Action 2005-2015 (HFA). Held in Kobe, the Conference led to the adoption of the Hyogo Framework for Action 2005-2015 (HFA) Building the Resilience of Nations and Communities to Disasters. The framework has been signed by 168 countries; however, it is not legally binding.

The HFA specified five Priorities for Action which are as follows:

1. Ensuring that disaster risk reduction (DRR) is a national and a local priority with a strong institutional basis for implementation;

2. Identifying, assessing and monitoring disaster risks and enhancing early warning;
3. Using knowledge, innovation and education to build a culture of safety and resilience at all levels;
4. Reducing the underlying risk factors;
5. Strengthening disaster preparedness for effective response at all levels.
6. The framework also emphasized the need to monitor and review the progress in DRR at the national, subnational and regional levels.

The Mauritius Strategy for the Further Implementation of the Programme of Action for SIDS:

The strategy has set out the basic principles and specific actions required at the national, regional and international levels to support sustainable development. The pillars of sustainable development that the strategy includes are economic development, social development, and environmental protection. It has been adopted by 129 countries and territories in the global conference held in 2005 and covers the decade **2005-2015**. It is the **only global development strategy** that addresses the **unique development problems of SIDS.**

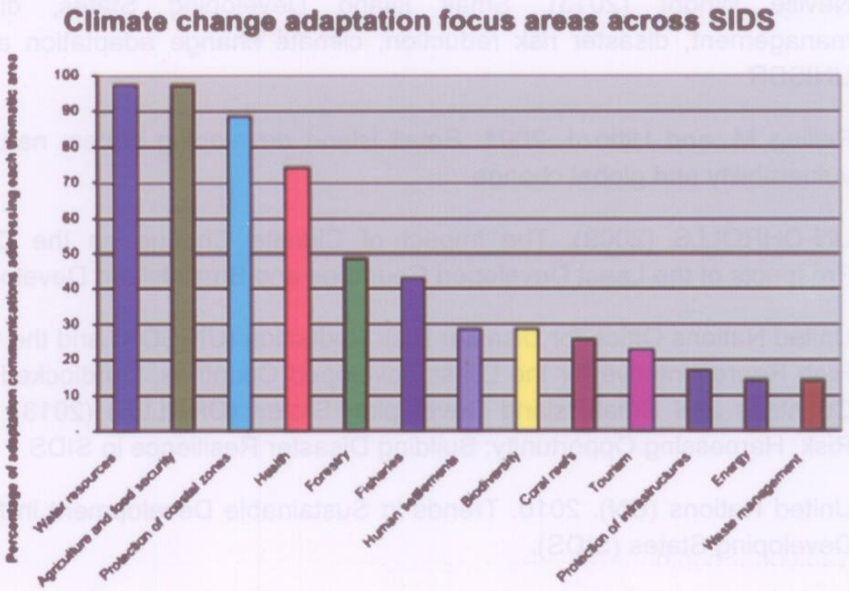
Essential components of DRR Plan:

- **Identification of the root causes of disaster risk** in terms of hazard, exposed elements and vulnerability
- **Promotion of a multi-hazard approach** to DRR which addresses all the major disaster risks which the country faces.
- **Development** of lasting in-country **capacity**
- **Reduction of the vulnerabilities** of the poorest and other marginalised groups..
- Reduction of specific risks and vulnerabilities that may undermine efforts to achieve the MDGs and other international conventions to which the country is party.
- Public commitment and institutional frameworks, including organizational, policy, legislation and community action
- **Building on existing experiences, capacities and mechanisms,** including utilising lessons learned on DRR from past development and humanitarian

- Application of measures, including environmental management, land use and urban planning, protection of critical facilities, application of science and technology, partnership and networking, and financial instruments; and
- Early warning systems, including forecasting, dissemination of warnings, preparedness measures and reaction capacities.

Mitigation and Adaptation:

- Adaptation has been taking place through individual, ad-hoc actions on a local scale. Different measures taken for mitigation and adaptation include;
- Placing concrete blocks on the top of zinc roofs to prevent the roofs from being blown away during hurricanes (Jamaica).
- Relocating villagers to elevated ground levels (15 m above sea level).
- Traditional coping strategies to new climate conditions. For example, on Timor Island farmers have developed their own varieties of major staple crops to adapt to erratic rainfall and cyclones and to ensure food security.
- Building sand dune fences, and planting trees along the coast can reduce the impact of coastal erosion on communities.
- Mainstreaming of climate change into government policies
- Establishing river buffer zones to enhance the resilience of the river and catchment area
- Improved water resources management,
- Development of hazard maps
- Development of appropriate building codes and land use policies.
- creating land use plans and corresponding enforcement strategies;
- Rainwater harvesting, water demand management, provision of water storage and water efficient household appliances;
- Flood risk analysis with land zoning and flood mitigation actions; strengthening of institutional capacity to enforce land zoning restrictions.



Source: **SIDS Unit, based on NAPAs and UNFCCC National Communications.**

Fig. 4

Conclusion:

Given the current scenario, efforts to enhance island resilience must be mainstreamed into general development policy formulation. Small islands need their voice to be heard at the international fora, in the WTO, the UN system and international climate change talks. SIDS should tap the regional co-operation, international linkages and funding and invest on DRR. Nevertheless, much remains to be done to turn rhetoric into action.

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VULNERABILITY OF SMALL ISLAND DEVELOPING STATES TO CLIMATE CHANGE

M. Zia ur Rahman Hashmi, M. Munir Sheikh, M. Mohsin Iqbal, Ghazanfar Ali and Arshad M. Khan

1. INTRODUCTION

Climate change has now been accepted as a blatant reality which is mainly human induced (IPCC, 2013) and is widely recognized as the greatest challenge ever faced by mankind (King, 2004). The UN Secretary General Ban Kimoon said in a keynote speech at a gathering of the 39th Plenary Assembly of the World Federation of United Nations Associations, "It is, simply greatest collective challenge we face as a human family" (UN News Centre, 2009). Figure-1 presents observed changes in global surface temperature during last century as reported by Intergovernmental Panel on Climate Change (IPCC) which reveals temperature changes in the range -0.6 to +2.5 ^{0}C in different parts of the world with the average global temperature change being +0.6 ^{0}C. Major impacts of climate change include changes in the pattern of precipitation resulting in floods and droughts, increased snow/ice melting and sea level rise. Recognizing it as a "greatest collective challenge", scientists all over the world are striving to devise means for proper assessment of anticipated climate change impacts to work out mitigation and adaptation strategies, especially for the most vulnerable countries around the world including the Small Island Developing States (SIDS).

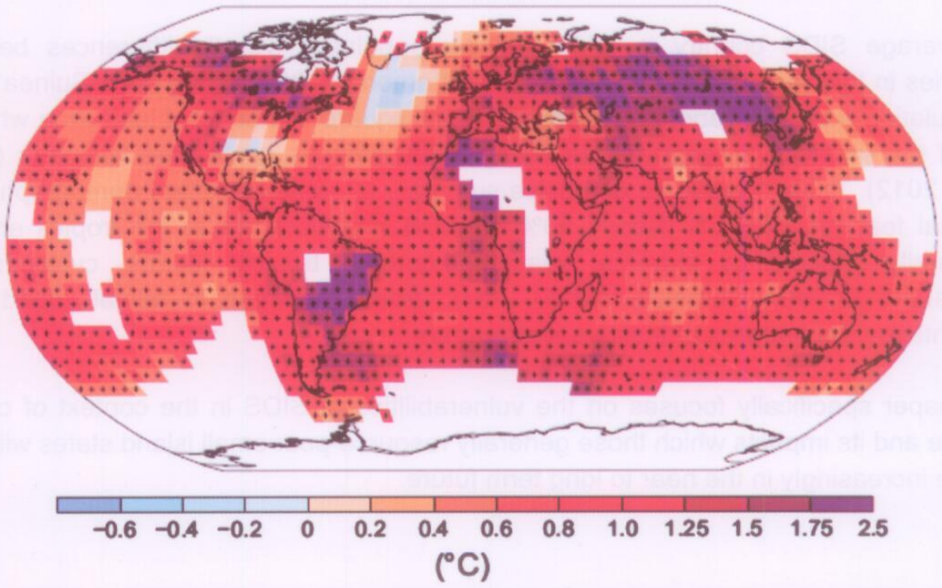


Figure 1: Observed changes in global surface temperature during last century(IPCC, 2013).

The United Nations Department of Economics and Social Affairs lists 51 countries and territories as SIDS that often work together in the United Nations through the Alliance of Small Island States (AOSIS). These island nations are spread around the world in three major concentration zones i) The AIMS (Africa, Indian Ocean, Mediterranean and South China Sea); ii) Caribbean;and iii) Pacific (Fig. 2). Their characteristic features: population, Area, Coast line length and Maximum Elevation, are listed in Annex 1.

SIDS are among the least responsible of all nations for emission of Green House Gases causing climate change. Yet SIDS are believed to be the first and the most affected places from the adverse effects of climate change and could in some cases even become uninhabitable due to irrecoverable physical damage (Kelman, 2014). This makes them the most vulnerable human settlements requiring the help and special attention of the international community.

As per latest available data 63.2 million people live in Small Island Developing States (UN, 2014) which is approximately 1% of the total world population today. Economically, SIDS have a combined gross domestic product (GDP) of $575.3 billion which is slightly less than 1% of the global GDP. Most of SIDS have Exclusive Economic Zones (EEZs) i.e. sea zone, larger than their land area due to skewed land to sea ratios (Overmoe, 2009). For example, Nauru's EEZ is nearly 15,000 times the size of its land area, whereas Samoa's is eight. Many SIDS – the Maldives, for example – have solely or mostly low-lying flat land areas; others, such as Haiti, have a varied terrain, including mountainous areas (UNFCCC, 2005).

An average SIDS country is fairly densely populated, yet thedifferences between countries in this respect are large. The largest among SIDS– Papua New Guinea – has a population density of about one inhabitant per square kilometer of land area whereas one of the smallest, Singapore, has nearly 5,000 persons per square kilometer (World Bank, 2012). Table 1 presents a concise summary of some important demographic and physical features of SIDS. Nearly 90% of SIDS members are in the tropics and are seasonally affected by extreme weather events – tropical storms, cyclones and hurricanes (Guyana Chronicle, 2014). Also, drastic changes in rainfall, floods and droughts are the features of their weather pattern.

This paper specifically focuses on the vulnerabilities of SIDS in the context of climate change and its impacts which those generally resource-poor small island states will have to face increasingly in the near to long term future.

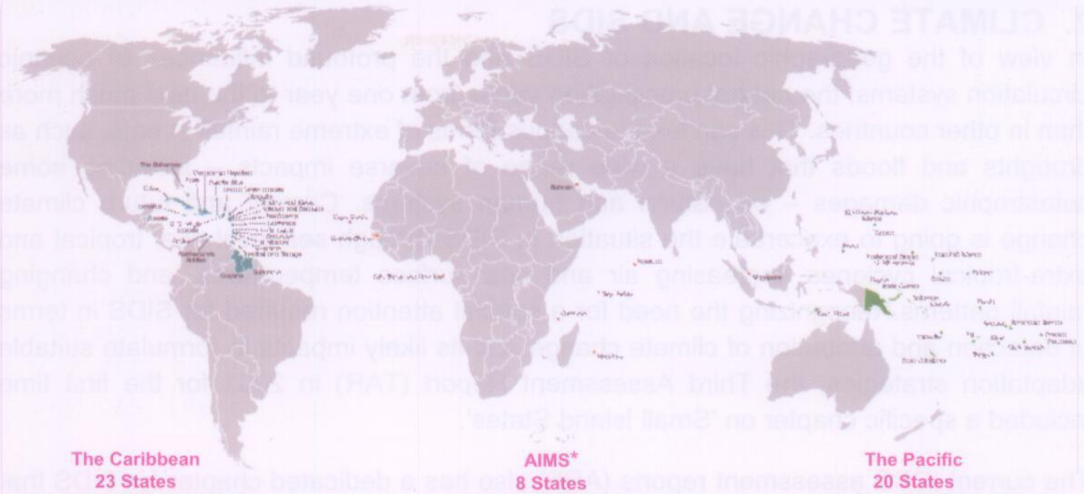


Figure 2: Geographical distribution of Small Island Developing States (SIDS)in three zones

Table 1: Some key facts related to demographic and physical features of SIDS

Parameter	Value	Remarks
Range of Population (Million)	0.0017- 11.2	Min^{m}: Niue Max^{m}: Cuba
Number of SIDS with Population below 10,000	2	Niue, Montserrat
Range of Area (km^2)	21- 463,000	Min^{m}: Nauru Max^{m}: Papua New Guinea
Number of SIDS with Area less than 100 km^2	3	
Range of Average Width (km)	5 - 700	Min^{m}: Nauru Max^{m}: Papua New Guinea
Number of SIDS with Width less than 10 km	3	
Range of Coastline (Km)	24 - 6,112	Min^{m}: Tuvalu Max^{m}: Fed. State of Micronesia
Number of SIDS with Coastline less than 100 Km	9	
Range of Maximum Height (m) above sea level	2.4 - 4,509	Min^{m}: Maldives Max^{m}: Papua New Guinea
Number of SIDS with Max. Height less than 10 m above sea level	3	

2. CLIMATE CHANGE AND SIDS

In view of the geographic location of SIDS and the profound influences of oceanic circulation systems, the natural precipitation varies from one year to the next much more than in other countries. This can lead to various forms of extreme rainfall events, such as droughts and floods that have a wide range of adverse impacts – including some catastrophic damages – on natural and human systems. Current and future climate change is going to exacerbate the situation in SIDS through sea-level rise, tropical and extra-tropical cyclones, increasing air and sea surface temperatures, and changing rainfall patterns.Recognizing the need for a special attention required for SIDS in terms of detection and attribution of climate change and its likely impacts to formulate suitable adaptation strategies, the Third Assessment Report (TAR) in 2001 for the first time included a specific chapter on 'Small Island States'.

The current IPCC assessment reports (AR5) also has a dedicated chapter for SIDS that says, "Rather their high diversity in both physical and human attributes and their response to climate-related drivers means that climate change impacts, vulnerability and adaptation will be variable from one island region to another and between countries in the same region".

2.1 OBSERVED CLIMATIC CHANGES

According to the IPCC AR5, the following are the main observed changes in the global climate and the associated major impacts:

- 0.6 ^{0}C increase in average global temperature during the last century (During the first 12 years of this century the temperature has increased further by about 0.2 ^{0}C);
- Large changes (both, increases and decreases) of temperature and precipitation in different world regions;
- Considerable increase in Frequency and Intensity of Extreme Climatic Events (cyclonic storms, floods, droughts etc.);
- Large scale melting of mountain glaciers and polar ice caps, particularly the Arctic;
- Sea level rise of 19 cm over 20th Century.

In pursuit of the observed climate change in SIDS, a number of studies have been conducted. For example, in the Caribbean, analysis of data from the late 1950s to 2000 has shown that the number of very warm days and nights is increasing dramatically and the number of very cool days and nights is decreasing, while the extremeinter-annual

temperature range is decreasing. The Caribbean Sea has warmed by 1.5^0C over the last century. The maximum number of consecutive dry days is decreasing and the number of heavy rain fall events is increasing. However, the reisatrend towards an overall decrease in precipitation, with prolonged dry spells having occurred over the last few decades (Tompkins etal., 2005).

A study by Manton et al. (2001), focusing on Southeast Asia and the South Pacific has detected significant increases in the annual number of hot days and warm nights, with significant decreases in the annual number of cool days and cold nights. Almost all observation stations have exhibited increases in the frequency of hot extremes and decreases in cold extremes, with many of the set rends being statistically significant. Mean rain fall has shown an increasing trend in, and northeast of, the South Pacific Convergence Zone. Extreme rainfall trends were less spatially coherent, with some stations showing increases in the proportion of annual rain fall from extreme events and some showing decrease in the number of rain days. The annual and seasonal ocean surface and island air temperatures have increased by 0.6 to 1.0^0 Csince 1910 through out a large part of the South Pacific and to the northeast where decadal increases of 0.3 ^{0}C to 0.5 ^{0}C in annual temperature have been observed since 1970. The increases in surface air temperatures have been greater in the Pacific than global rates of warming (World Bank, 2000).

2.2 PROJECTED CLIMATIC CHANGES

According to AR5 Summary for Policy Makers (SPM), the most likely range of global surface temperature change for the end of the 21st century is 1.5 – 4.6 ^{0}C projected over the 21st Century (In extreme case the temperature may increase by upto 6 ^{0}C) (Fig. 3). Warming will continue beyond 2100 under all RCP (Representative Concentration Pathways) scenarios except RCP2.6, exhibiting inter-annual-to-decadal variability and will not be regionally uniform (IPCC, 2013).

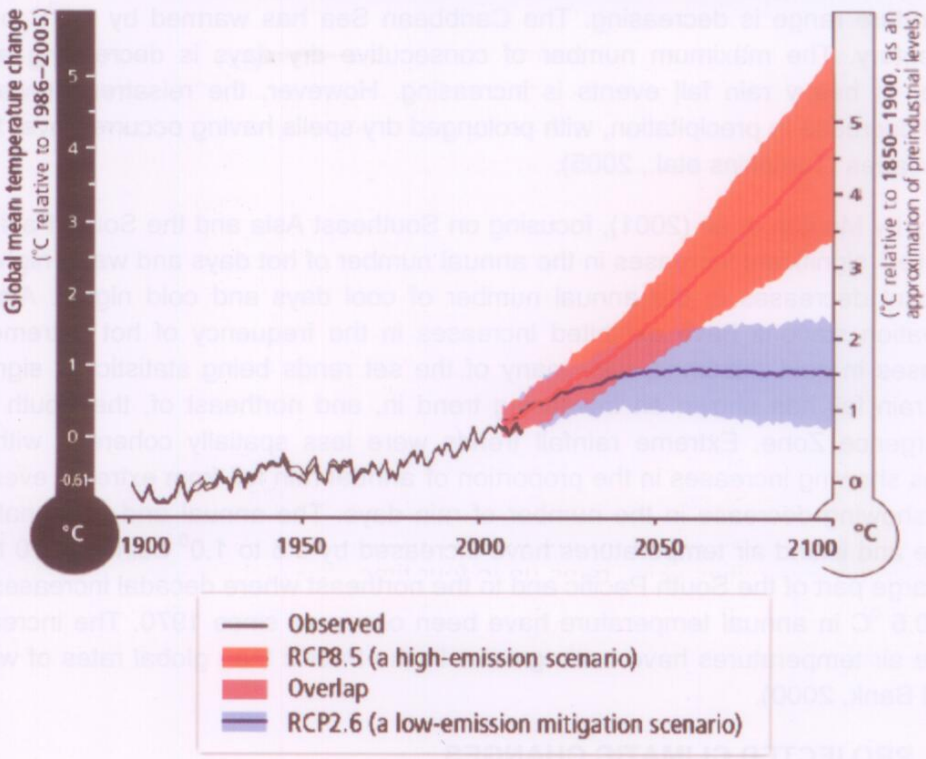


Figure 3: Future projections of temperature rise (IPCC, 2013)

In the context of SIDS, previously in IPCC AR4, the SRES A1B medium emissions scenario suggested about a 1.8 to 2.3 ^{0}C median annual increase in surface temperature in the Caribbean, Indian Ocean and Pacific Ocean small islands regions by 2100 compared to a 1980-1999 baseline, with an overall annual decrease in precipitation of about 12% in the Caribbean (IPCC, 2007) and a 3-5 per cent increase in the Indian and Pacific Oceans small island regions. Comparative projections for the new RCP4.5 scenario suggest a 1.2 to 2.3 ^{0}C increase in surface temperature by 2100 compared to a 1986-2005 baseline and a decrease in precipitation of about 5 or 6 per cent in the Caribbean and Mediterranean respectively signalingpotential future problems for agriculture and water availability compared to a 1-9 per cent increase in the Indian Ocean and Pacific Ocean small islands regions (IPCC, 2013: WG1 SPM).

Future projections for the Mediterranean islands also differ from those for the tropical small islands. Throughout the Mediterranean region, the length, frequency, and/or intensity of warm spells or heat waves are very likely to increase to the year 2100 (AR5 WGI, 14.7.6).

2.3 SEA LEVEL RISE

Sea level rise (SLR) is the most important factor to consider when analyzing the vulnerabilities of SIDS and the factors largely responsible for it are ocean thermalexpansion, which expands existing water volume, and global glacier/icesheet melt,largely from Greenland and Antarctica that adds water to the oceans(Hemming et al., 2007).

IPCC AR5 reported with a high confidence that the rate of sea level rise (SLR) since the mid-19th century has been larger than the mean rate during the previous two millennia. Over the period 1901 to 2010, global mean sea level rose by 0.19 [0.17 to 0.21] m (Fig. 4). Over much of the 20th Century, global mean sea level rose at a rate between 1.3 to 1.7 mm yr^{-1} and since 1993, at a rate between 2.8 to 3.6 mm yr^{-1}(IPCC, 2013).

Acceding to a research study by a team of scientists working with UN, one meter rise in sea level by the end of 21st century would displace around 130 million people world-wide (The Washington Post, 2007). In the tropical western Pacific where a large number of small island communities exist, rates up to four times the global average (approximately 12 mm yr^{-1}) have been reported between 1993 and 2009, generally taken as short-term variations associated with ENSO (El Niño-Southern Oscillation)(Becker et al.,2011).

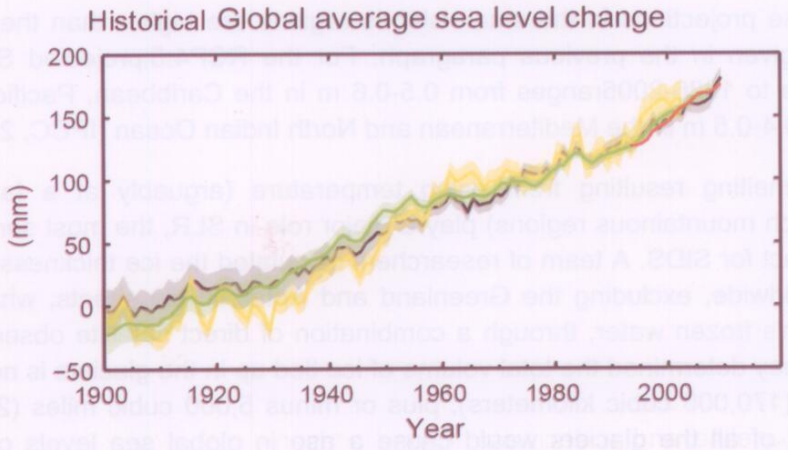


Figure 4: Historical changes in global average sea level (IPCC AR5, SPM)

Global mean sea level rise for 2081–2100 relative to 1986–2005 period, considering all contributing factors,will likely be in the range of 0.26 to 0.82 m for the four IPCC RCP scenarios (Fig. 5). For RCP8.5, the rise by the year 2100 is 0.52 to 0.98 m, with a rate during 2081 to 2100 of 8 to 16 mm yr^{-1} (medium confidence). These ranges are derived from CMIP5 climate projections in combination with process-based models and literature assessment of glacier and ice sheet contributions.

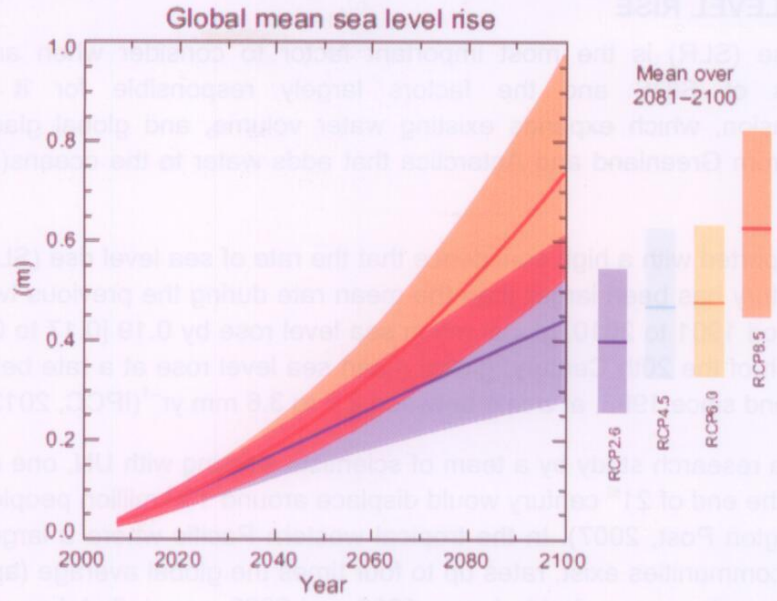


Figure 5: Future projections of global mean sea level rise under different IPCC scenarios (IPCC, 2013)

Sea level rise projections in the small islands regions are higher than the global SLR projections given in the previous paragraph. For the RCP4.5,projected SLR by year 2100 relative to 1986-2005ranges from 0.5-0.6 m in the Caribbean, Pacific and Indian Ocean,and 0.4-0.5 m in the Mediterranean and North Indian Ocean (IPCC, 2013).

Global ice melting resulting from rising temperature (arguably at a faster rate in glacier/ice-rich mountainous regions) play a major role in SLR, the most serious climate change impact for SIDS. A team of researchers calculated the ice thickness for 171,000 glaciers worldwide, excluding the Greenland and Antarctic ice sheets, which hold the bulk of Earth's frozen water, through a combination of direct satellite observations and modeling. They determined the total volume of ice tied up in the glaciers is nearly 41,000 cubic miles (170,000 cubic kilometers), plus or minus 5,000 cubic miles (21,000 cubic km). Melting of all the glaciers would cause a rise in global sea levels of almost 17 inches (43 centimeters) (Huss and Farinotti, 2012). Moreover, according to an estimate made by IPCC in 2007, completely melting the Greenland ice sheet would add 23 feet (7 meters) to the average global sea level.

According to IPCC, global mean SLR will continue beyond 2100 and contribution of thermal expansion to this is likely to continue for many centuries (Fig. 6). The few available model results that go beyond 2100 indicate global mean SLR above the pre-industrial level by 2300 to be less than 1 m for a radiative forcing (RF, defined as the

measurement of the capacity a forcing agent e.g. a greenhouse gas to affect earth's energy balance)that corresponds to CO_2 concentrations that peak and decline and remain below 500 ppm, as in the scenario RCP2.6. For a radiative forcing that corresponds to a CO_2 concentration that is above 700 ppm but below 1500 ppm, as in the scenario RCP8.5, the projected rise is 1 m to more than 3 m (IPCC, 2013).

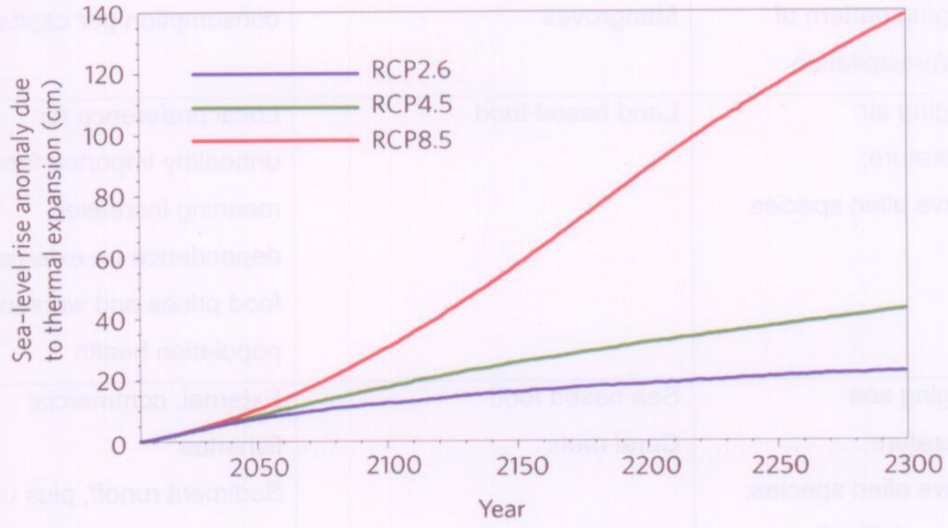


Figure 6: Projections of SLR due to thermal expansion (IPCC, 2013)

3. VULNERABILITIES OF SIDS TO CLIMATE CHANGE

Vulnerability refers to the tendency of something to be damaged. The opposite of this is resilience, or the ability to resist and/or recover from damage. "Something is vulnerable to the extent that it is not resilient, and vice versa" (THESSISMUN, 2014). There are four key factors that determine Island vulnerability;

1. Small size
2. Geographic isolation
3. Sea level rise
4. Natural and Environmental disasters

Based on the above mentioned four key factors, Kelman (2014) has determined vulnerabilities of SIDS to different types of climate change impacts and some factors that further exacerbate the impact of climate change (Table 2).

Table 2: Impacts and vulnerabilities in the SIDS context (cf. Kelman, 2014)

Climate change impact/s	Vulnerabilities (Affected sector/s)	Exacerbating factor/s
Sea level rise; Changing pattern of storm/precipitation	Freshwater Mangroves	Increased water consumption per capita
Changing air temperature; Invasive alien species	Land based food	Local preference for unhealthy imported foods, meaning increased dependence on external food prices and worsening population health
Changing sea temperature; Invasive alien species; Ocean acidification	Sea based food Coral reefs	External, commercial fisheries Sediment runoff, plus using dynamite and poison for fishing
Less healthy coral reefs; Sea level rise; Storm/precipitation regime changing	Coastal erosion	Sediment runoff and relying on unsustainable structural defenses

The climate characteristics combined with their particular socio-economic situations make SIDS some of the most vulnerable countries in the world to climate change along with the 12 least developed countries (LDCs).Based on the Environmental Vulnerability Index (EVI) developed by the South Pacific Applied Geoscience Commission (SOPAC), the United Nations Environment Programme (UNEP) and their partners in 2005, a comparison of SIDS with all countries is shown in Table 3 which reveals that about 70% of the studied SIDS fall in the two categories of Highly vulnerable and Extremely vulnerable with no SIDS country potentially resilient.

Table 3: Comparison of SIDS with all countries in terms of EVI scores

Level of Vulnerability	No. of All Countries of the World	No. of SIDS	SIDS as % of Total
Extremely Vulnerable	35	17	49%
Highly Vulnerable	62	17	27%
Vulnerable	81	10	12%
At Risk	43	3	7%
Resilient	14	-	-
Total	**235**	**47***	

*** 4 SIDS have been left out due to non-availability of adequate data.**

A comprehensive study of 12,983 islands of all sizes above 2.5 hectares across the Pacific Ocean, including the Philippines and Hawaiian Islands, found that some 15 to 62% of islands would entirely disappear under SLR ranging from 1 to 6 meters respectively (Florian et al., 2013).Although SIDS have variation in geographical, physical, climatic, social, political, cultural and ethnic features and economic development, they share certain characteristics that underscore their overall vulnerability to climate change, climate variability and in particular to sea-level rise which includes the following but not limited to these:

- Strong possibility of submersion of large areas of land under the sea, where most of the population is located.
- Irrespective of their geographic location, besides sea level rise, SIDS are also extremely vulnerable to tropical storms: typhoons, hurricanes etc.;
- Deterioration of coastal conditions, (e.g. erosion of beaches, and coral bleaching) resulting in loss of local resources (e.g. fish production, mangroves etc.) that support the livelihood of island communities.
- By mid-21st Century, fresh water resources in many SIDS in the Caribbean and the Pacific are projected to decline considerably during low-rainfall periods.
- Some impacts of Climate change (e.g. coral bleaching and reduced beach areas due to sea level rise) will negatively impact the all-important tourism industry in these Island States.

3.1 SOME SPECIAL CASES OF SIDS VULNERABILITY

A few examples of the vulnerabilities in specific islands illustrate the high level of tendency to the adverse impacts of climate change (UNFCCC, 2005):

- On average the Maldives is 1.3 meter above mean sea level (amsl) and 80 per cent of its land area is below 1 meter amsl and is highly susceptible to rising sea level. As per President Mohamed Nasheed of the Maldives just three feet of SLR would submerge the Maldives and make them uninhabitable (Business Insider, 2012). Mr. AbdullahiMajeed (Madives) made the following statement on 11 December 2003, Milan, Italy (COP 9 Round-Table);

  "In April 1987, Maldives experienced unusual high waves causing extensive damage to the islands. Two thirds of the whole Maldives, including the capital island, Malé, was inundated for two days causing extensive damage to the infrastructure. Male International Airport, the only gateway to the Maldives, was closed for two days, causing delays in receiving the relief assistance from the international community, cancellation of tourist arrivals and lot more."
- In the Papua New Guinea, some 50–80 per cent of the land area is less than 1 meter above mean sea level and is highly susceptible to rising sea level as in the case of Maldives.
- The availability of freshwater is a major limiting factor for economic and social development in SIDS such as the Mauritius, Bahamas and Barbados, which are almost entirely dependent on groundwater supplies, will be seriously affected by sea water intrusion.
- In the Seychelles, about 80 per cent of the infrastructure and population are found along the coast which is highly vulnerable to extreme weather events – tropical storms, cyclones and hurricanes.
- In Barbados and many other islands, almost all foods, fuels, construction materials and other goods are imported through sea.
- In Palau, prolonged droughts are experienced during El Niño Southern Oscillation events.
- Throughout the South Pacific region, frequent and more intense tropical cyclones, as well as climate-related and other extreme events, were experienced during the 1990s.

3.2 HIGHLY VULNERABLE SIDS

Acording to IPCC Third Assessment Report (TAR) released in 2001, "Many small island states—especially the atoll nations of the Pacific and Indian Oceans—are among the most vulnerable to climate change, seasonal-to-interannual climate variability, and sea-level rise". More precisely, Marshall Islands, Kiribati, Tuvalu, Tonga, the Federated States of Micronesia, and the Cook Islands (in the Pacific Ocean); Antigua and Nevis (in the Caribbean Sea); and the Maldives (in the Indian Ocean) are more vulnerable then rest of SIDS. Figs. 7and 8 (originally Figs. 7 and 8 in Hay, 2013) where two types of vulnerability indices (defined by UN Secretary General, 2010) scores i.e. economic and environmental, of SIDS(for which the required data were available)are plotted along with average scores of these indicescalculated for all LDCs. Examination of Figs. 7 and 8 shows that generally most of SIDS are economically and environmentally more vulnerable than an average vulnerable LDC.Specifically, Comoros, Solomon Islands,

São Tomé and Príncipe, Vanuatu, Maldives and Samoa are the most vulnerable of all SIDS as these are in LDCs list and have environmental and economic vulnerability above an average vulnerable LDC.

In terms of sea level rise only, the low-lying flat (the highest island elevation (HIE) ≤ 10 meter above average sea level) islands are expected to suffer the most. These include Marshal Islands (HIE = 10 masl), Tuvalu (HIE = 4.6 masl) and Maldives (HIE = 2.4 masl) (Appendix I).As an example of mode of the sea level rise impact, IPCC TAR noted that an 80-cm sea-level rise could inundate two-thirds of the Marshall Islands and Kiribati, A 90-cm sea-level rise could cause 85% of Male, the capital of the Maldives, to be inundated (Pernetta, 1989).

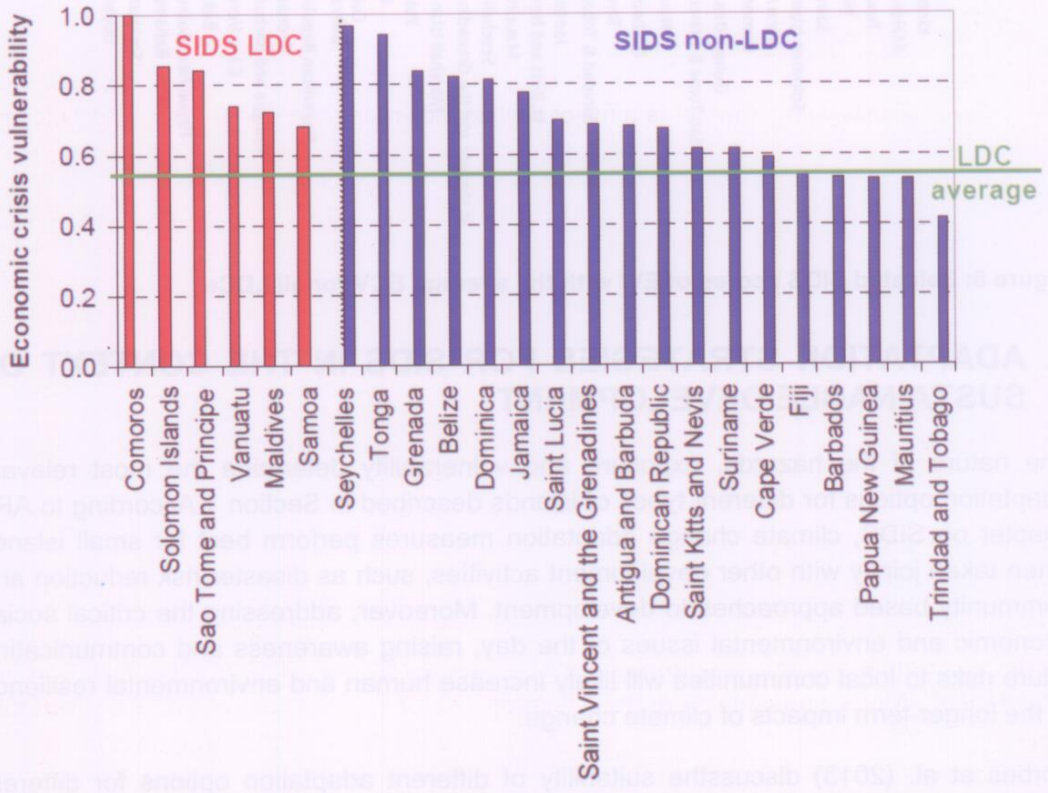


Figure 7: Selceted SIDS scores of ECVI with the average ECV for all LDCs

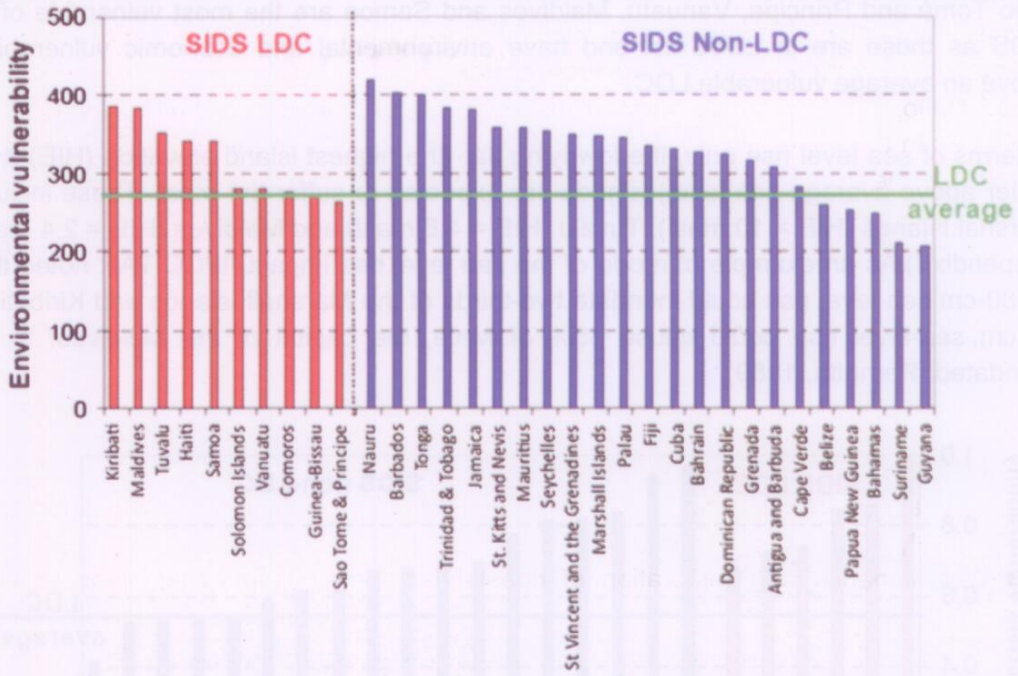


Figure 8: Selceted SIDS scores of EVI with the average ECV for all LDCs

4. ADAPTATION STRATEGIES FOR SIDS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

The nature of the hazards, exposure and vulnerability determine the most relevant adaptation options for different types of islands described in Section 1.According to AR5 chapter on SIDS, climate change adaptation measures perform best for small islands when taken jointly with other development activities, such as disaster risk reduction and community based approaches to development. Moreover, addressing the critical social, economic and environmental issues of the day, raising awareness and communicating future risks to local communities will likely increase human and environmental resilience to the longer-term impacts of climate change.

Forbes et al. (2013) discussthe suitability of different adaptation options for different island types e.g. an ecosystem-basedmangrove conservation or restoration which is more suitable for continental and volcanic high islands and locally on atolls, but irrelevant on raised carbonate atolls. Another adaptation option is known as Coastal setback (a minimum distance from the shoreline within which no development is allowed)which is a globally recognized and applicable to all island types, but most

suitable for high carbonate islands such as Bermuda or Niue, where major tropical cyclone waves can demolish cliff-top facilities.
United Nation Environmental program (UNEP) Regional Office for Latin America and Caribbean in collaboration with CARICOM published special report in 2008 highlighting climate change trends and climate variability, the impact they have on Caribbean SIDS in particular, and the efforts in responding to these issues. The report provides guidance on how the Region should respond, not only in developing national climate change agendas, but also in building an international regime on adaptation to climate change as well as on the implementation of the Kyoto Protocol and beyond, taking into account the particular needs of the Caribbean SIDS (UNEP, 2008).

In our opinion the following measure will go a long way in countering the negative impacts of Climate Change in SIDS:

- Enhanced international cooperation to provide technical and financial support to needy SIDS, in particular to ensure their food and water security;
- Maintenance and restoration of coastal landform by controlling land erosion through construction of dikes etc., wherever appropriate;
- Improving existing mangrove forests and developing new mangrove plantations to protect against storm surges and inundation of coastal infrastructure by cyclones etc.;
- Protection of the available soil through improved management;
- Introduction of appropriate building codes and settlement patterns to protect against the increasing risk of climate related disasters;
- International arrangements to shift population from some of the most vulnerable SIDS to other countries and resettle them properly.

4.1 ADAPTATION FUNDING FOR SIDS

In order to bring in practice different adaptation strategies for SIDS, considerable financial resources are required. Therefore, it is very important to explore the funding options for SIDS to help them build their resilience against climate change adversities. One of the principal channels of support for SIDS in the area of climate change is the Global Environment Facility (GEF) Trust Fund. With resources made available through this channel, but also using resources of their own and those obtained from multilateral and bilateral sources, SIDS have been able to undertake a number of important activities designed not only to meet their reporting obligations under the Convention, but also to take early action in the area of climate change.

One example of regional cooperation on climate change is the Caribbean Planning for Adaptation to Climate Change (CPACC) programme. With resources obtained from the GEF trust fund, Caribbean SIDS cooperated in identifying strategies to cope with

adverse effects of climate change, particularly SLR. In addition, work was undertaken to develop an integrated management and planning framework for cost-effective responses and adaptation to climate change in coastal and marine areas, to provide training and institutional strengthening that could enhance regional and national capacities, and to identify and assess policy options.

In 2001, two new funds – the Least Developed Countries (LDC) Fund and the Special Climate Change Fund (SCCF) – were established, and an Adaptation Fund was set up under the Kyoto Protocol. Collectively, these constitute important new channels for mobilizing resources to support the implementation of climate change activities in SIDS in addition to those available through the GEF Trust Fund, through bilateral and multilateral funding, and through private-sector investments. Of the three funds, only the LDC Fund was operational by the end of 2002 – supporting, among other efforts, the preparation and implementation of National Adaptation Programmes of Action (NAPAs). These are just a few examples of concrete actions being undertaken by SIDS both to contribute to the Climate Change Convention and to take steps to mitigate the inevitable impacts of climate change.

5. CONCLUSIONS

This paper aimed to explore climate change, vulnerabilities and adaptationpossibilities of SIDS.Climate change is a major challenge for SIDS alongside someother challenges such as small population,limited resources,remoteness susceptibility to natural disasters, vulnerability to external shocks and excessive dependence on international trade. In terms of current and future climate change, SIDS are no exception to what is happening globally and are experiencing rising temperatures and associated changes in other climatic features.Among the climate change impacts sea level rise caused by global ice melting and thermal sea expansion is a major threat for SIDS and almost all of their adaptation strategies mainly focus on it.

The projected changes are likely to exacerbate the current climate-related stresses in various SIDS, particularly;

- Higher temperatures are expected to adversely affect the health of some island inhabitants who already suffer through heat waves and associated increased outbreaks of vector borne diseases. The health of important marine species such as coral reefs will also suffer.
- Changes in seasonal rainfall patterns may take the form of more frequent and more intense droughts and floods for many of the already troubled SIDS.

Although natural systems and people living in SIDS have developed a wide range of adaptive strategies and measures to cope with a certain degree of change in climate and

sea level, in many of these nations the environment and various biological systems are already close to their tolerance limits or are experiencing climate related stress. Their vulnerability to climate change – already high – thus worsens with each passing year.

One of the major research gaps identified by the authors of IPCC AR5 chapter on SIDS is that there is very little published literature documenting the probability, frequency, severity or consequences of climate change risks such as sea-level rise, ocean acidification, and salinization of freshwater resources – or associated adaptation measures. There is a need for providing adequate funding to SIDS by the international agencies so that suitable adaptation action are taken well before any major climate change induced catastrophes cause them irreversible damage.

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Annexure I: Demographic and Physical Features of the Three SIDS Regions

The Aims

Member	Population (x 1000)	Area (Km^2)	Coastline (Km)	Maximum Elevation (meter above sea level)
Cape Verde	491 (2007)	4,033	965	2829
Comoros	576 (2007)	2,235	340	860
Guinea-Bissau	1,389 (2007)	36,125	350	300
Maldives	304 (2007)	298	644	2.4
Mauritius	1,253 (2007)	2,040	177	828
Sao Tome & Principe	155 (2007)	1,001	209	948
Seychelles	85 (2007)	459	491	905
Singapore	4,608 (2008)	716.1	193	163.3

The Caribbean

Member	Population (x 1000)	Area (Km^2)	Coastline (Km)	Maximum elevation (meter above sea level)
Anguilla	13 (2004)	91	61	65
Antigua and Barbuda	81 (2006)	440	153	402
Aruba	103 (2007)	178.91	70	188
The Bahamas	323 (2006)	13,878	3,542	63

Member	Population (x 1000)	Area (Km^2)	Coastline (Km)	Maximum elevation (meter above sea level)
Barbados	274 (2007)	432	97	336
Belize	311 (2007)	22,966	386	1124
British Virgin Islands	20 (2004)	153	80	521
Cuba	11,237 (2007)	109,884	5,746	1974
Dominica	79 (2005)	750	148	1447
Dominican Republic	9,482 (2007)	48,442		3098
Grenada	107 (2007)	344	121	840
Guyana	752 (2007)	214,970	459	2835
Haiti	8,407 (2002)	27,750	1,771	2680
Jamaica	2,676 (2007)	10,991	1,022	2256
Montserrat	9 (2004)	102	40	915
Netherlands Antilles	189 (2007)	999	364	887
Puerto Rico	3,944 (2007)	9,104	501	1338
Saint Kitts and Nevis	48 (2005)	261	135	1156
Saint Lucia	167 (2007)	617	158	950

Member	Population (x 1000)	Area (Km^2)	Coastline (Km)	Maximum elevation (meter above sea level)
Saint Vincent & the Grenadines	119 (2005)	389	84	1234
Suriname	510 (2007)	163,821	386	1230
Trinidad & Tobago	1,300 (2005)	5,131	362	940
U.S. Virgin Islands	108 (2007)	346.36	188	474

The Pacific

Member	Population (x 1000)	Area (Km^2)	Coastline (Km)	Maximum elevation (meter above sea level)
American Samoa	68 (2007)	199	116	964
Commonwealth of the Northern Marianas	79 (2005)	463.63	1,482	652
Cook Islands	21 (2007)	240	120	791
Fiji	833 (2007)	18,274	1,129	1324
French Polynesia	256 (2007)	4,167	2,525	2241
Guam	173 (2007)	541.3	125.5	1332
Kiribati	92 (2007)	811	1,143	81

Member	Population (x 1000)	Area (Km^2)	Coastline (Km)	Maximum elevation (meter above sea level)
Marshall Islands	53 (2007)	181	370	10
Federated State of Micronesia	110 (2005)	702	6,112	71
Nauru	13 (2006)	21	30	1628
New Caledonia	240 (2007)	18,576	2,254	68
Niue	2 (2007)	260	64	965
Palau	21 (2007)	459	1,519	242
Papua New Guinea	5,887 (2007)	462,840	5,152	4509
Samoa	179 (2006)	2,842	403	1857
Solomon Islands	186 (2007)	28,400	5,313	2332
Timor-Leste	947 (2005)	14,874	706	2963
Tonga	114 (2006)	748	419	1033
Tuvalu	11 (2006)	26	24	4.6
Vanuatu	221 (2007)	12,190	2,528	1877

CLIMATE CHANGE EFFECTS ON SMALL ISLAND DEVELOPING STATES BIODIVERSITY AND RELATED ISSUES

Dr. Abdul Aleem Chaudhry

Introduction

Today, it is widely agreed by the scientific community that climate change is already a reality. The Intergovernmental Panel on Climate Change (IPCC) has concluded that human activities are altering our climate system and will continue to do so. Over the past century, surface temperatures have increased and associated impacts on physical and biological systems are increasingly being observed. Science tells us that climate change will bring about gradual changes, such as sea level rise, and shifts of climatic zones due to increased temperatures and changes in precipitation patterns. Also, climate change is very likely to increase the frequency and magnitude of extreme weather events such as droughts, floods, and storms. While there is uncertainty in the projections with regard to the exact magnitude, rate, and regional patterns of climate change, its consequences will change the fate of many generations to come and particularly impact on the poor if no appropriate measures are taken.

Oceans and climate change

The oceans, which are part of the climate system, are the blue lungs of the planet e breathing in CO_2 and exhaling oxygen. Over the last 200 years, oceans have been responsible for absorbing nearly half of the increased CO_2 emissions produced by burning fossil fuels (WBGU, 2006) as well as a significant portion of increased greenhouse gas emissions due to land-use change (Sabine et al., 2004). Importantly, acting as the largest active carbon sink on earth, ocean absorption of CO_2 reduces the rate at which it accumulates in the atmosphere, and thus slows the rate of global warming (Denman et al., 2007).

Ocean temperature changes are similar to trends in the atmosphere, but differ because of changes in ocean circulation. The large global jump in the temperature record that began in the late 1970s can be explained by increasing heat content in the oceans (Levitus et al., 2000). As the warms, evaporating sea water increases tropical humidity and winds, causing a rise in tropical heat, moisture, cloud, wind, and energy circulation (Flohn and Kappala, 1989; Flohn et al., 1990). Water vapor is actually the most significant atmospheric greenhouse gas, absorbing much more heat than carbon dioxide, and driving a positive feedback mechanism that amplifies global warming driven by fossil fuel emissions.

Ocean warming: impacts and climate change

Sensitive to climate and can suffer severe damage from exposure to rising ocean temperatures; 20 percent of the world's coral reefs are already estimated to be damaged due to ocean warming (Nurse and Moore, 2007). The oceans have absorbed over 80 percent of the heat added to the climate system since the onset of the industrial revolution (IPCC, 2007). A steady rise in global temperature over the last century, computed as a combination of both land and sea temperatures, is effectively injecting more energy into global weather systems. Increased concentrations of greenhouse gases in the atmosphere due to human activities are the most likely underlying cause of warming in the 20th century (Brohan *et al.*, 2006). The time series in Figure 1 show the combined global land and marine surface temperature records from 1850 to 2009, which is the sixth warmest year on record, exceeded since 1998 by 2005, 2003, 2002, and 2004. This global temperature record, compiled jointly by the Climatic Research Unit and the UK Met. Office Hadley Centre, is being continually up-dated and improved, incorporating new and more thorough assessment of errors, recognizing that these differ on annual and decadal timescales.

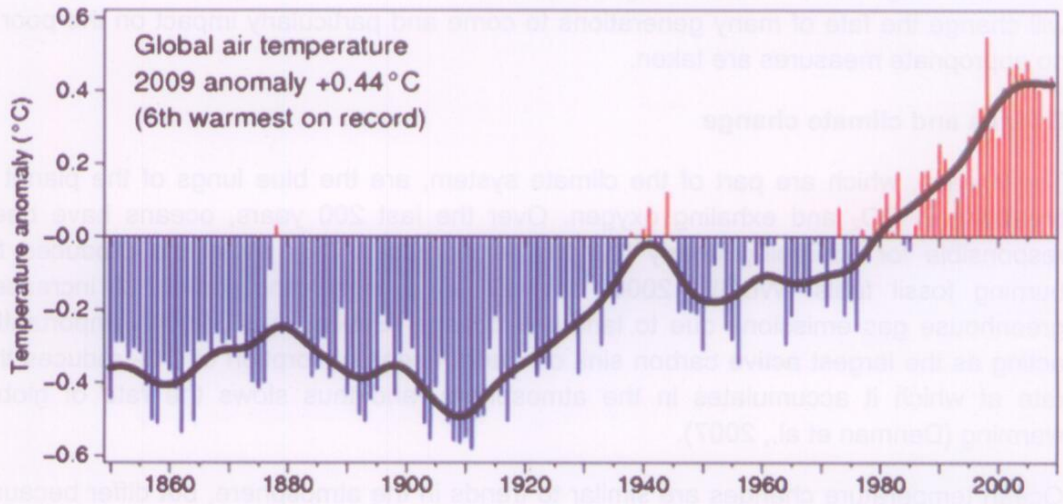


Fig. 1. Combined global land and marine surface temperature records from 1850 to 2009.

Sea level rise: facts, impacts, and action

The degree of sea level rise under different scenarios remains one of the most discussed findings of the 2007 IPCC report. Although there is still uncertainty on the specific rate of sea level rise and its eventual effects on land, especially in low-lying coral atolls, evidence for sea level rise is clearly established in the scientific literature.

Humanitarian impacts are already occurring through increased storm surge height, frequency and severity of flooding in low-lying areas, saline intrusion, erosion of beaches and other coastal habitats, resulting in loss and damage to infrastructure, agriculture and the environment (IPCC, 2012). Due to increasing atmospheric concentrations of anthropogenic CO_2 and other greenhouse gases, the prospect for the future is a progressively warmer world, with large implications for future sea level. Increases in global temperature result in changes in sea level through i) the thermal expansion of warming ocean water, ii) some water from melting glaciers and polar ice, and iii) additional water from land surface runoff. All three processes are accelerated by global warming.

Over the past 100 years the world has warmed by about 0.5°C (Brohan *et al.*, 2006) and the rate of sea level rise has increased from roughly 1.5 mm/year to about 3.3 after 1990, primarily due to increased rates of warming in the southern and tropical oceans (Merrifield and Merrifield, 2009). Addressing the question, "Sea Level Rise: Not If but When, and How Much?", the 2007 UN World Population report underscored the alarming prospects of climate change impacts on sea level rise in light of potential consequences for coastal urban areas and small island states. Combined with extreme weather events, sea level rise threatens to flood large parts of coastal areas, introduce salt water into fresh water supplies and aquifers, and modify coastal ecosystems. These threats to the biodiversity, vital ecological services and natural resources upon which coastal populations depend, will inevitably provoke large-scale migration (UNFPA, 2007). Small islands and coastal developing states are differentially impacted by sea level rise, and cannot afford to wait for emissions reductions to become more acceptable to the industrialized states. Aggressive mitigation targets and timetables are urgently needed, along with technical and financial adaptation assistance for the most vulnerable countries and peoples.

Small Island populations are on the frontline of climate Change

Climate change and its varied impacts threaten thousands of islands (McGranahan *et al.*, 2007), encompassing some of the world's most significant biodiversity, while compounding existing pressures on fisheries and ecosystems. Coastal and inland communities with ocean-based livelihoods are differentially impacted by sea level rise, the migration of important marine species including global fish stocks, and ocean acidification. Uncontrolled coastal development and increasing uses of the ocean are threatening sensitive and important ecosystems and marine resources, while growing numbers of people are exposed to coastal hazards that are exacerbated by climate variability and change.

Small island developing states (SIDS) already face significant challenges, many of which stand to worsen with global climate change. Water resources will be increasingly stressed in the future for some areas, whereas by 2080 in Pacific atoll countries flood risk is expected to be on the order of 200 times greater than at present (Nicholls et al., 1999). For many SIDS, life-sustaining ecosystems such as coral reefs are highly climate-sensitive and can suffer severe damage from exposure to sea temperatures as low as 1°C above the seasonal maximum (Nurse and Moore, 2007). In many SIDS extreme events such as hurricanes and floods are causing damage in excess of 20 percent of GDP (Payet *et al*., 2008). In 1993, 30 percent of the forested area on the Santa Cruz Islands was lost during one cyclone event (Nurse et al., 2001). Hurricane Ivan's impact on Grenada in 2004 caused losses in the agricultural sector equivalent to 10 percent of GDP

Many SIDS would be unable to adapt effectively to climate change impacts associated with a global 2-3°C mean temperature increase, given the potential impacts on their economies, infrastructure and overall human well-being (IPCC, 2007).

In Kiribati, a 50 cm rise in sea level and a reduction in rainfall of 25 percent would reduce the freshwater lens (floating freshwater store) by 65 percent (World Bank, 2000). With a 50 cm increase in sea level, over one-third of the beaches in the Caribbean would be lost (UNDP, 2007). Sea level rise leads to the disappearance of beaches and low lying islands (IPCC, 2007). In Maldives, a 1 m rise in sea level could amount to the complete disappearance of the nation. Former Maldives President Mohamed Nasheed said that he intended to create a "sovereign wealth fund" to purchase a new land in case global warming causes the country to disappear into the sea (Telegraph, 2008). President Anote Tong of Kiribati says his country's decision in 2009 to establish what was, at the time, the world's largest marine protected area (the Phoenix Islands) was a gift to humanity that should become the basis of an endowment to sustain the people should rising sea levels caused by climate change already claiming more and more of the island nation's land threaten the end of the Kiribati way of life.

Kiribati's elevation is no more than 2 m above sea level. Its fresh water comes from aquifers, but saltwater intrusion into the aquifers is expected to make the islands uninhabitable before rising water overtakes settlements. With the loss of homes and the islands' ability to sustain life, working with other countries to plan for the gradual evacuation of his nation of 110,360 people, President Tong has struck deals with Australia and New Zealand to train a small number of I-Kiribati to perform jobs those countries have trouble filling, while exploring other options for relocating 1000 I-Kiribati a year for the next 20 years. "We want to move our people with as much dignity as possible. For us it is not a matter of economics, it is a matter of survival" (Tong, 2004).

Pacific Islands and extreme weather

The Pacific Islands are becoming increasingly vulnerable to extreme weather events as growing urbanization and squatter settlements, degradation of coastal ecosystems, and rapidly developing infrastructure on coastal areas intensify the islands' natural exposure to climate events. In the 1990s alone, the cost of cyclones and typhoons exceeded US$800 million, while the 1997 drought cost upwards of US$175 million even before nutrition-related deficiencies were taken into account. During the 1997–98 drought in Fiji US$18 million in food and water rations had to be distributed. Source: IPCC 2001b; IFRC-RCS 2002.

Small island states have been shown to be at great risk from projected impacts of climate change, particularly sea-level rise. The projected global rate of rise of 5 mm yr^{-1} (±2–9 mm yr^{-1}) is two to four times greater than the rate experienced in the previous 100 years (IPCC, 1998). Many of the small islands rarely exceed 3–4 m above present mean sea level; even on the higher islands, most of the settlements, economic activity, infrastructure, and services are located at or near the coast.

Reliable instrumental records indicate that on average, Caribbean islands have experienced an increase in temperature exceeding 0.5°C since 1900. During the same period, there has been a significant increase in rainfall variability, with mean annual total rainfall declining by approximately 250 mm. For Pacific islands, the post-1900 temperature increase has been slightly lower than in the Caribbean: less than 0.5°C. In the case of rainfall, no clear trend emerges from the record, which shows decadal fluctuations of ±200 mm and 50–100 mm for mean annual and mean seasonal totals, respectively (IPCC, 1998).

Given the strong influence of the ocean on the climate of islands, and based on projected warming of the oceans (1–2°C for the Caribbean Sea and Atlantic, Pacific, and Indian Oceans) with a doubling of carbon dioxide (CO_2), small islands in these regions are expected to continue to experience moderate warming in the future. Under a similar scenario, mean rainfall intensity also is projected to increase by 20–30% over the tropical oceans, where most small island states are located. However, a decrease in mean summer precipitation over the Mediterranean Sea, where the small islands of Malta and Cyprus are located, is projected (IPCC, 1998).

Based on these projections, certain marine and coastal ecosystems are most likely to be adversely affected. Corals—many species of which currently exist near the upper limits of their tolerance to temperature—are projected to experience more frequent bleaching episodes as a result of elevated sea surface temperatures (SSTs). Bleaching therefore poses a distinct threat to the productivity and survival of these valuable ecosystems

(Wilkinson, 1996; Brown, 1997a,b; CARICOMP, 1997; Woodley *et al.*, 1997). On some islands, mangroves also are expected to be threatened by the impacts of climate change. Where the rate of sedimentation is slower than the projected rate of sea-level rise and where mangroves cannot naturally adapt and migrate landward, the vulnerability of these ecosystems will increase (IPCC, 1996, 1998). In some cases, the natural resilience of these ecosystems already has been impaired by anthropogenic stresses; thus, their capacity to cope with an additional stressor such as climate change will be further compromised.

Sea-level rise poses by far the greatest threat to small island states relative to other countries. Although the severity of the threat will vary from island to island, it is projected that beach erosion and coastal land loss, inundation, flooding, and salinization of coastal aquifers and soils will be widespread. Moreover, protection costs for settlement, critical infrastructure, and economic activities that are at risk from sea-level rise will be burdensome for many small island states. Similarly, tourism — the leading revenue earner in many states—is projected to suffer severe disruption as a consequence of adverse impacts expected to accompany sea-level rise (Teh, 1997; IPCC, 1998).

Special Circumstances of Small Islands

Small island states are by no means a homogeneous group of countries. They vary by geography; physical, climatic, social, political, cultural, and ethnic character; and stage of economic development. Yet they tend to share several common characteristics that not only identify them as a distinct group but underscore their overall vulnerability in the context of sustainable development (Maul, 1996; Leatherman, 1997). These common characteristics include the following:

- Limited physical size, which effectively reduces some adaptation options to climate change and sea-level rise (e.g., retreat; in some cases entire islands could be eliminated, so abandonment would be the only option)
- Generally limited natural resources, many of which already are heavily stressed from unsustainable human activities
- High susceptibility to natural hazards such as tropical cyclones (hurricanes) and associated storm surge, droughts, tsunamis, and volcanic eruptions
- Relatively thin water lenses that are highly sensitive to sea-level changes
- In some cases, relative isolation and great distance to major markets
- Extreme openness of small economies and high sensitivity to external market shocks, over which they exert little or no control (low economic resilience)

- Generally high population densities and in some cases high population growth rates
- Frequently poorly developed infrastructure (except for major foreign exchange-earning sectors such as tourism)
- Limited funds and human resource skills, which may severely limit the capacity of small islands to mitigate and adapt to the effects of climate change.

Climate change scenario in Small Island States in 2050 and 2080

The use of the state-of-the-art coupled atmosphere-ocean general circulation models (AOGCMs) to estimate future response of climate to anthropogenic radiative forcing suggests an enhanced climate change in the future. Several AOGCMs have been analyzed for the Atlantic, Pacific, and Indian Ocean regions and the Caribbean and Mediterranean Seas. The outputs from these models indicate general increases in surface air temperature for the 2050s and 2080s and an increase in rainfall of about 0.3% for the 2050s and 0.7% for the 2080s for the Pacific region. However, a marginal decline in rainfall is projected for the other regions, with a possible reduction of water availability. The diurnal temperature range is projected to decrease marginally for the regions of the small island states for both time horizons.

Tables-1,-2, and-3 provide an ensemble of climate change scenario results inferred from the five AOGCMs for four regions. These tables summarize projected seasonal mean changes in surface air temperature and precipitation during the 2050s and 2080s. The projected area-averaged annual mean warming as a consequence of increases in atmospheric concentrations of Green House Gases (GHGs) over the Atlantic Ocean and Caribbean Sea, the Pacific Ocean, the Indian Ocean, and the Mediterranean Sea is approximately 2.0, 2.0, 2.1, and 2.8°C, respectively, for the 2050s, and approximately 3.1, 3.0, 3.2, and 4.3°C, respectively, for the 2080s (see Table 17-1). Projected warming over the Mediterranean Sea area is marginally higher during Northern Hemisphere (NH) summer than during NH winter for both time periods.

The increase in surface air temperature is more or less uniform in both seasons in the other three regions (Tables 17-2 and 17-3). The area-averaged annual increase in mean surface temperature resulting from increases in GHGs is projected to be the smallest over the Pacific Ocean region and highest over the Mediterranean Sea. It is evident that even though aerosol forcing marginally reduces surface warming, the magnitude of projected warming is still considerable and could substantially impact the small island states.

***Table -1**: Ensemble of annual mean climate change scenarios for small islands for the 2050s and 2080s as inferred from AOGCMs (numbers in brackets show standard deviation between model projections).*

Regions	Annual MeanTemperature Change (°C)				Annual Mean Precipitation Change (%)			
	2050s		*2080s*		*2050s*		*2080s*	
	GHG	GHG+A	GHG	GHG+A	GHG	GHG+A	GHG	GHG+A
Atlantic Ocean and	2.03	1.71	3.06	2.64	-5.2	-1.3	-6.8	-0.7
Caribbean	(±0.43)	(±0.25)	(±0.84)	(±0.61)	(±11.9)	(±7.8)	(±15.8)	(±12.3)
Pacific Ocean	1.98	1.63	2.99	2.54	5.5	4.9	7.6	7.0
	(±0.41)	(±0.23)	(±0.87)	(±0.63)	(±2.5)	(±0.8)	(±3.3)	(±1.9)
Indian Ocean	2.10	1.64	3.16	2.61	3.1	1.6	5.1	4.3
	(±0.43)	(±0.23)	(±0.89)	(±0.65)	(±4.5)	(±3.9)	(±4.3)	(±4.9)
Mediterranean	2.83	2.31	4.27	3.57	1.0	-2.4	4.3	-0.1
	(±0.62)	(±0.29)	(±1.26)	(±0.83)	(±11.0)	(±8.6)	(±14.9)	(±12.9)

***Table -2**: Ensemble of seasonal mean climate change scenarios for small islands for the 2050s as inferred from AOGCMs (numbers in brackets show standard deviation between model projections).*

Regions	Temperature Change (°C) *December–February*		*June–August*		Precipitation Change (%) *December–February*		*June–August*	
	GHG	GHG+A	GHG	GHG+A	GHG	GHG+A	GHG	GHG+A
Atlantic Ocean and	2.00	1.68	2.01	1.71	3.4	5.9	-14.4	-6.9
Caribbean	(±0.46)	(±0.32)	(±0.44)	(±0.21)	(±14.3)	(±7.4)	(±12.2)	(±11.5)
Pacific Ocean	1.98	1.65	1.98	1.61	4.3	3.7	7.2	6.8
	(±0.39)	(±0.20)	(±0.43)	(±0.27)	(±1.9)	(±1.2)	(±4.8)	(±3.3)
Indian Ocean	2.11	1.67	2.09	1.63	3.5	2.0	-1.8	-4.7
	(±0.43)	(±0.15)	(±0.44)	(±0.30)	(±6.0)	(±7.5)	(±10.0)	(±4.5)
Mediterranean	2.64	2.27	2.93	2.27	8.1	2.6	-4.8	-8.9
	(±0.72)	(±0.44)	(±0.53)	(±0.17)	(±14.7)	(±15.7)	(±10.3)	(±6.0)

***Table -3**: Ensemble of seasonal mean climate change scenarios for small islands for the 2080s as inferred from AOGCMs (numbers in brackets show standard deviation between model projections).*

Regions	Temperature Change (°C)				Precipitation Change (%)			
	December-February		December-February		June-August		June-August	
	GHG	GHG+A	GHG	GHG+A	GHG	GHG+A	GHG	GHG+A
Atlantic Ocean & Caribbean	3.01 (±0.87)	2.61 (±0.66)	3.07 (±0.86)	2.64 (±0.61)	4.8 (±14.6)	8.5 (±12.9)	-19.2 (±18.8)	-8.2 (±17.1)
Pacific Ocean	2.97	2.56	2.98	2.52	6.0	5.6	10.2	8.9
	(±0.82)	(±0.57)	(±0.91)	(±0.67)	(±1.5)	(±1.6)	(±5.9)	(±4.9)
Indian Ocean	3.18	2.61	3.16	2.62	5.9	6.2	-2.6	-5.9
	(±0.88)	(±0.60)	(±0.91)	(±0.69)	(±10.3)	(±10.5)	(±12.6)	(±7.4)
Mediterranean	3.94	3.31	4.52	3.70	16.1	9.9	-7.4	-11.6
	(±1.34)	(±1.01)	(±1.16)	(±0.72)	(±21.1)	(±21.6)	(±16.2)	(±10.7)

Key Regional Concerns

Development, Sustainability, and Equity Issues

The small island states account for less than 1% of global GHG emissions but are among the most vulnerable of all areas to the potential adverse effects of climate change and sea-level rise (Jones, 1998; Nurse *et al.,* 1998). It has been established that there already is a global commitment to climate change and sea-level rise as a result of greenhouse forcing arising from historic emissions (Jones, 1998; Nicholls *et al*., 1999; Parry *et al*., 1999). Moreover, analysis has shown that even with a fully implemented Kyoto Protocol, by 2050 warming would be only about 1/20th of a degree less than what is projected by the IPCC (Parry *et al*., 1999). Therefore, climate change impacts are inevitable.

Thus, owing to their high vulnerability and low adaptive capacity to climate change, communities in small island states have legitimate concerns about their future on the basis of the past observational record and present climate model projections. Economic development, quality of life, and alleviation of poverty presently constitute the most pressing concerns of many small island states. Thus, with limited resources and low adaptive capacity, these islands face the considerable challenge of charting development paths that are sustainable and controlling GHG emissions, without jeopardizing prospects for economic development and improvements in human welfare (Munasinghe, 2000; Toth, 2000). At the same time, given the inevitability of climate

change and sea-level rise, they are forced to find resources to implement strategies to adapt to increasing threats resulting from GHG forcing of the climate system, to which they contribute little (Sachs, 2000). Consequently, the already meager resources of these island states will be placed under further pressure.

Water-Level Changes

Sea-Level Rise

Although the severity of the threat will vary regionally, sea-level rise of the magnitude currently projected (i.e., 5 mm yr^{-1}, with a range of 2–9 mm yr^{-1}), is expected to have disproportionately great effects on the economic and social development of many small island states (Granger, 1997; IPCC, 1998). Coastal land loss already is projected to have widespread adverse consequences. Indeed, it is argued that land loss from sea-level rise, especially on atolls (e.g., those in the Pacific and Indian Oceans) and low limestone islands (e.g., those in the Caribbean), is likely to be of a magnitude that would disrupt virtually all economic and social sectors in these countries (Leatherman, 1997). Recent estimates indicate that with a 1-m rise in sea level, 10.3 km^2 of land in Tongatapu island, Tonga, would be lost. This figure would increase to 37.3 km^2 (14%) with storm surge superimposed on a 1-m sea-level rise scenario. For some main Yap Island (Federated States of Micronesia) sites, a retreat of 9 to 96 m is projected with a 1-m rise in sea level (Richmond *et al.*, 1997). On Majuro Atoll, Marshall Islands, land loss from one area based on the Bruun rule is estimated to be nearly 65 ha of dry land from a 1-m rise in sea level (Holthus *et al.*, 1992).

One of the most serious considerations for some small islands is whether they will have adequate potential to adapt to sea- level rise within their own national boundaries (Nurse, 1992; IPCC, 1998). In tiny islands where physical space already is very scarce, adaptation measures such as retreat to higher ground and use of building set-backs appear to have little practical utility. In extreme circumstances, sea-level rise and its associated consequences could trigger abandonment and significant "off-island migration," at great economic and social costs (Leatherman, 1997; Nicholls and Mimura, 1998).

Storm Surge and Flood Risks

Changes in the highest sea levels at a given locality will result from the change in mean sea level at that location and changes in storm-surge heights. If mean sea level rises, present extreme levels will be attained more frequently, all else being equal. The increase in maximum heights will be equal to the change in the mean, which implies a significant increase in the area threatened with inundation. This will be especially true in areas with a small surge envelope, which is typical in most small islands. Under such

circumstances, even incrementally small elevations in sea level would have severely negative effects on atolls and low islands (Forbes and Solomon, 1997; Nicholls *et al.*, 1999).

Changes in storm-surge heights also would result from alterations in the occurrence of strong winds and low pressures, as would occur during the passage of tropical storms and cyclones. It is already known that tropical cyclones are the major cause of storm surges that impact small islands in the Atlantic, Pacific, and Indian Oceans. Changes in the frequency and intensity of tropical cyclones could result from alterations to SST, large- scale atmospheric circulation, and the characteristics of ENSO (Pittock *et al.*, 1996). Although there is no consensus yet with regard to whether there will be changes in the behavior of these systems (Royer *et al.*, 1998; Jones *et al.*, 1999), the prospect of extreme sea levels (related to storm surges and higher wave amplitudes) is a concern that small island states cannot easily ignore.

Based on global sea-level rise scenarios produced by the Hadley Centre (HADCM2 and HADCM3), Nicholls *et al.* (1999) estimate that global sea levels are expected to rise by about 38 cm between 1990 and the 2080s. They project that many coastal areas are likely to experience annual or more frequent flooding, with the islands of the Caribbean and the Indian and Pacific Oceans facing the largest relative increase in flood risk. Projected out to the 2080s, the number of people facing high flood risk from sea-level rise in these regions would be 200 times higher than in the case of no climate change (Nicholls *et al.*, 1999). Recent studies for Cuba (based on HADCM2 and IS92a scenarios) also project that 98 coastal settlements with a combined population exceeding 50,000 persons would be inundated by a 1-m rise in sea level (Perez *et al.*, 1999).

Beach and Coastal Changes

The morphology, characteristics, and classification of beaches are influenced by a variety of factors, including island origin, geologic structure and composition (e.g., volcanic, coral atoll, raised atoll, Reef Island, or emergent limestone), age, elevation, and size (Gillie, 1997; Solomon and Forbes, 1999). Thus, given their varied origins, a wide range of beach types and characteristics is represented in the small island states of the Caribbean and Mediterranean Seas and the Atlantic, Pacific, and Indian Oceans.

Coastal erosion—partly the result of anthropogenic factors such as sand mining (Gillie, 1997; Ragoonaden, 1997)— already is a problem on many islands and evidently may be exacerbated by sea-level rise (Mimura and Nunn, 1998). On many atolls (as in the Pacific) and low reef islands (as in the Caribbean), carbonate beaches are maintained by sand produced from productive reefs whose degradation already is causing

accelerated beach erosion. Similarly, in the Mediterranean Sea, where the islands are periodically susceptible to flooding and scour from storm surges, an increase in storminess would further stress natural and human systems located at the coast (Nicholls and Hoozemans, 1996). The impact of the equivalent of a 1-m rise in sea level for a cumulative few hours on the coast was observed in Singapore on 7-14 February 1974. The event indicates clearly the vulnerability of the island's low-lying area to flooding and coastal erosion if sea-level rise takes place (Wong, 1992).

Beach erosion rates of approximately 2–4 m yr^{-1}, on average, have been reported for several beaches in Trinidad and Tobago, where mean relative sea-level rise of 8–10 mm yr^{-1} has been recorded by two gauges during the past 15 years. Although beach erosion results from multiple forces, sea-level rise is considered a contributory factor (Singh, 1997a, b). Ragoonaden (1997) measured shoreline retreat of 2.7 m yr^{-1} at Flic-en-Flac (Mauritius), and Nunn and Mimura (1997) report that the coasts of some islands in Fiji have retreated by more than 30 m in the past 70 years. In the specific case of Viti Levu and Taveuni, Fiji, beach erosion has been attributed to a combination of human-induced causes (including loss of the mangrove fringe and other natural protection) and elevated sea level, which has been rising at a rate of approximately 1–1.5 mm yr^{-1} since 1960 (Forbes and Solomon, 1997; Nunn and Mimura, 1997).

Response, Adaptation, and Management

It is now widely accepted that strategies for adaptation to sea- level rise tend to fall into three main categories: retreat, accommodate, and protect (Bijlsma, 1996; IPCC, 1996, 1998). Hard engineering—involving the construction of groynes, seawalls, breakwaters, and bulkheads—has long been the traditional response to coastal erosion and flooding in many small island states. Unfortunately, this approach has not always been efficiently implemented and has even helped to increase coastal vulnerability in some cases (Mimura and Nunn, 1998; Solomon and Forbes, 1999). In these specific circumstances, the term "maladaptation" (which refers to a response that does not succeed in reducing vulnerability but increases it instead) may be applied. Realistically, however, for some islands the application of hard solutions may be the only practical option along well-developed coasts, where vital infrastructure is at immediate risk.

There are other potential options available to small island states, including enhancement and preservation of natural protection (e.g., replanting of mangroves and protection of coral reefs), use of softer options such as artificial nourishment, and raising the height of the ground of coastal villages (Nunn and Mimura, 1997). Raising the height of the ground requires additional aggregate such as sand and stone and a lot of pumping, in which many small islands are seriously deficient. Removal of materials from "unimportant" islands to build up important islands via sand transfer by pipes and

barges has been suggested by the IPCC (1990). Some island states may be faced with few practical options. Thus, it might be necessary for them to lose some islands so that the entire nation is not completely inundated (Nicholls and Mimura, 1998).

Similarly, beach nourishment may not be a practical or economical option for many island nations because sand often is a scarce resource (Leatherman, 1997; IPCC, 1998). Moreover, beach nourishment requires maintenance in the form of periodic sand replenishment, sometimes every 5–10 years or less (Amadore *et al*., 1996). Such a requirement could prove to be unsustainable in small economies. In contrast, on some islands such as Singapore, where the technology and resources are more readily available, beach fill projects (used in combination with offshore breakwaters to form artificial headlands) is a feasible option (Wong, 1985). As a general strategy to respond to sea-level rise, it is likely that Singapore will focus on three main types of responses: coastal protection for developed or heavily populated areas and reclaimed land, anti-salt-intrusion measures for coastal reservoirs, and flood prevention measures (such as tidal gates) for major canals (Wong 1992).

In some islands, such as those in the Caribbean, more emphasis is being placed on the application of "precautionary" approaches, such as enforcement of building set-backs, land-use regulations, building codes, and insurance coverage. In addition, application of traditional, appropriate responses (e.g., building on stilts and use of expendable, readily available indigenous building materials), which have proven to be effective responses in many islands in the past, ought to be more widely considered (Forbes and Solomon, 1997; Mimura and Nunn, 1998).

Given the vulnerability of many small island states to various aspects of global change, integrated coastal management (ICM) is rapidly becoming an attractive paradigm for planning adaptation (Bijlsma, 1996; Cicin-Sain, 1998; Nicholls and Mimura, 1998). Furthermore, ICM can be regarded as both an anticipatory and a predictive tool, with the capability to plan for and respond to medium- and long-term concerns such as sea-level rise as well as short-term, present-day needs (Nurse, 1999; Solomon and Forbes, 1999). In addition, ICM can provide an effective framework for resolving potential conflict among competing stakeholder interests, in a manner that is equitable to all groups. In this context, it is noteworthy that all of the small island states that recently participated in the U.S. Country Studies Program (i.e., Federated States of Micronesia, Samoa, Fiji, Kiribati, Marshall Islands, Sri Lanka, and Mauritius) concluded that ICM was the most appropriate adaptation strategy and should form an essential part of their climate change national action plans (Huang, 1997).

Enhancing the resilience of coastal systems has been suggested (e.g., Bijlsma, 1996) as an appropriate proactive adaptive response to reduce vulnerability. Klein and Nicholls

(1998) agree that this could be a more cost-effective way to prepare for uncertain changes such as sea-level rise, rather than relying entirely on building traditional, more costly coastal defenses. Helmer *et al.* (1996) strongly support the notion of enhancement of coastal resilience whereby dynamic systems (e.g., dunes, lagoons, and estuaries) should be allowed to utilize their natural capacity to grow in response to rising sea levels. This philosophy could be applied through pilot studies in small islands. One of the ways in which a dynamic and resilient coast can be created is by managed retreat, based on an enforced building set-back that allows the coastline to recede to a new line of defense, thus restoring natural coastal processes and systems. An orderly plan to retreat could be a feasible option on larger islands that cannot commit the resources necessary to prevent coastal land loss in the face of rising sea levels (Leatherman, 1997).

One recommended approach to planning adaptation to sea- level rise and coastal change involves an estimation of the costs of protecting or abandoning developed properties. For developed coasts, West and Dowlatabadi (1999) propose that the real economic evaluation of sea-level rise should be regarded as the difference in utility (not just damages) with and without a sea-level rise scenario, in which it is assumed that physical conditions (e.g., erosion and storms) and human behavior remain constant. This is an improvement on past approaches, which provided the estimated costs of sea-level rise on the basis of market value of inundated land and property or the cost of structural protection.

Coral Reefs, Mangroves, and Sea grasses

Coral Reefs

Coral reefs represent one of the most important natural resources of many tropical islands. They are a source of food, beach sand, and building materials and function as natural breakwaters along the coasts of many tropical islands. They also provide habitats for many marine animals and reef fish and generate significant revenues for many small island economies through avenues such as tourism (e.g., snorkeling and scuba diving). On many islands, coral reefs are facing severe threats from climate- and non-climate-related stressors. The total areal extent of living coral reefs has been estimated at about 255,000–1,500,000 km^2 (Spalding and Grenfell, 1997), of which 58% are considered at risk from human activities, according to a global assessment.

Owing to their narrow temperature tolerances, some species of corals currently live at or near their thermal limits (Goreau, 1992; IPCC, 1998). SST projections (based on three variants of the Max Planck Institute ECHAM and CSIRO GCMs) suggest that the thermal tolerance of reef-building corals will be exceeded within the next few decades. Moreover, the incidence of bleaching will rise rapidly, with the rate of increase highest in the Caribbean and slowest in the central Pacific region (Hoegh-Guldberg, 1999).

There is now substantial evidence that indicates that "episodic" warming of the ocean surface, as occurs in El Niño years, leads to significant coral bleaching (Brown and Ogden, 1993; Glynn, 1993; Goreau and Hayes, 1994; Wilkinson and Buddemeier, 1994; Brown, 1997a,b; CARICOMP, 1997; Goreau *et al.*, 1997). The major coral bleaching episodes in the past 20 years were found to be associated with periods when ocean temperatures were about 1°C higher than the summer maximum. It also has been suggested that bleaching events could occur annually in most tropical oceans in the next 30–50 years (Hoegh-Guldberg, 1999). Bleaching was particularly severe and widespread during the period of the most recent El Niño episode of 1997–1998, which was considered to be the most intense such event on record. On some islands, more than 90% of all live reefs have been affected (Goreau and Hayes, 1994), with branching species generally most severely impacted (Wilkinson 1998, 1999). The impact of increasing CO_2 concentrations in the oceans on coral reefs is now the focus of an emerging though as yet unresolved debate. Since publication of the SAR and the *Special Report on Regional Impacts of Climate Change* (IPCC, 1998), it has been suggested that the ability of reef plants and animals to make the limestone skeletons that build the reefs is being reduced by rising atmospheric CO_2 concentrations. Indeed, some authors suggest that based on projected CO_2 concentration in the atmosphere, the calcification rate of corals would decline by approximately 14–30% by 2050 (Gattuso *et al.,* 1999; Kleypas *et al.,* 1999).

Earlier IPCC assessments have concluded that the threat of sea-level rise to reefs (as opposed to reef islands) is negligible. This conclusion was based on projected rates of global sea-level rise from Warrick *et al.* (1996) on the order of 2–9 mm yr^{-1} over the next 100 years. It has been suggested that healthy reef flats will be able to keep pace with projected sea-level rise, given an approximate upper limit of vertical reef growth during the Holocene of 10 mm yr^{-1} (Schlager, 1999). However, the prognosis is far less positive in many small island states (e.g., in the Caribbean Sea and the Indian Ocean), where reef structures have been weakened by a variety of anthropogenic stresses. This concern also is applicable to many island countries, where reefs in close proximity to major settlements have been severely stressed. The ability of reefs to keep pace with sea-level rise also will be adversely affected by more frequent coral bleaching episodes and by reduced calcification rates resulting from higher CO_2 concentrations.

Mangroves

Mangroves provide important functions as protection against storms, tides, cyclones, and storm surges and are used as "filters" against the introduction of pests and exotic insects (Menendez and Priego, 1994; Suman, 1994). Mangroves have important

ecological and socioeconomic functions as well, particularly in relation to animal and plant productivity, as nutrient sinks, for substrate stabilization, and as a source of wood products. These functions sometimes may be in conflict and differ in importance between riverine, basin, and coastal fringe mangroves; the latter are important primarily for shoreline protection.

Many mangrove forests are under stress from excessive exploitation, reducing resilience in the face of sea-level rise. The importance of sediment flux in determining mangrove response to rising sea levels is well established in the literature. Ellison and Stoddart (1991), Ellison (1993), and Parkinson and Delaune (1994) have suggested that mangrove accretion in low- and high-island settings with low sediment supply may not be able to keep up with future rates of sea-level rise, but Snedaker and Meeder (1994) have suggested that low-island mangroves may be able to accommodate much higher rates. These observations necessarily represent conflicting views because the resilience of mangroves to sea-level rise also is conditioned by the composition and status of the stands and other factors such as tidal range and sediment supply (Woodroffe, 1995; Farnsworth, 1998). In some protected coastal settings, inundation of low-lying coastal land actually may promote progressive expansion of mangrove forest with rising sea level (Richmond *et al*., 1997), provided vertical accretion keeps pace.

Studies have shown that mangrove forests in some small islands will be lost as a result of elevated sea levels. For example, it is projected that with a 1-m sea-level rise in Cuba, more than 300 ha of mangroves, representing approximately 3% of that country's forests would be at risk (Perez *et al.,* 1999). Under similar conditions, Alleng (1998) projects a complete collapse of the Port Royal mangrove wetland in Jamaica, which has shown little capacity to migrate in the past 300 years; Suman (1994) envisages that accelerated sea- level rise would adversely affect mangroves in Puerto Rico, where 62% already has been eliminated by direct human activity.

Seagrasses

Seagrass communities provide useful habitat for many marine fish, particularly in the shallow, intertidal environments of many islands. It is postulated that an increase in SST will adversely affect seagrass communities because these ecosystems already are sensitive to land-based pollution and runoff in coastal environments (Edwards, 1995). It is argued further that the distribution of seagrasses will shift as a result of temperature stress, which in turn can cause changes in sexual reproduction patterns (Short and Neckles, 1999). In addition, an increase in temperature will alter seagrasses' growth rates and other physiological functions. Sea-level rise would mean increasing water

depth and reduction of the amount of light reaching the seagrass beds, which would reduce plant productivity.

The effect of increased CO_2 in the water column will vary according to species and environmental circumstances but will likely alter the competition between species, as well as between seagrasses and algal populations (Beer and Koch, 1996). Laboratory experiments suggest that some seagrasses, such as *Zostera marina,* are able to respond positively to increased CO_2 levels by increasing their rate of photosynthesis (Zimmerman *et al.*, 1997), although earlier research on field-collected samples of *Thallassia testudinum* suggests that maximum photosynthesis is lower with elevated CO_2 levels (Durako, 1993).

As with other submerged aquatic plants, seagrasses are sensitive to ultraviolet-B (UV-B) radiation because such radiation can penetrate depths of up to 10 m. Laboratory experiments have demonstrated that the response can vary from strong photosynthetic tolerance, in the case of *Halophila wrightii*, to moderate tolerance, as with *Syringodium filiforme*; to little photosynthetic tolerance, as exhibited by *Halophila engelmanni* (Hader, 1993; Short and Neckles, 1999).

Biodiversity of Islands

Small islands are highly variable with respect to their biological diversity. Some states, such as the low reef islands, have low biodiversity and low endemism. Coral reefs exhibit the highest known diversity among marine ecosystems, with 91,000 described species of reef taxa. Table -4 gives the diversity of mammals, birds, plants, and endemism for some select small island states. In general, small islands in absolute figures tend to have high terrestrial diversity and endemism. In Cuba, for instance, 50% of the flora and 41% of the fauna are endemic (Vales *et al.*, 1998). In the Canary Islands, 45% of all bird species are endemic. In the Hawaiian islands—the most isolated of all floristic regions—more than 90% of plant species are endemic (Biagini, 1999). When relative biodiversity and endemism are calculated in relation to area, the figures for many small island states tend to be higher than those for most other regions of the world.

Although there generally is high diversity associated with the ecosystems (marine and terrestrial) of islands, their long-term survival is threatened by anthropogenic stresses including pollution, overexploitation, and generally poor management. As in other regions, it is expected that climate change will affect the biodiversity of small islands directly and indirectly. Rising atmospheric CO_2 concentrations are projected to increase the productivity of some communities and alter competition among others by eliminating some species and introducing new species to take their place (McIver, 1998).

In marine ecosystems such as coral reefs, incremental increases in atmospheric CO_2 would be expected to threaten the diversity of these systems (Hatcher, 1997).

The impacts of climate change and sea-level rise on biota in island states are much greater than the impacts on continental areas. For example, sea-level rise could impact the habitats of the endangered Tuamotu sandpiper (*Prosobonia cancellata*) and bristle-thighed curlew (*Numenius tahitiensis*), as well as the seabird colony of 18 species on Laysan Island (Hawaii). Other potentially vulnerable areas (not inclusive) for breeding seabirds include the Kerguelen and Crozet Islands (seabirds), the Galapagos Islands (Galapagos penguin, *Spheniscus men - diculus*), and the nesting habitat for the Bermuda petrel (*Pterodroma cahow*) (Sattersfield *et al.,* 1998). Based on outputs from HADCM2 and scenarios IS92a and Kyoto 1. Suarez *et al.* (1999) also have found that in the eastern region of Cuba, certain endemic species of flora would face extinction.

Inundation and flooding of low-lying forested islets with species such as the Manus fantail (*Rhipidura semirubra*) also might be lost. The majority of threatened bird species on islands are found in forested habitats (Sattersfield *et al.,* 1998). Impacts of climate change on these species likely would be from physiological stress and changes and loss in habitat, especially from fires and cyclones. For example, 30% of the forested area on the Santa Cruz Islands was lost in one cyclone in 1993. Some vulnerable species and areas include the endangered New Caledonian lorikeet (*Charmosyna diadema*) and critically endangered New Caledonian rail *(Gallirallus lafresnayanus)* on New Caledonia, the Samoan white-eye (*Zosterops samoen - sis*) and critically endangered Samoan moorhen (*Gallinula pacifica*) on Savai'i (Samoa), and the Santo Mountain starling (*Aplonis santovestris*) on Espiritu Santo (Sattersfield *et al.,* 1998). In Samoa, most species of flowering plants are pollinated by a few species of animals; nearly 100% of seed dispersal in the dry season is mediated by flying foxes (*Pteropus spp.*) (Cox *et al.*, 1991). Likewise, flying foxes are the key pollinators and seed dispersers on many islands in the South Pacific. If their habitat is threatened by climate change, the result would be the loss of many dependent plant species.

Generally on islands, one of every three known threatened plants is endemic. Among birds, approximately 23% of the species found on islands are threatened, compared with only 11% of the global bird population (McNeely *et al.*, 1993). Establishment of terrestrial, marine, or coastal reserves such as the Morne Trois Pitons Park and Forestry Reserve (Dominica, 1986), Bonaire Marine Park (Netherlands Antilles, 1979), Tobago Cays Marine Park (St. Vincent and the Grenadines), Soufriere Marine Management Area (St. Lucia), and other similar management units ("biosphere reserves") established elsewhere is a useful management option. It has been demonstrated that the creation of such reserves helps to preserve endangered habitats and

ecosystems of small islands and will contribute to maintenance of biological diversity, while increasing the resilience of these systems to cope with climate change.

***Table -4**: Biodiversity status for selected small island states, 1990 (extracted from IPCC, 1998).*

Country	Known Mammal Species	Known Endemic Mammal Species	Known Bird Species	Known Endemic Bird Species	Known Plant Species	Known Endemic Plant Species
Cuba	31	12	342	22	6,004	3,229
Dominican Republic	20	—	254	0	5,000	1,800
Fiji	4	1	109	26	1,307	760
Haiti	3	0	220	0	4,685	1,623
Jamaica	24	3	262	25	2,746	923
Mauritius	4	2	81	9	700	325
Palau	214	57	708	80	10,000	—
Solomon Islands	53	19	223	44	2,780	30
Trinidad and Tobago	100	1	433	1	1,982	236

TOURISM

Tourism is a major economic sector in many small island states. Table -5, which expresses tourist arrivals in terms of the populations of small island states for which data were available, shows that in most small island states, the numbers of visitors substantially exceed the number of inhabitants. Table -5 also expresses tourism receipts in terms of gross national product (GNP) and in terms of foreign exchange inflows from exports of goods and services. Again, the ratios tend to be relatively high in most small island states; the Maldives, Antigua and Barbuda, and the Bahamas exhibit the highest ratios. In many countries, tourism also makes a significant contribution to employment. For example, the industry provides jobs for 70% of the labor force in the Bahamas, 40% in Malta, and 20% in Seychelles (Waters, 1998).

It is widely acknowledged that the effects of climate change on tourism will be both direct and indirect. For instance, sea- level rise would disrupt the sector through loss of beaches, inundation, degradation of coastal ecosystems, saline intrusion, and damage to critical infrastructure (Nicholls and Hoozemans, 1996; Teh, 1997; Perez *et al.,* 1999). Because many small islands are so heavily dependent on the tourism sector for their economic survival, adverse impacts on the industry, from climate change or other causes, would be of great concern in these countries. In many small islands, the industry also would be sensitive to other climate-related impacts, such as loss of attractiveness of coral reefs as a result of bleaching.

Table -5: Tourist inflows and receipts, various years, for select small island states (Waters, 1998).

Country	Number of Tourists (000s)[a]	Tourists as % of Population[a]	Tourist Receipts[b] as % of GNP	Tourist Receipts[b] as % of Exports
Antigua and Barbuda	232	364.2	63.4	73.5
Bahamas	1618	586.4	42.0	75.6
Barbados	472	182.4	39.2	56.2
Cape Verde	45	11.4	11.5	37.3
Comoros	26	4.9	10.6	47.8
Cuba	1153	10.5	8.8	n/a
Cyprus	2088	280.7	24.0	49.1
Dominica	65	97.6	15.9	32.5
Dominican Republic	2211	28.1	13.6	30.2
Fiji	359	45.3	19.2	29.1
Grenada	111	116.2	27.0	60.6
Haiti	149	2.2	3.9	50.5
Jamaica	1192	45.6	31.6	39.8
Maldives	366	130.7	95.0	68.4
Malta	1111	294.7	22.9	28.7
Mauritius	536	46.4	15.7	26.8
Papua New Guinea	66	1.5	2.1	3.0
St. Kitts and Nevis	88	210.5	30.6	63.6
St. Lucia	248	164.7	41.1	66.6
St. Vincent	65	54.6	23.8	45.9
Samoa	68	31.1	19.6	48.8
Seychelles	130	166.7	34.6	52.2
Singapore	7198	209.2	6.2	4.1
Solomon Islands	16	3.7	2.8	4.2
Trinidad and Tobago	324	28.7	4.2	8.3
Vanuatu	49	27.1	19.3	40.9

[a] Data on tourist inflows and ratio to population pertain to 1997.

[b] Data for tourist receipts pertain to 1997 for the Bahamas, Cape Verde, Jamaica, the Maldives, Malta, Mauritius, Samoa, Seychelles, Singapore, and Solomon Islands; to 1996 for Antigua and Barbuda, Cuba, Dominica, Dominican Republic, Fiji, Grenada, Haiti, Papua New Guinea, St. Lucia, and St. Vincent; to 1995 for Barbados, Comoros, Cyprus, Trinidad and Tobago, and Vanuatu; and to 1994 for St. Kitts and Nevis.

A high proportion of tourism in small island states is motivated by the desire of visitors from developed countries of the north (their largest market) to escape cold winters. Small island states are becoming increasingly concerned that projected milder winters in these markets could reduce the appeal of these islands as tourist destinations (Martin and Bruce, 1999). It is projected that tourism could be further harmed by increased airline fares if GHG mitigation measures (e.g., levies and emission charges) were to result in higher costs to airlines servicing routes between the main markets and small island states (Wall, 1996).

To ensure the sustainability of the tourist industry in Cyprus, it has been recommended that a strategy of protection of infrastructure combined with planned retreat would

be effective and appropriate to local circumstances. The overall goal would be to maintain the limited beach area to sustain the vital tourist industry, specifically by erecting hard structures, enforcing building set-backs, and use of artificial nourishment, although the latter measure may require external sources of sand (Nicholls and Hoozemans, 1996). Although not all these strategies may be applicable to the atoll states, many other island nations—such as Barbados, Jamaica, Grenada, St. Lucia, and Singapore—already have begun to implement similar approaches as part of the ICM process.

Fisheries

Although fishing is largely artisanal or small-scale commercial, it is an important activity on most small islands and makes a significant contribution to the protein intake of island inhabitants (Blommestein *et al*., 1996; Mahon, 1996). The impacts of climate change on fisheries are complex and in some cases are indirect. As with other renewable resources, an assessment of climate change impacts on fisheries is complicated by the presence of anthropogenic and other non-climate-related stresses, such as habitat loss and overexploitation (Challenger, 1997).

Many breeding grounds for commercially important fish and shellfish are located in shallow waters near coasts. These areas include mangroves, coral reefs, seagrass beds, and salt ponds—all of which are likely to be affected by climate change. Generally, fisheries in the small island states are not expected to be adversely affected by sea-level rise *per se*. Higher sea level would be a critical factor for fisheries only if the rate of rise were far more rapid than the current succession of coastal ecosystems (e.g., mangroves, seagrasses, corals) on which some fish species depend (Everett, 1996). In tropical islands, these ecosystems function as nurseries and forage sites for a variety of important commercial and subsistence species. In this context, the unfavorable effects of higher CO_2 concentrations on coral reef development, coupled with widespread coral bleaching, must be considered a significant threat in many small island states. Fish production obviously would suffer if these habitats were endangered or lost (Costa *et al*., 1994).

On a global scale, it is not expected that climate change and climate variability will lead to any significant reduction in fisheries production. However, important changes in the abundance and distribution of local stocks (which may be of direct concern to some small islands) are likely to occur (IPCC, 1996). For example, Lehodey *et al*. (1997) have shown that spatial shifts in the abundance of skipjack tuna in the Pacific are linked to the ENSO cycle. They note that catches are highest in the western equatorial Pacific warm pool, which can be displaced by as much as 50° of longitude eastward during El Niño episodes and westward in La Niña years (Lehodey *et al.*, 1997). This must be a concern to Pacific islanders whose access to the skipjack stocks now appears to be largely controlled by the periodicity of ENSO events.

Several management strategies for minimizing the adverse effects of climate change on fish stocks have been proposed. These measures—many of which already are being implemented in some island states—include conservation, restoration, and enhancement of vital habitats such as mangroves, coral reefs, and seagrass beds; establishment and management of marine reserves and protected areas for identified critical species; and implementation of bilateral and multilateral agreements and protocols for exploitation and management of shared fisheries (migratory and straddling stocks) (IPCC, 1998; Berkes *et al*., 2001). Aquaculture also may be considered by island states as another means of reducing stress on wild stocks. However, great precaution must be taken to ensure that this measure does not exacerbate existing problems of habitat loss and competition for nutrients (Carvalho and Clarke, 1998).

Ecosystem Collapse

One of the likely outcomes of climate change and sea-level rise in natural systems is their collapse. Although ecosystem collapse is not presently well-defined or understood, it is a concern of island countries, which depend heavily on resources provided by these systems to sustain their economic and social well- being (Burns, 2000; Gillespie and Burns, 2000). If mangrove systems are to migrate inland, for example, what is involved is the collapse of the original mangrove system on the existing shore and its eventual replacement with another ecosystem. It is unclear whether the old mangrove area would be replaced by a viable alternative marine ecosystem or whether the new mangroves produced inland would be a viable ecosystem, with all of the same functional characteristics of the original. These and similar questions are central to understanding the ability of human and natural systems to adapt to climate change and sea- level rise.

Recommendations

The following actions are recommended for the consideration of national and international decision makers: *Proceed with utmost caution to ensure continued functioning of oceans in sustaining life on Earth*:

- Adopt the most stringent and rapid reductions in greenhouse gas emissions, to avoid disastrous consequences on oceans, small islands and coastal communities around the world. Compelling scientific evidence indicates that to safeguard the essential role of oceans in regulating climate and sustain the productive function of marine ecosystems, adoption of policy with peak atmospheric carbon dioxide levels no higher than 450 ppm, and commitment to bring CO_2 levels below 350 ppm with urgency are required.
- Give special consideration to **SIDS** and especially vulnerable coastal nations.
- Promote management of natural carbon sinks in coastal areas.
- To protect biodiversity, save and restore global fisheries, recognize the deep links between ecosystem degradation and rural poverty, and change the 'world view' on the economic value of marine ecosystems and biodiversity to sustainable development of a low-or-no carbon 'green economy' and a 'blue' society.

- Establish global governance frameworks for ocean-related geo engineering research and potential use.

- Manage natural ecosystems to boost ecological resilience in a changing climate. Protecting ecosystem components such as biological diversity and ecologically important species have been shown to improve resilience and recovery from climate change impacts across many ecosystems.

- Gather and exchange information, improve public awareness and early warning system capacity for climate change impacts on marine ecosystems, communities, fisheries and other industries, as well as emergency preparedness, monitoring, and forecasting of extreme events and ocean variability.

- Enhance, at regional and national levels, exchange of lessons learned and best practices, and climate vulnerability assessment of oceans and coasts in order to facilitate the implementation of adaptation measures.

- Cooperate in furthering marine scientific research and sustaining integrated ocean observation systems; promote education and public awareness; and collaborate to improve understanding of the role of oceans in climate change and vice versa including effects on marine ecosystems, marine biodiversity and coastal communities especially in developing countries and small island states.

- Invite scientific communities and institutions to further develop reliable scientific information on the roles of coastal wetland, mangrove, algae, seagrass and coral reef ecosystems in reducing the effects of climate change, and share knowledge of best practices based on the dynamic relationship between oceans and climate.

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Seychelles
Tanzania
Dodoma
Glorioso Islands
Grande Comore
Mayotte
Mamoudzou
Malawi
Lilongwe
Tromelin Island
Juan de Nova Island
Mozambique
Mozambique Channel
The Indian Ocean Tobacco Company
Antananarivo
Madagascar
Mauritius
Port Louis
Rodrigues
Reunion
Saint Denis
Bassas da India
Europa Island
Google earth


Kentucky
Virginia
North Carolina
South Carolina
Georgia
Bermuda
Bermuda
Florida
The Bahamas
Nassau
Havana
Google earth

SMALL ISLAND STATES OF INDIAN OCEAN AND IMPACTS OF CLIMATE CHANGE AND ITS MITIGATION

BY
MR. ATTIA DASTGIR
ENGR. ISHTEQAQ AHMAD
DR. MUHAMMAD FAYYAZ AHMAD[1]

ABSTRACT

The Indian Ocean Island states are geomorphologically highly diverse and spans an area between the African, Asian and Australian continents. The major island states encompass Java, Madagascar, Sri Lanka and Sumatra and small island group enfolds Comoros Islands, The Maldives, Seychelles, Zanzibar, numerous atolls and archipelagos. Indian Ocean Small Island States are isolated cradle spots of unique ecosystems mainly dependent upon monsoons. These are one of the most vulnerable global sites towards onslaught of global warming. Highly at risk islands include Comoros, Maldives, Mauritius, and Seychelles etc. Global warming is now an established fact and triggering effect of human footprints is also imminent. Recent historical trends of climatic disasters, anthropogenic oriented increase in atmospheric CO_2 levels and ultimate susceptibility of IO-SISs is a revealing fact. The major threats to IO-SISs include the rising sea level resulting in submergence of littoral areas and coastal lowlands, coastal human settlements and deltas of rivers, depletion in biota quantitatively and qualitatively. In other looming threats, the Warming waters may encounter invasion of alien invasive species resulting in unpredictability in biotic components of established ecosystem changes in constituent species of mangrove vegetations and washing of coral reefs etc. To take stock of this menace of ripples, awareness of the gravity of the situation among all stakeholders is the key strategy. This has to be followed with improvement in governance and enhancement of socio-economic resilience in IO-SISs to avoid further degradation of ecosystems in the wake of climate change.

1. INTRODUCTION

The Indian ocean's majority of small island states (IO-SISs) are concentrated in tropical region. These encompass Comoros Islands, the Maldives and Seychelles; and numerous atolls and archipelagos alongwith Zanzibar etc. Mostly these countries have small land areas with a high population density, a limited range of natural resources, narrow range of skills of populace, low economic resilience; ultimately rendering them susceptible to natural hazards triggered by climate change. The recent unpredictability in monsoon patterns has further eroded their resilience to cope with climate change. That is why these IO-SISs are high risk tiny land masses in turbulent and ever-changing Indian Ocean.

[1] WAPDA Environment Cell, Lahore

Global warming is now an established fact, it is very much on the cards that we are cruising towards our virtual extinction because of blind pursuit of unfulfilled desires. In the bargain nature is taunting mankind (through global warming) to avoid anthropogenic hegemony. The gradual increase of atmospheric CO_2 levels from 1750s; 280 ppm to present 400 ppm tells the story of anthropogenic footprints on climate. As a result, seeds of climatic unpredictability are sprouting into detrimental coastal flooding, tsunamis, annihilating drought and ravaging cyclones on IO-SISs.

The records shows that past 5 years have been the warmest time of the past five centuries. The global warming has resulted in the warming of the oceans, rising of sea levels melting of glaciers and diminished snow covers. During the 21st century, climatic disasters occurred five times as frequently and killed or affected seventy times as many people. The tectonic triggered 2004 Tsunami ravaged the Indian Ocean small island states in an unprecedented manner and global warming phenomenon aggravated the situation by downplaying the resilience of vulnerable coastal ecosystems.

It is alarming that Indian Ocean Sea Surface Temperature (IO-SST) has risen rapidly in recent decades, partly owing to the increasing Green House Gases (GHGs) forcing two to three times faster than the warming in the tropical Pacific according to multi-decadal analysis of sea surface temperatures, which renders IO-SISs more vulnerable towards global warming.

Climate Change and Indian Ocean SISs

The Indian Ocean small island states are mainly clustered near western and southern boundaries of Indian Ocean, within coordinates 20°S to 15°N and 40° to 80°E encompassing a vast stretch of globe. The average projected annual mean warming as a consequence of increases in atmospheric concentration of GHGs over the region covering the key SISs of Indian Ocean is 2.10 ± 0.43°C for the 2050 and 3.16 ± 0.89°C for 2080. The second parameter of climatic changing trend is precipitation pattern changes in IO-SISs. The annual mean precipitation change inferred from data generated in 5 skillful A-O GCM experiments due to increase in GHGs is expected to be 3.1 ± 4.5% for 2050 and 5.1 ± 4.3% for 2080. Both these parameters would impact the SIS countries in scores of ways. The economy of most of IO-SISs is intrinsically linked with the subsistence agricultural production, aquaculture, fisheries and tourism (HESS 1990). The heat stress due to a rise in surface air temperature stands a good chance of disturbing the terrestrial, marine and agro ecosystems in IO-SISs. The rise in mean temperature will lead to more frequent occurrences of extreme heat waves and consequently higher incidences of related illness and mortality. This phenomenon would affect the abundance and distribution of disease vectors or disease-causing microbes as well as vulnerability of population (Epstein et al 1998). Malaria and dengue are likely to spread into large swaths of IO-SISs. Waterborne diseases would be rampant and higher sea surface temperatures would reduce the fish catches and would lead to bleaching of coral reefs. Sea level rise (due to thermal expansion of the Indian Ocean resulting from global warming and melting of ice caps and glaciers) poses significant risk to IO-SISs. The projected global rate of mean sea level rise of 5mm/year is 2 to 4 times greater than

the rate experienced in the previous 100 years. Many of the key IO-SIS rarely exceeds 3 to 4m above present sea level and even on the islands with higher elevation, most of the settlements, economic activity, infrastructure and services are located at or near the coast while severity of risk will vary from island to island. While rise in level of magnitude of Indian Ocean currently projected is expected to have profound impact on the economic and social development of many IO-SISs. Coastal land loss and beach erosion is likely to have widespread adverse consequences including disruption / displacement of communities. The land losses due to sea level rise in low-lying atolls in Indian Ocean are likely to be of a magnitude which would disrupt virtually all economic and social sectors of these countries. In case of one meter rise in sea level, 1190 tiny islands that constitute the Republic of Maldives may be submerged. In low-lying atolls of Marshal Islands land loss is estimated to be nearly 60 hectares of dry land (8.6% of total land area).

Other Indian Ocean Islands that can be impacted to considerable extent includes Comoros Islands, Seychelles, Galapagos archipelagos and numerous Atolls.

In IO-SIS, the impact will be widespread on following habitats i.e. coastal low-lands, including coral reefs, sea grass beds / meadows, barrier islands, inter-tidal zones, sandy beaches, saline / freshwater or brackish water lagoons, coastal human settlements and coastal river floodplains. The rich marine biodiversity in IO-SIS littoral zones is another likely victim of climate change resulting in depletion of Ichthyofauna qualitatively and quantitatively. Ocean acidification would harm aquatic flora and fauna that form shells from $CaCo_3$. Another aspect requiring contemplation is invasion of alien invasive species in warmer waters and changing ecosystem and unpredictability in occurrence of biotic components resulting in loss of flora and fauna, species composition of community and ecosystem services. Acidification of oceans around IO-SISs, will yield high number of invasive species and low biodiversity. Phenomenon including shift in rainfall pattern, increased CO_2 levels changes in storm and wave action coupled with coastal squeeze would result in changes in the constituent species of mangroves vegetation.

Challenges and Opportunities

The key challenge to IO-SISs while addressing the climate threat is timely adaptation to global warming. This end can be achieved by inculcating resilience in ecosystem providing good and services and restricting anthropogenic footprints within sustainable strives. To reach this end a more cohesive and coordinated Indian Ocean based strategy is to be adopted by IO-SISs nations. Another lacuna that is being felt while mitigating climate change in IO-SISs lack of awareness regarding impending climate risks, special vulnerabilities of particular populations and clear-cut demarcation responsibilities of stakeholders.

The ever-increasing population in the coastal regions has resulted in indiscriminate use of this zone for development and this aspect has overridden the concerns regarding climate change, national disasters or environmental quality. There is dire need to improve published information based on the required type of quality on effect of climate

change on coastal aquatic ecology of IO-SIS. This lacking is mostly due to under resourced institutions and insufficient number of professional scientists.

We must adopt a strategy to connect specific processes taking place in populations, and communities at broader canvas affecting whole regions and their constituent ecosystems. We must not wait for the outcomes of climate change to wake us from slumber through vagaries of natural disasters and emergencies i.e. another tsunami is not required to force us to undertake better coastal zone management in IO-SISs.

Another challenge to face is depleting biodiversity with changes in temperature and rainfall, increasing fire risk and weed invasion; and changing species range. Changes to our climate are likely to increase the frequency and intensity of extreme weather events such as heat waves, typhoons, floods and droughts on IO-SIS clusters. Another phenomenon is widening of tropics by a degree in latitude each decade since 1979. The biggest change is occurring in South Indian Ocean, where most of the IO-SIS lies. This further aggravates the situation of vulnerability for these already fragile economies.

We need to pre-empt and take this bull by the horns by developing resilience in our system before it is too late.

Mitigation Measures

For most Indian Ocean Small Island States, there seem little choice but to attempt to reduce the exposure to climate change risks of the most vulnerable populations, build resilience where possible and salvage what they can of their ecosystems to prevent further degradation and virtual extinction. Following mitigation measures may be adopted.

- To cope with increasing temperature and salt water intrusion in coastal regions, adaptation include planting drought / salt tolerant and deep rooted crop varieties, changing in farm management to improve water retention capacity and culturing of salinity tolerant fish and prawns such as Chanos chanos and Machrobracium rosenbergii, etc.
- In case of sea level rise in IO-SIS, the tackling of this problem may involve shifting anthropogenic activities higher or further inland, building sea walls and mangrove rehabilitation.
- To mitigate the impact of climate change on biodiversity the measures include; ecosystem based adaptation incorporating sustainable management, conservation and restoration of biodiversity and ecosystem services.
- To adopt to increased intensity of extreme events, IO-SISs need to adopt improved use of climate and weather data, weather forecasts and other management tools.

- The challenges of public health deterioration in the backdrop of climate change in IO-SISs need to be tackled through awareness of this effect on public health and development of early warming system about outbreak. Provision of better medical facilities to isolated, remote and marginalized settlements will also go many a mile in combating such menacing outbreaks.

- To improve the ground reality of adaptability and resilience in case of climate change triggered disaster. The identification of plan of refuge and evacuation early warming system improved use of climate and weather data and forecast are important measures.

- Last but not least important is the poverty alleviation in IO-SISs countries, which is an inherent cause of vulnerability towards devastation of climate change.

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ENVIRONMENTAL ETHICS (A PROLOGUE TO SUSTENANCE FROM AIR TO OCEANS AND FROM ISLANDS TO MAINLANDS)

By

Engr. Usman-e-Ghani[1]

1. ABSTRACT

Environmental ethics studies the moral relationship of human beings with the environment and its non-human contents. It covers the early development of the discipline in the 19th and the 20th century; application of traditional ethical theories to support contemporary environmental concerns; the challenge of environmental ethics to the anthropocentrism; the link of shallow/deep and social ecology to the corporatism and politics; the focus of environmental literature on wilderness; and the possible future development.

Environmental ethics starts with human concern for a quality environment. The proponents of environmental ethics take the ground that the plea to uphold the environmental ethics, for the Earth to continue to be good place, is not just current but centuries old and it gives a shape to the related ethics from start to finish; i.e. how the humans relate themselves to the animals and/or to the plants; or the overall ecosystem as a whole. The disregard to the environmental ethics is being termed as a major reason behind the turmoil of our current environmental issues.

The paper under consideration would dilate upon the above noted dimensions. It would attempt to see and discuss how the wider human interactions with the environment have thwarted the global security and the overall environment today and what could be the basis for a possible prologue to retain or to regain the environmental sustenance for our future generations.

2. KEYWORDS

Environmental Ethics, Sustenance, Anthropocentrism, Last Man, Sentience, Moral Specks, Brown Cloud, Global Security.

3. INTRODUCTION

Being sapiens, humans are the only self-reflective and deliberative moral agents. But are humans the only valuable or the valuing agents in our otherwise a value-free world?

It has been estimated that humans co-inhabit the earth with five to ten million species. Nature has equipped homosapiens, i.e. the wise species, with a

[1] Chief Engineer (Coordination), C&M Water, WAPDA, Lahore

conscience. Perhaps conscience is less wisely used than it ought to be when, as in classical enlightenment ethics, it excludes the whole of the global community from consideration, perhaps with the resulting paradox that the self-conscious moral species acts only in their own collective self-interest.

Environmental ethics claims that we humans are not so 'enlightened' as once supposed, at least not until we reach to more considerate or rather one of the most urgently required to implemented set of ethics, i.e. the environmental ethics. If someone had been attempting to foresee the future of philosophy at the middle of the twentieth century and onwards, the most surprising development would have been the rise of environmental ethics.

Environmental ethics remained unknown until the mid-1970s. But that was to change rapidly. Philosophers published dozens of anthologies and systematic works in the field, with courses taught in several hundred universities and colleges around the world.

Environmental ethics apply ethics to the environment, analogously to ethics applied to business, medicine, engineering, law and technology, etc. Such humanist applications are indeed challenging - limiting population growth or development, questioning consumerism and the distribution of wealth, advocating the inclusion of women or aboriginal peoples in the mainstream works, or fearing the global warming - but necessary as humans are helped or hurt by the condition of their environment. Ecofeminists have found this to be especially true where both women and nature are together exploited.

Suppose that putting out the natural fires, culling feral animals or destroying some individual members of overpopulated indigenous species is necessary for the protection of a certain ecosystem. The questions then arise whether such actions would morally be permissible or even required? Or would it be morally acceptable to the farmers in non-industrial countries to practice slash and burn techniques to clear areas for agriculture? Or what would be the value of some humanly restored environment compared with the originally the natural environment?

Many traditional western ethical perspectives, however, answer these questions with *anthropocentric* or human-centered approach in which either they assign intrinsic value to human beings alone or they assign a significantly greater amount of intrinsic value to human beings than to any nonhuman things. For example, Aristotle (*Politics*, Bk. 1, Ch. 8) maintains that "nature has made all things specifically for the sake of man" and that the value of non-human things in nature is merely instrumental. In an interesting contrast though, Immanuel Kant ("Duties to Animals and Spirits", in *Lectures on Ethics*) suggests that cruelty towards a dog might encourage a person to develop a character which would be desensitized to the cruelty towards humans. From this standpoint, cruelty towards non-humans would instrumentally, rather than intrinsically be wrong.

Hence, when environmental ethics emerged as a new sub-discipline of philosophy in the early 1970s, it did so by posing a challenge to traditional anthropocentrism. In the first place, it questioned the assumed moral superiority of human beings to the

members of other species on earth. And in the second, it investigated the possibility of rational arguments for assigning intrinsic value to the natural environment and its non-human contents.

It should be noted, however, that some theorists working in the field see no need to develop new, non-anthropocentric theories. Instead, they advocate what may be termed as *enlightened* anthropocentrism (or more appropriately, the *prudential* anthropocentrism) with the view that all the moral duties we have towards the environment are derived from our direct duties to its human inhabitants. The practical purpose of environmental ethics, they maintain, is to provide moral grounds for social policies aimed at protecting the earth's environment and undoing environmental degradation/damage already done.

4. EARLY DEVELOPMENTS IN ENVIRONMENTAL ETHICS

Although nature was the focus of much of nineteenth and twentieth century philosophy, as already said contemporary environmental ethics only emerged as an academic discipline in the 1970s. The questioning and rethinking of the relationship of human beings with the natural environment over the last four or five decades, however, reflect an already widespread perception of the 1960s that the late twentieth century would face a "population time bomb" and a serious environmental crisis. Among the accessible work that drew attention to a sense of crisis was Rachel Carson's *Silent Spring* (1963), which consisted of a number of essays published earlier in the *New Yorker* magazine elaborating how pesticides such as DDT, aldrin and deildrin concentrated through the food web. Commercial farming practices aimed at maximizing crop yields and profits, Carson noted, as capable of impacting simultaneously the environmental and the public health.

Around the same time, the Stanford ecologist, Paul Ehrlich, published *The Population Bomb* (1968), warning that the growth of human population would threaten the viability of planetary life-support systems. The sense of environmental crisis stimulated by those and other popular works was intensified by NASA's production and wide dissemination of a particularly potent image of earth from space taken at Christmas 1968 and featured in the *Scientific American* in September 1970. In 1972 a team of researchers at MIT, led by Dennis Meadows, published the *Limits to Growth* study, a work that summed up in many ways the emerging concerns of the previous decade, as well as the sense of vulnerability triggered by the view of the earth from space.

The call for a "basic change of values" in connection to the environment (a call that could be interpreted in terms of either instrumental or intrinsic values) hence reflected a need for the development of environmental ethics as a new sub-discipline of philosophy.

The new field emerged almost simultaneously in three countries -- the United States, Australia, and Norway. In the first two of these countries, direction and inspiration largely came from the earlier twentieth century American literature of the environment. For instance, the Scottish emigrant John Muir (founder of the Sierra Club and "father of American conservation") and subsequently the forester Aldo

Leopold advocated an appreciation and conservation of things as "natural, wild and free". Their concerns were motivated by a combination of ethical and aesthetic responses to nature, as well as a rejection of crudely economic approach to the value of natural objects. For instance, it was brought forward that:

> *A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.*

His views thus nurtured a challenge and opportunity for moral theorists in a way that:

> *Could some ethical theory be devised to justify the injunction to preserve the integrity, stability and beauty of the biosphere?*

The land ethics sketched by Leopold were explicitly drawn on the work by an Australian philosopher Richard Routley. According to Routley (1973), anthropocentrism imbedded in "dominant western view", or "the western superethic", is in effect a "human chauvinism". Furthermore, in his "last man" (and "last people") arguments, Routley asked to imagine an hypothetical situation in which the last person surviving the world catastrophe acted to ensure the elimination of all other living things and the destruction of all the landscapes after his demise. From the human-chauvinistic (or absolutely anthropocentric) perspective, the last person would do nothing morally wrong, since his or her destructive act in question would not cause any damage to the interest and well-being of humans. Nevertheless, there is a moral intuition that the imagined act would morally be wrong.

In the meantime, the work of Christopher Stone (a professor of law at the University of Southern California) was also widely discussed. Stone (1972) proposed that trees and other natural objects should have at least the same standing in law as corporations. Stone reasoned that if trees, forests and mountains could be given standing in law then they could be represented in their own right in the courts by the groups such as the Sierra Club. Moreover, like any other *legal person*, these natural things could become beneficiaries of compensation if it could be shown that they had suffered some injury through human activity. When the case went to the U.S. Supreme Court, it was determined by a narrow majority that the Sierra Club did not meet the condition for bringing the case to the court, for the Club failed to prove the likelihood of injury to the interest of the Club or its members.

On the other hand, John Passmore (1974) argued that the Judeo-Christian tradition of thought about nature, despite being predominantly "despotic", contain resources for regarding humans as "stewards" or "perfectors" of God's creation. Hence, any change in our attitude towards the natural surroundings would have to resonate through the very traditions, which had long legitimized the destructive practices.

Leopold's land ethics, the historical analyses of Passmore, the pioneering work of Routley and Stone, and the warnings of scientists, had by the late 1970s, focused the attention of philosophers and political theorists firmly on the environment. The subsequent rise of environmental or "green" parties in Europe in the 1980s was thus accompanied by almost the similar schisms between groups known as "realists" and

"fundamentalists" (Dobson 1992). The "realists" stood for reform environmentalism, working with business and government to soften the impact of pollution and resource depletion especially on fragile ecosystems or endangered species. The "fundies" argued for radical change, the setting of stringent new priorities, and even the overthrow of capitalism and liberal individualism, which were taken as the major ideological causes of anthropogenic environmental devastation.

5. SHALLOW/DEEP ECOLOGY, BIOREGIONALISM AND INCEPTION OF MORAL SPECKS

Underlying the disagreements on the environment debate of the 60s and 70s was also the distinction between "shallow" and "deep" environmental movements, as introduced in the early 1970s by a Norwegian philosopher and climber Arne Næss. It was followed by a debate/work by Murray Bookchin on social ecology and bioregionalism in the 80s and 90s. The base of these discussions, however, appears to be resting upon the inception of moral specks in the environmental ethics starting from the late eighteenth century. Since all these aspects are vital to the environmental ethics, a short discourse on each is being sited hereunder:

5.1 Shallow/Deep Ecology

"Deep ecology" was born in Scandinavia as a result of discussions between Næss and his colleagues Sigmund Kvaløy and Nils Faarlund (Næss 1973 and 1989; Witoszek and Brennan 1999). All three shared a passion for the great mountains. On a visit to the Himalayas, they became impressed with aspects of "Sherpa culture", particularly when they found that their Sherpa guides considering certain mountains as sacred. Subsequently, Næss formulated a position, which extended the reverence felt for mountains to other natural things by the three Norwegians and the Sherpas in general.

The "shallow ecology movement" of Næss is the fight by environmentalists against pollution and resource depletion, the central objective of which is "the health and affluence of people in the developed countries." The "deep ecology movement", in contrast, endorses "biospheric egalitarianism", a view that all living things are alike in having value in their own right and independent of their usefulness to others. The deep ecologist respects this intrinsic value, taking care, for example, when walking on the mountainside not to cause unnecessary damage to the plants.

Inspired by Spinoza's metaphysics, another key feature of Næss's deep ecology is the rejection of atomistic individualism. If people conceptualize themselves and the world in relational terms, the deep ecologists would then argue, that the people would then take better care of nature and the world in general.

5.2 Social Ecology and Bioregionalism

Other than the feminist-environmentalist theories and Næss's deep ecology theory, Murray Bookchin's "social ecology" has also been claimed to be radical, subversive, or countercultural (Bookchin 1980, 1987, 1990). Bookchin's version of critical theory takes the "outer" physical world as constituting what he calls the "first nature", from which culture or the "second nature" would evolve. Environmentalism, in his view, is

a social movement, and the problems it confronts are social problems. While Bookchin is prepared to take the (first) nature as an aesthetic and sensuous marvel, he also considered that the human intervention in environmental issues is necessary. He suggested that we are to choose to put ourselves at the service of natural evolution so as to help in maintaining the complexity and diversity, diminish sufferings and reduce pollutions. Bookchin's social ecology recommends that we use our gifts of sociability, communication and intelligence as if we were "nature rendered conscious", instead of turning them against the very source from which such gifts are originally derived. Exploitation of nature should, therefore, be replaced by a richer form of life devoted to nature's preservation.

5.3 INCEPTION OF MORAL SPECKS

Although environmental ethicists often try to distance themselves from the anthropocentrism embedded in traditional ethical views, they also quite often draw their theoretical resources from traditional ethical systems and theories. Consider the following two basic moral questions:

1. What kinds of thing are intrinsically valuable, good or bad?
2. What makes an action right or wrong?

As the utilitarian focus is the balance of pleasure and pain, the question that to whom a pleasure or pain belongs is irrelevant for the calculation and assessment of the rightness or wrongness of actions. That is why, the eighteenth century utilitarian Jeremy Bentham (1789), and now Peter Singer (1993), have argued that the interests of all the sentient beings (i.e., beings who are capable of experiencing pleasure or pain) - including non-human ones - affected by an action should be taken equally into consideration in assessing the action. Like Routley, Singer also argued that the anthropocentric privilege of homosapiens is just arbitrary.

Criticizing the individualistic approach, because of its failure to accommodate conservation concerns for ecological wholes, J. Baird Callicott (1980) also advocated a version of land-ethical *holism*, which takes Leopold's statement that "a thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community and it is wrong when it tends otherwise" to be the supreme deontological principle. Though Callicott received some criticism too, but the controversy surrounding Callicott's original position inspired efforts in environment ethics, which led to the investigation of the possibilities to attribute intrinsic value to ecological wholes, not just to the individual constituent parts. Following in Callicott's footsteps, and inspired by Næss's relational account of value, Warwick Fox championed a theory of "responsive cohesion" which apparently gives a supreme moral priority to the maintenance of ecosystems and the biophysical world (Fox 2007).

6. PERSONHOOD IN ENVIRONMENTAL ETHICS

In line with the various dimensions of moral philosophy, the concept of a "person" is central also to the environmental philosophy/ethics. The list of criteria, which may identify the "personhood" in environmental ethics, may include the following basic characteristics (Patridge 1980):

- Sentience or the ability to feel pain.
- Consciousness towards the external objects and events.
- Reasoning or the ability to solve the problems.
- Self-motivated activities.
- The capacity to communicate through the use of a complete, syntactic system of significant symbols (i.e., a language or a set of languages).
- A concept of oneself as a being continuing through time.
- A capacity to conceptualize and choose among alternative futures.
- A capacity to act on principle, i.e. to deliberately govern one's behavior according to rules.
- Recognition of the personhood of other persons.

Based upon the premise discussed above, Patridge also presents the following concerns to address the concept of "personhood" in environmental ethics:

- Why care about nature "for itself" when only people "matter"?
- If one denies that "only people matter," on what grounds one can defend that denial? If no people are around to regret it, what difference does it make if a species, a canyon, or even a planet is destroyed?
- When species or landscapes or wilderness areas are destroyed, what value is lost to the mankind?
- Would the future generations miss what have been "taken from them"? How they would know that what they have lost?
- Does a land ownership makes a moral sense, or is it a morally absurd and repugnant concept among different cultures (as the native Americans claim)?
- What is wrong with the developer's anthropocentric and utilitarian land ethic? Why not treat land as a "commodity" rather than a "community"?
- Do future generations (who, after all, do not exist now) have a right "now" to a clean and natural environment?

As a note here, it would be worthwhile here to add that *Axiology* is the branch of philosophy that deals with the values in general, while ethics, a subdivision of axiology, is concerned with moral values or with non-moral values as they relate to moral values.

Now one may note that until recently, our effects upon the natural environment were regarded as morally neutral as the nature was assumed to be both impersonal and too vast to be injured. But, at the very least, we have not been able to foresee the harm inflicted upon the nature through our various actions. Patridge thus further raises a point that at least now, we know about the environment and the issues a lot better. Now we do know well that we can cause massive and/or permanent damage to natural landscapes, resources and ecosystems. Not only do we now know that we

can cause these insults, we do know too, how we can cause them and/or how we can prevent or remedy them. Knowing all this exacts a moral obligation upon us to act with care, foresight and at times, with forbearance and constraint.

7. ENVIRONMENTAL ETHICS AND PHILOSOPHICAL TRADITIONS

Based on the discussion so far, one may find that if it is attempted to derive a truly cogent, coherent and far-seeing set of environmental ethics, grounded in the theory and with the perspective of the ecological point of view, such an ethic may have to challenge the four basic philosophical traditions, i.e.:

a) *Anthropocentrism:*

We are used to define values and ethics with human beings in the center of our conceptual scheme of things. Thus acts or policies are viewed as "good" if they benefit human individuals or communities (a more generous view would place non-human but sentient creatures in the suburbs of our moral concern). Alternatively, other moral theories identify as "good" those acts and policies that are motivated by a respect for the "dignity of personhood" of human beings. "Lesser beings" and nature itself does not, in this view, share such "dignity".

The ecological moralist, on the contrary, is more inclined to view the humanity not at the center of the moral universe but as an ingredient in the realm of morality, particularly when morality pertains to responsibility to the nature.

b) *Reductive Analysis:*

We are accustomed, through our scholarly traditions, to move from secure knowledge to insecure conjecture. We do so by acquiring our knowledge in bite-sized pieces and accumulating this knowledge piece-by-piece until a whole emerges out of the parts. From such a tradition, it is easy to conclude that in order to understand something or to solve problems we must first identify the parts and then their rules of combination. The approach of identifying the parts in order to comprehend the whole is called "reductive analysis".

The ecological point of view reverses this approach. An ecologist would rather suggest to "grasp the whole - think like a mountain - and then the whole will explain the parts", i.e. a holism. But an incautious insistence upon holism and an aversion to analysis can also limit our understanding. An astute historian or philosopher of science will acknowledge a need for a dynamic balance between the apprehension and application of parts and whole in scientific theory and practice.

c) *The Egocentric Perspective:*

The philosophical method of "reductive analysis" leads almost irresistibly, to "the egocentric point of view". Thus, following a philosophical tradition endorsed and exemplified by Hume and Descartes, philosophers have insisted that philosophical inquiry starts with the hard and secure data of immediate experience and awareness and then move out cautiously and deliberately to conjectures about the external worlds or other minds.

An ecologist on the other hand conceives nature as a complicated system of interacting parts. Such a concept, however, is out of reach of such methodologies which begins with immediate subjective experience and awareness. Thus the very method of many philosophers has kept them uninvolved with questions of environmental ethics. Moreover, by placing mankind in the center of their theory of knowledge, many philosophers have been drawn towards the unwarranted conclusion that humanity is also in the center of nature. The ecological moralist, of course, adopts a different perspective by regarding man as a member, rather than the master, or as a sole justification of the natural community.

d) *The Fact/Value Gap:*

For centuries, many philosophers have contended that no amount of factual information can logically entail an evaluative conclusion. The maxim "no ought from is" (or "no values from the facts") is virtually axiomatic among philosophers today. The most troublesome thing about this maxim is that it may probably be correct.

Moral cognitivists insist that too much has been made of the "gap" between factual assertions and moral claims. While it is true that formally speaking some value assumptions must be made if a value conclusion is to be drawn, it may also be the case that these value premises can be seen to be so basic and self-evident as to command virtually the universal assent. Once again, empirical science offers an instructive analogy. Science, it seems, rests upon such "unproven" assumptions as these:

- Nature is uniform and will behave in the future according to the same universal laws that governed it in the past.
- Though there are other minds besides my own but only my mind is obviously the one about which I may know directly. The rest would thus only be conjectures.
- Besides minds and their ideas, there are objects and events that exist in a physical world, that persist unobserved, and which pre-existed the development of sentient and cognitive life.

Analogously, the axiomatic core of ethics may also include such "obvious", yet unproven assumptions, i.e.:

- The satisfaction of desire and aspiration, as such, is prima facie better than frustration and denial.
- Even if we cannot fully and explicitly define "happiness", we all know when we are happy and when we are not.
- If, with equal effort, we can enhance the well-being of others or harm them, we all are duty-bound to choose the former.
- A world with viable life-forms on it is preferable to a world without them. Still better if the life community is stable and diversified, and better even further if some of the life-forms are conscious and reflective, i.e. if they are moral agents or persons.

The above listed prominent traditions in philosophy and in other scholarly disciplines tend to discourage and complicate the attempts to articulate and defend an ecological perspective and an affirmative code of responsibility toward nature. Do these established methods and viewpoints of analytic and moral philosophy constitute grounds for rejecting the assistance to the philosophers or ignoring their traditions entirely?

At the first place, we should not overlook the fact that many philosophers (like Spinoza and Whitehead) were very much "in tune" with the ecological point of view. As for the rest, the answer is not to abandon moral philosophy, but to reform it. Hence, these traditions of disciplined, rational and critical thought should not hastily be set aside. The ecological moralist has much to learn from the philosophers and needs the philosophers' persistent and disciplined criticism. And if, in general, philosophers have failed to be favorably affected by the ecologists, then the best response to inappropriate and confining philosophy is a better philosophy.

8. ENVIRONMENTAL JUSTICE – AN IMPRESSION FROM A COMBATANT

Rachel Sahlman (2014) makes an interesting mention of 'Sitting Bull', whose Indian name was Tatanka Iyotake. He was born in the Grand River region (South Dakota) in 1831. Sitting Bull was a member of the Sioux tribe. He joined his first war party against the Crow at age 14. Soon, Sitting Bull became known for his fearlessness in battle, and wisdom and generosity otherwise.

In 1867, Sitting Bull became the first principal chief of the Sioux. Shortly thereafter peace was made with the U.S. government, although Sitting Bull refused to attend the peace conference or sign the Fort Laramie Treaty, which promised the Black Hills would remain in Sioux possession forever.

In the 1870s the gold was discovered in Black Hills and the press reports brought a rush of prospectors. By 1875, more than a thousand prospectors were camping in the Black Hills. The government ordered the Sioux to their reservations. They were given a deadline of 31 January 1876. The demand was ignored by the Sioux and in March 1876, General George Crook set up a camp in order to attack the natives.

On 17 June, however, the invading troops resorted to a retreat at the Battle of the Rosebud. After the battle, Sitting Bull performed an important ritual called a Sun Dance. On emerging from the trance after his ritual, Sitting Bull told his companions about his vision of soldiers falling from the sky.

His prediction came true on June 25 when Lieutenant Colonel George Armstrong Custer led his soldiers into the village along the river Little Big Horn. By the end of the day, Custer and his army of more than 200 soldiers were dead. But as the battles continued, many of Sitting Bull's followers surrendered.

In 1877, Sitting Bull and his followers escaped into Canada, where famine forced them to surrender. Sitting Bull was held as a prisoner of war for two years and then sent to join other Sioux in North Dakota. In 1885, Sitting Bull joined Buffalo Bill's Wild West Show and traveled throughout the U. S. and Canada.

When Sitting Bull returned to the reservation in 1889, many natives had joined a new religion called the Ghost Dance. Because of this new religion, Sitting Bull was arrested again on 15 December 1890 and it was planned to send him to the prison. However, when his warriors attempted to rescue him, Sitting Bull was killed.

Some appealing excerpts from various speeches/addresses of Sitting Bull, showing his amazing feel of environmental justice, are placed hereunder:

1. *I am a red man. If the Great Spirit had desired me to be a white man he would have made me so in the first place. He put in your heart certain wishes and plans, in my heart he put other and different desires. Each man is good in his sight. It is not necessary for Eagles to be Crows. We are poor but we are free. No white man controls our footsteps. If we must die, we die while defending our rights. Sitting Bull as Hunkpapa Sioux.*
2. *Behold, my brothers, the spring has come; the earth has received the embraces of the sun and we shall soon see the results of that love! Every seed has awakened and so has all animal life. It is through this mysterious power that we too have our being and we therefore yield to our neighbours, even our animal neighbours, the same right as ourselves, to inhabit this land. Yet hear me, my people, we have now to deal with another race - small and feeble when our fathers first met them, but now great and overbearing. Strangely enough they have a mind to till the soil and the love of possessions is a disease with them . . . They claim this mother of ours, the earth, for their own, and fence their neighbours away; they deface her with their buildings and their refuse. They threaten to take [the land] away from us. My brothers, shall we submit, or shall we say to them: "First kill me before you take possession of my Fatherland." Sitting Bull at Powder River Council.*

9. ENVIRONMENTAL ETHICS IN SOUTHEAST ASIA – A SHORT CASE STUDY

a) Asia's Brown Cloud Blamed for Flooding and Drought

Charles W. Petit of the U.S. News and World Report quoted on 17 March 2003 that the researchers have realized that the brown cloud over Asia is also to be blamed for drought and flooding. These brown clouds are dark with soot and as a result, they absorb sunlight and double the rate at which the atmosphere is warmed-up, while shading and cooling the ground below. The net effect rather boosts the global warming too.

Jeff Kiehl of the National Center for Atmospheric Research in Boulder, Colo., says that the more certain impact of these hazes is on rainfall as they are radically changing the temperature profile of the atmosphere in many areas with a big impact on where and how much the rain falls.

Some computer climate models have also predicted that the hazes over India have started displacing the annual monsoon rains, leading to floods in the south and east of the country while drying the north and shrinking the vital Himalayan snowpack. Surabi Menon of the Goddard Institute for Space Studies in New York City emphasizes that that's just the pattern we have started to see to emerge.

Some scientists also suspect that these pollution clouds could be cooling the sea surface and slowing evaporation in the far western Pacific. The effects could ripple across half the globe as the western Pacific is the breeding ground for El Niños, the bouts of Pacific warming that change rainfall across the Americas and beyond.

b) Indian Ocean Pollution Haze Linked to Melting of Himalayan Glaciers

Michael Casey reported at AP on 3 August 2007 that the huge haze clouds over the Indian Ocean contribute as much to the atmospheric warming in Asia as greenhouse gases and play a significant role in the melting of the Himalayan glaciers. This has further been supported by the studies through unmanned measuring devices, which were sent into the haze pollution, known as Atmospheric Brown Clouds over the Indian Ocean in March 2006 near the island of Hanimadhoo to measure aerosol concentrations, soot levels and solar radiation.

It has also been concluded that the pollution - mostly caused by the burning of wood and plant matter for cooking in India and other South Asian countries - enhanced heating of the atmosphere by around 50 percent and contributed to about half of the temperature increases blamed in recent decades for the glacial retreat. Research has further shown that the brown clouds are the additional factor in the melting of glaciers, along with overall global warming caused by greenhouse gas emissions (Veerabhadran Ramanathan 2007).

Scientists have expressed the concerns that the Himalayan glaciers may melt entirely and the rivers may run dry for months at a time, fed only by annual rains like the monsoons. Melting may get exacerbated by the coal-fed economies. Scientists further add that the glaciers are melting at a rate of up to 49 feet a year and predict that they could shrink even more. Hence, all would now depend on the energy path, which would be taken in the region in near and the distant future.

10. CONCLUSION

Michael Collins said of Earth on looking at the view as it appears from the space:

> *"What I saw when I looked back at my fragile home - a glistening, inviting beacon, delicate blue and white - a tiny outpost suspended in the black infinity. Earth is to be treasured and nurtured, something precious that must endure".*

There is a vision of an Earth ethic in what he saw. But - as the argument goes - there are the duties owed by the people to other people; caring for the planet is a means to this end.

Environmental ethics on global and regional scales is inextricably coupled with development ethics. The Rio Declaration notes:

> *"Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature".*

The United Nations World Commission on Environment and Development declares:

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".*

Science, technology, industry, democracy, human rights, freedom, preference satisfaction, maximizing benefits over costs, consumerism - all are supposed to be bound by professional or management ethics - as all of them are seriously implicated as cause of the environmental crisis of today. Development of today may be based upon the enlightened myths - whether one may consider agricultural development, forests cut, rivers dammed and diverted for water, lands fenced, minerals extracted, or highways and subdivisions built - but the next hundred years may not be similar to that of the last hundred years. None of even the developed nations have yet fully settled into a sustainable culture on their landscapes. On the scales on the other hand, 'sustainable' still means 'fair' or 'just', much against the pure ethics of eco-justice.

On Earth, the developed nations hold about one-fifth of the world's 7 billion persons, and they produce and consume about four-fifths of all goods and services. The underdeveloped nations, with four-fifths of the world's people, produce and consume one-fifth. The over-consumption problem in the developed nations is linked with the under- consumption problem in the developing nations. This results in increasing environmental degradation in both sets of nations.

Even if there would have been an equitable distribution of wealth, the human population cannot go on escalating without people becoming poorer, because the pie is to be constantly divided into smaller pieces. Even if there were no future population growth, consumption patterns cannot go on escalating on a finite Earth.

Hence, it is not enough to be a good 'citizen', for that is only half the truth. In the nineteenth century, the call for community was typically phrased as the brotherhood of man. For most of the twentieth century the call, however, was phrased in justice and human rights. But now, such a call must be globally ecological. Ethics, therefore, are getting expanded. Now they are not just what a society does to its slaves, women, blacks, minorities, handicapped, children or future generations, but they are also what a society does to its fauna, flora, species, ecosystems and landscapes. Similar points about the role of empirical investigations can also be made about

theorizing over a range of other problems, including drought, the preservation of biodiversity, and climate change.

Side by side, where it has become common to refer to the present era as "the age of terror", there is increasing agreement across the entire globe that the world is facing chronic and unprecedented environmental problems, most of them from the human origin. The United States military, responding to a report on abrupt climate change prepared for the Pentagon by the Global Business Network (Schwartz and Randall 2003), declared that the problems of adjustment to climate change constitute a far more severe threat to national and international security than does terrorism itself. The continuing destruction of natural environments and the widespread loss of both plant and animal species, as well as those of other ecological constituents, pose an increasing problem for other forms of life on the planet. In facing these problems, there will likely be many great opportunities for co-operation and synergy between the world leaders, philosophers and the both natural and the social scientists.

However, like many other important and interesting questions, no single discipline could claim sole ownership of the issue as has been raised about the origins of modern environmental crisis and the quandaries we now face. An inquiry and a resort may hence be inevitable not only in environmental ethics, but also in all other areas of knowledge, as well as those of political/practical philosophy.

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