

Impact of Landfill Gas and Global Warming

Agamuthu P. and Fauziah S.H.
Institute of Biological Sciences, Faculty of Science,
University of Malaya,
50603 Kuala Lumpur, Malaysia.
agamuthu@um.edu.my

Content

- Introduction
- Emission of Greenhouse Gases
- CH₄ in Atmosphere
- Solid Waste Management
- Disposal of waste
- Current situations
- LFG in non sanitary landfills
- LFG contributions towards climate change
- Current and future mitigation methods
- Conclusions

Introduction

- Global climate change a significant environmental issue
- Environmental catastrophe
 - rise in sea level,
 - alteration of rainfall pattern,
 - heat wave-related fatalities
 - extinction of biodiversity
 - etc.
- Mitigating measures need to be implemented.



Melting of ice caps



Image in 1979

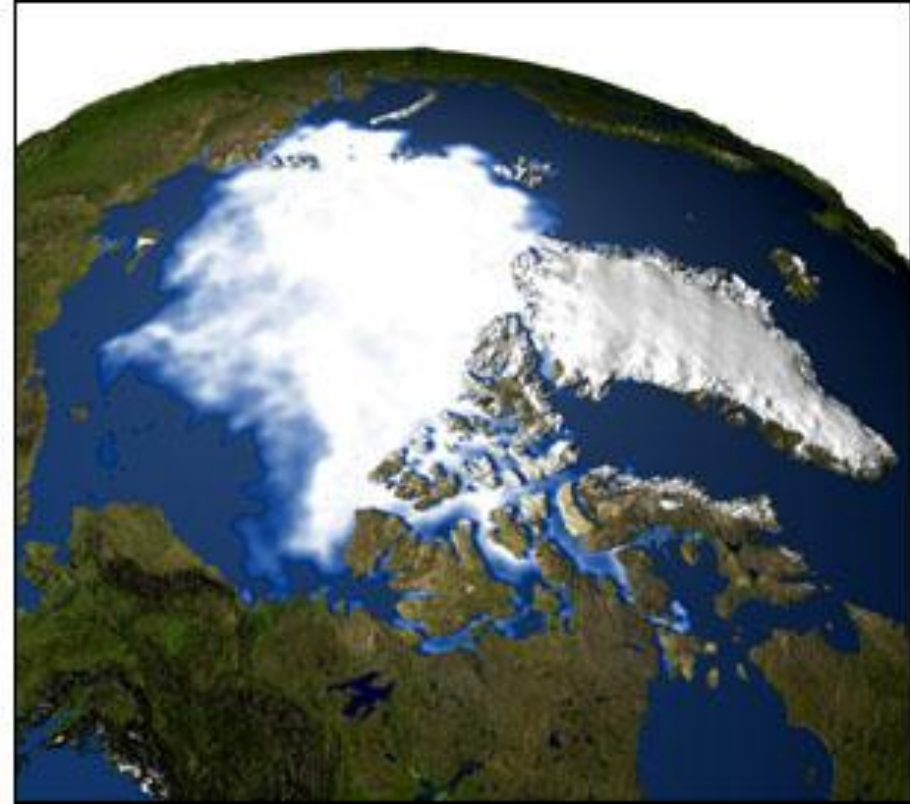
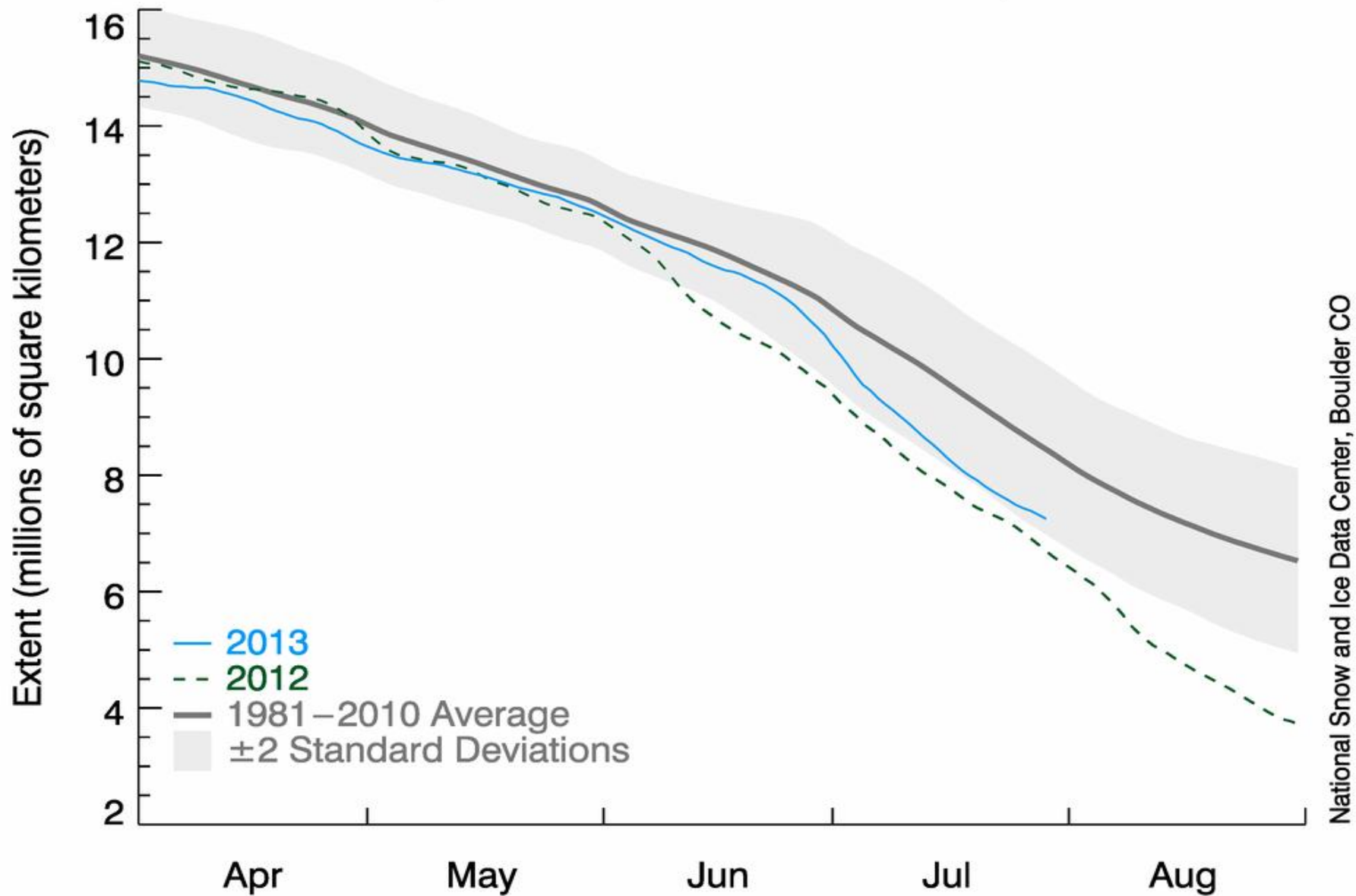


Image in 2005

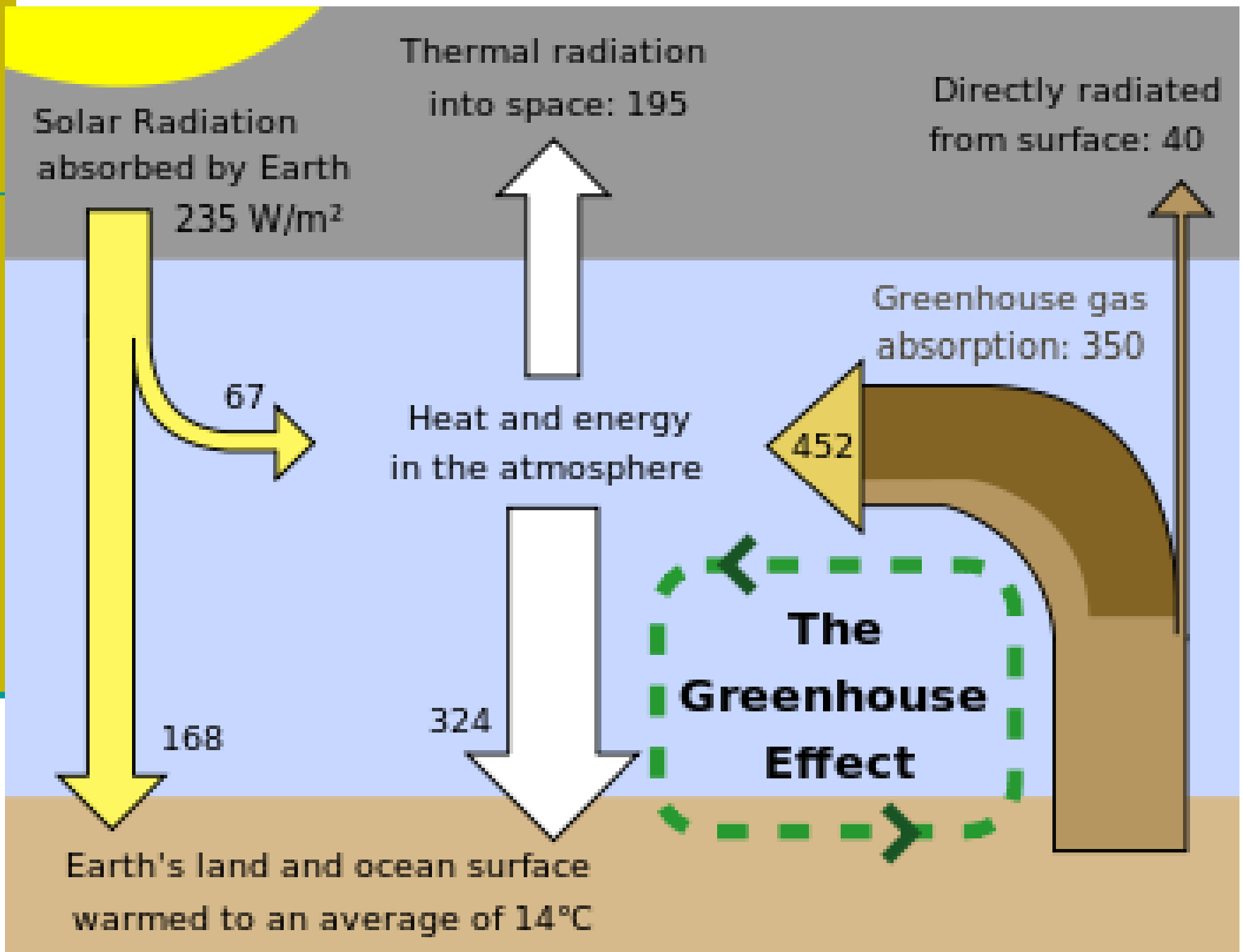
Arctic Sea Ice Extent

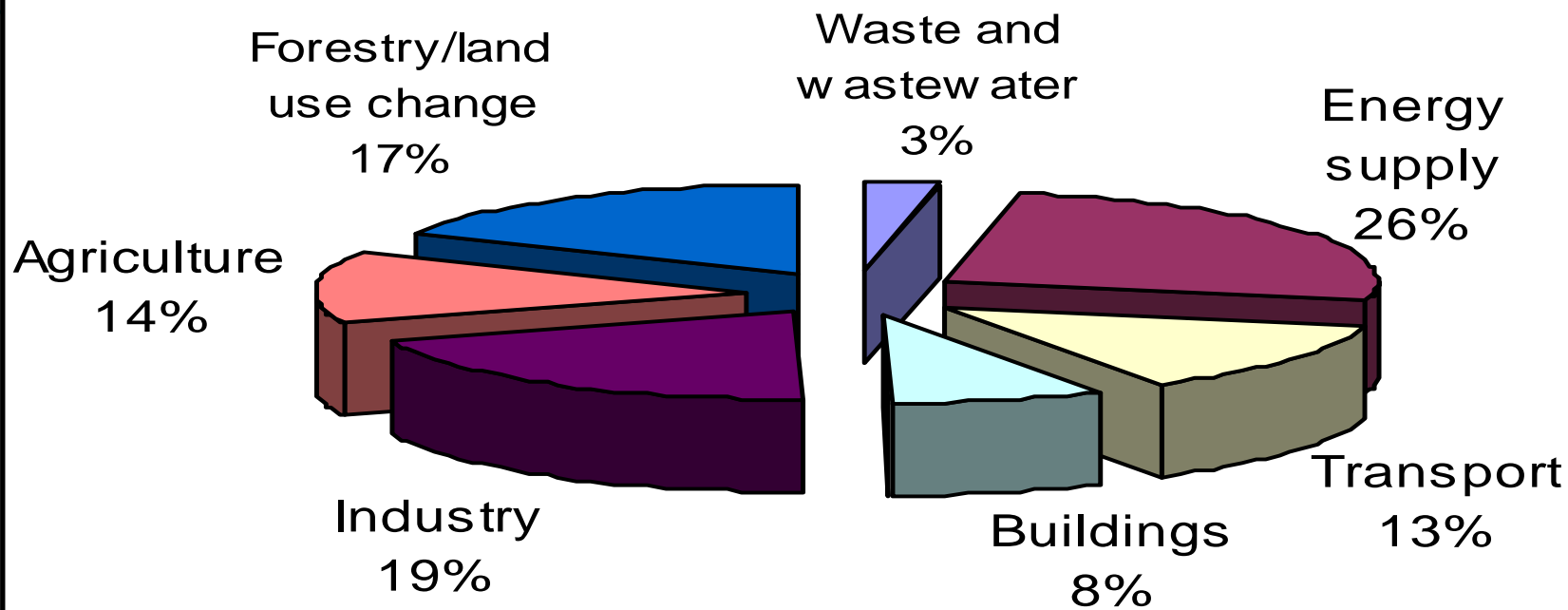
(Area of ocean with at least 15% sea ice)



Emission of Greenhouse Gases

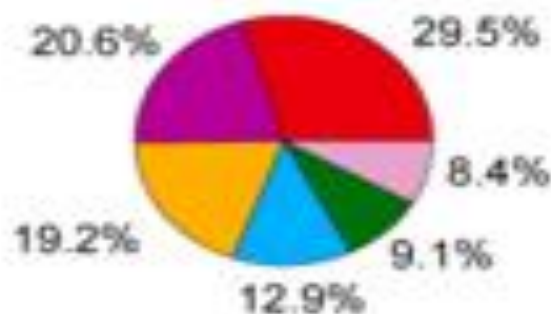
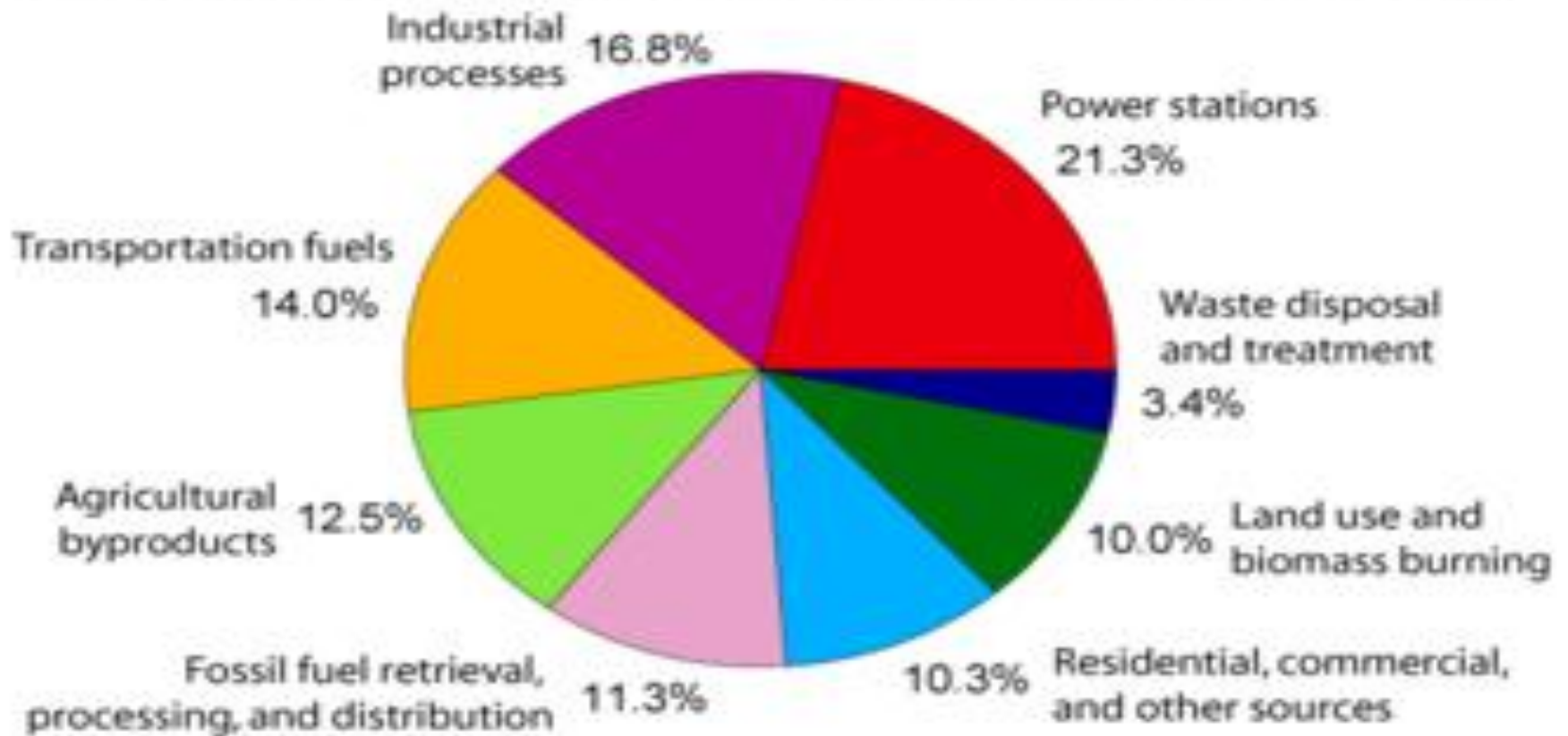
- Carbon dioxide (CO₂),
- Methane (CH₄),
- Nitrous oxide (N₂O),
- Perfluorocarbons (PFCs),
- Sulphurhexafluoride (SF₆) and
- Hydrofluorocarbon (HFCs)



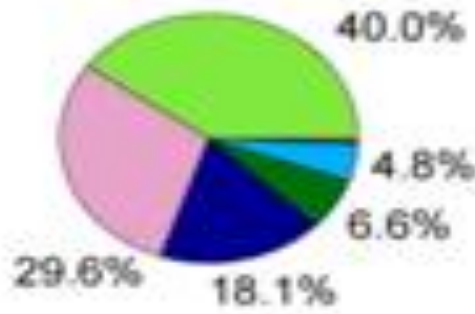


Distribution of anthropogenic GHG emissions by sectors in 2004

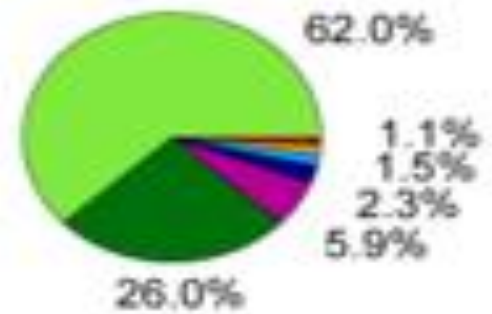
Annual Greenhouse Gas Emissions by Sector



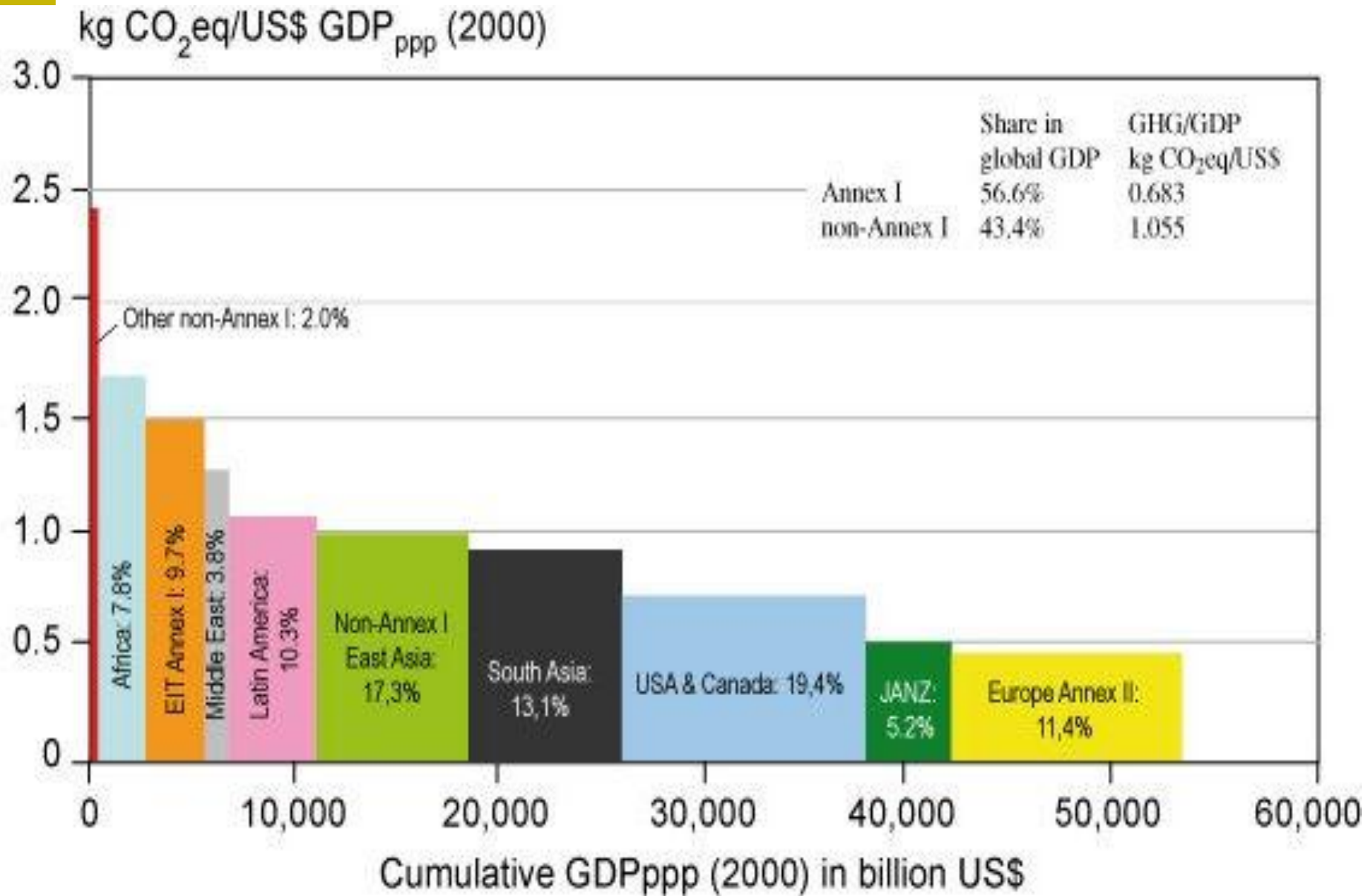
Carbon Dioxide
(72% of total)



Methane
(18% of total)



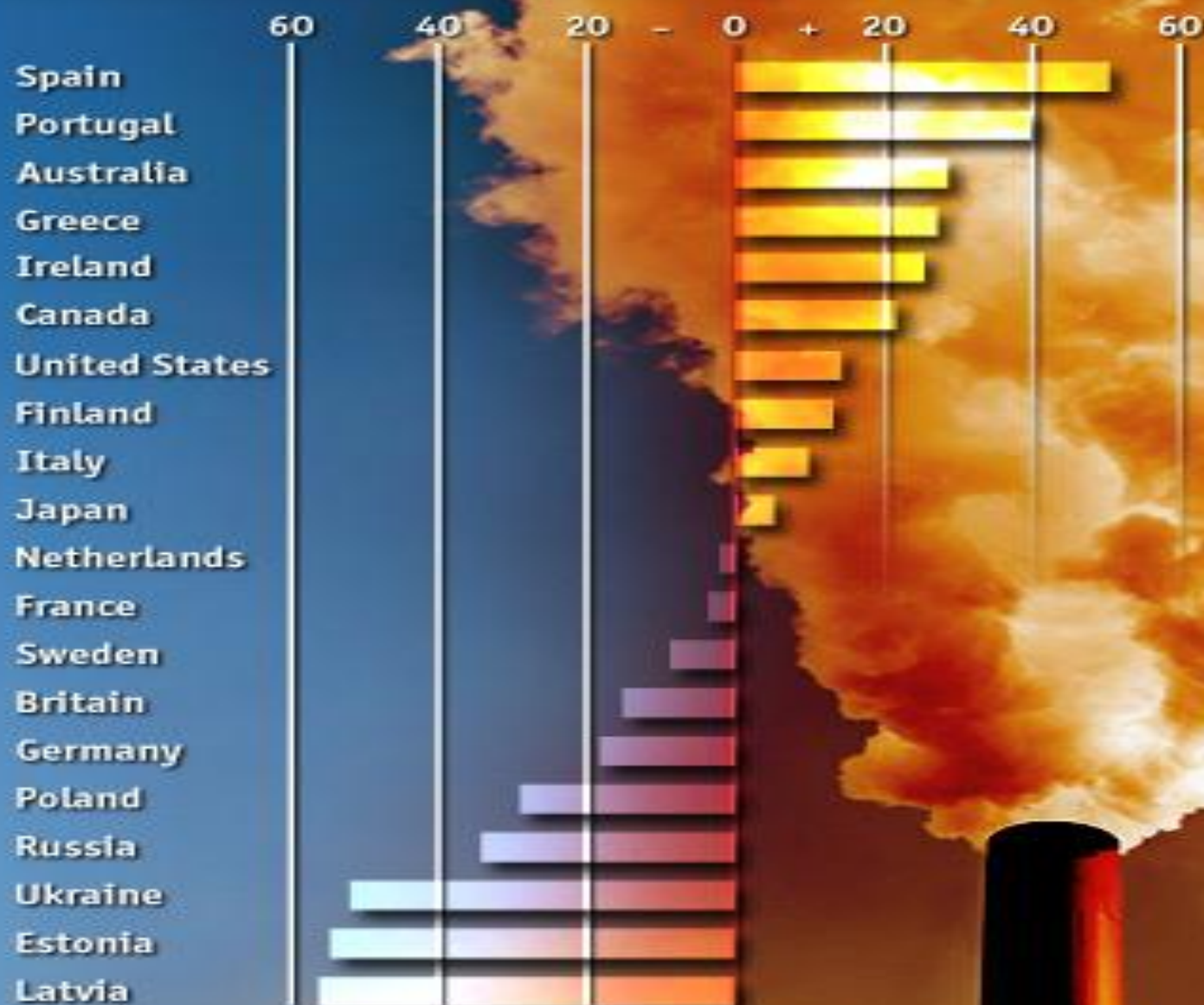
Nitrous Oxide
(9% of total)



Global emission of GHG according to cumulative GDP

Change in greenhouse-gas emissions*, 1990-2006, %

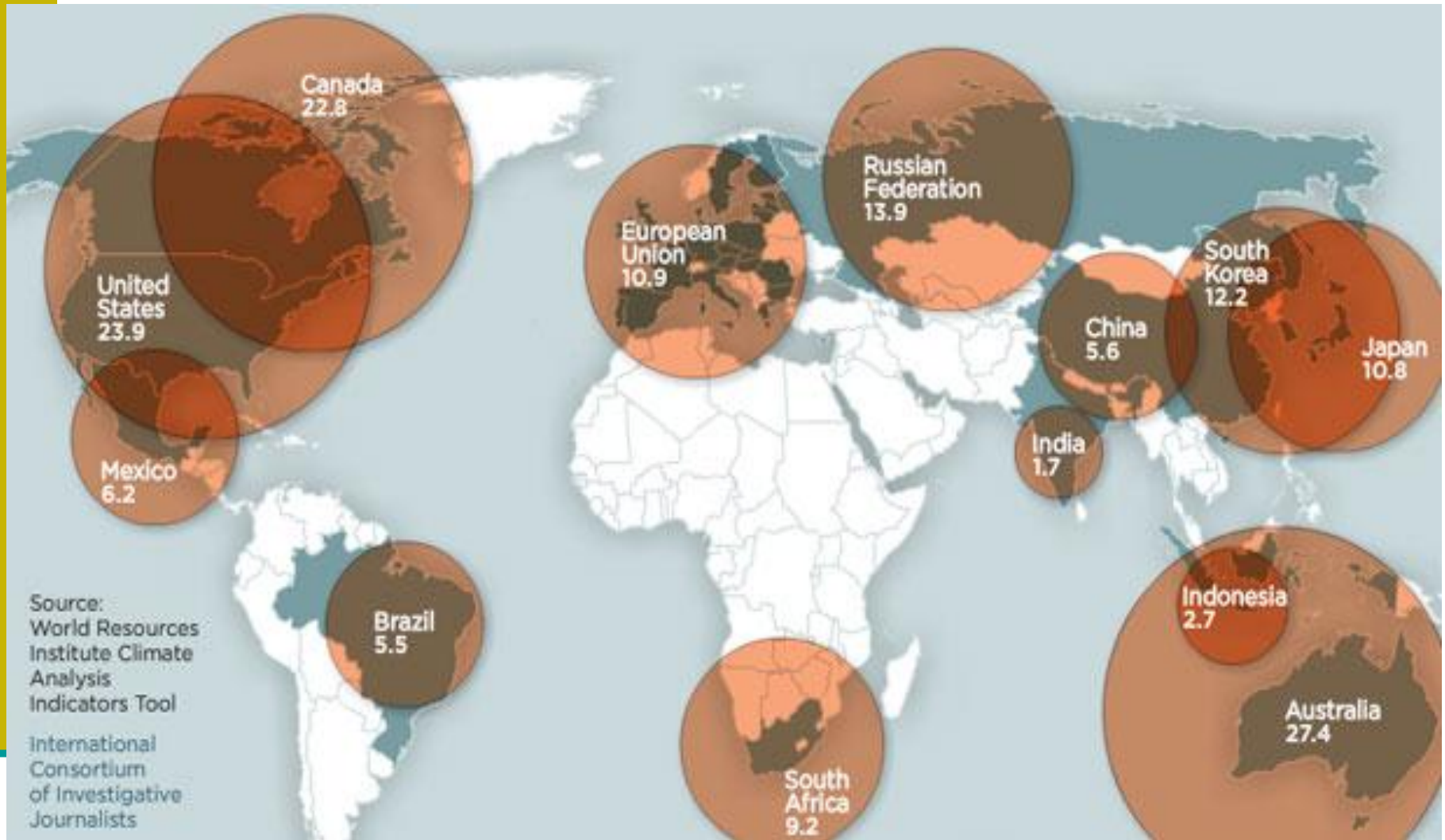
Selected countries†



*Excluding land use, land-use change and forestry

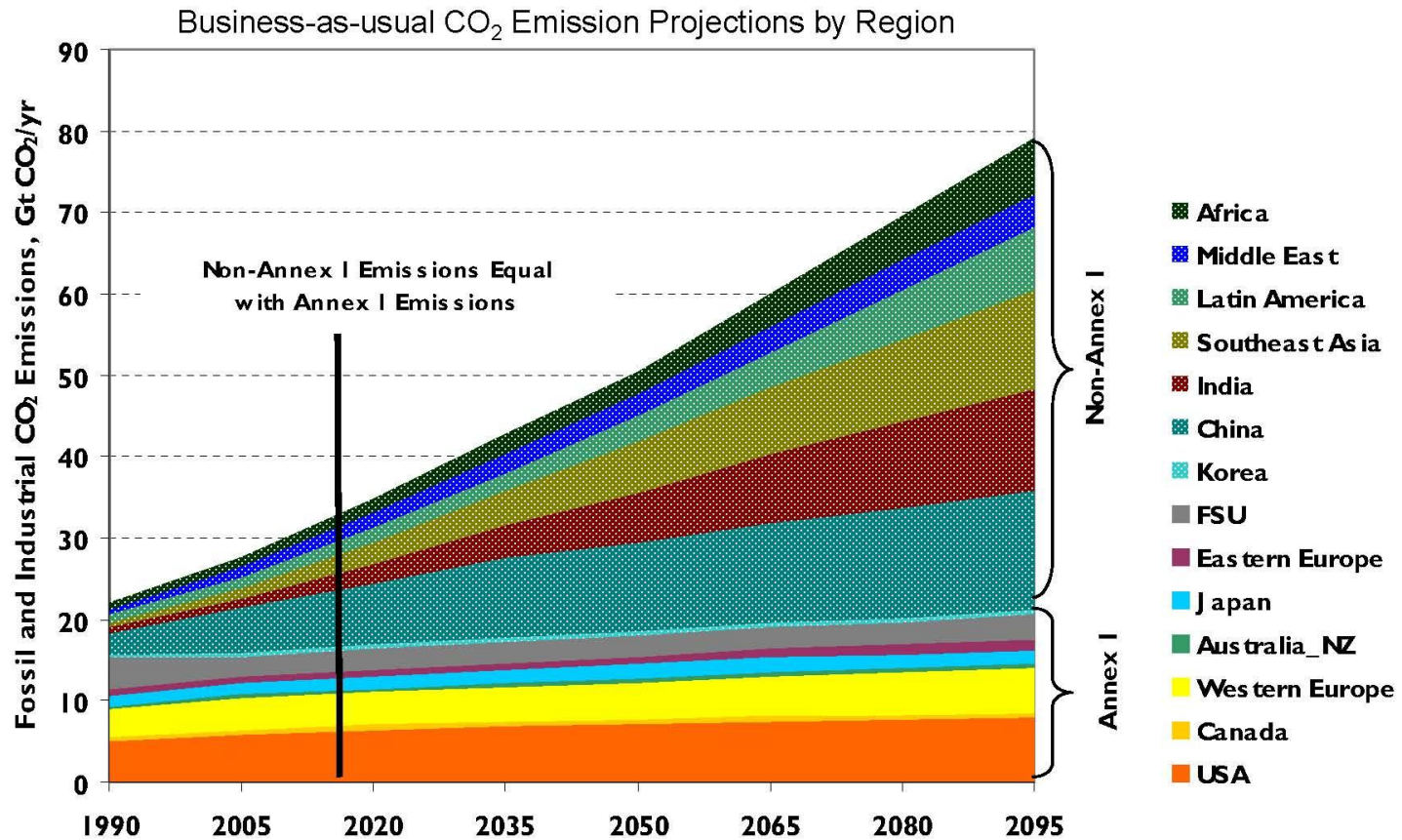
†With reporting obligations under UN Framework Convention on Climate Change

Source: UNFCCC



The per capita (tons) GHG emission by selected nations in the world

Important Transitions in Emitting Countries Over the Coming Century



Data derived from *Global Energy Technology Strategy, Addressing Climate Change: Phase 2 Findings from an International Public-Private Sponsored Research Program*, Battelle Memorial Institute, 2007.

Qualitative assessment of GHG emissions by common waste treatment techniques

	GHG Generation					
	Pyrogenic			Biogenic		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
Landfilling	-	-	-	+	+	+
Landfilling with gas utilization	+	-	+	+	+	+
Incineration	+	-	(+)	-	-	-
Mechanical biological Treatment (with combustion of the light fraction)	+	-	(+)	+	+	+

+ present

- absent

Global Warming Potential (GWP) values and lifetimes from 2007 IPCC AR4 p212

	Lifetime (years)	GWP time horizon		
		20	100	500
CH ₄	12	72	25	7.6
N ₂ O	114	289	298	153
HFC-23	270	12,000	14,800	12,200
HFC-134a	14	3830	1430	435
SF ₆	3,200	14,300	22,800	32,600

CH₄ in Atmosphere

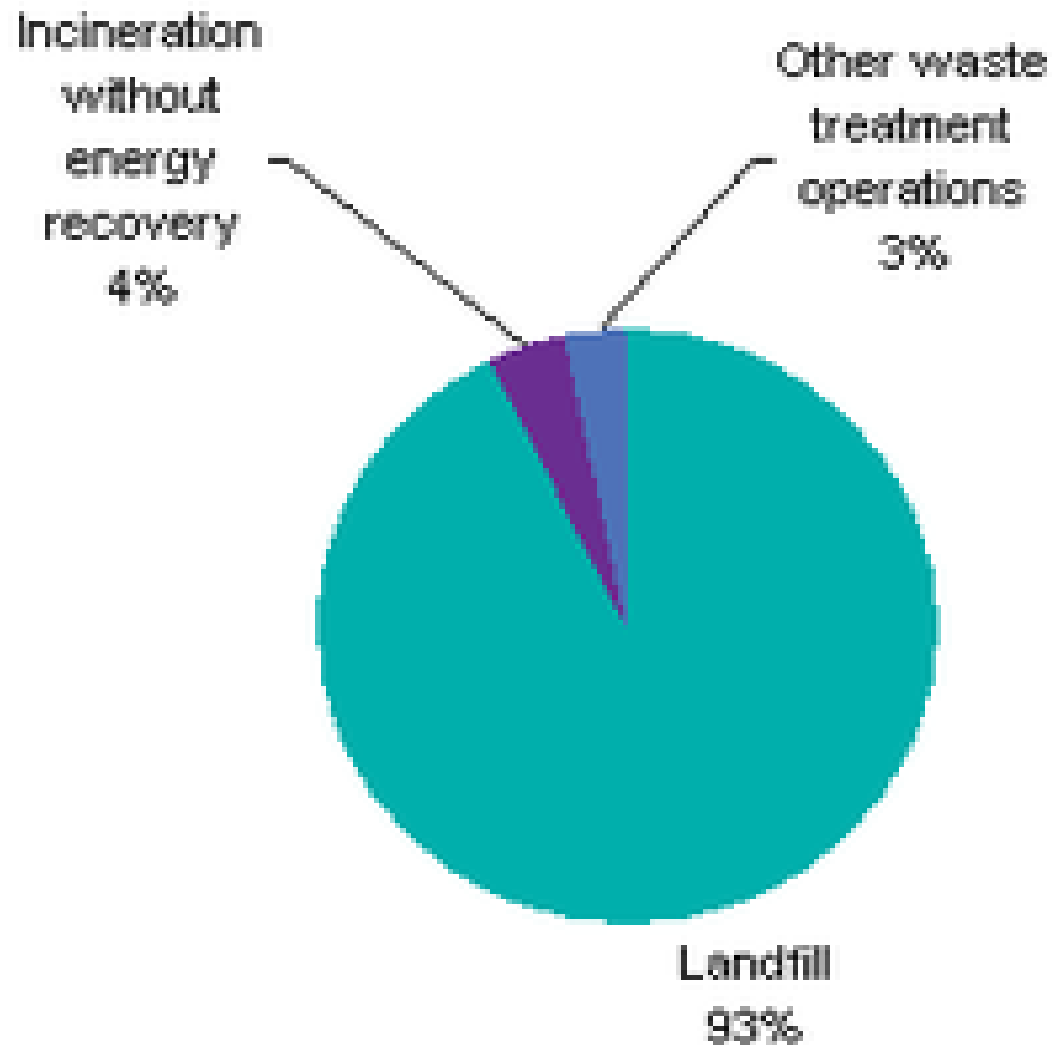
- ~ 18% of the global anthropogenic sourced from landfill and wastewater
- contributed 90% of the total emissions from waste segment.
- ~ 40-60 Mtonnes are in landfill gas
 - 11-12% of global emission
- the concentration is 200X lower than that of CO₂, but accounted 20% of the current warming capacity.

Trends in GHG emissions calculated based on 2006 IPCC inventory guidelines

Source	1990	1995	2000	2005	2010	2015	2020	2030	2050
Landfill CH ₄	340	400	450	520	640	800	1000	1500	2900
Incineration CO ₂	40	40	50	50	60	60	60	70	80
Total GHG emissions	1120	1205	1250	1345	1460	1585	1740		

Solid Waste Management

- Has been identified as one of the three main sources of environmental degradation in Asian countries.
- Apply to the developing countries including India, China, Malaysia, Indonesia, the Philippines, Thailand and Vietnam.
- Solid waste management is still developing due to various factors which impede sustainable waste management.
- > 90% of the waste generated will be disposed off into landfills.



Source: Annual European Union greenhouse gas inventory 1990–2008 and inventory report 2010, Submission to the UNFCCC Secretariat, 15. April 2010



Highly mixed waste



Leachate oozing out from the landfill contaminating surface water



The flowing river dilute the pollution impact of the leachate

Disposal of waste

- In Malaysia, < 80% of the disposal sites are sanitary landfills
- Similarly in Indonesia and Vietnam, non-engineered landfills are the main method of waste disposal.
- Lack of appropriate mechanisms such as
 - lining system
 - landfill gas collection system



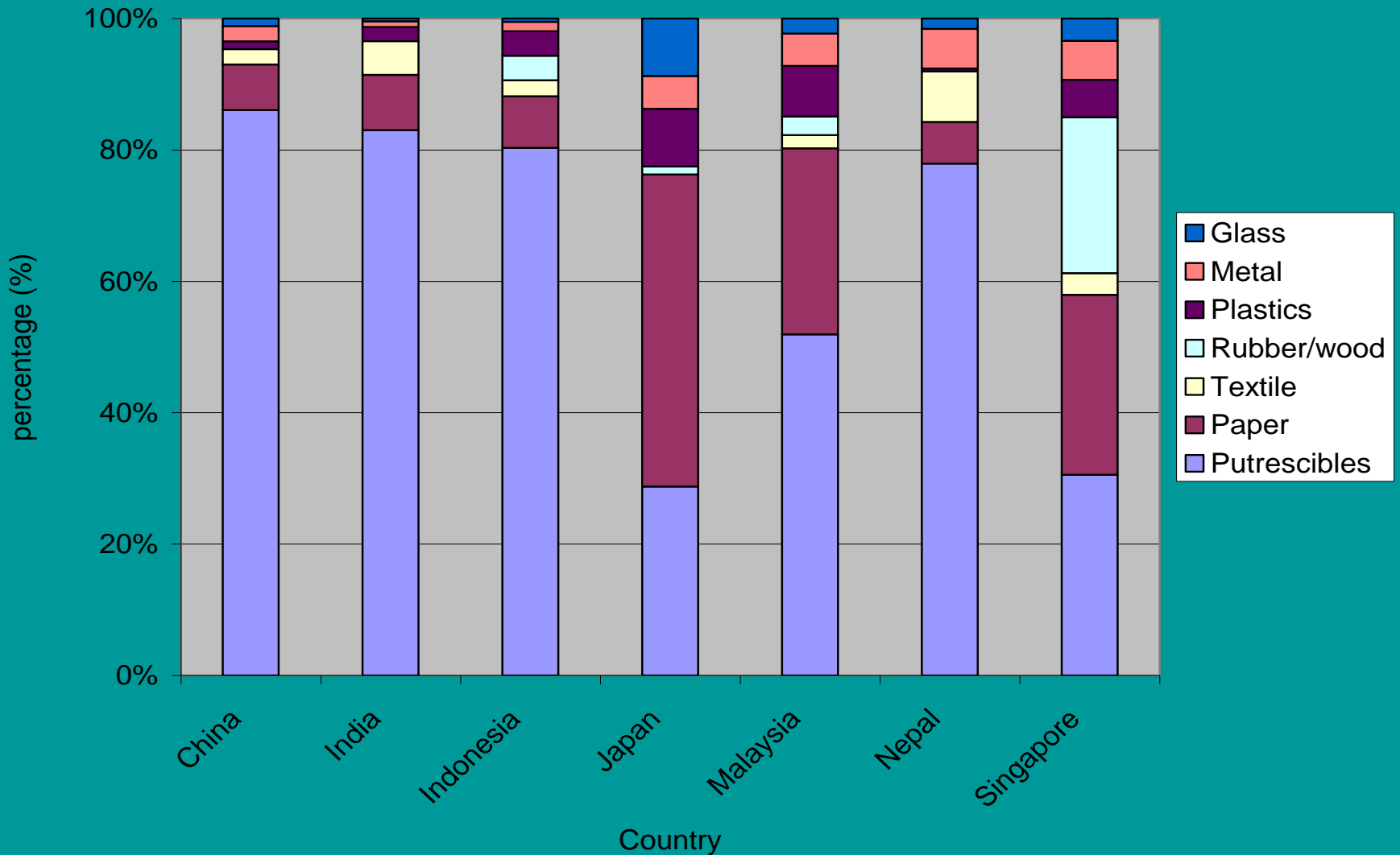
Activities in an operating disposal site-risks due to GHG.



LFG released from leachate pond

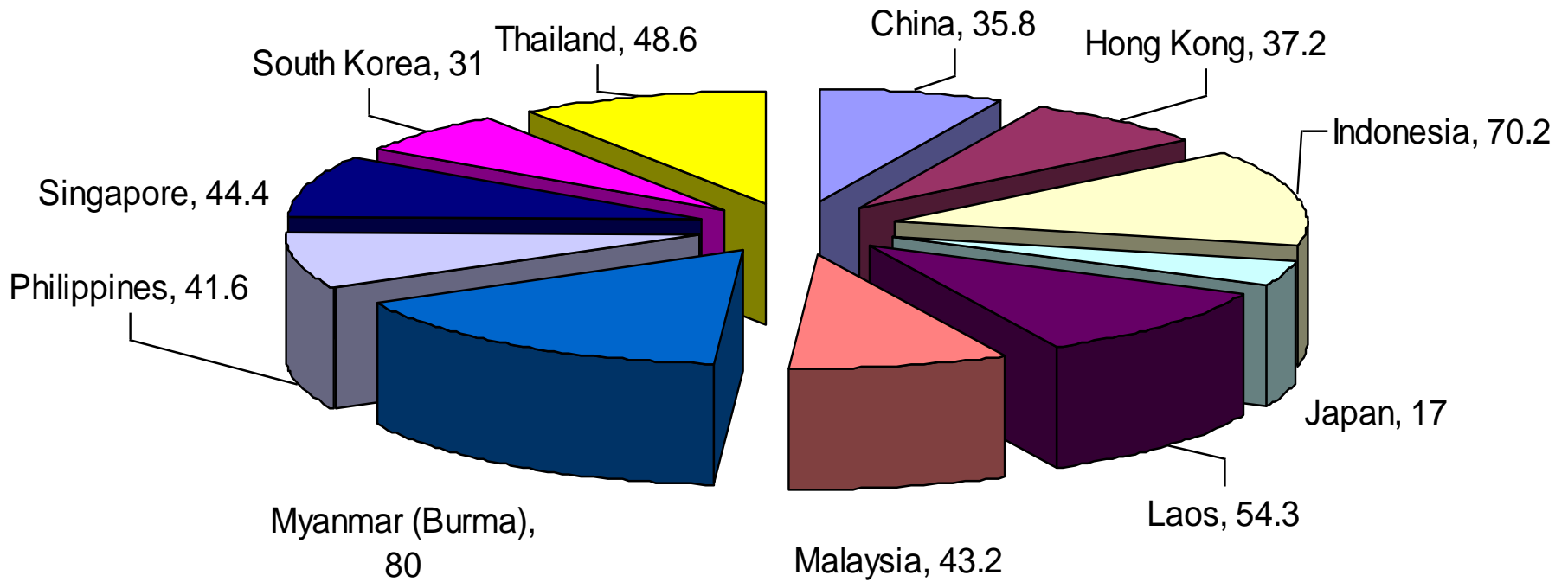
Current Situation

- The lack of alternative options to waste disposal
- high organic components of at least 40% of the total waste generation.
- humid climate and high precipitation rate enhanced rapid degradation
- economic constrains.
- Low rate of recycling among the public
 - lack of policy on waste recycling
 - cannot reduce the waste volume
- composting is not very conducive
 - lack of market
 - non competitive compared to inorganic fertilizer
 - Non-sustainable strategy



Percentage of Waste Generated by Some of The Asian Countries (Adapted from UNESCAP, 2000).

Organic waste in MSW in selected Asian countries (%)



Generation of Organic Solid Waste in Selected Asian Countries



Valuable waste sorted out from waste stream



Heterogeneous wastes received by landfills



Recyclable material includes plastics, paper etc

LFG in non sanitary landfills

- Lacked LFG collection and treatment system.
- LFG escape into the atmosphere from cracks of landfill cover
- LFG emission difficult to monitor and collected.
- LFG harvesting or flaring is not viable.
- Passive release is more practical and economically feasible.



No control of LFG emission in a landfill in India



Passive release of landfill gas into the atmosphere



Gases bubbling out from leachate



Sanitary landfills have the potential to harvest LFG for energy conversion

LFG contributions towards climate change

- Sea rising
- Alteration in earth surface pressure
- Changes in microclimate
- Etc.

Potential Impacts in Asia



Floods

Glacier Melt in the Himalayas



Waterlogging



Cyclones & tidal surges



River bank erosion



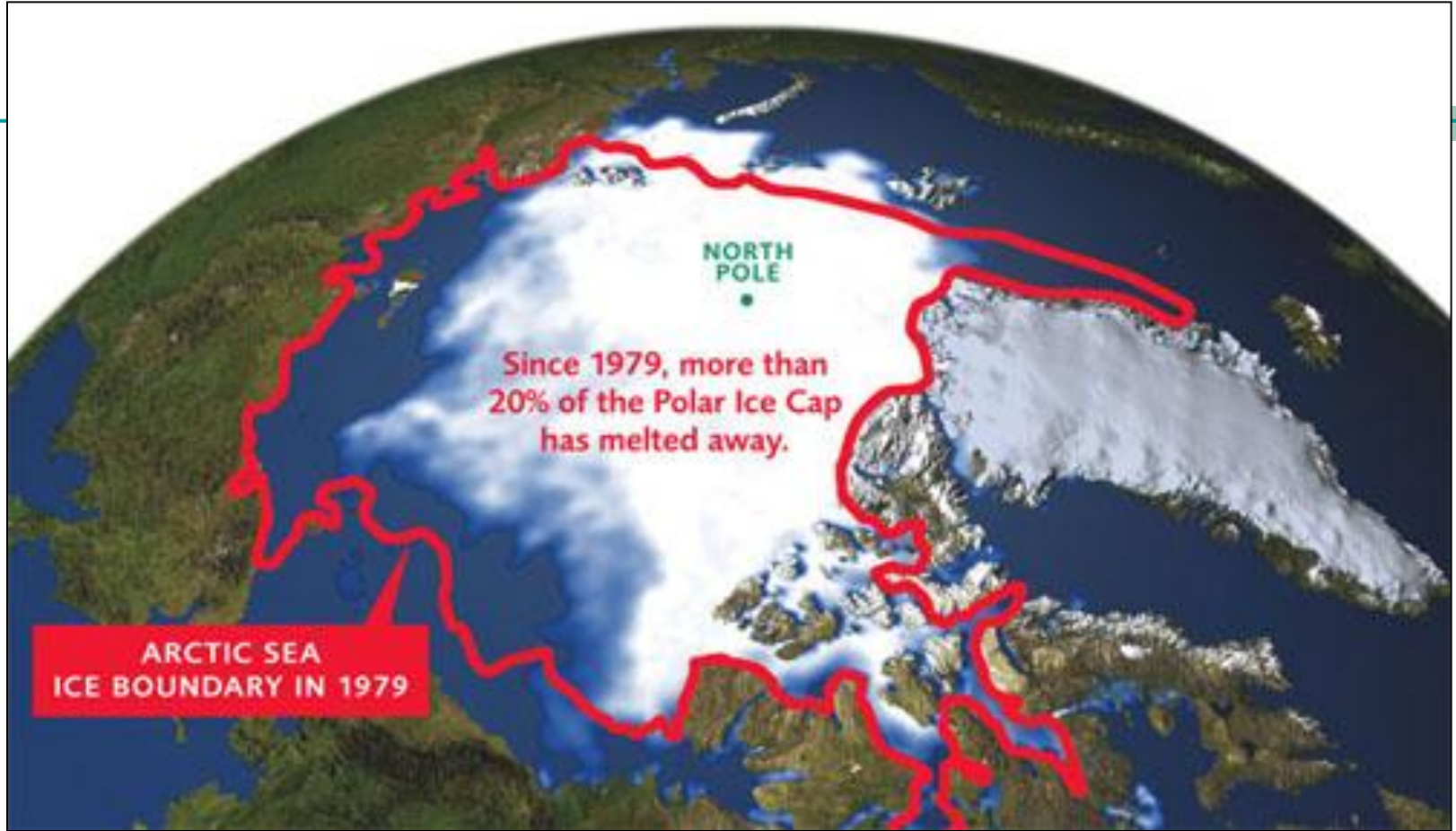
Salinity



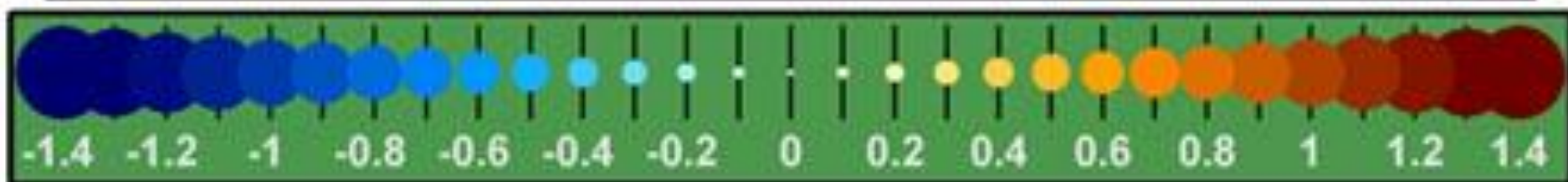
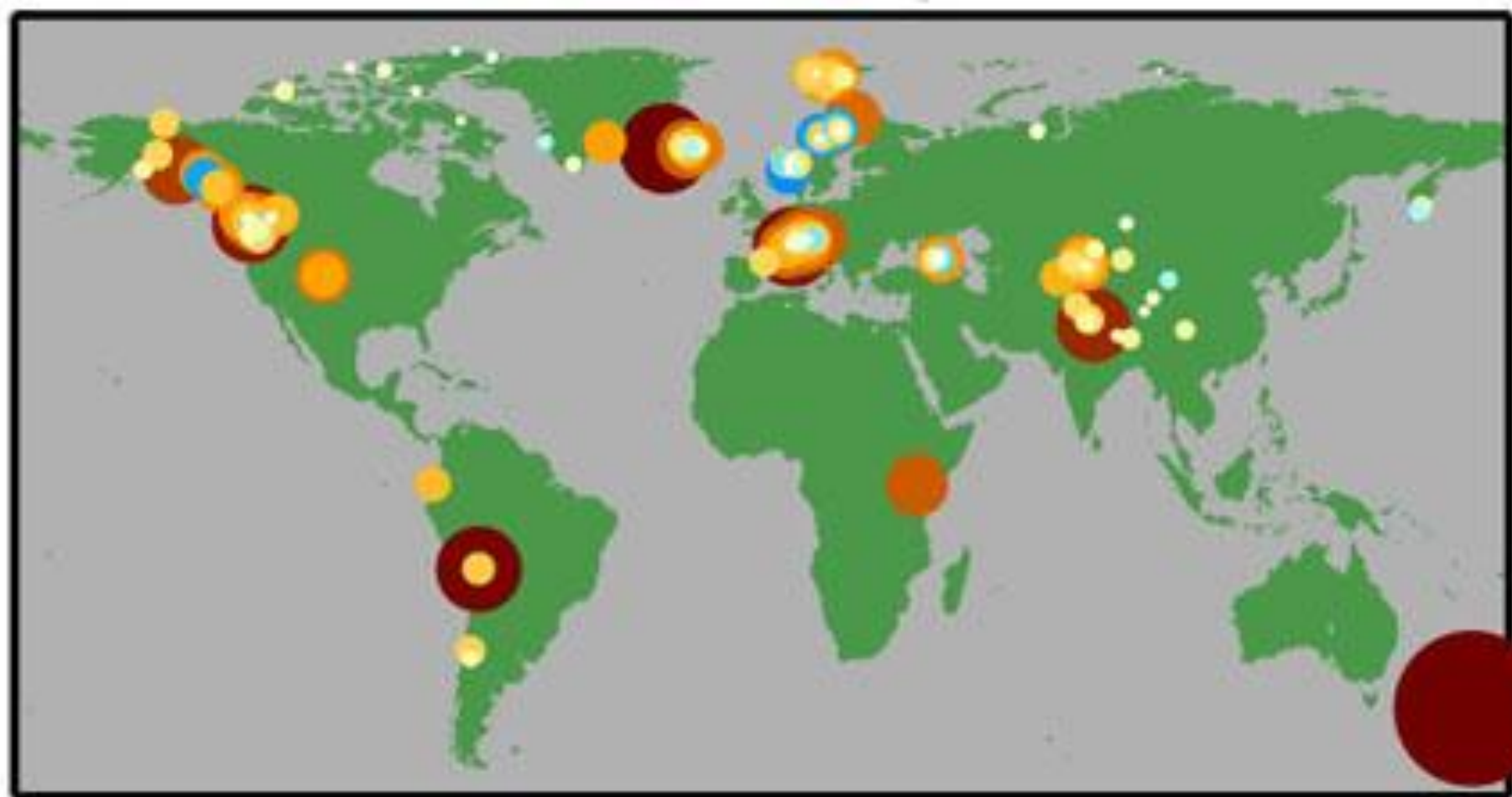
Droughts

Climate change impact : Sea rising

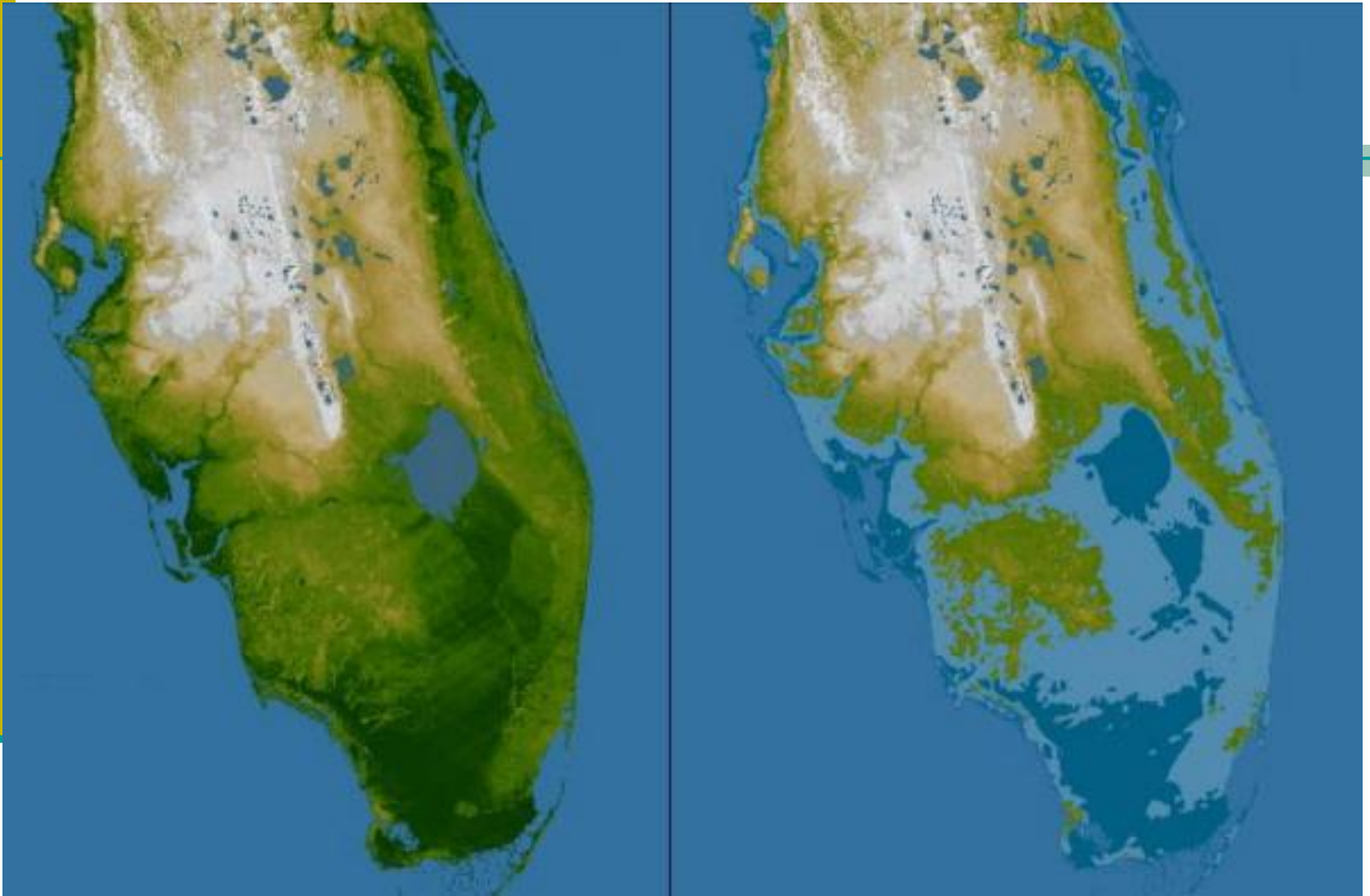
- melting of polar ice caps
- increase the volume of water in the sea resulting with the level to rise.
- floods low laying terrestrial areas and destroy the ecosystems within.
- Increase salinity of the fresh water system.
- Create global water crisis



Impact of increase in temperature



Effective Glacier Thinning (m / yr)



Florida then and Florida in future

Potential impact of sea-level rise on Bangladesh



Today

Total population: 112 Million

Total land area: 134,000 km²

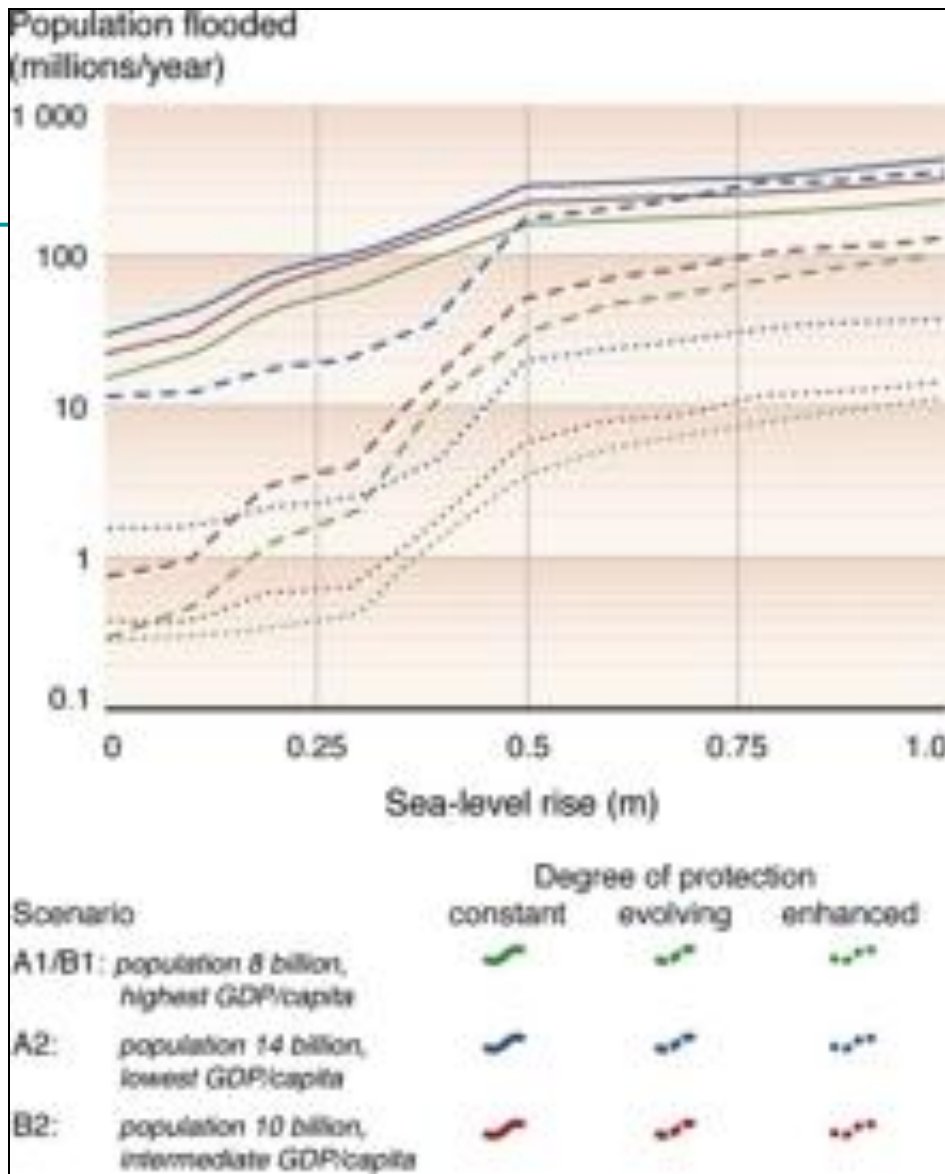


1.5 m - Impact

Total population affected: 17 Million (15%)

Total land area affected: 22,000 km² (16%)

What would be the future for Bangladesh?



Estimates of people flooded in coastal areas in the 2080s as a result of sea level rising



Galloway Wash floods Spur Cross Road, 10.30 AM. Oct 10, 2003. (There is no bridge.) TMcG

Flood episodes will be more frequent



Low-laying area will no longer be inhabitable



Salinification of a
rice field



Ordinary varieties
of rice wither

Strain 6-99

Candidate for salt-resistant rice in the second filial
generation produced by heavy-ion-beam irradiation



'Nipponbare'



Salt-resistant strain
(Strain 6-99)

New strain of rice with tolerance to high salinity will incur
higher cost- unaffordable to poor farmers

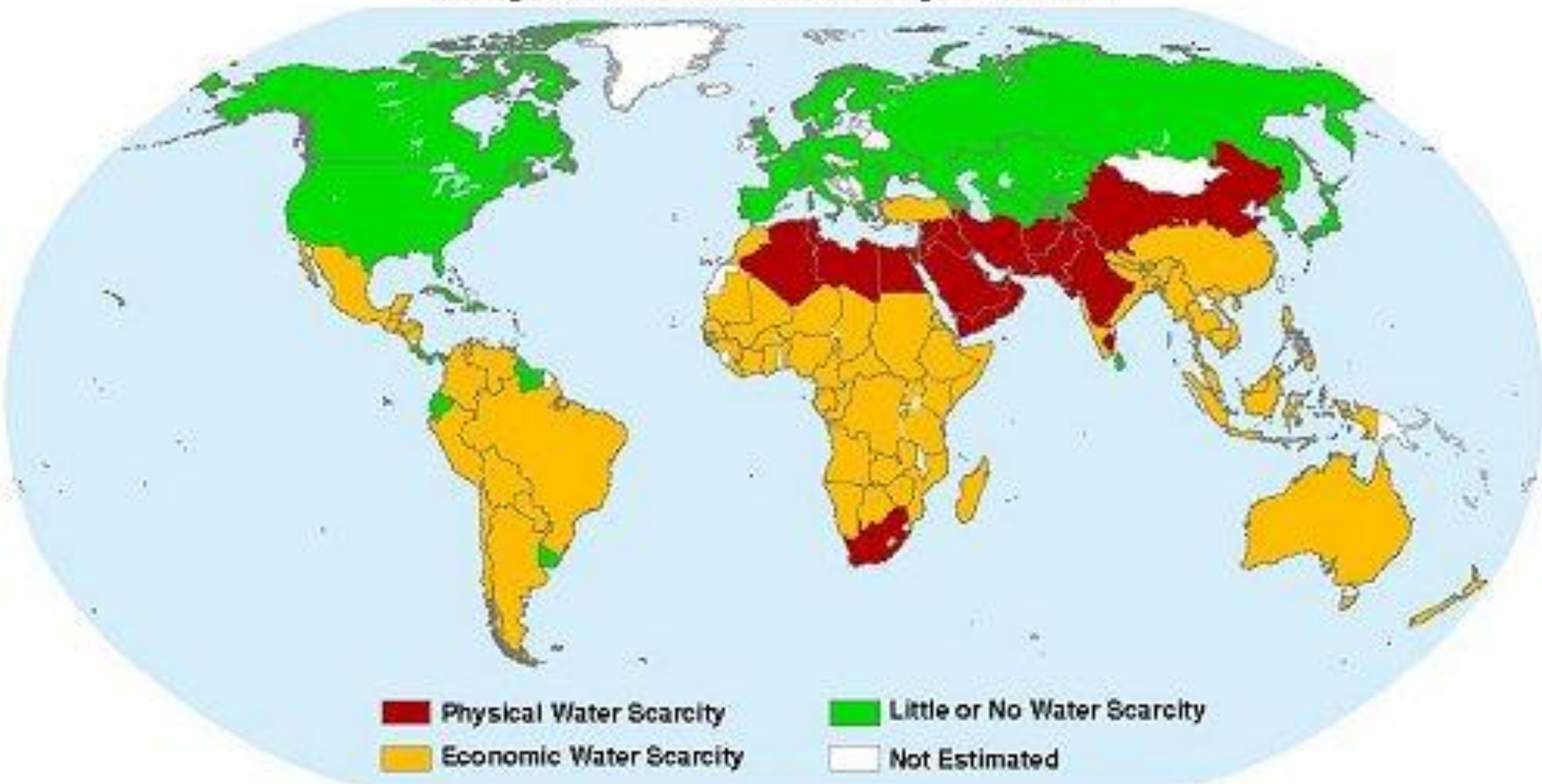


Drought impacts are serious



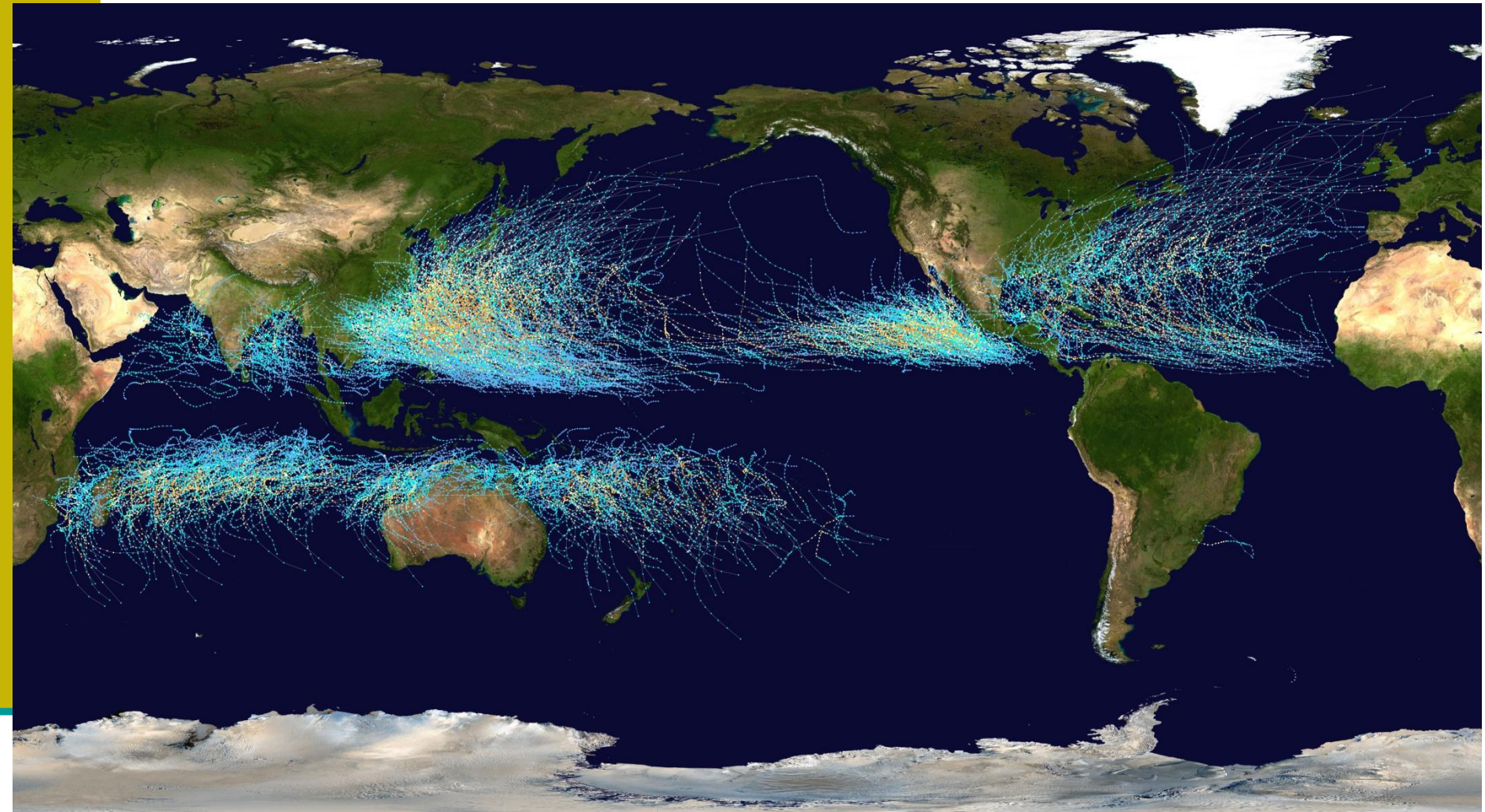
Global water crisis

Projected Water Scarcity in 2025



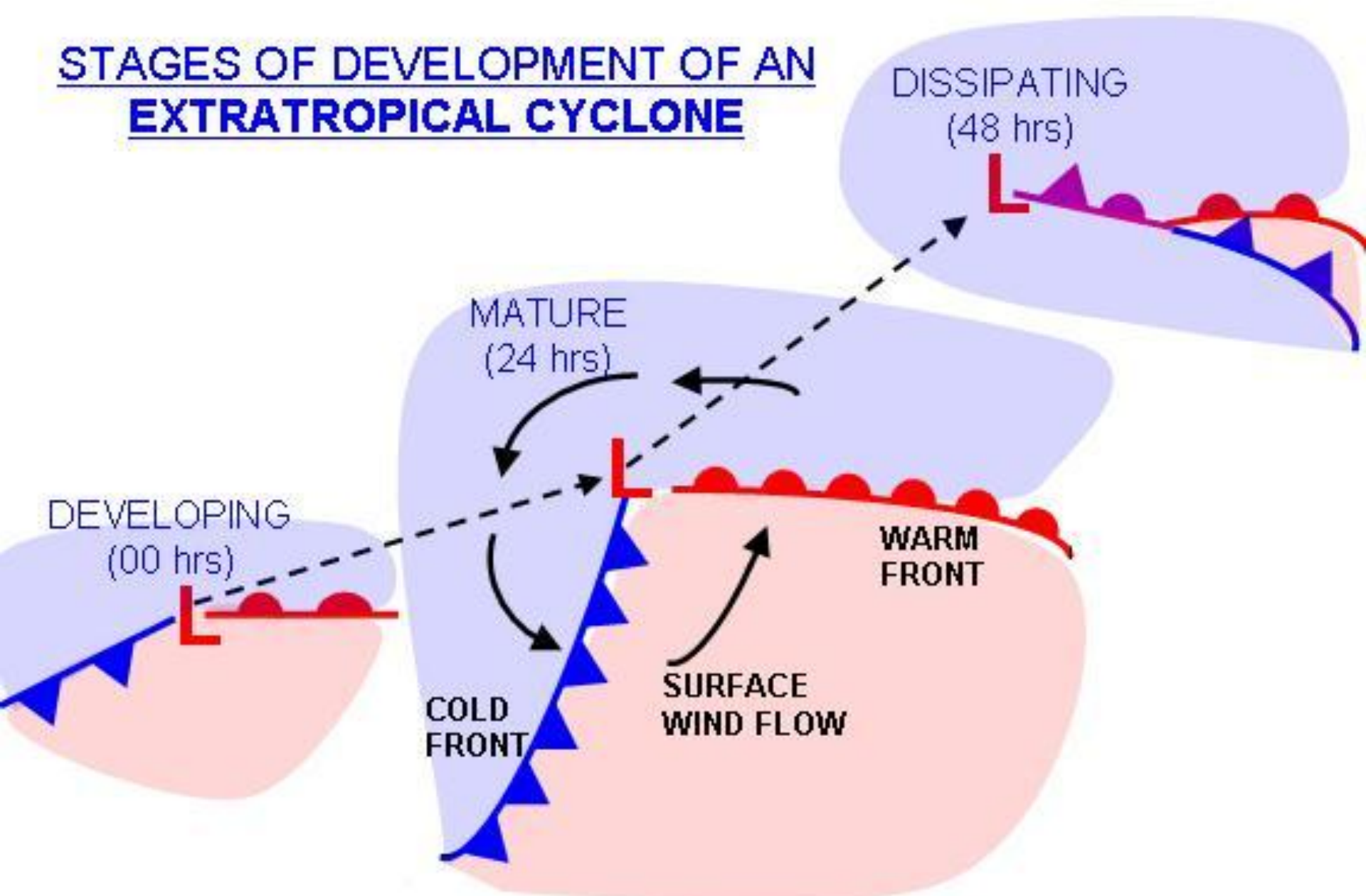
Climate change impact : Pressure alteration

- Alter the earth surface pressure.
- Change the intensity of the air movement
- More powerful cyclone
- alter the frequency of the occurrence of cyclones, typhoons and hurricanes.
- change the rainfall patterns.
- Rain dependent crops will be severely affected.
 - global food shortage



Formation and location of cyclones

STAGES OF DEVELOPMENT OF AN EXTRATROPICAL CYCLONE



EXTRATROPICAL CYCLONES FORM ALONG THE BOUNDARIES BETWEEN COOL AND WARM AIR MASSES



REUTERS



Destructions by cyclones

DJF EL NINO PRECIPITATION ANOMALIES (MM)
AND FREQUENCY OF OCCURRENCE (%)

ANOMALIES

FREQUENCY



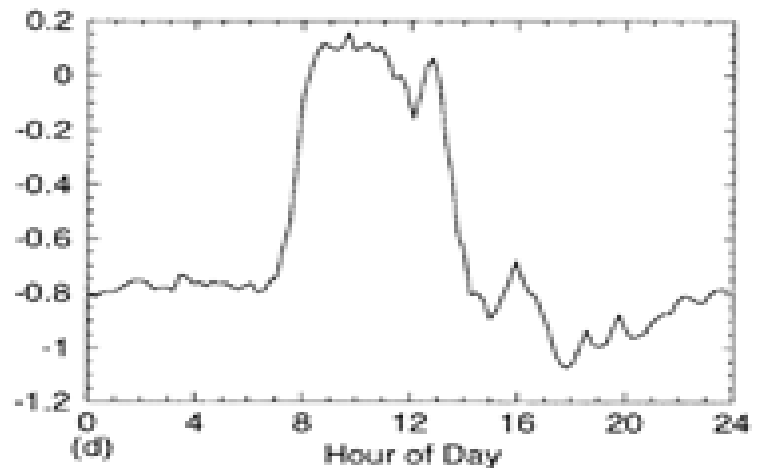
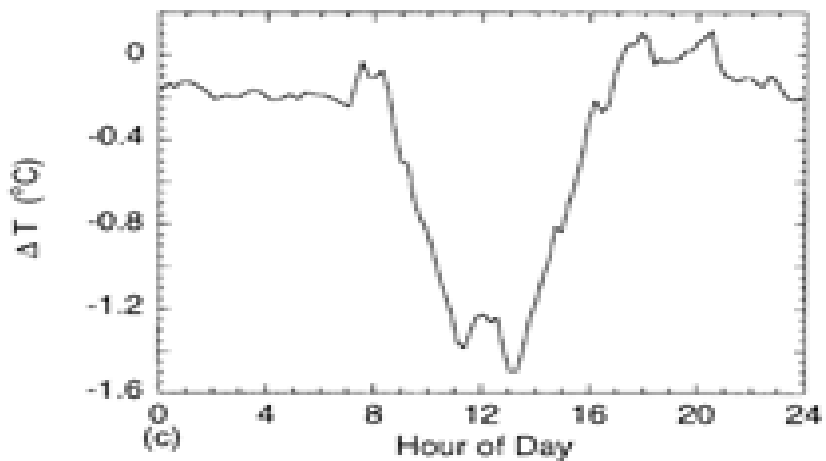
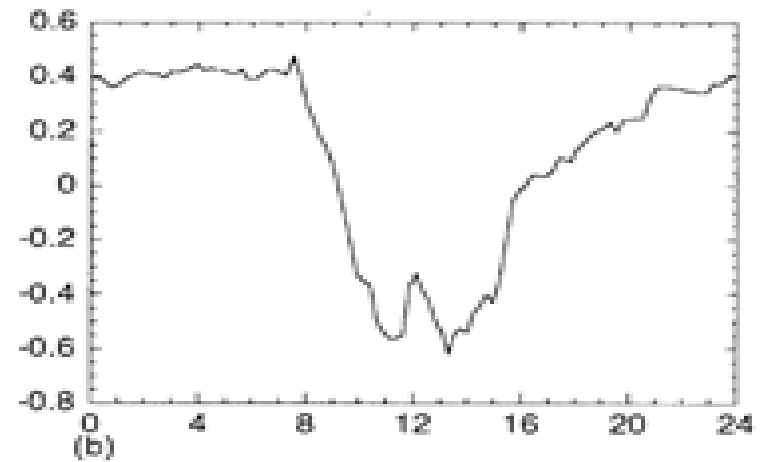
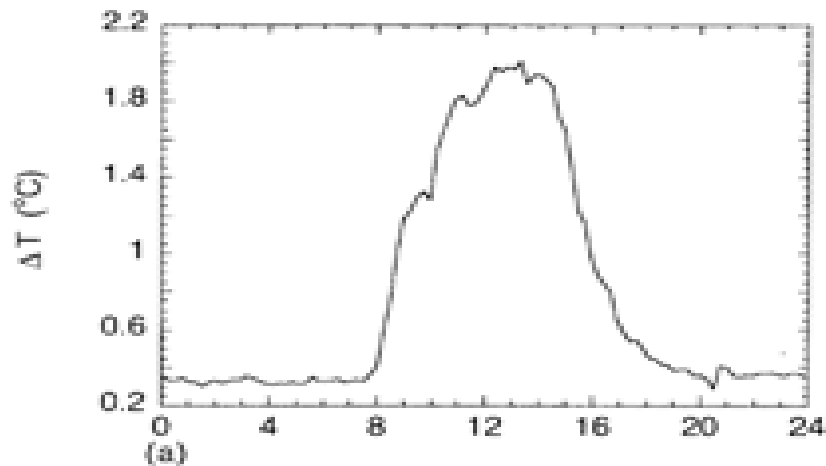
Change in rainfall pattern will cause destruction to existing ecosystem



Changes in rainfall patterns will influence water supply

Climate change impact : Changes in microclimate

- the loss of biodiversity
- unfavorable conditions for the organisms to strive
- Alter the food web → unstable ecosystem.
- Encourage insect infestation.
 - more conducive environment for breeding
 - epidemics due to insect-borne diseases increase.



Change in microclimate will severely affect the sensitive organisms



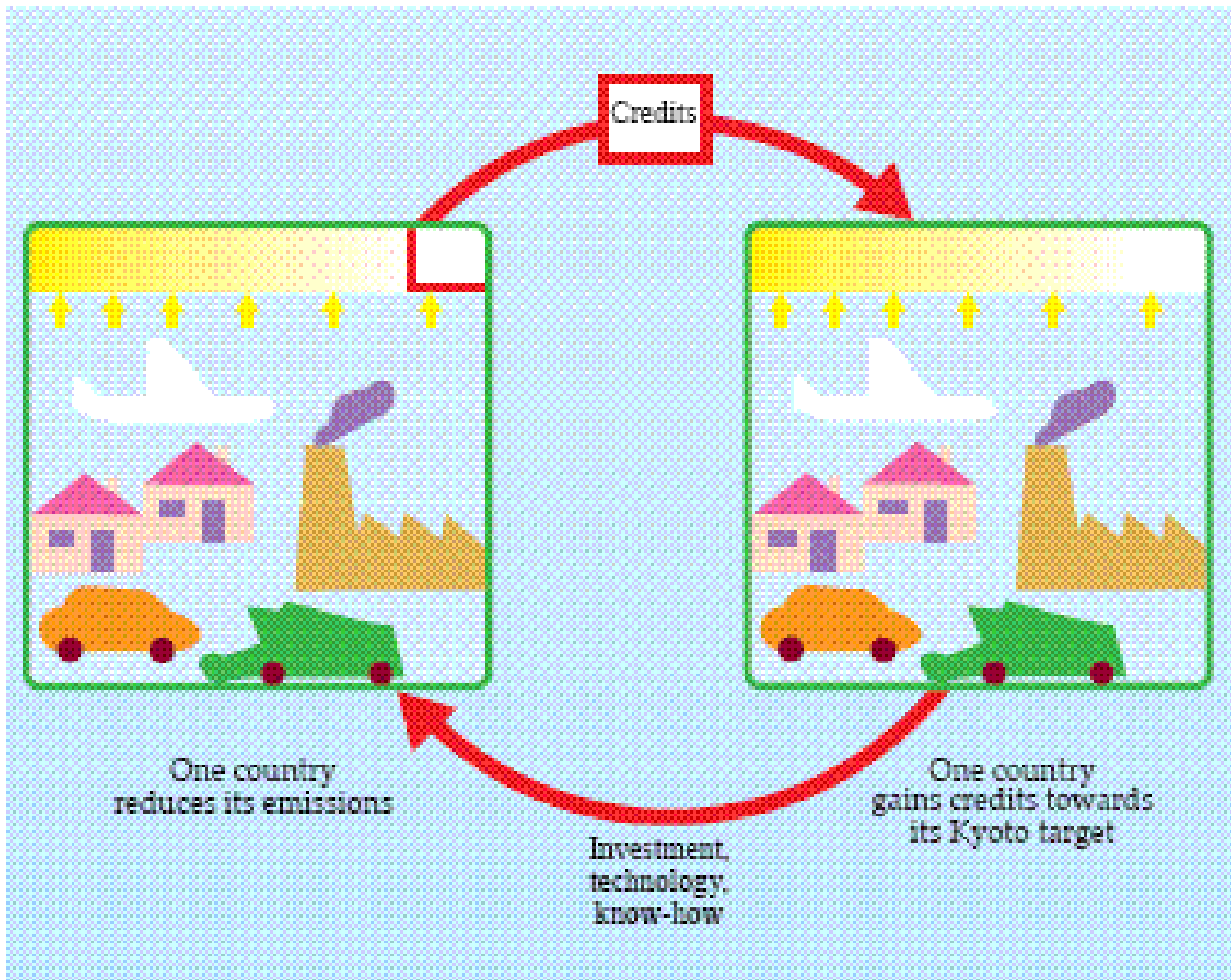
A polar bear died of exhaustion due to the change in microclimate. More energy is required for the bear to reach their hunting ground



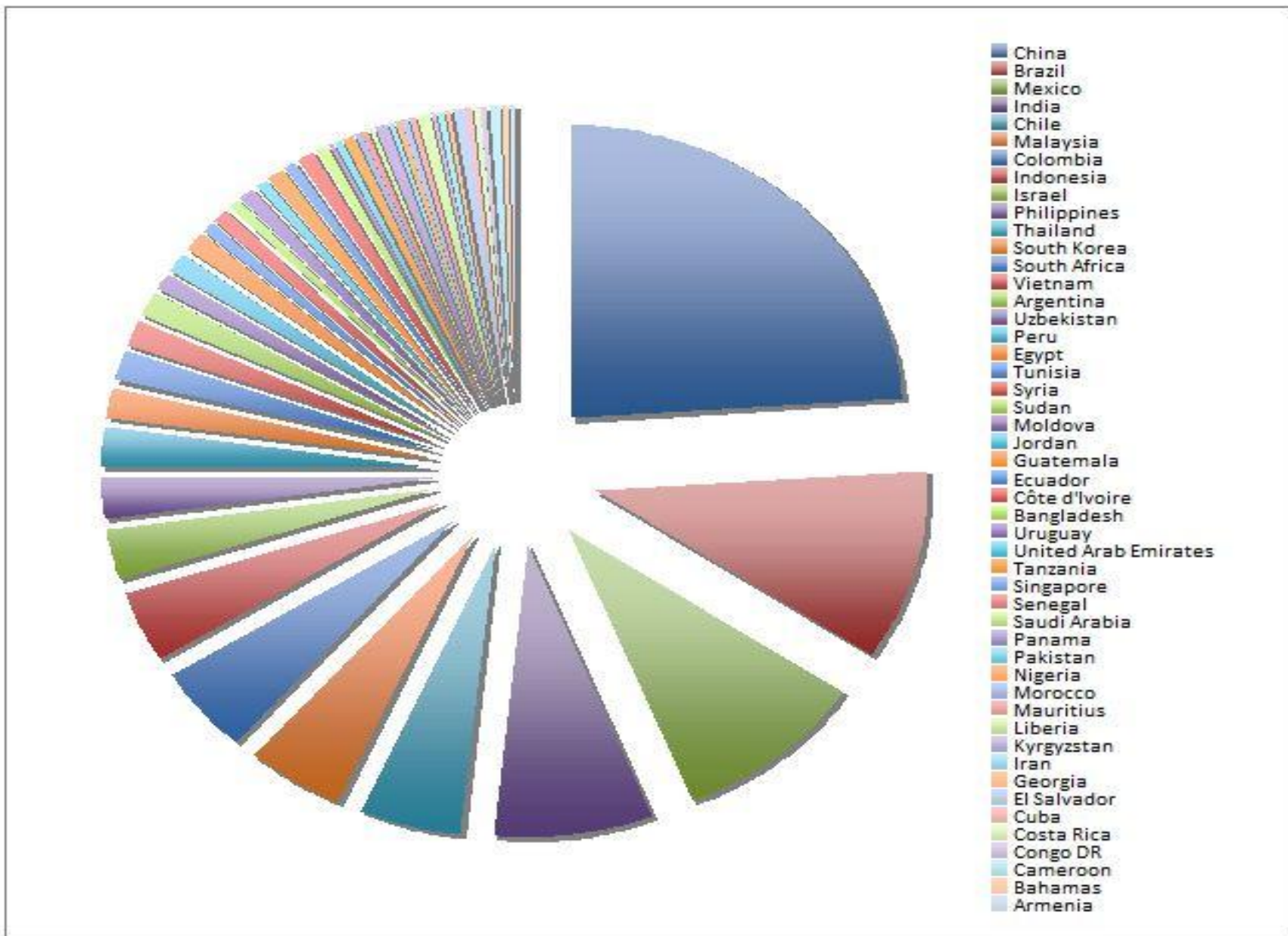
Warmer temperature create conducive environment for insects; Bad news to human!

Current and future mitigations methods

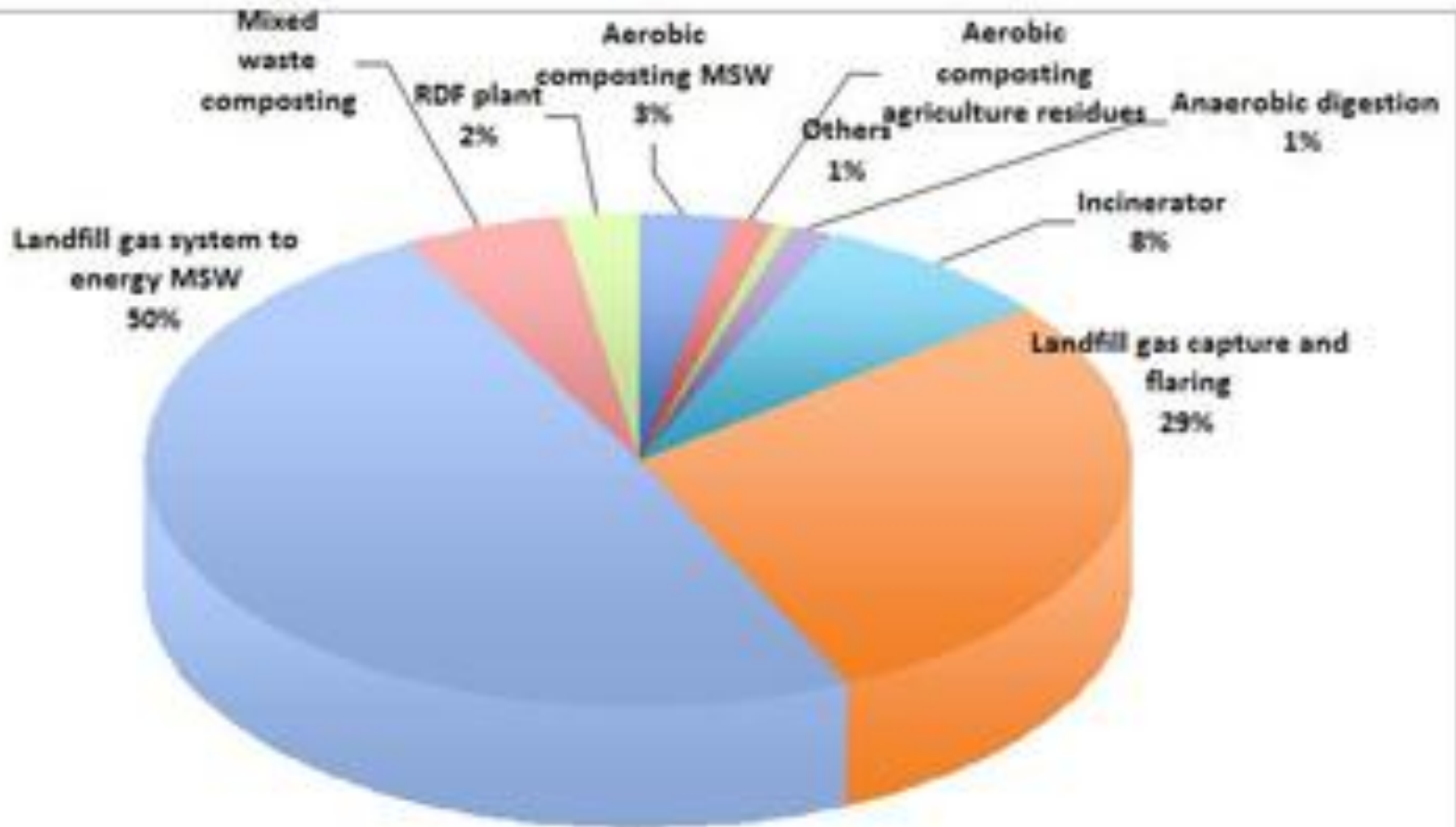
- Appropriate technologies applicable to local condition require the integration of various factors
 - flexible strategies
 - financial incentives
- Clean Development Mechanism (CDM)
- reduce the ecological footprint → reduce the GHG emission globally.
- Waste management sector has a potential to reduce 20% of global GHG
 - the climate change can be lessened.



Clean Development Mechanisms

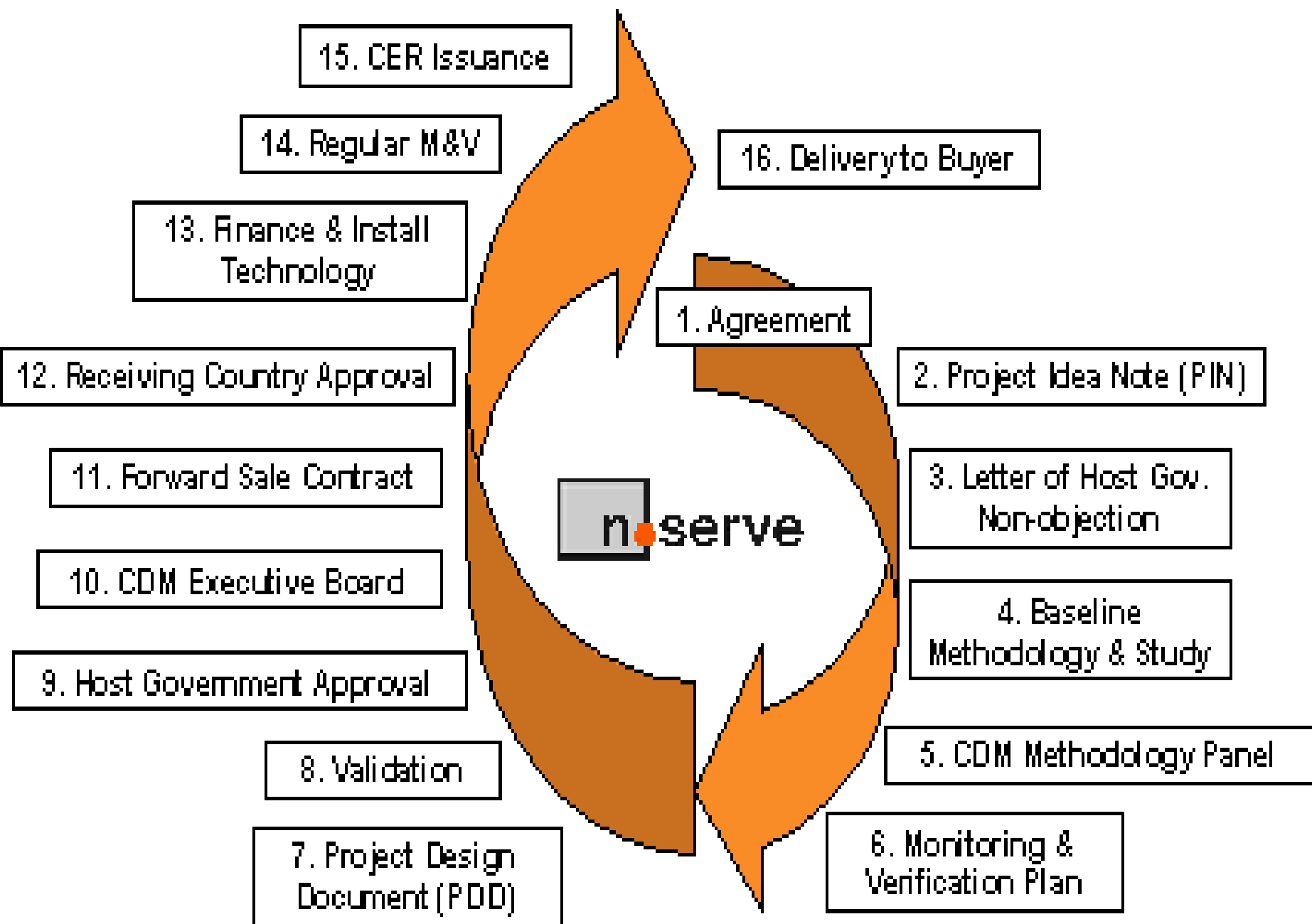


Host countries of CDM municipal solid waste projects



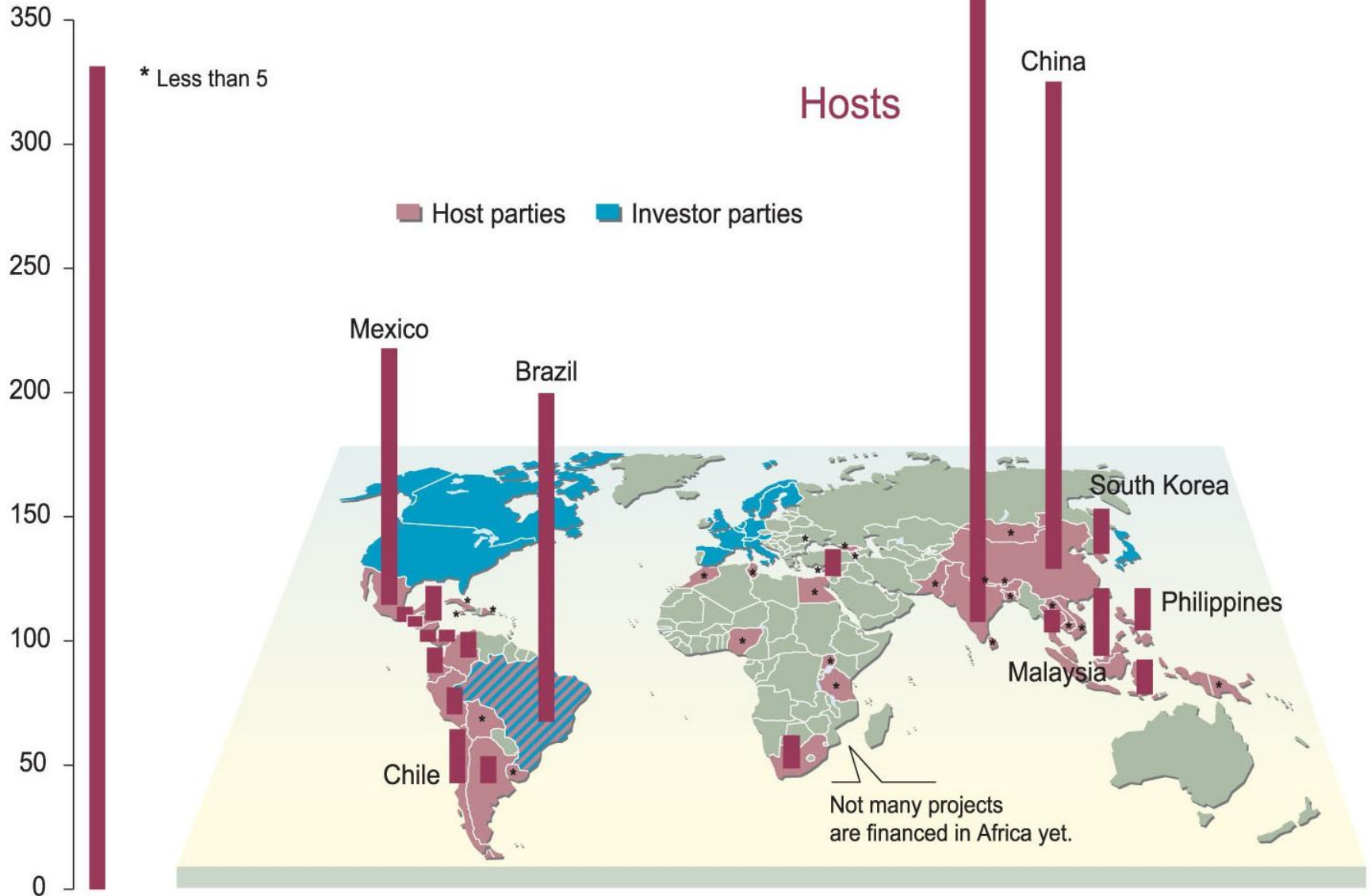
Type of technologies supported by CDM

Simplified CDM Project Cycle



Registered projects implemented under Kyoto's "Clean Development Mechanism"

Number of projects by host parties



Conclusions

- The generation of LFG has serious repercussions on climate change.
- necessary mitigation measures need to be implemented to reduce the GHG emission
- The sooner we initiate remedial measures, the better our chances of sustainable living.

GOOD NEWS! AT THE
CURRENT RATE OF GLOBAL
WARMING WE SHOULD BE
ABLE TO JUST SWIM OVER
THERE AND EAT HIM IN
UNDER FIVE YEARS...!

THANK YOU