SUSTAINABLE DEVELOPMENT, CLIMATE CHANGE AND FOOD SECURITY

LECTURE VI: CLIMATE CHANGE

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OVERVIEW

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MODULE OUTLINE AND OBJECTIVES

- I: Introduction to Sustainable Development
- Vocational Guidance/Employability Skills in the Green Economy
- II: KZN and Sustainable Development Projects
- III: SADCC and SD Projects
- IV: Green Living
- V: SD, Pollution and Environment
- **VI: Climate Change**
- VII: Local Industries, Ecosystems and Environment
- VIII: Local Industrial Companies and SD Initiatives
- IX: SD Sports and Nutrition Strategies
- X: Food Security Solutions
- XI: Chemical Waste Strategies
- XII: Water Resource Management and Strategies

DEFINING CLIMATE CHANGE

The IPCC (2015) assessment report and the 2012 updated version of the United Nations Framework Convention on Climate Change define climate as:

> **The statistical measurement of the mean and variability of meteorological variables such as temperature, precipitation, wind speed and direction, atmospheric pressure and others over a period of time ranging from months to billions of years. (UNFCCC 2012, pg. 3**).

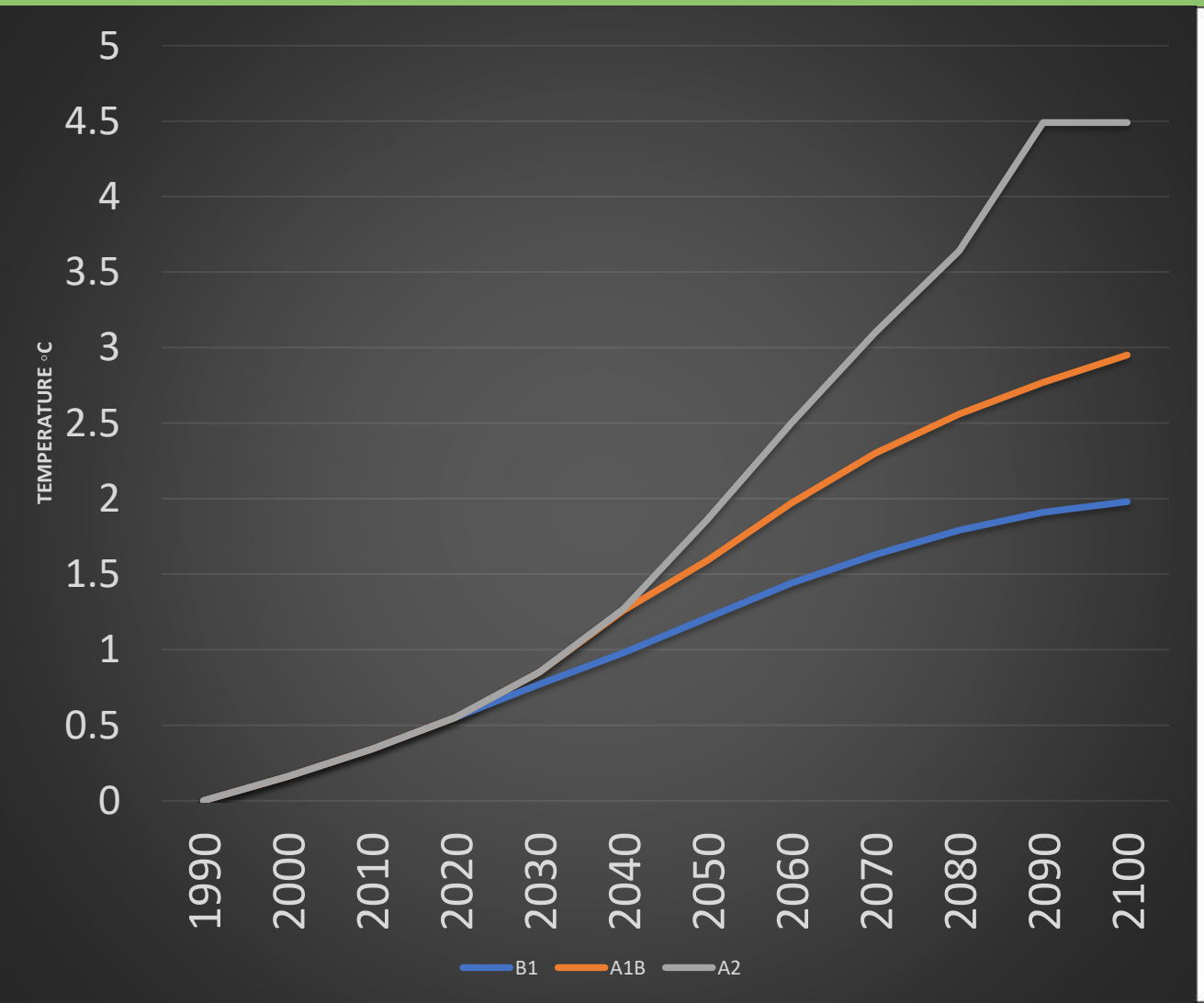
Climate change is defined as:

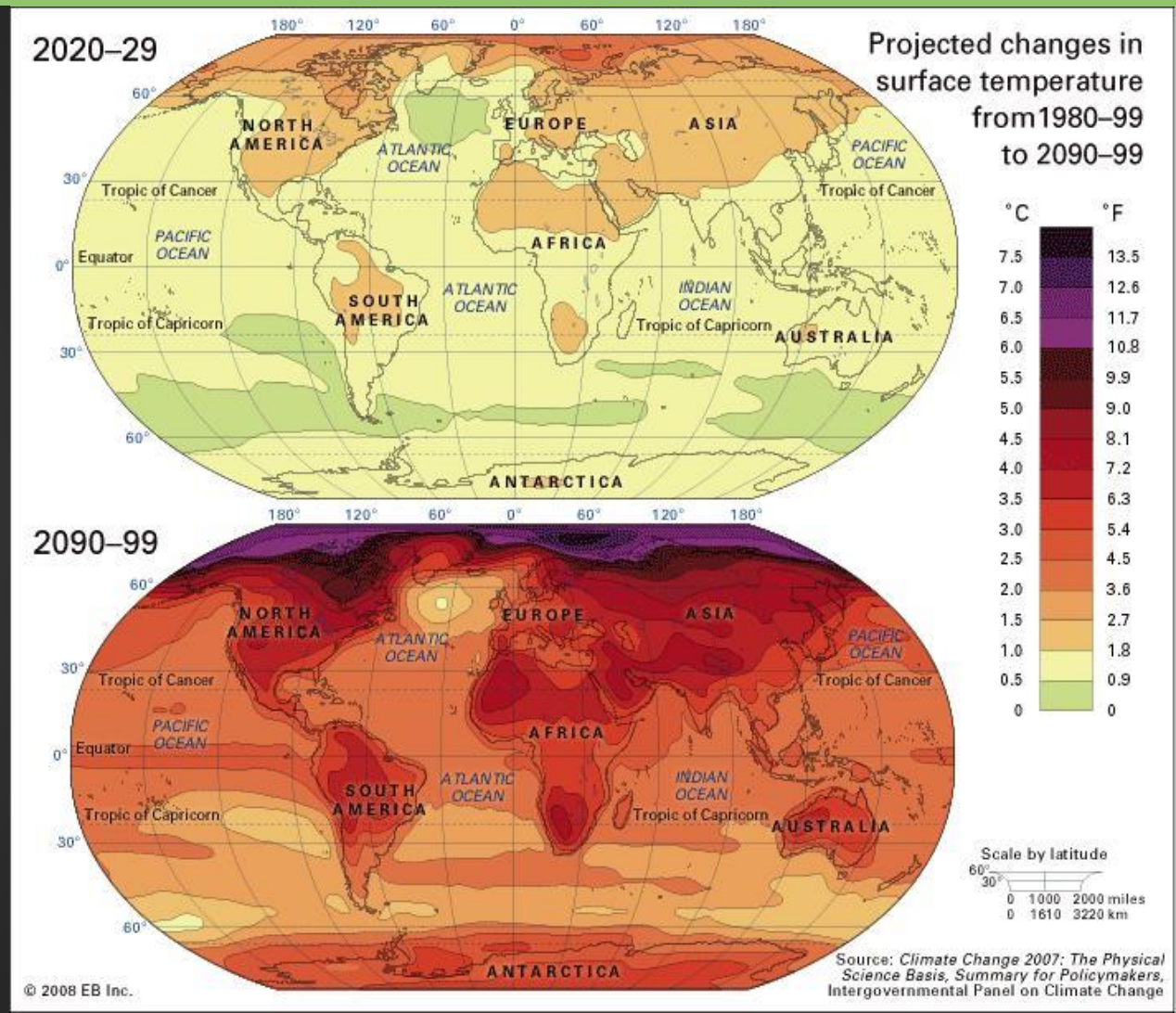
> **Any statistically significant and prolonged alteration in either the variability or the mean of the climate, persisting for an extended time period (frequently defined as decades or longer), which is considered directly or indirectly to primarily occur from anthropogenic causes; that modifies global atmospheric, land and oceanic conditions in contrast to climate variability which relates to natural causes (UNFCCC 2012, pg. 3).**

GLOBAL CLIMATE CHANGE

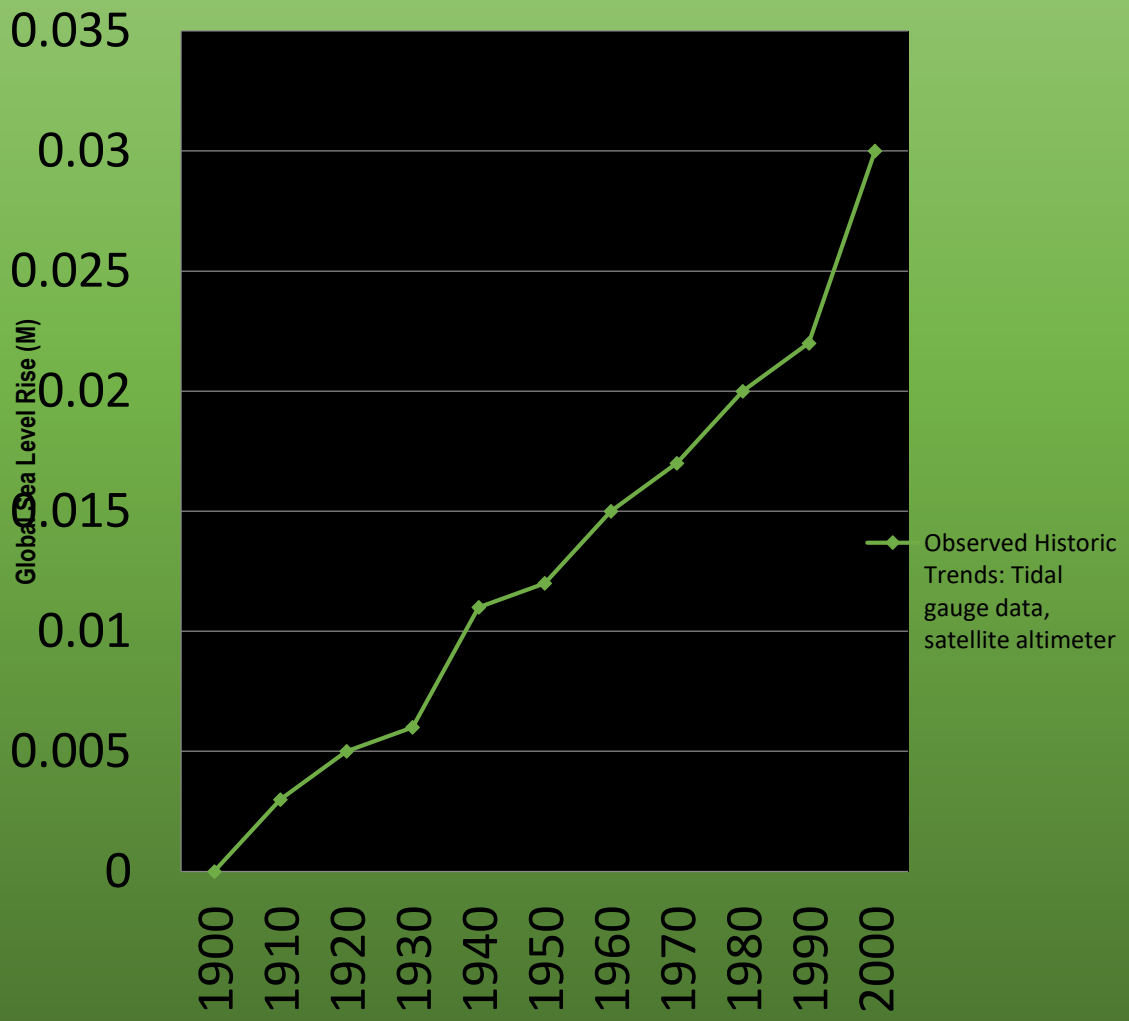
- An increase of 1.5-2º Celsius in global average surface, atmosphere and sea level temperature levels based on historic inventory levels; even if emissions were to cease.
- An increase of 2.5-4º if emissions are stabilised at the current, medium growth rate by 2100.
- Increases of 4-7º if emissions are not reduced.
- A 0.5 metre global, average sea level rise (SLR) is projected for a low risk, current growth, scenario, where emissions are highly reduced. A 1.0 m rise exists for a medium risk (if emissions are stabilised). Up to 2m exists for a high risk, continued emissions increase scenario by 2100 if current, global GDP growth rates of 3-5% annually remain pursued.
- Greenhouse CO_2 emissions would have to stabilise around 430-450 parts per million (ppm) at present. It could reach no higher than 550 ppm (530–580) by 2100 to ensure survival conditions.
- A projected increase in the frequency, duration and intensity of climate-change related natural disasters includes storms, flooding, superstorms, tsunamis, hurricanes, typhoons, heatwaves and landslides, varying throughout

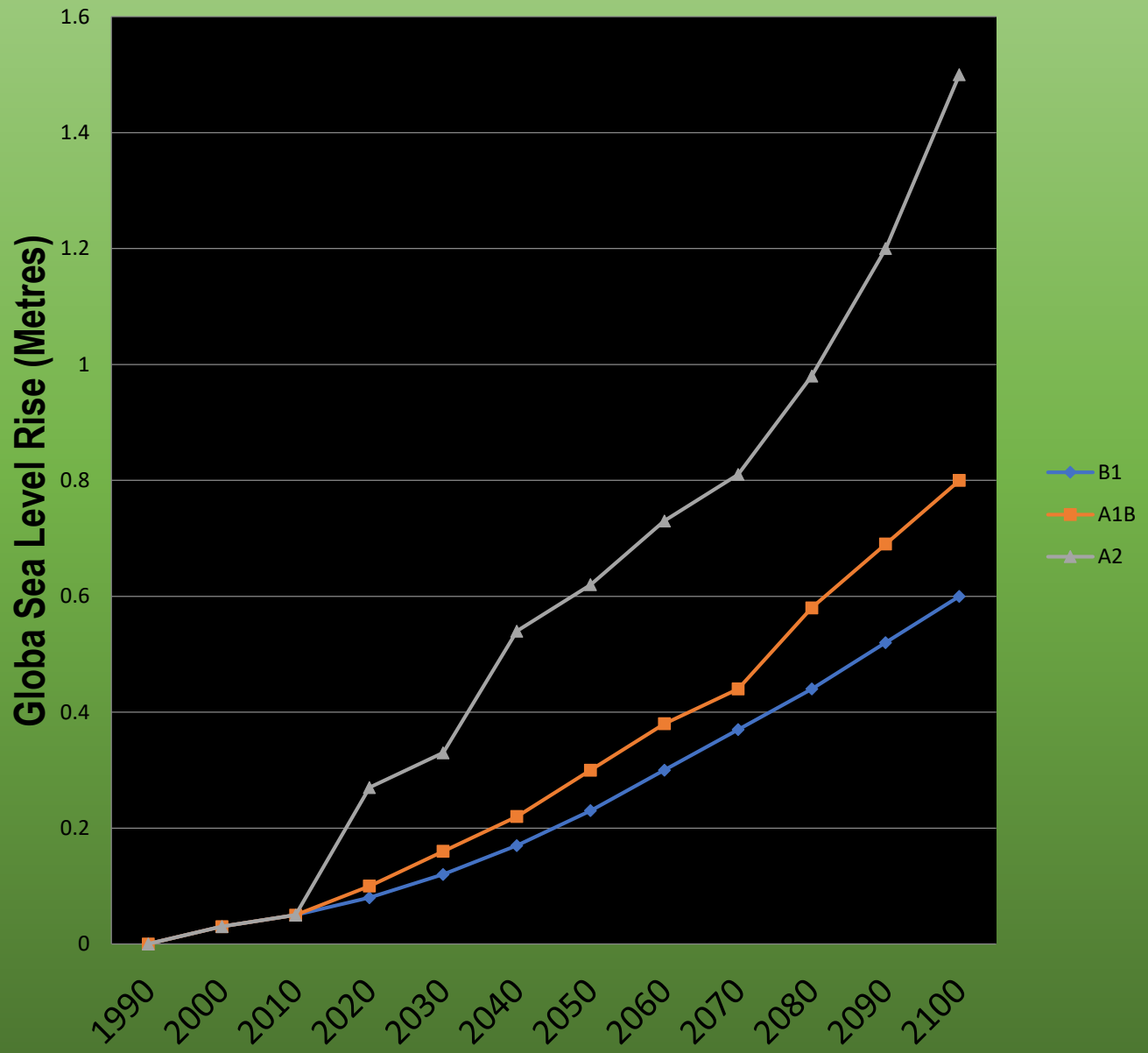
GLOBAL CLIMATE CHANGE





GLOBAL CLIMATE CHANGE



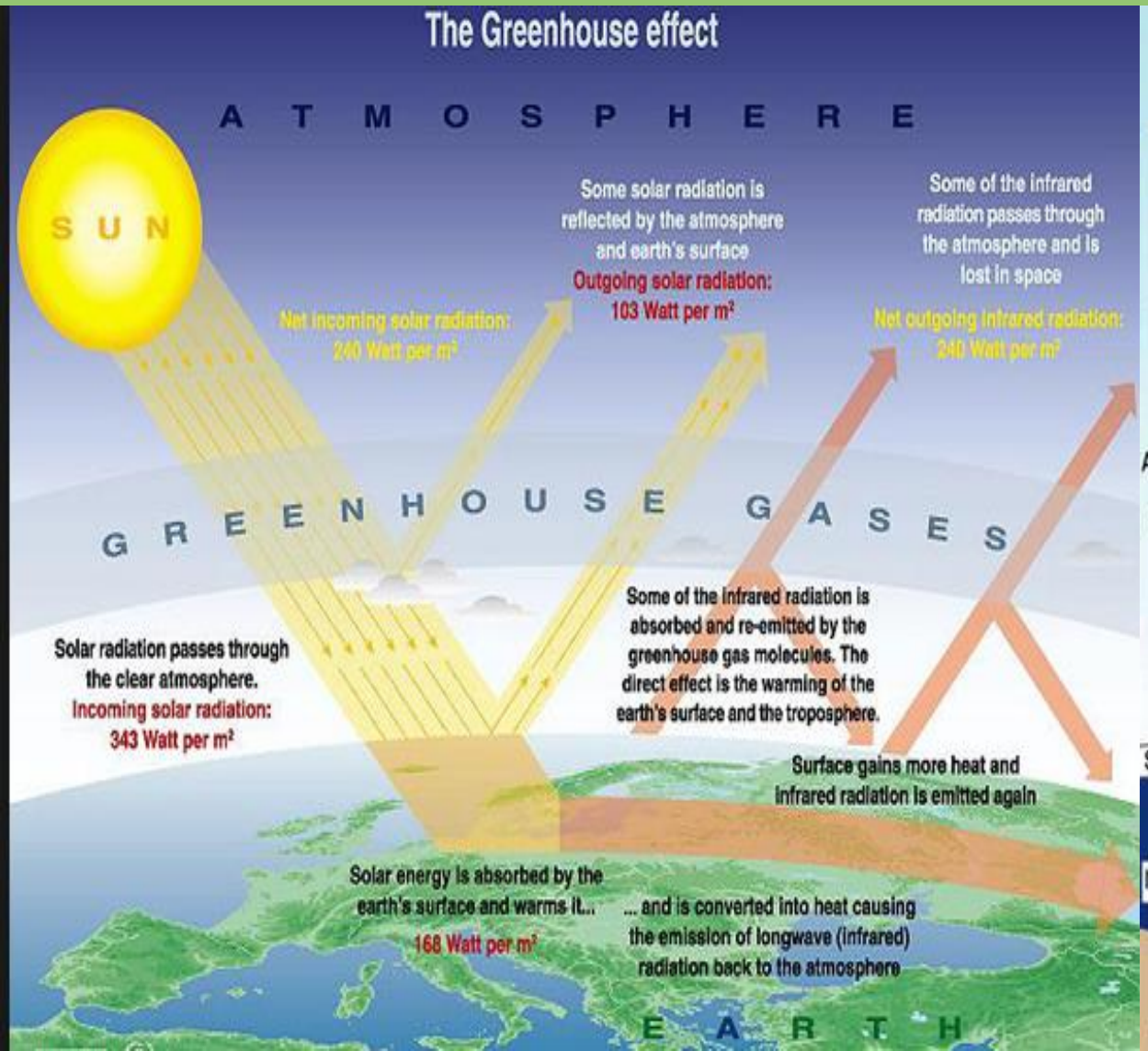


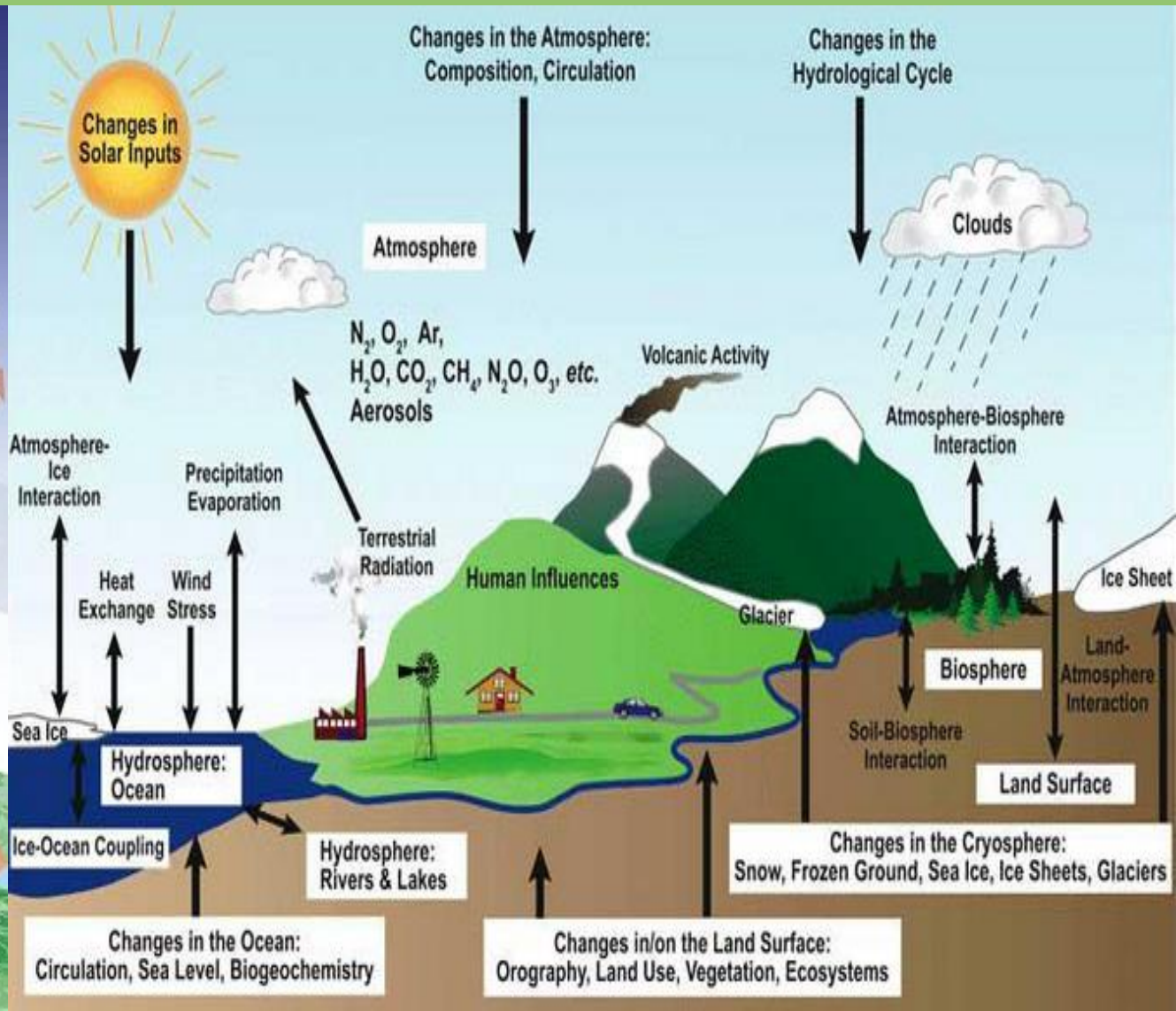
DEFINING GLOBAL WARMING

- The “natural greenhouse effect” refers to the process by which the earth’s atmosphere and clouds continuously absorb terrestrial surface, infrared radiation emitted by natural gases, confining the heat in the troposphere.
- The “enhanced greenhouse effect” growth in emissions concentration/ production increases the infrared transparency, reducing the ozone layer atmospheric shield, intensifying terrestrial radiation, countered by an expansion in troposphere and surface temperature.
- The combination of both natural and anthropogenic caused, greenhouse gas emissions and solar irradiance, and other processes produces “global warming.”
- Global warming as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

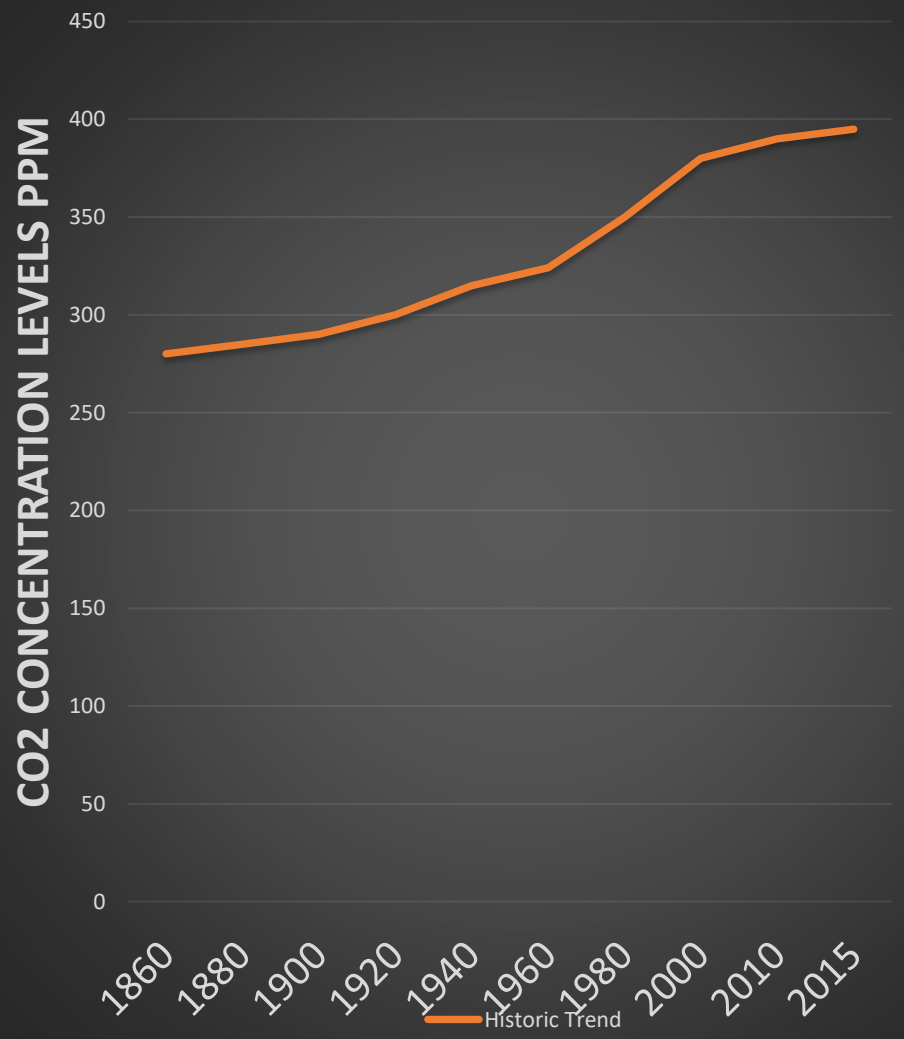
Global Warming Definition, According to the United Nations | Newsmax.com

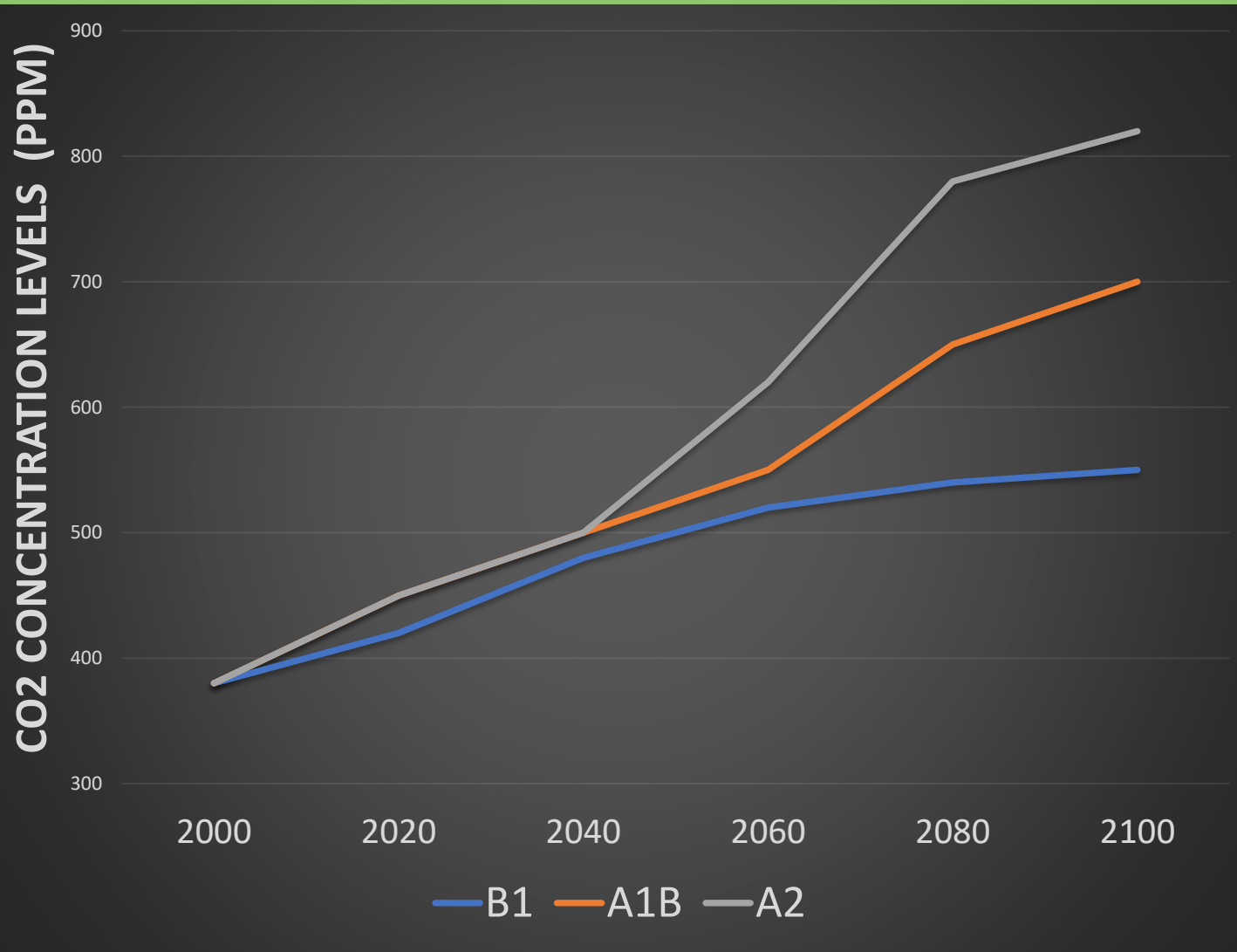
DEFINING GLOBAL WARMING



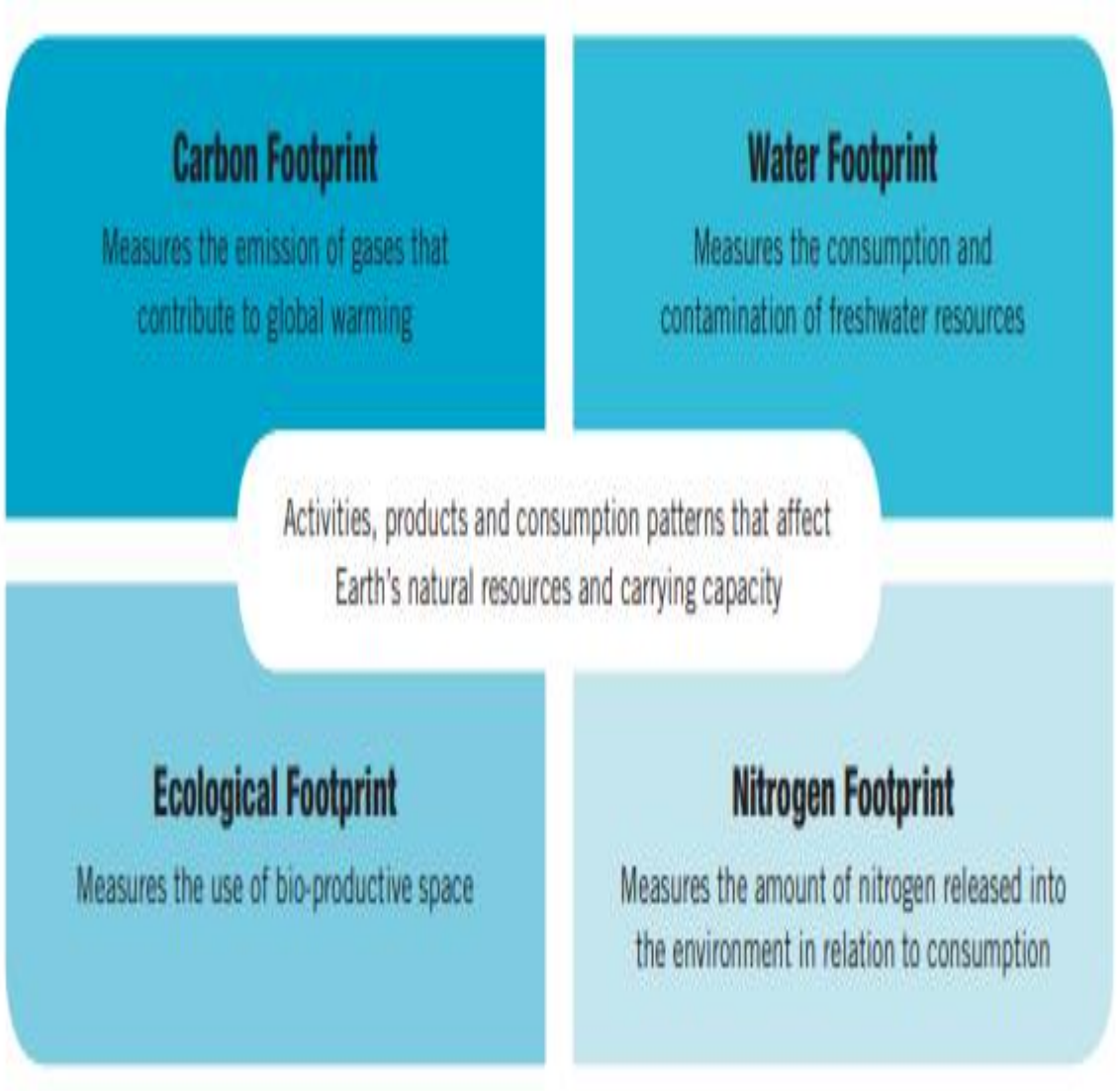


DEFINING GLOBAL WARMING





DEFINING CO_2 FOOTPRINT



A '**carbon footprint**' is a measure of the greenhouse gas (GHG)**emissions caused by or** associated with an activity, group of activities or a product.

Kyoto gas	GWP*	Example sources
Carbon dioxide (CO_2)	1	Burning fossil fuels
Methane (CH_4)	23	Cattle, landfill sites, leaks from disused mines, burning fossil fuels.
Nitrous oxide (N_2O)	296	Emissions from fertilised soils, burning fossil fuels.
Sulphur Hexafluoride (SF_6)	22,200	Leaks from electrical and electronics industries.
Perfluorocarbons (PFCs)	4,800 – 9,200	Electronics industries, fire extinguishers
Hydrofluorocarbons (HFCs)	12-12,000	Leaks from air conditioning and refrigeration systems. LPG storage.

DEFINING CO_2 FOOTPRINT

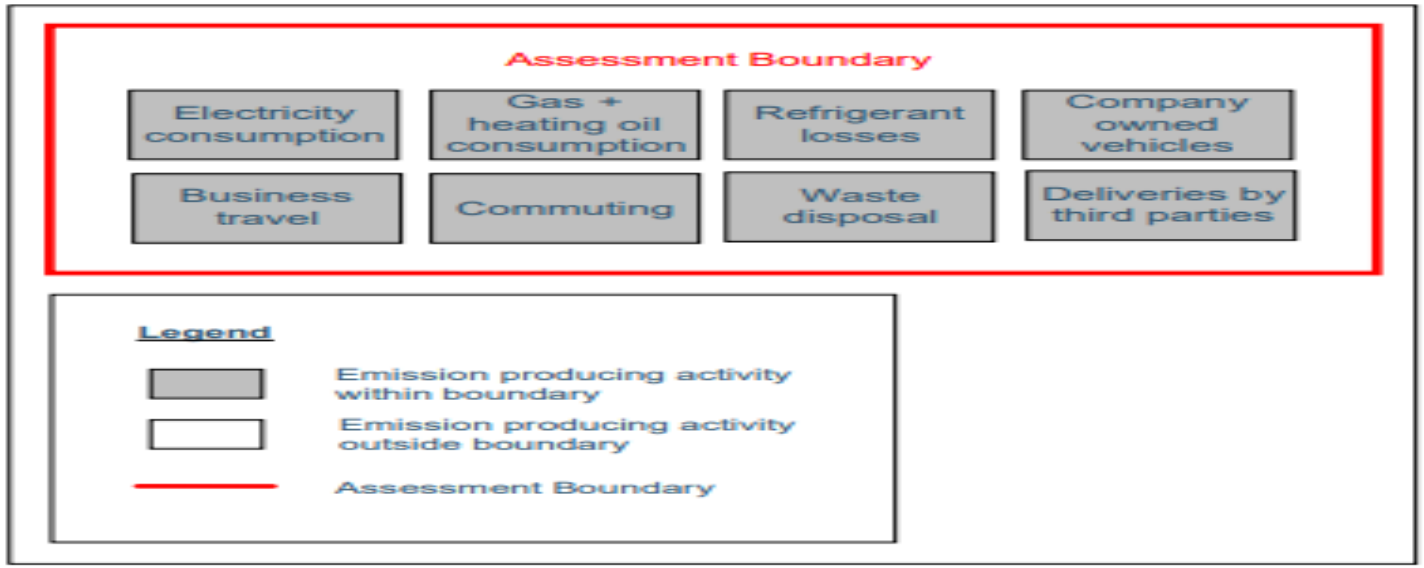
Table 1. Breakdown of company emissions by activity

Source of emissions	Equivalent emissions CO_2 (t/yr)	Proportion of total
Premises - electricity	2,342.4	40%
Premises - gas	394.3	7%
Premises - heating Oil	530.5	9%
Premises - Backup generators	1.6	0%
Premises - refrigerant loss	0.0	0%
Company owned vehicles - petrol cars	587.3	10%
Business travel - petrol cars	162.1	3%
Business travel - taxi hire	85.5	1%
Business travel - air travel	830.4	14%
Business travel - train travel	11.5	0%
Business travel - hotel stays	401.9	7%
Commuting - petrol car	206.9	4%
Commuting - motorcycle travel	7.3	0%
Commuting - train	37.6	1%
Commuting - bus	40.4	1%
Deliveries - van	3.7	0%
Premises - landfilled waste	191	3%
Total	**5,834**	**100%**

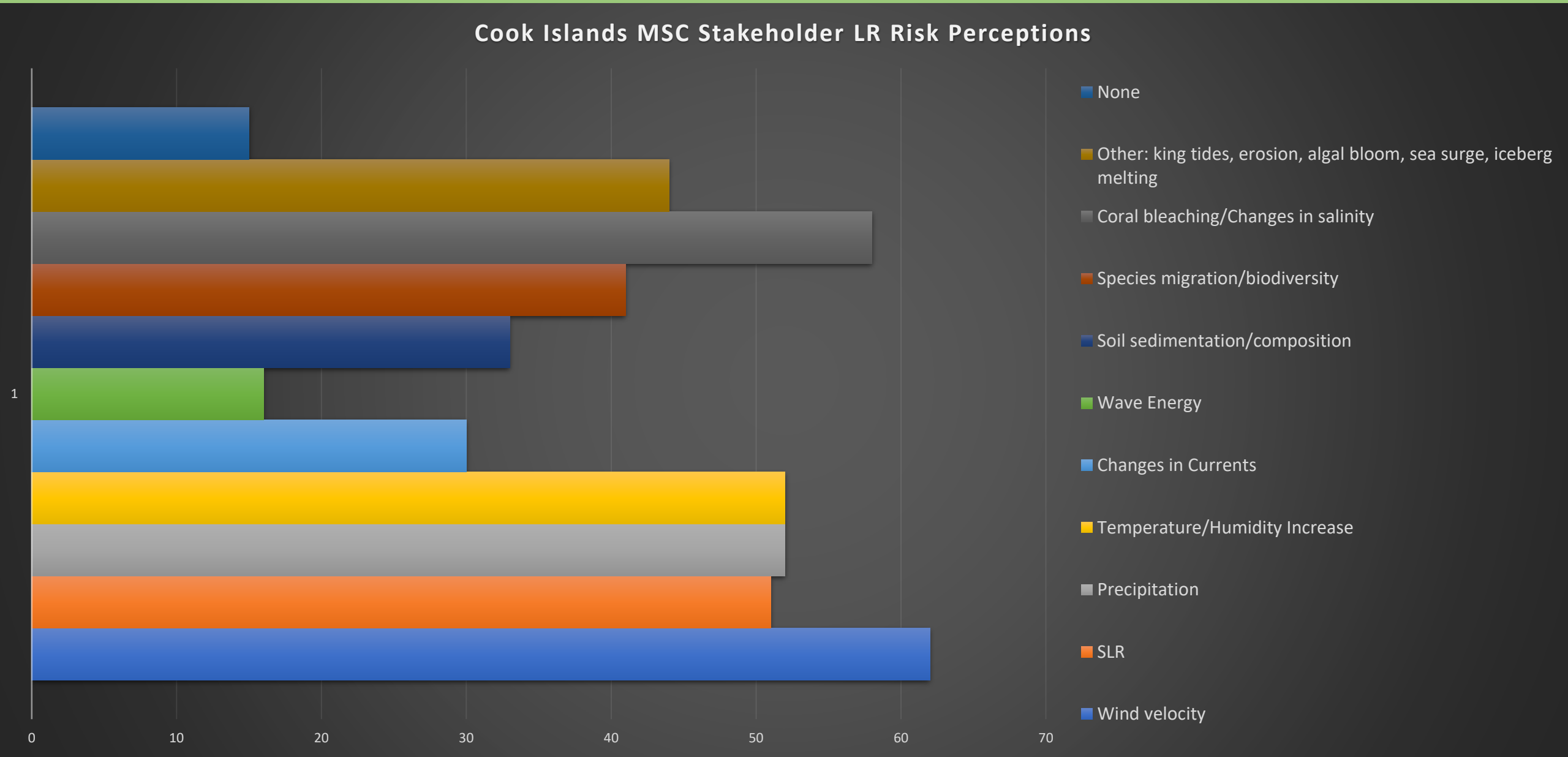
The basic steps required to calculate a carbon footprint for an organisation are as follows:

1. Establishment of the assessment boundaries:
   - Organisational
   - Operational
   - Greenhouse gases
2. Collection of data.
3. Calculation of emissions using appropriate emissions factors (see Box 2).

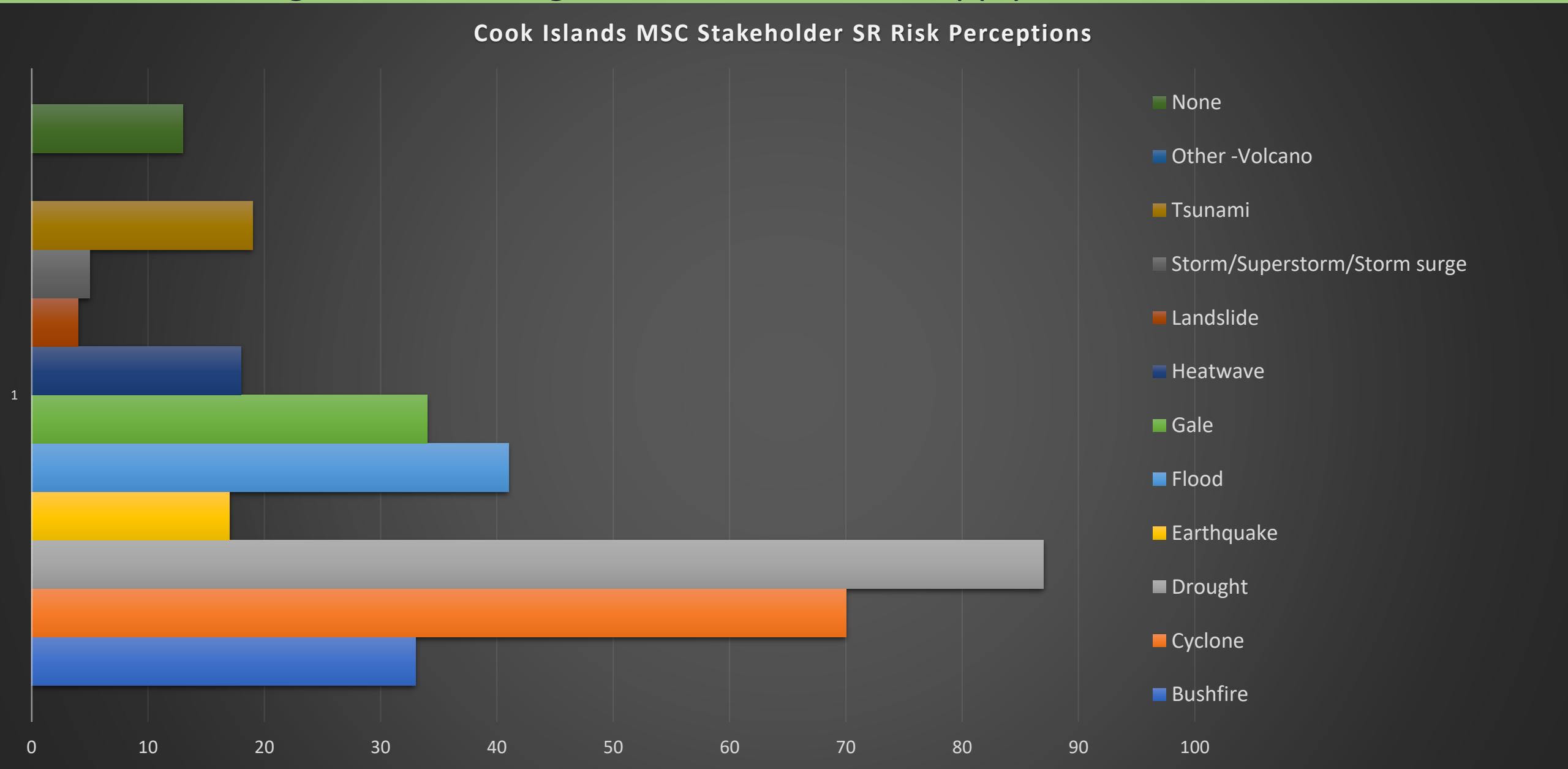
Figure 5. Operational boundary for Business Carbon Footprint



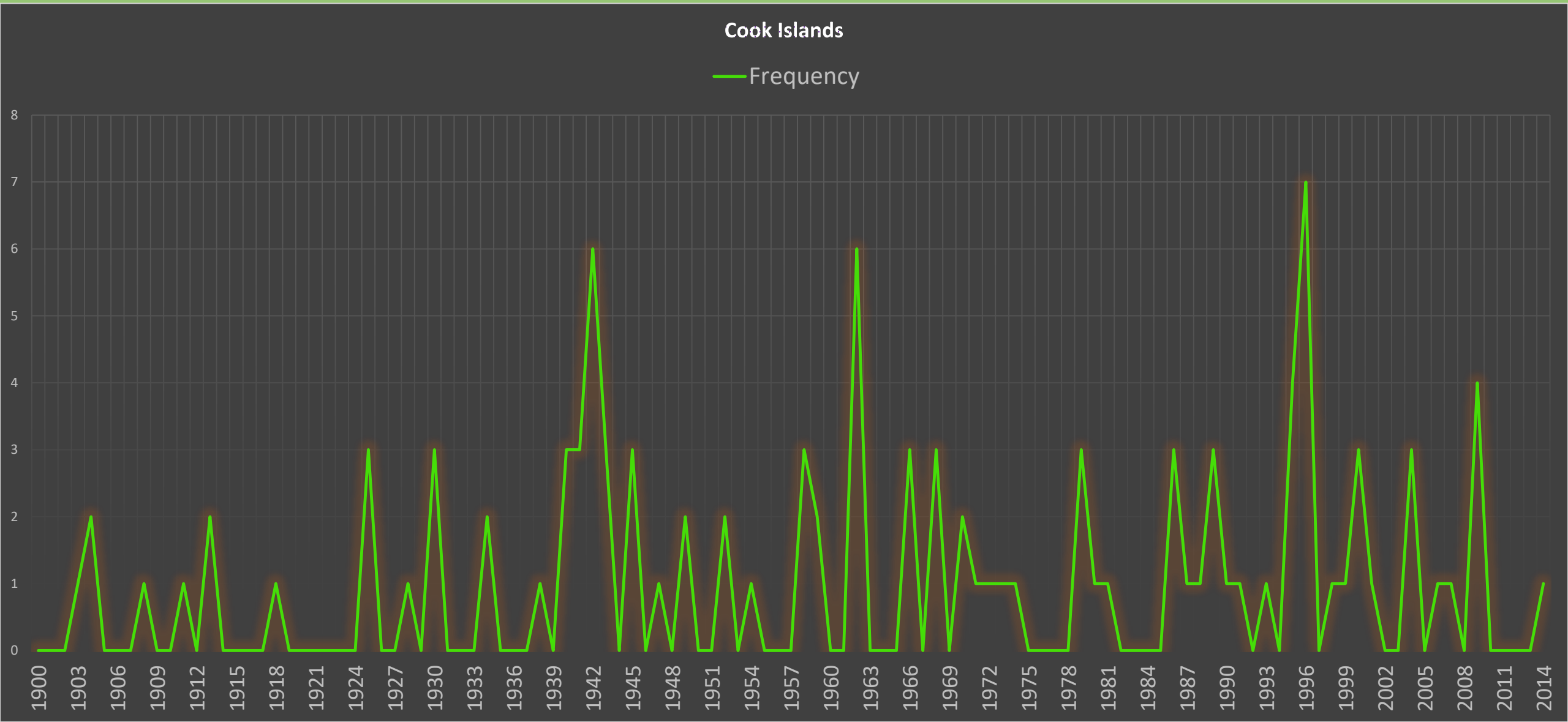
Prioritising Climate Change Risks For A Pacific Supply Chain



Prioritising Climate Change Risks For A Pacific Supply Chain



Cook Islands Historic Climate Change Risks 1900-2015



Prioritising Climate Change Risks For A Pacific Supply Chain

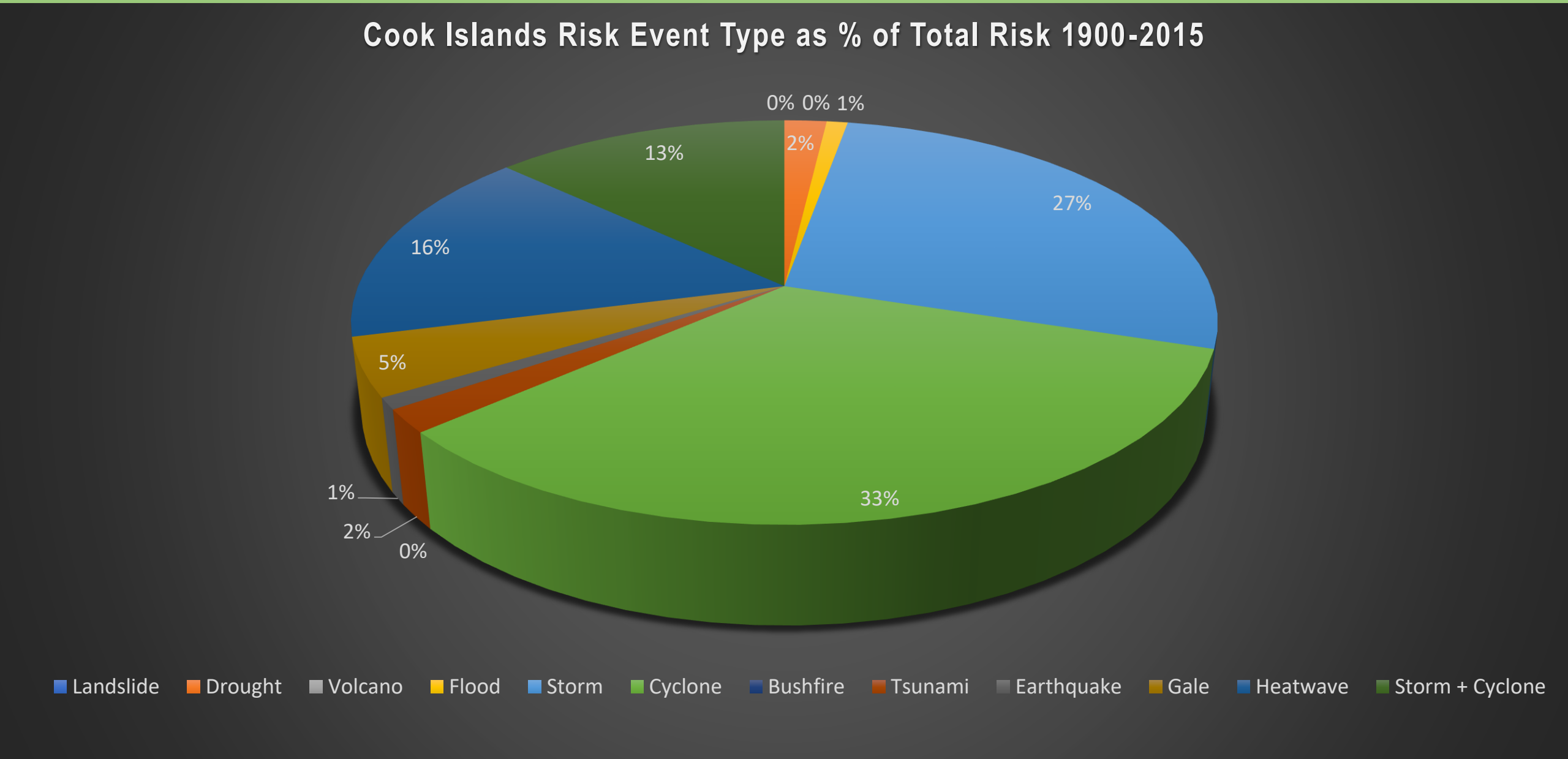
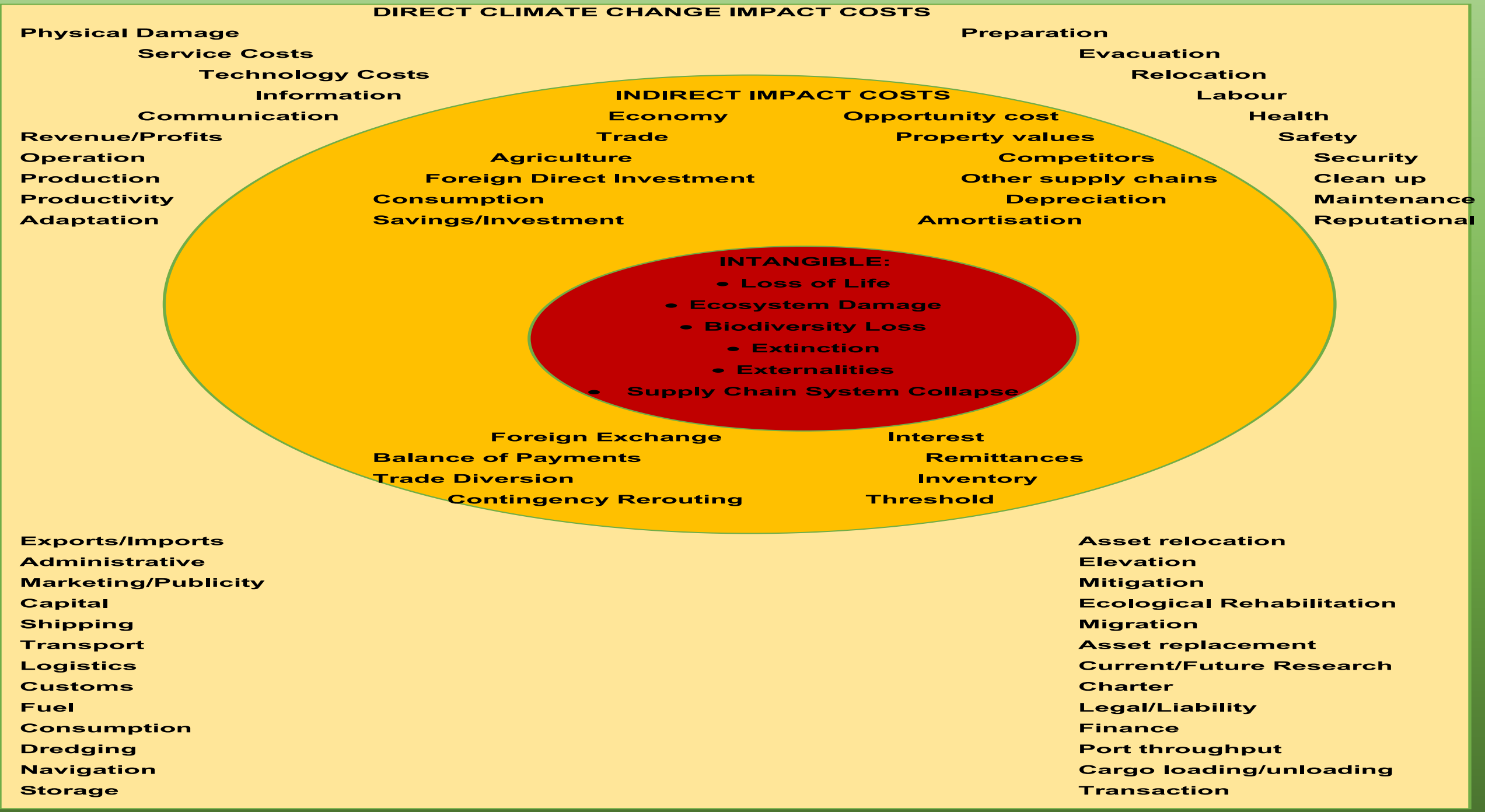
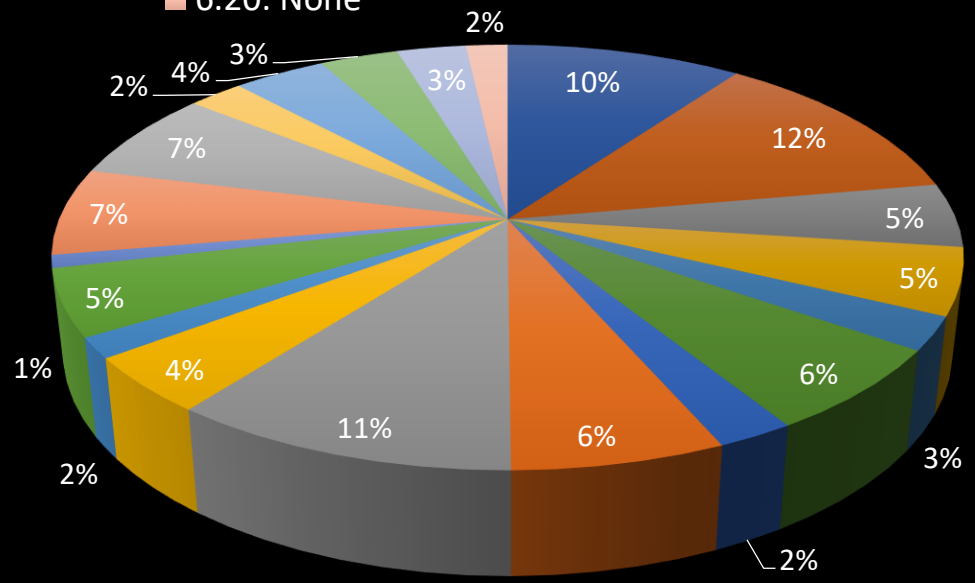


Figure 6.2: Direct, Indirect and Intangible Climate Change Costs For a Pacific MSC....

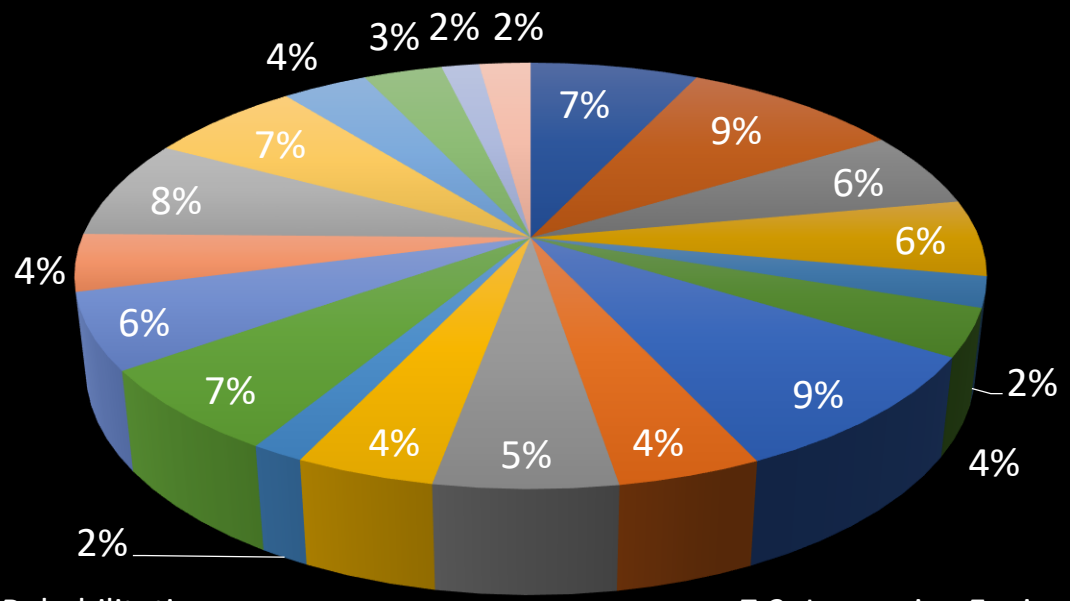


MSC' Stakeholder Constraints to Climate Change Adaptation

- 6.1: Geophysical/Environmental
- 6.2: Information/Research
- 6.3: Communication
- 6.4: Labour/Migration
- 6.5: Land
- 6.6: Financial/Funding
- 6.7: Commercial: Fixed/Variable costs
- 6.8: Legal/Policy
- 6.9: Psychological
- 6.10: Political
- 6.11: Equipment/Resources
- 6.12: Technical/Technological
- 6.13: Lack of Coordination
- 6.14: Lack of Other Stakeholder Cooperation
- 6.15: Education/Training
- 6.16: Planning/zoning
- 6.17: Transport
- 6.18: Uncertainty of climate change projections
- 6.19: Other- Leadership
- 6.20: None



MSC' Climateproofing Stakeholder Adaptation Strategies



- 7.1: Natural Engineering/Ecological Rehabilitation.
- 7.2: Increasing Environmental Sustainability/Mitigation.
- 7.3: Physical Engineering –Climateproofing.
- 7.4: New Equipment and other assets.
- 7.5: Facility Elevation.
- 7.6: Retreat-Surrender/Migration
- 7.7: Information.
- 7.8: Training.
- 7.9: Communication.
- 7.10: Marketing/Income Source Diversification.
- 7.11: Increasing Flexibility.
- 7.12: Legislation and reviewed policy/planning.
- 7.13: Taxes, subsidies, fines/other financial incentives.
- 7.14: Infrastructure/Technical Standards.
- 7.15: Risk Monitoring/Management
- 7.16: Increased Stakeholder Cooperation
- 7.17: Increased Stakeholder Information Sharing.
- 7.18: Technology
- 7.19: Other –Psychology/Indigenous Knowledge/Leadership
- 7:20: None

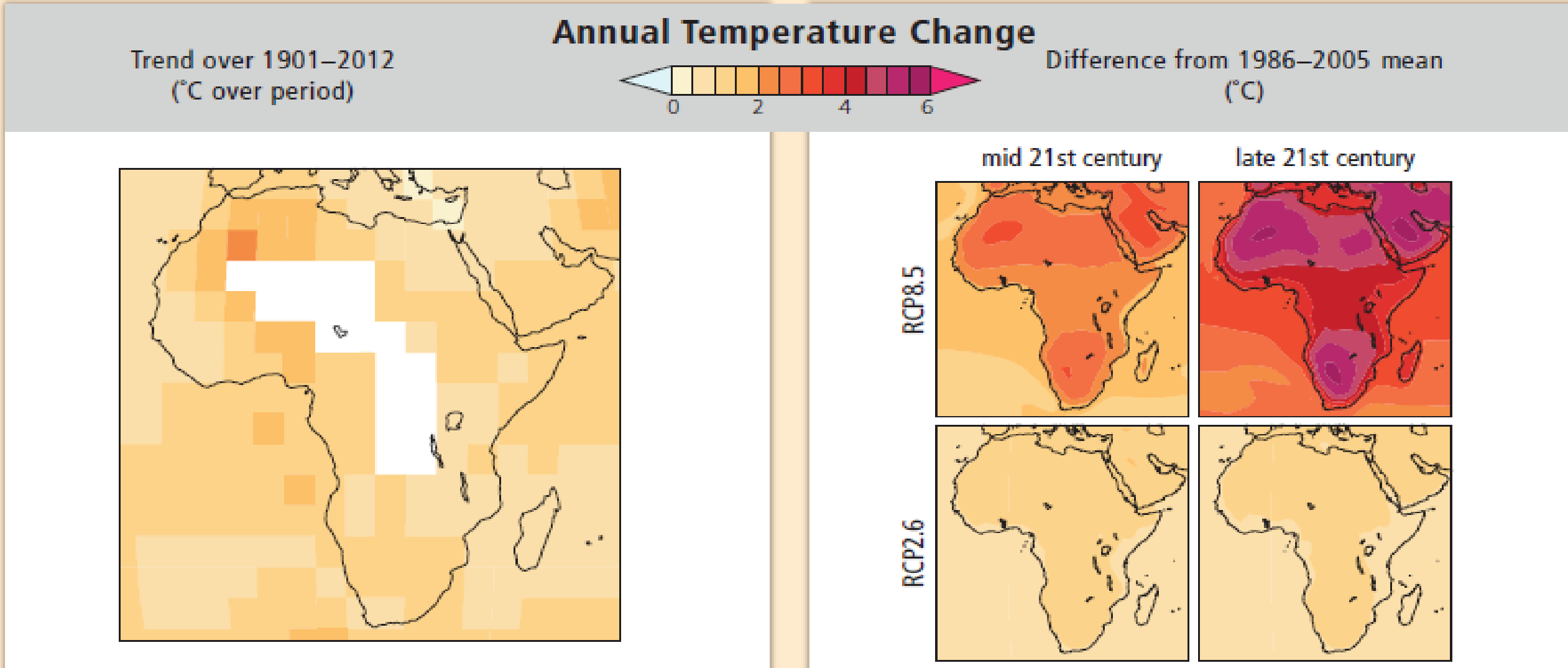
AFRICAN REGIONAL CLIMATE CHANGE

Table 22-1 | Major conclusions from previous IPCC assessments.

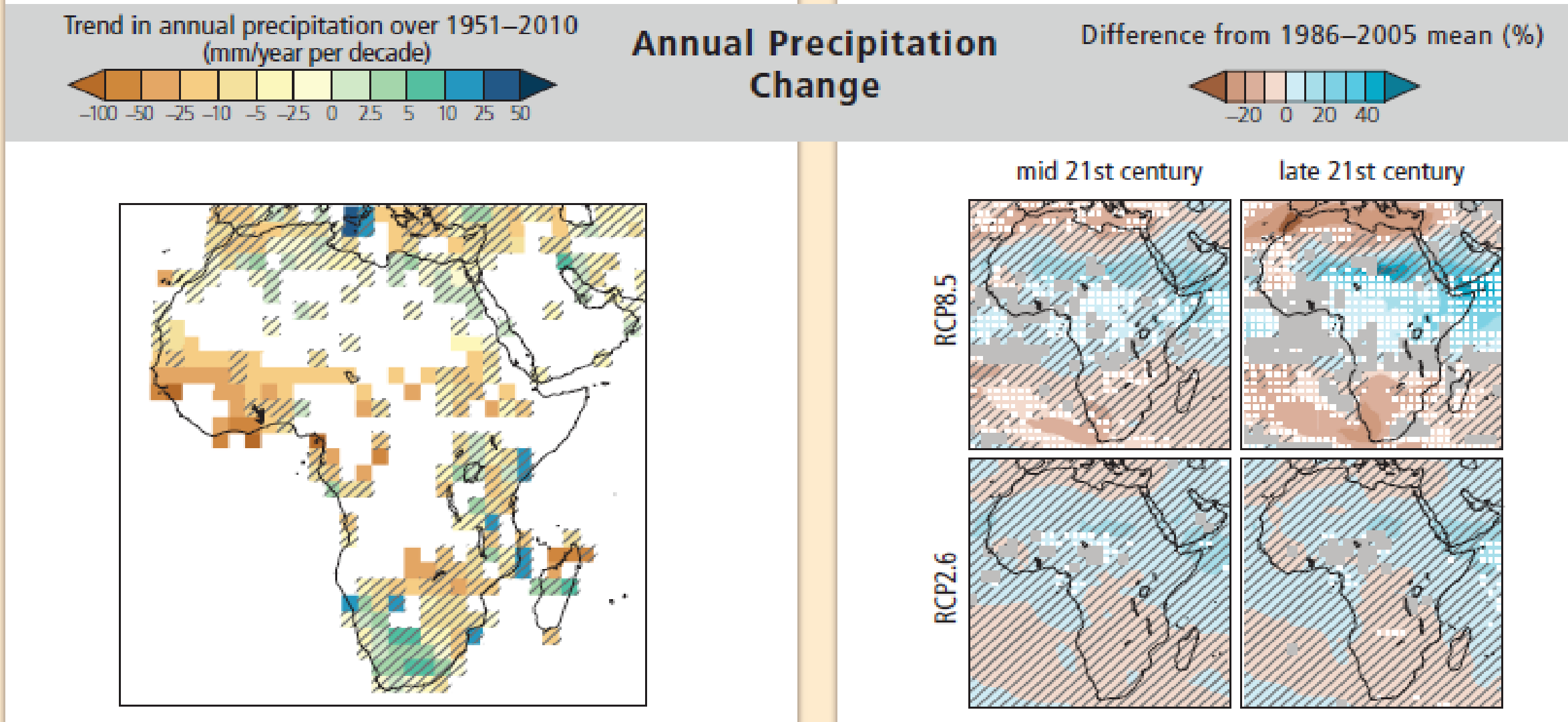
Report	Major conclusions
Special Report on the Regional Impacts of Climate Change	• Sensitivity of water resources and coastal zones to climatic parameters • Identification of climate change as an additional burden on an already stressful situation • Major challenges for Africa: lack of data on energy sources; uncertainties linked to climate change scenarios (mainly for precipitation); need for integrated studies; and the necessary links between science and decision makers
Third Assessment Report	• Impacts of climate change on and vulnerability of six sectors: water resources; food security; natural resources and biodiversity management; health; human settlements and infrastructure; desertification • Adaptation strategies for each of the sectors • Threats of desertification and droughts to the economy of the continent • Suggestion of adaptation options: mainly linked with better resource management • Identification of research gaps and needs: capacity building; data needs; development of integrated analysis; consideration of literature in other languages

Fourth Assessment Report	• Vulnerability of Africa due mainly to its low adaptive capacity
	• Sources of vulnerability mainly socioeconomic causes (demographic growth, governance, conflicts, etc.)
	• Impacts of climate change on various sectors: energy, tourism, and coastal zones considered separately
	• Potential impacts of extreme weather events (droughts and floods)
	• Adaptation costs
	• Need for mainstreaming climate change adaptation into national development policies
	• Two case studies:
	  • Food security: Climate change could affect the three main components of food security.
	  • Traditional knowledge: African communities have prior experience with climate variability, although this knowledge will not be sufficient to face climate change impacts.
	• Research needs: better knowledge of climate variability; more studies on the impacts of climate change on water resources, energy, biodiversity, tourism, and health; the links between different sectors (e.g., between agriculture, land availability, and biofuels); developing links with the disaster reduction community; increasing interdisciplinary analysis of climate change; and strengthening institutional capacities

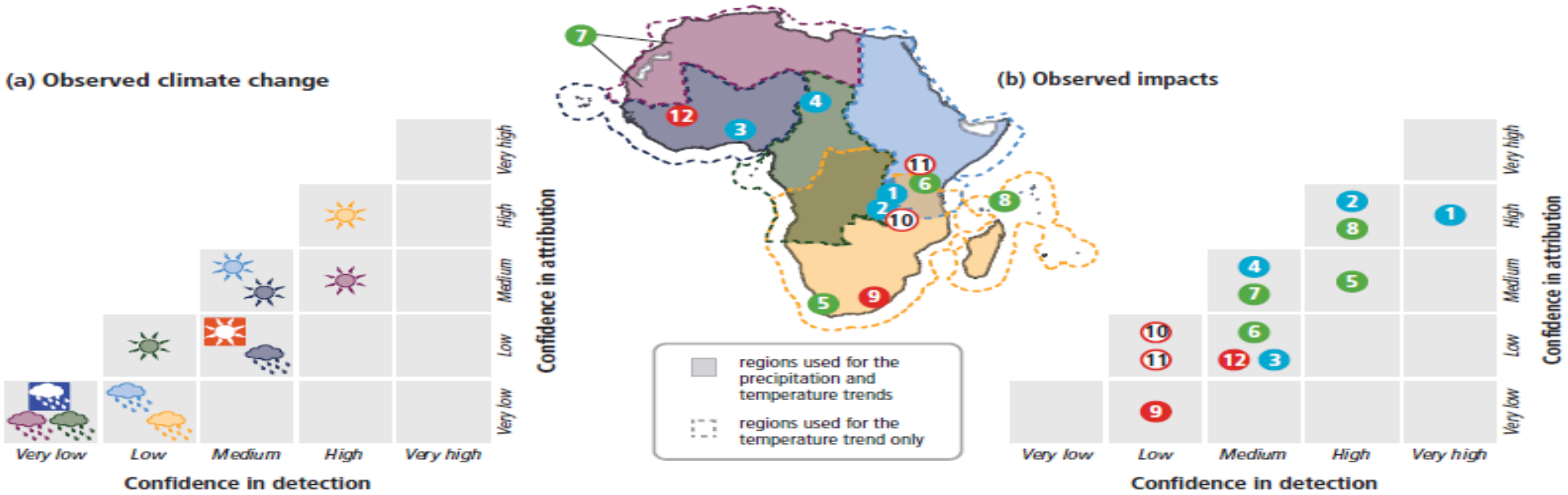
AFRICAN REGIONAL CLIMATE CHANGE



AFRICAN REGIONAL CLIMATE CHANGE



AFRICAN REGIONAL CLIMATE CHANGE



(a)

- AMU
- ECOWAS
- ECCAS
- SADC
- EAC/IGAD/Egypt
- Unaffiliated

Regional-scale

- Warming
- Precipitation changes

Continental-scale

- More frequent hot events / Less frequent cold events
- Change in wet events

(b)

Physical systems

1. Glacier retreat
2. Great Lakes warming
3. West African river discharge
4. Sahel drought

Biological systems

5. Southern species ranges
6. Mt. Kilimanjaro wildfires
7. Western Sahel tree density
8. Coral reefs in tropical waters

Human and managed systems

9. Adapting South African farmers
10. Great Lakes fisheries
11. Kenyan highlands malaria
12. Sahel fruit trees

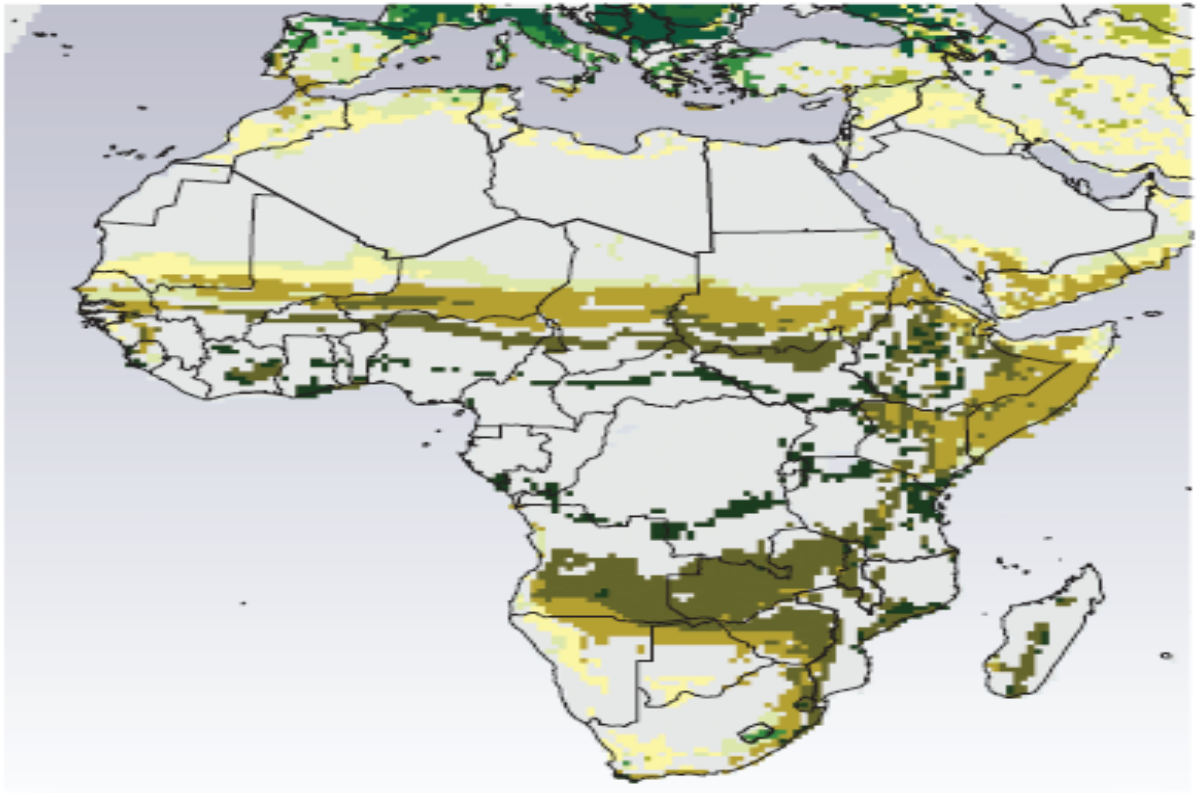
- Attribution of **major role**
- Attribution of **minor role**

AFRICAN REGIONAL CLIMATE CHANGE

Type of change and nature of evidence	Examples	Time scale of observations	Confidence in the detection of change	Potential climate change driver(s)	Confidence in the role of climate vs. other drivers
Changes in ecosystem types *Robust evidence*	Across sub-Saharan Africa, 57% increase in agricultural areas and 15% increase in barren (largely desert) areas was accompanied by 16% decrease in total forest cover and 5% decrease in total non-forest cover (Brink and Eva, 2009).	~25 years (1975–2000)	*Medium*	Increasing CO_2, changing precipitation patterns, increasing temperatures	*Low*
	On Mt. Kilimanjaro, increased vulnerability to anthropogenic fires has driven 9% decreases in montane forest and 83% decreases in subalpine forest (Hemp, 2009).	~25 years (1976–2000)	*High*	Increasing temperatures, decreasing precipitation	*Low*
	In the Democratic Republic of Congo, total forest cover declined by 2.3%, with most losses in secondary humid forest (Potapov et al., 2012).	~10 years (2000–2010)	*High*	None proposed	*Low*
	Dieback of seaward edge of mangroves in Cameroon at rates up to 3 m yr^{-1} (Ellison and Zouh, 2012)	~35 years (1975–2010)	*High*	Sea level rise	*Medium*
	Across western Africa, central Africa, and Madagascar, net deforestation was 0.28% yr^{-1} for 1990–2000 and 0.14% yr^{-1} for 2000–2010 (Mayaux et al., 2013).	~20 years (1990–2010)	*High*	None proposed	*Low*
Changes in ecosystem structure *Robust evidence*	Surveys of coral reefs in northern Tanzania indicate relative stability in the abundance and diversity of species, despite climate and non-climate stressors (McClanahan et al., 2009).	~9 years (1996–2005)	*High*	None proposed	*Low*
	Analysis of sediment cores from Lake Victoria indicates current community structure (i.e., dominated by cyanobacteria and invasive fish) was established rapidly, during the 1980s (Hecky et al., 2010).	~100 years (1900–2000)	*High*	Increasing temperatures	*Low*
	Long-term declines in density of trees and shrubs in the Sahel zone of Senegal (Vincke et al., 2010) and Mali (Ruelland et al., 2011)	~20–50 years (Senegal, 1976–1995; Mali, 1952–2003)	*High*	Drought stress induced by decreasing precipitation	*Low*
	Southward shift in the Sahel, Sudan, and Guinean savanna vegetation zones inferred from declines in tree density in Senegal and declines in tree species richness and changes in species composition in Mauritania, Mali, Burkina Faso, Niger, and Chad (Gonzalez et al., 2012)	~40–50 years (density, 1954–2002; diversity, 1960–2000)	*Medium*	Increasing temperatures, decreasing precipitation	*Medium*
	Long-term increase in shrub and tree cover across mesic savanna sites (700–1000 mm mean annual precipitation (MAP)) with contrasting land use histories in South Africa (Wigley et al., 2009; 2010)	~67 years (1937–2004)	*High*	Increasing CO_2	*Low*
	In long-term field experiments (between 1970s and 1990s) in South Africa where disturbance from fire and herbivory was controlled, density of trees and shrubs increased almost threefold in mesic savannas (from original MAP of more than 700 mm yr^{-1} in	~30–50 years (1980–2010 for 600-mm MAP site;	*High*	In mesic site, increasing CO_2; but lack of response	*Medium*

AFRICAN REGIONAL CLIMATE CHANGE

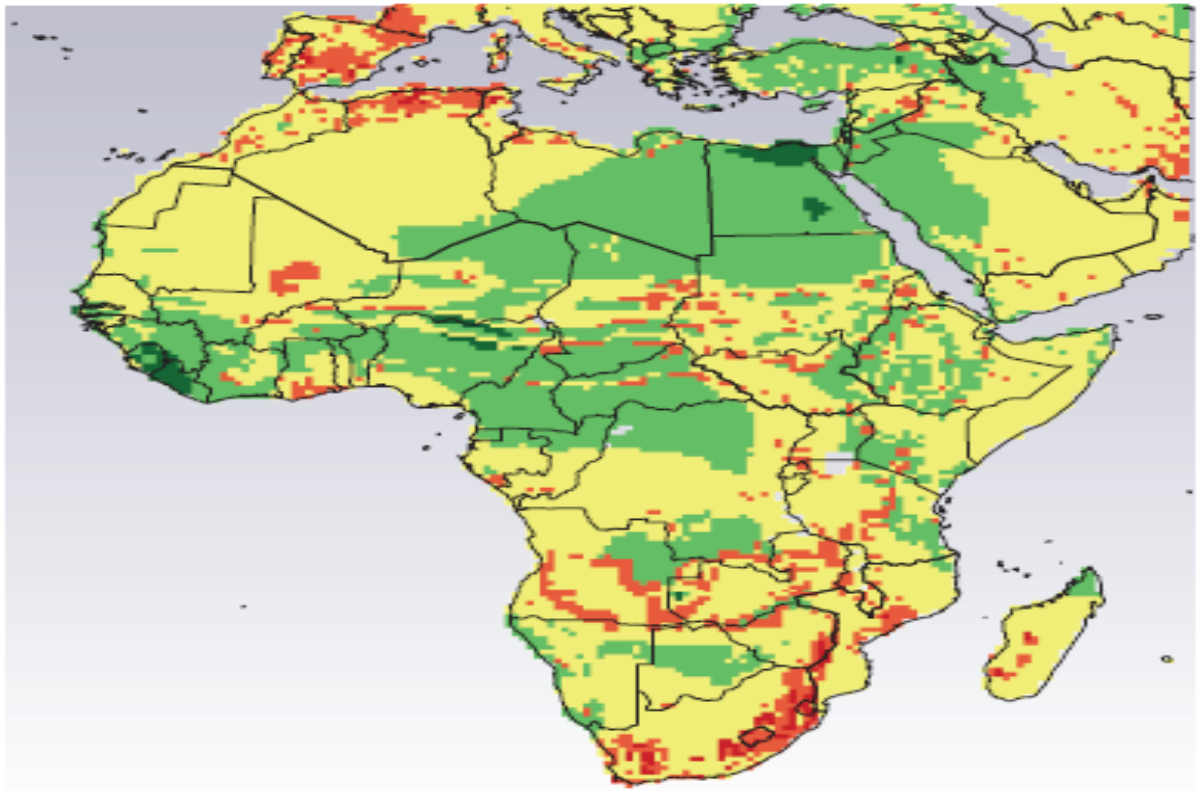
(a) Projected biome change from the period 1961–1990 to 2071–2100



Projected worst-case biome changes

Temperate	Tropical	
Conifer forest	Grassland	Desert
Broadleaf forest	Woodland	
Mixed forest	Deciduous broadleaf forest	
Shrubland	Evergreen broadleaf forest	

(b) Vulnerability of ecosystems to biome shifts based on historical climate (1901–2002) and projected vegetation (2071–2100)



Vulnerability to biome change

	Very low	*Low*	*Medium*	*High*	*Very high*
Confidence:	≤ 0.05	0.05–0.20	0.20–0.80	0.80–0.95	≥ 0.95

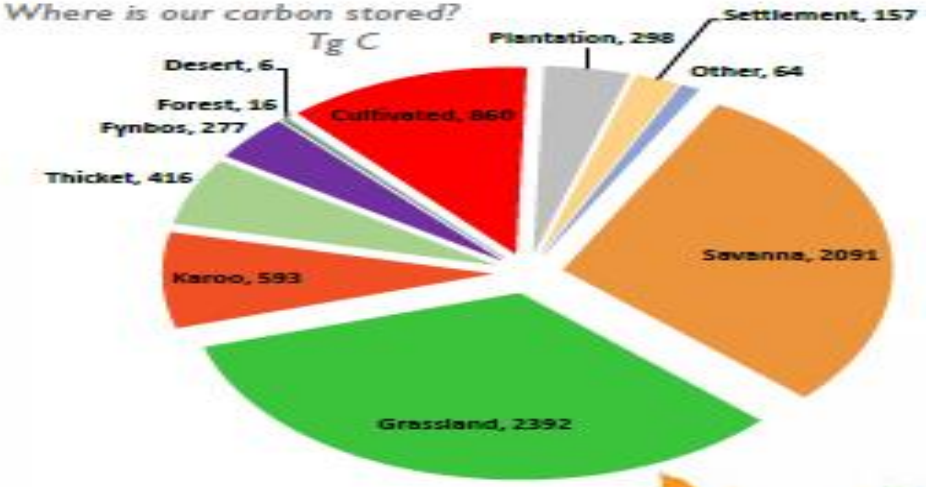
SOUTH AFRICA

Did you know?

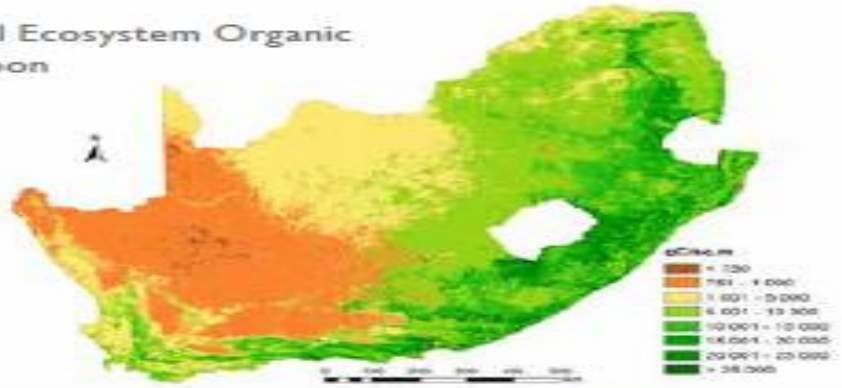
The grassland and savanna biomes contain approximately three quarters of the country's terrestrial carbon stock and account for over 90% of the Gross Primary Production (GPP).

Where is our carbon stored?

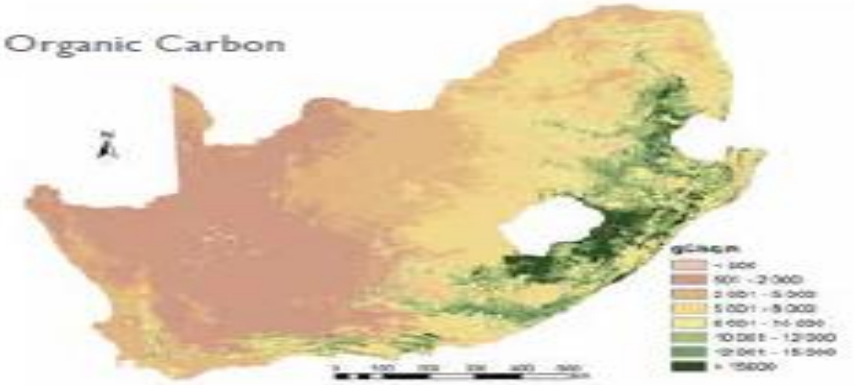
Tg C



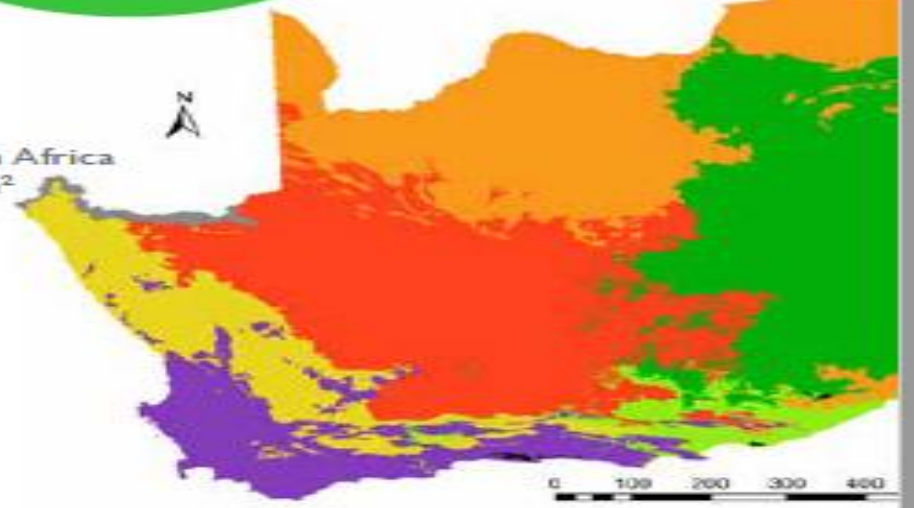
Total Ecosystem Organic Carbon



Soil Organic Carbon



Total area of South Africa is 1.221 million km²



Introduction

Total Ecosystem Organic Carbon (TEOC)

Soil Carbon

SOUTH AFRICA

South Africa, as a signatory to the UNFCCC, has to fulfil certain obligations including:

- Prepare and periodically update a national inventory of greenhouse gas emissions and sinks.
- Formulate and implement national and, where appropriate, regional programmes to mitigate climate change and facilitate adequate adaptation to climate change.
- Promote and cooperate in the development, application and diffusion of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases.
- Promote sustainable management, and promote and cooperate in the conservation and enhancement of sinks and reservoirs of all greenhouse gases.
- Cooperate in preparing for adaptation to the impacts of climate change.

- Take climate change considerations into account in the relevant social, economic and environmental policies and actions with a view to minimising adverse effects on the economy, on public health and on the quality of the environment.
- Promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system and intended to further the understanding and to reduce or eliminate uncertainties.
- Promote and cooperate in the full, open and prompt exchange of relevant scientific, technological, technical, socio-economic and legal information related to the climate system and climate change.
- Promote and cooperate in education, training and public awareness related to climate change.

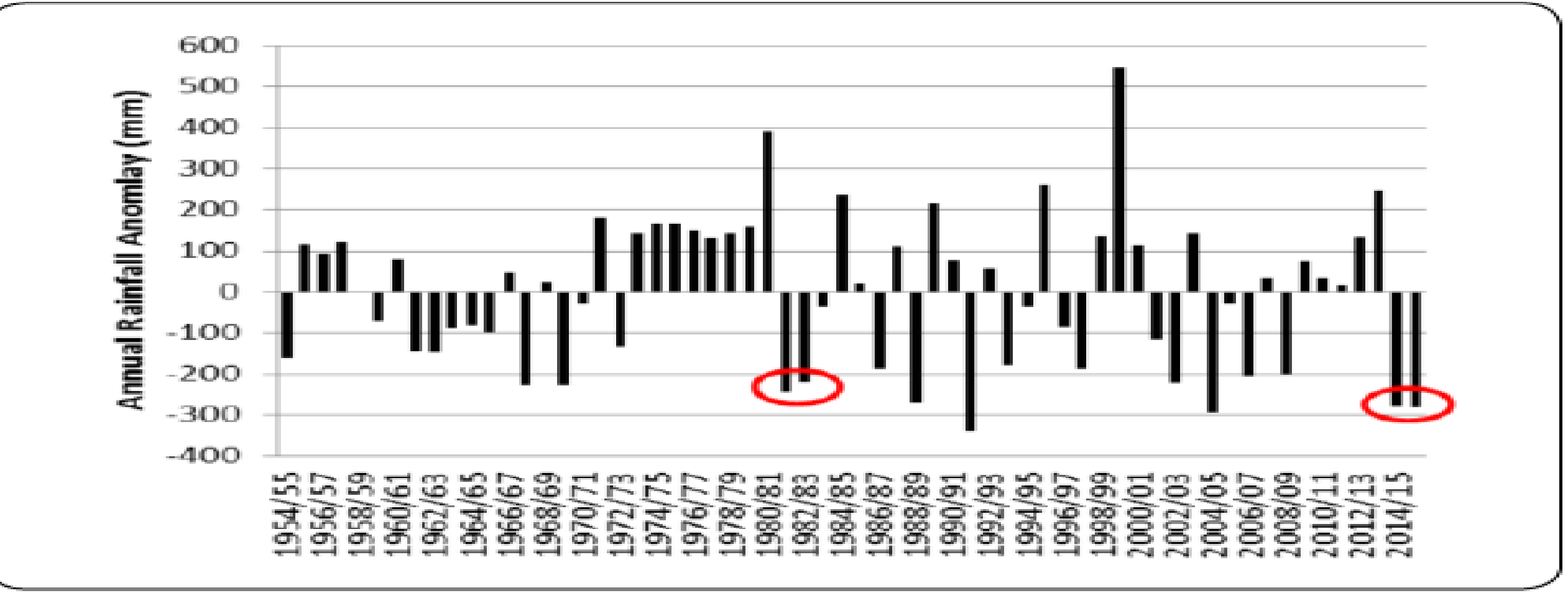
The integration of climate change response in government

Although the Department of Environmental Affairs and Tourism has been designated as the lead agency for climate change response in South Africa, it is recognized that this is a cross cutting issue that has ramifications for diverse activities in other government departments. A national climate change strategy will thus require that many government departments work together in a coordinated manner, to ensure that response measures are properly directed, acceptable to all and carried out with a national focus. General awareness within government on the likely impacts of climate change is somewhat limited in those departments not directly involved with the issue. In order to adapt to climate change, and to prepare adequately for the likely impacts, capacity has to be built. This will ensure that the policies formulated will adequately address climate change adaptation. Further, it is important that the available skills and competencies within government are efficiently harnessed. Officials in other departments, within all spheres of government, often do not see climate change as a priority and some even see it as working against national development priorities. They are concerned that South Africa has a huge backlog of service delivery where the performance of each department is measured by how effective and efficient it is on service delivery. Therefore climate change needs to be addressed in such a way as to assist these departments to achieve their service delivery objectives i.e. through so-called "win-win" or "no regrets" measures.

Domestic legal obligations

South Africa currently has a number of laws relating to the protection and management of the environment. The overarching legislation is contained within the provisions of the National Environmental Management Act of 1998. Climate change is referred to explicitly in the White Paper on Integrated Pollution and Waste Management of 2000, and referenced in the White Paper on a National Water Policy for South Africa, 1997. It is also specifically addressed in the Government's imminent National Water Resource Strategy. Climate change is not addressed in current air quality legislation. The impending National Environmental Management: Air Quality Act will, however, specifically contain provisions for greenhouse gas emissions.

SOUTH AFRICA



igure 15: Deviation of annual rainfall from the long-term mean of 533 mm for Phalaborwa in the Limpopo Lowveld. The combined rainfall for 2014–15 and 2015–16 is 507 mm. Data from FOSKOR mine and SAEON. Red circles indicate the two most severe multi-year droughts on record.

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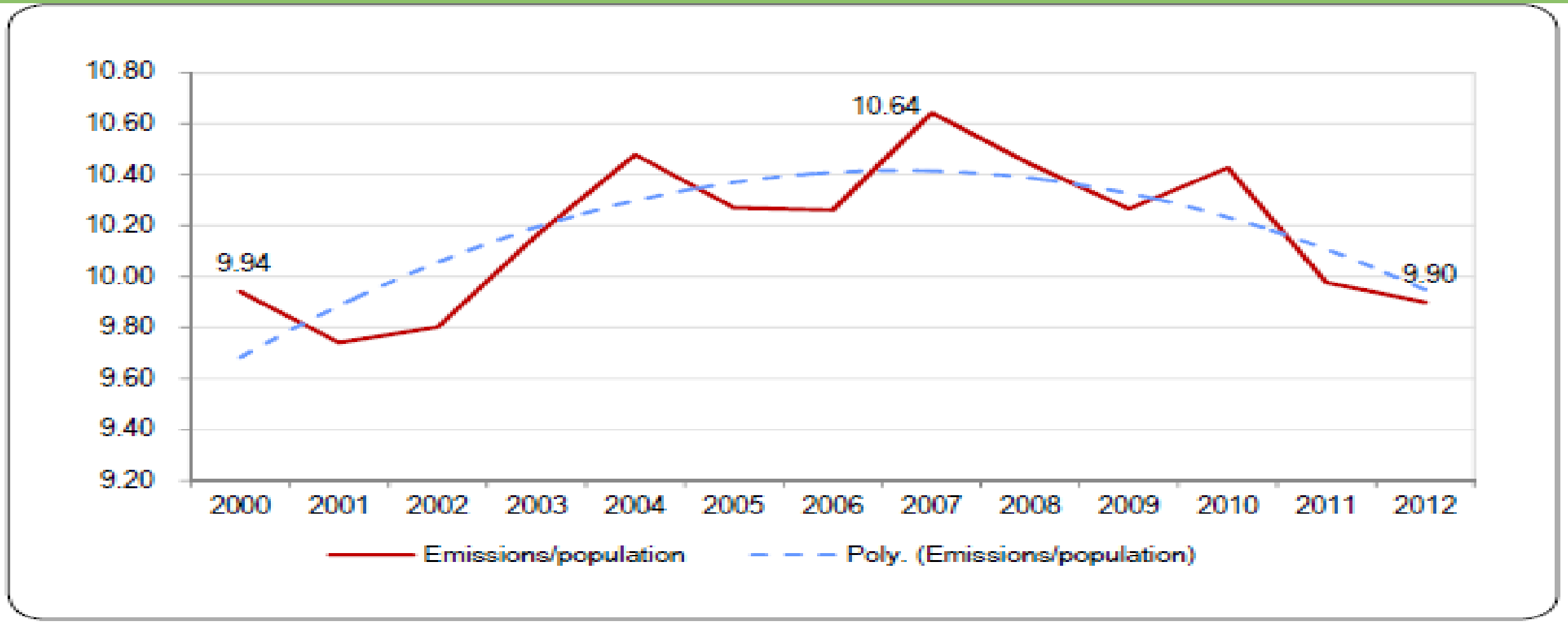

Figure 31: Per capita GHG emissions

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91.2%
of fuel combustion emissions comes from road transport

The greenhouse gas inventory for 2010 also provides the emissions for international aviation (2.57 Mt CO_2e). The emissions from South Africa's international marine bunkers were given by the International Energy Agency for 2010 as 9.82 Mt CO_2e)8.

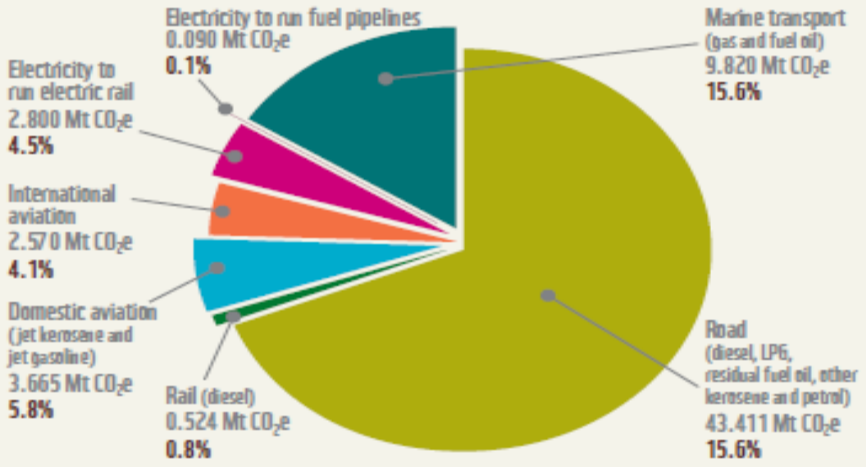
An indication of the emissions associated with electric rail and pipelines used for fuel transport can be obtained by looking at electricity consumption associated with these activities. An estimate of the contributions of these two sources to emissions in 2010 is presented in *Table 3*.

Table 3 **Estimate of emissions from electricity associated with rail and fuel pipeline transport (2010)[9]**

Mode	Electricity consumption [GWh]	Greenhouse gas emissions [Mt CO e]
Electric rail	2 938	2.8
Pipelines	100	0.09

All of the emissions described here exclude emissions from the production of fuels in crude oil refineries and Sasol, which can be substantial. These are discussed in the following section.

Figure 1 **Contributions to total transport emissions (excluding emissions from the production of fuels) in 2010**



Options for reducing emissions from the transport sector

The Long Term Mitigation Scenarios (LTMS) study and Mitigation Potential Analysis (MPA) explored various options for greenhouse gas mitigation in South Africa. These included:

- Higher use of rail for freight
- Passenger model shifts from private vehicles to public transport use
- Increases in vehicle occupancy
- Ramp up of the number of hybrid vehicles on the road
- Introduction of electric vehicles
- Increases in efficiency of private passenger vehicles
- Increases in the number of private diesel cars, which are less CO_2-intensive than petrol vehicles
- Blending of biofuels with petrol and diesel (although as discussed previously, calculation of the benefits should take into account life cycle considerations in producing biofuels)

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Activity	Sub-class	Spatial extent (ha)	Reduction in emissions over 20 yr (tCO_2e) (min)
Restoration of sub-tropical thicket, forests and woodlands	Sub-tropical thicket Coastal and scarp forests Broadleaf woodleaf	500 000 8 570 300 000	44 000 000 1 131 240 24 200 000
Restoration and management of grasslands	Restoration – Erosion Mesic Restoration – Erosion Dry Restoration – Grasslands Mesic Avoided degradation mesic	270 000 320 000 600 000 15 000	13 860 000 11 733 333 22 000 000 1 100 000
Commercial small-grower afforestation	Eastern Cape KwaZulu-Natal	60 000 40 000	2 750 000 1 833 333
Biomass energy (IAPs & bush encroachment)	Country-wide		39 806 316
Biomass energy (bagasse)	Country-wide		6 579 099
Anaerobic biogas digesters	Country-wide		72 848 160
Biochar*****	Country-wide	700 000	12 833 333
Reduced tillage*****	Country-wide	2 878 960	21 112 373
Reducing deforestation and degradation	Through planning Through regulation		
Total			275 787 189

The rehabilitation and sustainable management of these systems enhances both the ecological infrastructure and its function. This in turn delivers ecosystem goods and services that inter alia include water provision, improved soil health, carbon and nutrient cycling.

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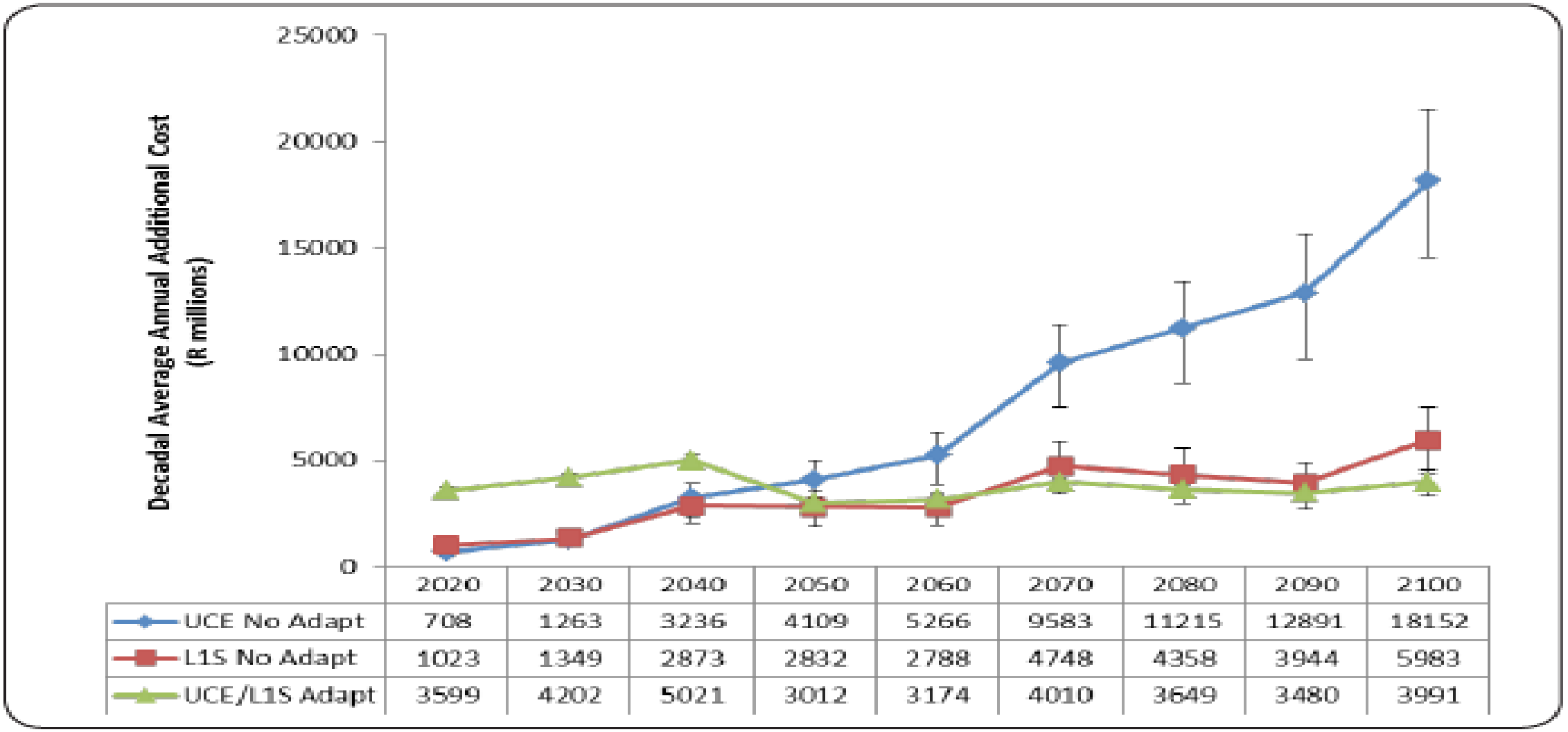
of the century the annual additional costs for road



	2020	2030	2040	2050	2060	2070	2080	2090	2100
UCE No Adapt	708	1263	3236	4109	5266	9583	11215	12891	18152
L1S No Adapt	1023	1349	2873	2832	2788	4748	4358	3944	5983
UCE/L1S Adapt	3599	4202	5021	3012	3174	4010	3649	3480	3991

Figure 42: Median decadal average annual additional costs (R millions) on the roads infrastructure of South Africa for the adapt and no-adapt management scenarios under the UCE and L1S climate scenarios. Whiskers represent one standard deviation in the results for

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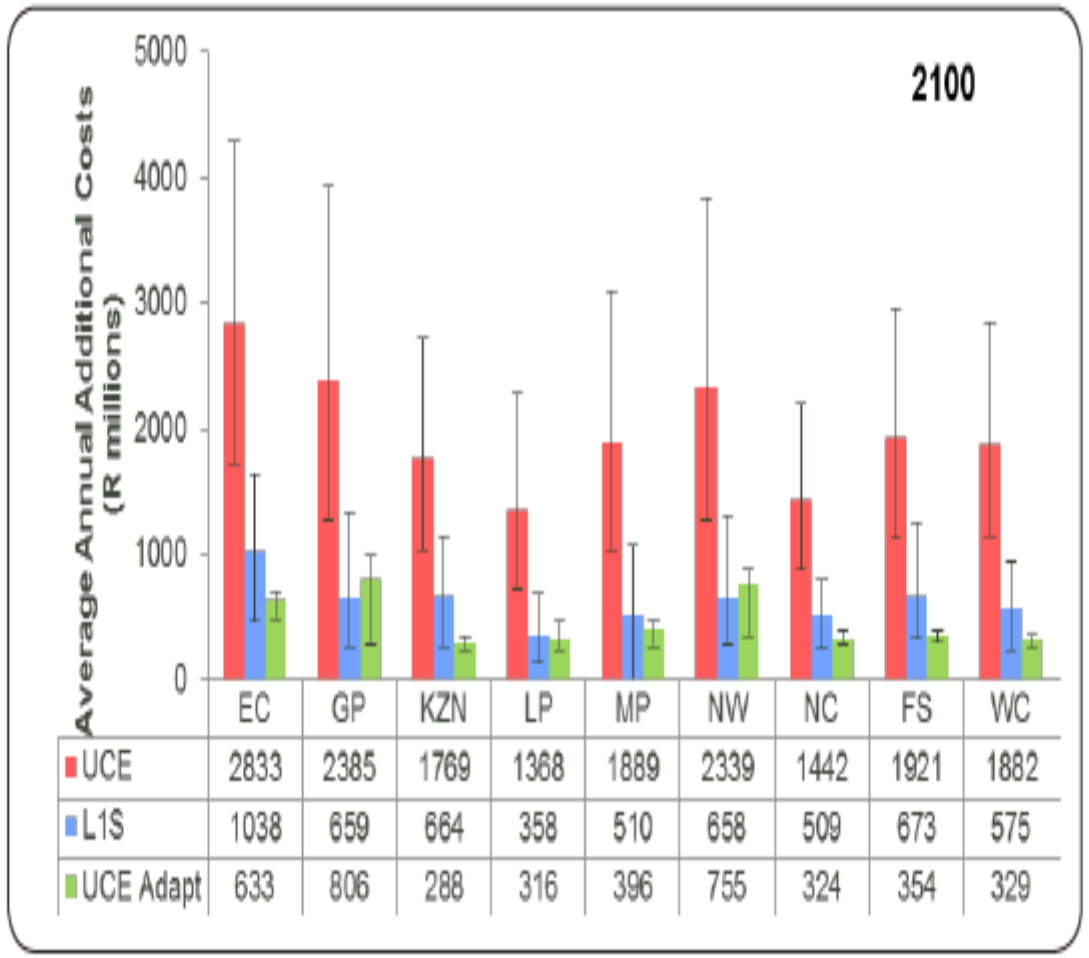
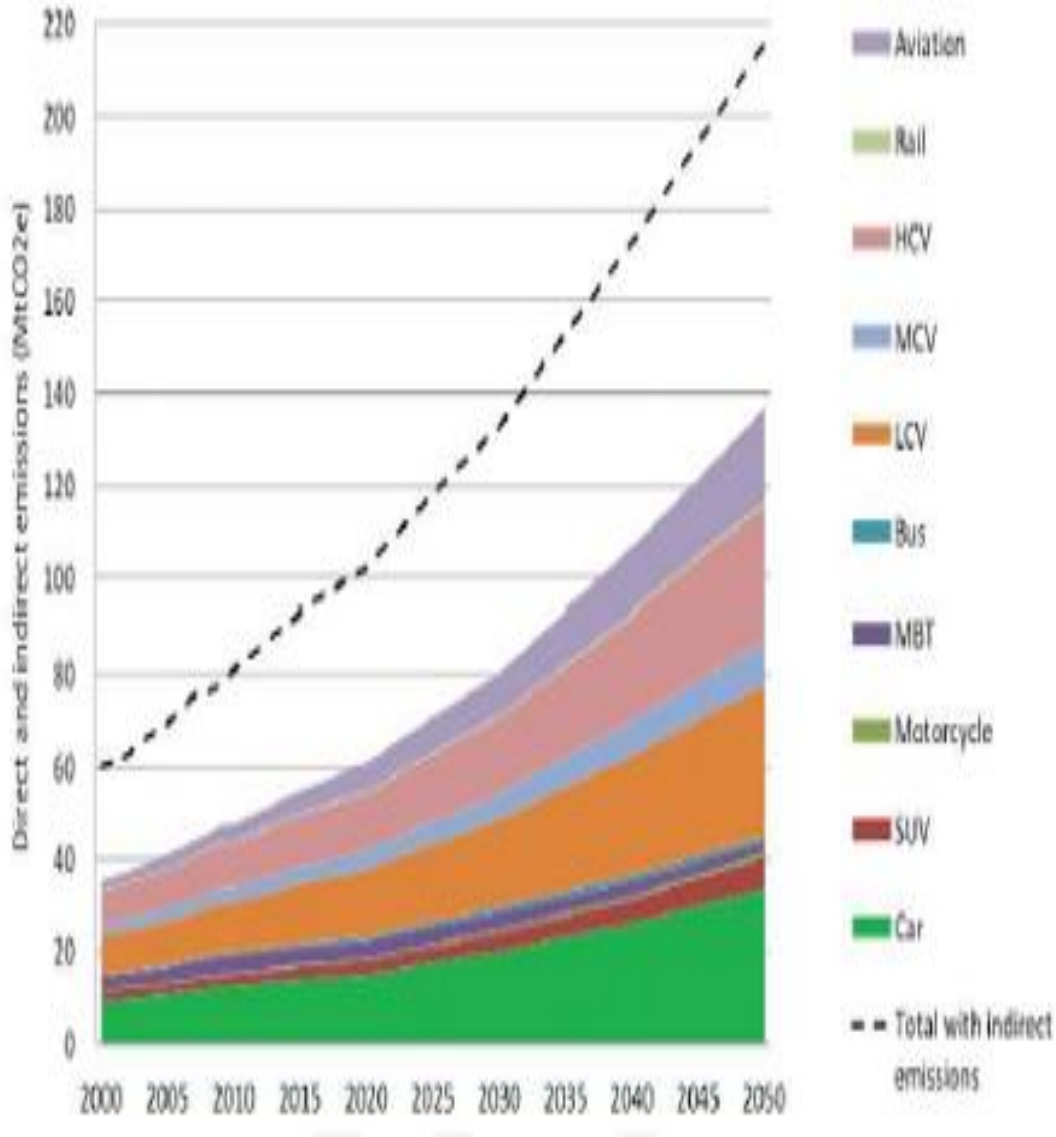


	EC	GP	KZN	LP	MP	NW	NC	FS	WC
UCE	2833	2385	1769	1368	1889	2339	1442	1921	1882
L1S	1038	659	664	358	510	658	509	673	575
UCE Adapt	633	806	288	316	396	755	324	354	329

Figure 44: Average annual additional costs for the final decade of the century (2095–2105) by province for the UCE and LIS no adapt scenarios and the UCE adapt scenarios. Values shown are the median of the HFD climate scenarios with whiskers representing the range of potential impacts from the 5th to the 95th percentile of the modelled scenarios.



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Mitigation Action	Model description and parameters	GHG emission reduction 2003-2050	Mitigation cost	Rank cost -lowest cost is no 1
Escalating CO_2 tax	Impose tax on all energy related CO2 emissions including process emissions from Sasol plants	12,287	42	20
Nuclear and renewable energy extended	Combines both scenarios. At 50% each = 0 carbon scenario	8,297	52	23
Electric vehicles/nuclear	Up to 10% of passenger kilometre demand 2003-2050	6,255	102	28
Nuclear/renewables	No electricity from fossil fuels 2050	5,559	64	24
Industrial efficiency	Improved boiler efficiency, HVAC, refrigeration, water heating, aircon…	4,752	34	8
Renewables/learning	As with extended but assuming renewable energy unit costs decline as global installed capacity increases	3,990	3	13
Subsidy for renewables	On electricity from power tower/off-grid,	3,887,	125	30
Improved vehicle efficiency	Improve private cars and light commercial vehicles by 0.9-1.2% per year	758	269	3
Biofuel subsidy	R1.06 per litre as incentive	573	697	35
Passenger modal shift	From cars to public transport, from air to inter-city rail from 51.8% of passenger km to 75% by 2050	469	1,131	2
Hybrids	20% of cars by 2030 -0 in 2001	381	1,987	36
Biofuels	Biofuel blends increased to 8%, ethanol with petrol and 2% biodiesel with diesel 2013 -to 20% ad 5% 2030			

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Climate Change Factor	Potential Implications	Adaptation Measure
• **Rising/high temperatures** • **Melting ice** • **Large variations (spatial and temporal** • **Frequent freeze-thaw cycles**	• Shorter distance for Asia-Europe trade/less fuel consumption • Competition, lower passage tolls, reduced transport costs • Damage to infrastructure, equipment, cargo • Increased construction and maintenance costs, new ship design and strengthened hulls • Higher energy consumption in ports • Variation in demand for and supply of shipping/port services • Challenges to service reliability	• Heat resistant construction and materials • Continuous inspection, repair and maintenance • Monitoring of infrastructure temperatures • Reduced cargo loads, speeds and service frequency • Insulation and refrigeration • Modal shift • Transit management scheme/navigation • Ship design, skilled labour and training requirements
• **Rising sea levels** • **Flooding and inundation** • **Erosion of coastal areas**	• Damage to infrastructure, equipment, cargo • Increased erosion, sedimentation, construction and maintenance costs • Relocation and migration, labour shortage, shipyard closure • Variation in Demand/Supply ship services • Structure and direction of trade • Challenge to service reliability, increased dredging • Changes in water levies in harbours	• Relocation, redesign and construction of coastal protection schemes • Migration • Insurance
• **Extreme weather conditions** • **Tropical cyclones** • **Storms** • **Floods** • **Precipitation** • **Wind**	• Damage to infrastructure, cargo, equipment • Increased damage to ships as a result of storm-wave-current interaction	• Integrate emergency evacuation procedures into operations • Set up barriers and protection measures • Relocate infrastructure, Alternative routes, Redesigned ports • Amended beach nourishment programs

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Table 1 **Summary of mitigation opportunites and initiatives applicable to passenger transport**

Opportunity	Initiatives	Description	Reference
Avoid or reduce the need for transport	Subsidised housing provision	Medium to high density subsidised housing, within urban core areas, in close proximity to public transport should be provided to lower income groups.	(Gauteng DRT, 2013a)
	Land use densification and mixed use land development	These two spatial planning interventions allow people to live closer to work and services, as well as to public transport networks.	(Gauteng DRT, 2013a)
	Telecommuting and videoconferencing	Reduces the need for employee travel either to work or to meetings.	(Gauteng DRT, 2012; Gauteng DRT, 2013a; Tunçer & Narberhaus, 2008)
	Online shopping	Online shopping with enhanced delivery services is a low carbon alternative to consumers making trips to shop.	(Tunçer & Narberhaus, 2008)
Shift to lower carbon modes for passenger	Bus Rapid Transit (BRT)	Cheaper and quicker alternative to expanding the rail system. A BRT system has designated bus lanes, integrated fare systems, well-designed bus stops and quick boarding systems.	(Bohler-Baedeker & Huging, 2012)
	Construction of new passenger rail routes	Building new rail routes where there are none existing at present.	(Gauteng DRT, 2013a)
	Mainstreaming non-motorised transport	NMT infrastructure to link community facilities, schools and transport nodes.	
	Two and three wheelers	Motorised two and three wheelers have lower fuel usage and emissions than cars.	(DoT, 2007)
Improved efficiency of passenger transport: operational measures	Upgrading and improving rail infrastructure and efficiency	Rail transport provides mass transport services, high average travel speeds and has lower carbon emissions than private vehicle transport.	(Gauteng DRT, 2013a)
	Improved maintenance of transport infrastructure	Ensuring travel infrastructure including roads and rail systems are well maintained improves efficiency of use.	(Gauteng DRT, 2012)
	Flexi work hours	Allowing employees staggered work times reduces congestion during peak hours.	(Gauteng DRT, 2012; Gauteng DRT, 2013a)
	Extended hours of operation and more frequent public transport services	Public transport should be operated 7 days a week, for 16-24 hours a day. During peak periods, public transport frequency should be every 5-10 minutes and every 10-30 minutes off peak.	(DoT, 2007)
	Multi-modal integration systems with public and road transport	Core road and trunk rail corridors with feeder systems increases efficiency.	(DoT, 2007)
	Park and ride facilities	Such facilities promote connectivity with the public transport network.	(DoT, 2007)
	Ease of access to disabled, elderly and scholars	All forms of public transport and changeovers need to be readily accessible to everyone.	(DoT, 2007)

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		monitoring systems.	
Improve greenhouse gas emissions efficiency of passenger transport: alternative fuels	Use of gas as alternative fuels	Compressed Natural Gas (CNG) and Liquid Natural Gas (LNG) are preferred lower carbon alternative energy options for public transport vehicles. Liquid Petroleum Gas (LPG) can also be used as an alternative fuel.	(Gauteng DRT, 2012; UNEP, 2011)
	Use of hydrogen as an energy carrier	Vehicles running on fuel cell technology use an electrochemical process to convert fuel into electricity with hydrogen as the primary fuel source.	(UNEP, 2011)
	Promoting increased uptake of biofuels (bioethanol and biodiesel)	Alternative fuels produced from certain crops, crop residues, municipal waste or algae.	(Tunçer & Narberhaus, 2008)
	Promoting uptake of electric vehicles	Battery electric vehicles (BEV) depend entirely on on-board rechargeable batteries, others use hydrogen-powered fuel cells and some rely on a grid connection. Plug-in hybrid vehicles (PHEV) combine an internal combustion engine with batteries that can be charged by plugging into the grid. Emission savings depend largely on how a country produces its electricity.	(Bohler-Baedeker & Huging, 2012)
	Promoting uptake of hybrid vehicles	Hybrid electric-diesel vehicles combine diesel and electric engines. Hybrids often incorporate various efficiency-improving technologies like those that recover energy during braking. Hybrids are especially effective for vehicles driving in traffic that stop frequently, allowing batteries to recharge.	(Bohler-Baedeker & Huging, 2012)

measure		be supported	
Planning measures	Land use planning	Planning for shops, public services, residential areas and places of employment within a close proximity to each other, with effective travel links. This thus supports land use densification and mixed use land development	(Dalkmann & Brannigan, 2007)
	Sustainable transport and related infrastructure planning	Effective planning including development of integrated transport systems and intermodal links is required to support the shift from private vehicles to mass transit public transport and NMT. Also refers to employing the principles of sustainability when designing and rehabilitating transport infrastructure, using low impact designs and materials. For example, lower temperature asphalt designs use less energy, ultra-thin concrete pavement layers use less material and the use of energy efficient luminaries will lower energy consumption for road lighting.	(Bohler-Baedeker & Huging, 2012; Gauteng DRT, 2014)
	Reversible lanes and road space reallocation to balance private cars and more sustainable modes	Having designated public transport vehicle lanes and reversible lanes designated for public transport vehicles would ease congestion and decrease travel time through encouraging increased use of public transport.	(Gauteng DRT, 2012; Gauteng DRT, 2013a)
	Benchmarking	Benchmarking the performance of a transport system against other systems nationally or globally helps to identify congestion and energy intensive nodes and provides decision makers with the information required to identify gaps, set targets and decide which of the initiatives identified above will help improve the system.	(Bohler-Baedeker & Huging, 2012)
	Green procurement policies	Municipalities and companies lead the way by implementing measures to preferentially purchase vehicles for the fleets that are fuel-efficient and meet environmental performance standards.	(Bohler-Baedeker & Huging, 2012)
	Planning for NMT infrastructure	Includes dedicated bicycle lanes, bicycle parking, park and ride facilities and bike share systems, as well changing facilities, showers and bicycle stands at workplaces. NMT needs to be integrated into the public transport network along with pedestrian zones, sidewalks and crossings.	(Bohler-Baedeker & Huging, 2012)
	Planning for public transport systems with improved comfort of stations and public transport vehicles	Good shelters, boarding islands, improved lighting, information kiosks, signage and multi-modal terminals at public transport stations and stops. Public transport is more attractive to passengers when it is reliable and comfortable as a result of high design standards.	(Bohler-Baedeker & Huging, 2012; DoT, 2007)
	Incorporating traffic impact assessments in development	Economic developments should carry out traffic impact assessments when selecting locations for business and residential developments to ensure the adoption of appropriate initiatives for the area.	(Bohler-Baedeker & Huging, 2012)
	Electricity generation from less carbon intensive	The production of a country's electricity affects the energy efficiency of railway electrification and electric vehicles and hence introducing planning measures to reduce the emissions intensity thereof will	(Bohler-Baedeker & Huging, 2012)

Table III: Constraints to Climate Change Adaptation for South African Logistics Supply Chains

✓ Land/Geophysical	✓ Environmental
✓ Information	✓ Political
✓ Communication	✓ Administrative
✓ Labour	✓ Technical/Technological
✓ Capital	✓ Lack of Coordination
✓ Financial/Funding	✓ Lack of Cooperation
✓ Commercial: Profits	✓ Education/Training
○ Fixed costs	✓ Planning/zoning
○ Variable costs	✓ Transport
✓ Demand/Supply	✓ Uncertainty of Climate Change
✓ Enforcement Capacity, Legal and Policy	✓ Other
✓ High risk perceptions from technological/other uncertainty	✓ Policy risks -lacking clear, long term obligations and commitments
✓ Enforcement	✓ Equity -ensuring risk exposed pays

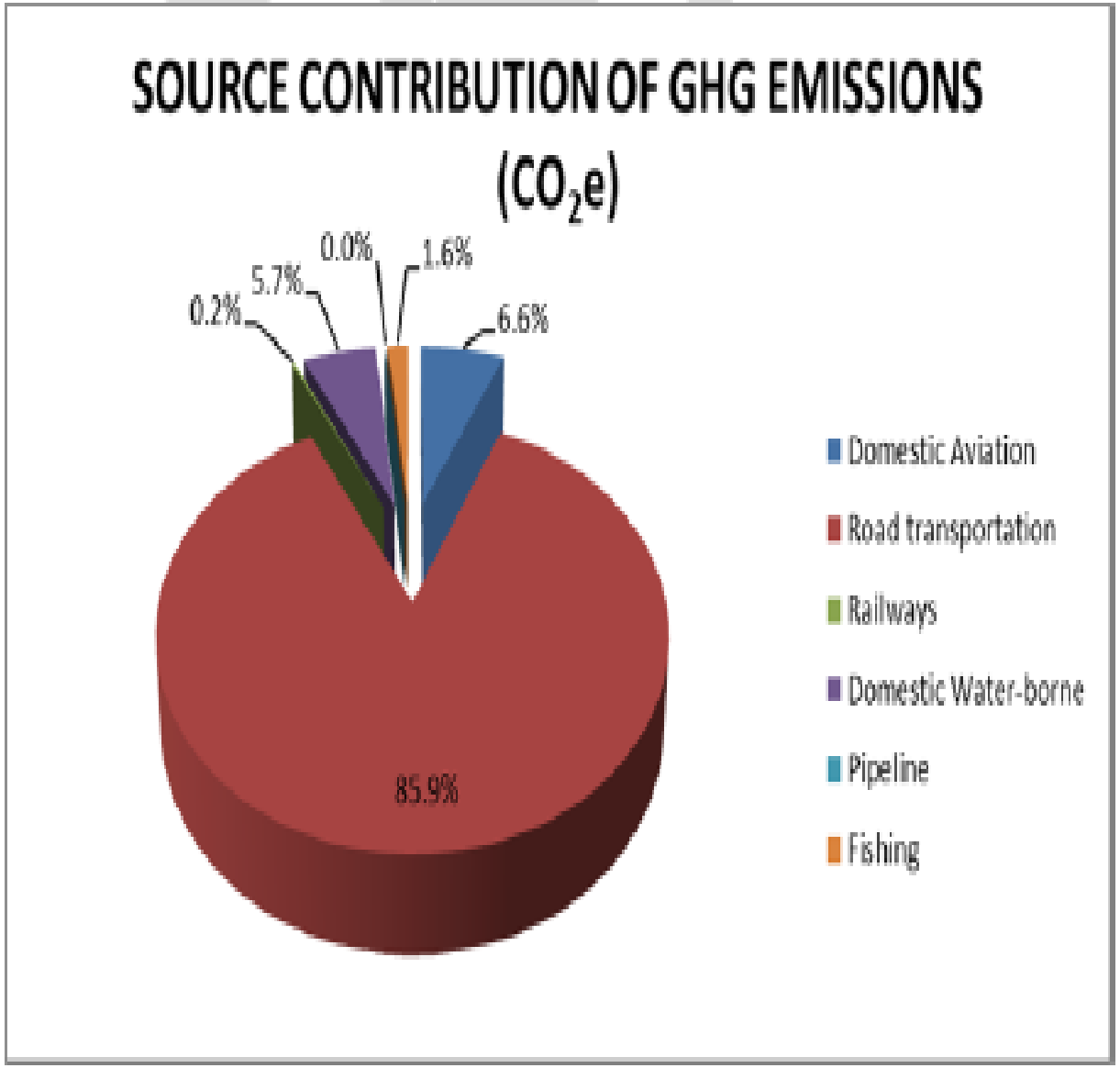

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Figure I: Top Fifteen Climate Change Adaptation Research Priorities in South Africa.

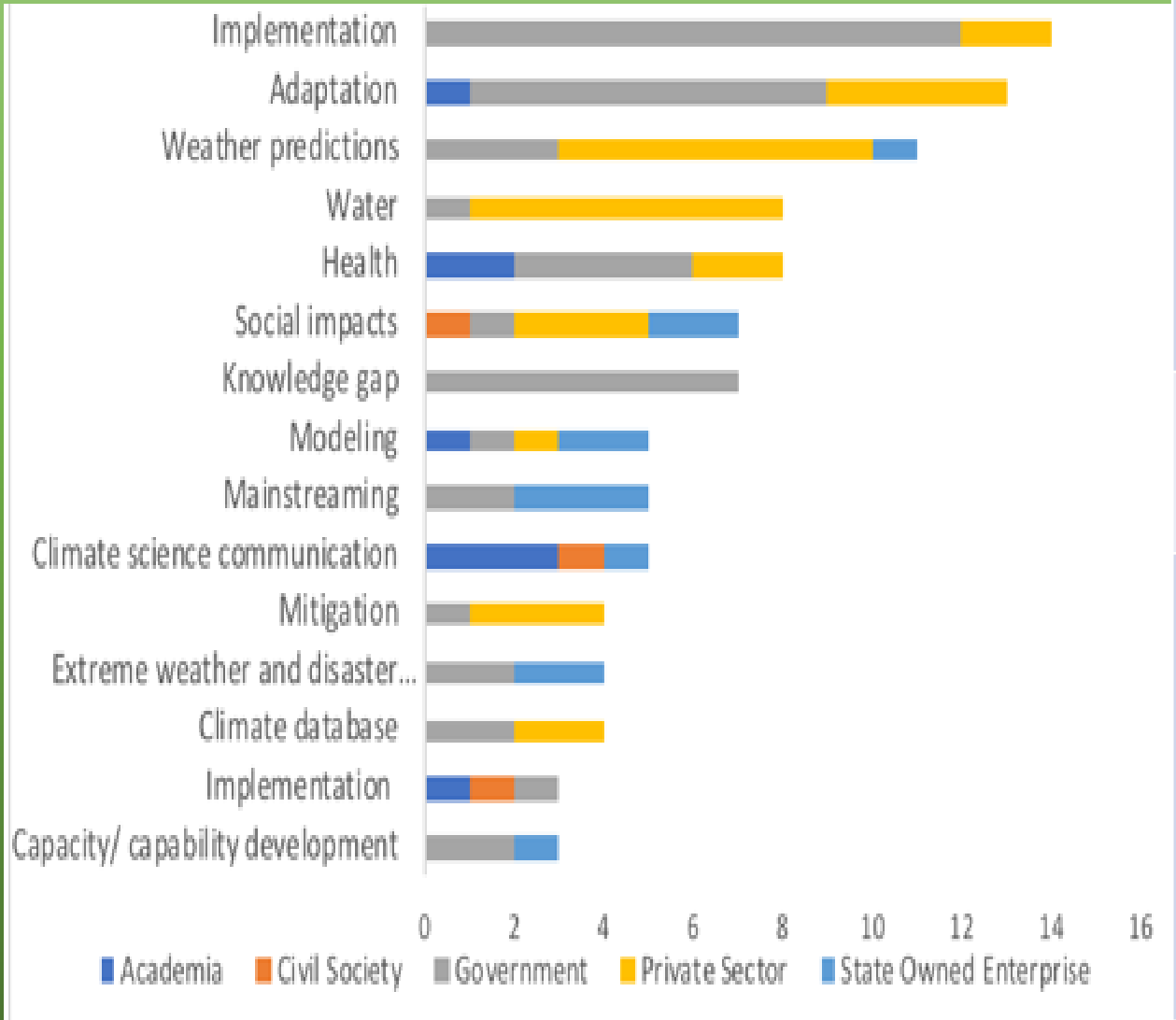

Table II: Climate Change Data Strengths and Research Gaps

Infrastructure	• Knowledge about general climate risks available • Some national entities such as ESKOM have undertaken specific studies	• Location specific risks not known • Vulnerability of major forthcoming investments (e.g. SIPS) generally not known.
Integration/ Interactions	• General awareness of importance of interactions, such as Food, Energy, Water	• Very few detailed studies
Social and economic impacts	• National scale study on economic impacts using general equilibrium model • Western Cape Government • SA Vulnerability Atlas • Disaster management vulnerability data	• Impacts on labour, inequality, etc…

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Table 2: Priority areas from the National Adaptation Strategy.

Adaptive Measures	Enabling Measures
Strategic priority 1: Reduce human vulnerability and build human adaptive capacity • Sub-priority 1.1: Design and deliver targeted climate change vulnerability reduction programmes in human settlements for at-risk individuals and communities. • Sub-priority 1.2: Capacitate and operationalise South Africa's National Disaster Management Framework to strengthen proactive adaptive capacity, preparedness, response and recovery. • Sub-priority 1.3: Launch an enhanced climate change public health flagship programme to build a healthier, more resilient population.	*Strategic priority 5: Ensure institutional support for climate change adaptation* • Sub-priority 5.1: Create formal climate change legislation and policy for adaptation. • Sub-priority 5.2: Integrate climate change adaptation within existing development planning and implementation processes.
Strategic priority 2: Reduce economic vulnerability and build economic adaptive capacity • Sub-priority 2.1: Build resilience in key sectors against climate change-related water variability. • Sub-priority 2.2: Expand successful resilience-building programmes and projects, including development initiatives, to other areas with similar environments. • Sub-priority 2.3: Investigate the potential for expanding sectors and kick-starting new industries that are likely to thrive as a direct or indirect result of climate change effects.	*Strategic priority 6: Enhance public-private-civil society collaboration and stewardship* • Sub-priority 6.1: Launch an integrated development planning process that has a strong role for the private sector, the research and academic community, and civil society organisations.
Strategic priority 3: Ensure resilient physical capital • Sub-priority 3.1: Mandate that all public infrastructure be planned, designed, operated and managed after explicitly taking current and predicted future climate change impacts into account.	*Strategic priority 7: Enable substantial flows of climate change adaptation finance* • Sub-priority 7.1: Identify current strategies, plans and processes that enable adaptation finance and ensure their readiness to attract climate finance.

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into account. • Sub-priority 3.2: Ensure that sectors traditionally focused on mitigation incorporate adaptation and climate resilience into their planning, and contribute to building resilience.	readiness to attract climate finance. • Sub-priority 7.2: Design and implement strategies that are systemic with broad reach and place adaptation on the highest national agenda to address barriers to accessing finance.
Strategic priority 4: Ensure resilient ecological infrastructure • Sub-priority 4.1: Protect and conserve South Africa's most vulnerable ecosystems and landscapes. • Sub-priority 4.2: Adopt climate resilient approaches to natural resource management and use to restore and maintain ecosystem goods and services. • Sub-priority 4.3: Strengthen land-use planning and management, including spatial planning, to protect livelihoods and promote climate resilience.	*Strategic priority 8: Improve our understanding of climate change impacts and their development implications* • Sub-priority 8.1: Grow the knowledge base of climate change impacts and solutions, and how these link with socio-economic development. • Sub-priority 8.2: Implement an effective M&E system to track and assess adaptation efforts across the country.
	Strategic priority 9: Build capacity and awareness for effective action • Sub-priority 9.1: Build adaptation capacity through training programmes to ensure climate resilience is integrated into socio-economic development. • Sub-priority 9.2: Develop and implement an effective communication and outreach programme.

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Greener public transport. The report specifically mentions:

- Finding an alternative to company car schemes and allowances;
- Maximizing persons per vehicle by purchasing a dedicated staff bus,
- Provide a space where employees can publicise travel times and routes for car sharing;
- Provide bicycle lock-ups, changing rooms and showers at work,
- Subsidise employees who use public transport instead of providing on-site parking;
- Enable certain employees to work from home occasionally;
- Prioritise video conferencing so business meetings can be held without employees flying long distances;
- Lobby for better public transport;
- Lobby for better freight rail transport.
- Stop offering air tickets as awards to high achievers
- Implementing a zoned road freight tax in urban areas/suburbs
- Retest all vehicles annually to ensure compliance to emissions standards
- Adding catalytic converters to all vehicles as mandatory.
- Providing hub and spoke rail/bus systems than line haul projects.
- Discourage urban sprawl.

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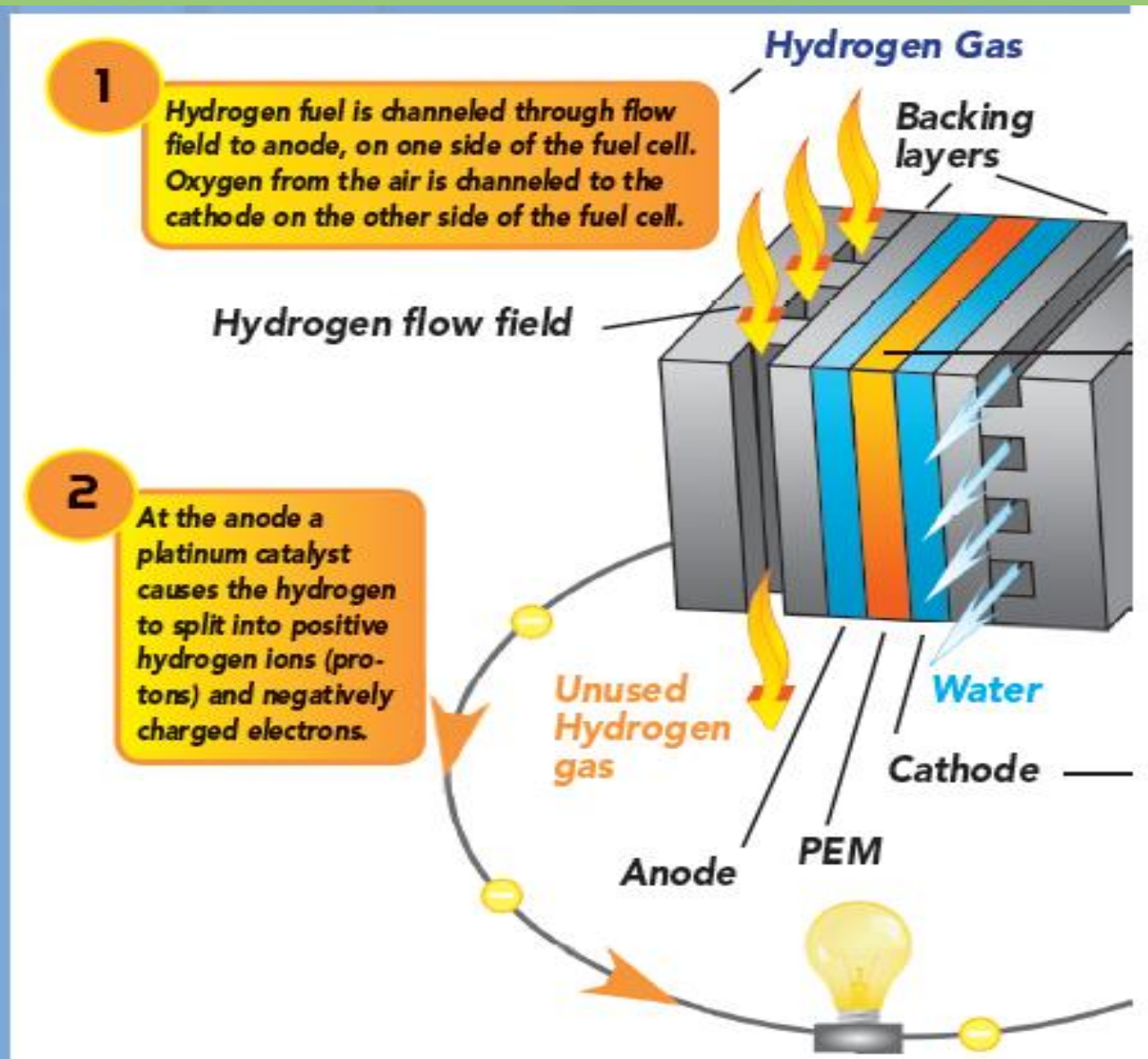
One of the most common current methods to produce hydrogen uses steam to separate it from hydrocarbons found in petroleum and natural gas – a process which still emits CO_2. A longer term option to produce hydrogen will be to extract it from water, a process known as "water splitting". This process uses either heat (thermolysis) or electricity (electrolysis) to separate out the hydrogen from the oxygen in water – both methods can directly use renewable energy sources.

Once hydrogen has been produced or extracted the energy it stores is transportable. This energy can be converted into electricity or heat as needed at the point of use through using a device such as a fuel cell.



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What are the uses of Hydrogen Fuel Cells?

HFC can potentially be tailored for use wherever needed, for stationary and portable uses as well as in transportation, and applications range from powering cell phones to cars and houses and even entire neighbourhoods. They are especially useful in remote locations, such as for remote weather stations, nature reserves, military operations or even in submarines and space craft. HFC have the potential to replace the internal combustion engine in vehicles, and could radically change transportation.

Around the world, fuel cells are being developed for:

- Car and buses.
- Motorbikes, scooters and bicycles.
- Utility vehicles (e.g. forklift trucks, golf carts and tractors).
- Aircraft/aviation.
- Locomotives.
- Boats and submersibles.
- Combined heat and power (CHP) domestic and commercial energy needs.
- Back-up power, including Uninterrupted Power Supply (UPS) technology.
- Portable power (to replace power in portable electronic devices such as cell phones and laptop computers).
- Off grid power supply.
- Base load power plants.

Countries around the world have different motivations for investing in R&D in the area of HFCT. For example, Canada is investigating HFCT related to environmental protection and the United States of America is doing likewise, but for reasons of energy security. Japan plans to offer domestic fuel cells commercially soon and aims for a quarter of all Japanese homes to be powered by fuel cells by 2020. Some more advanced countries are also building up hydrogen fuelling infrastructure for hydrogen powered vehicles.

The South African government is driving the R&D on HFCT and related technologies for three main reasons:

- South Africa has an abundance of Platinum Group Metals (PGM), which are the key catalytic materials used in most fuel cells. This provides great potential for socio-economic benefits to be obtained from these natural resources due to the increased global demand for PGM products.
- The Human Capital Development (HCD) required to develop this sector will lead to job creation in South Africa – in order to supply the rest of the world with a much needed resource.
- R&D of HFCT as a viable alternative, renewable energy source is essential to reduce CO_2 and GHG emissions and help meet the country's commitment to the global targets.

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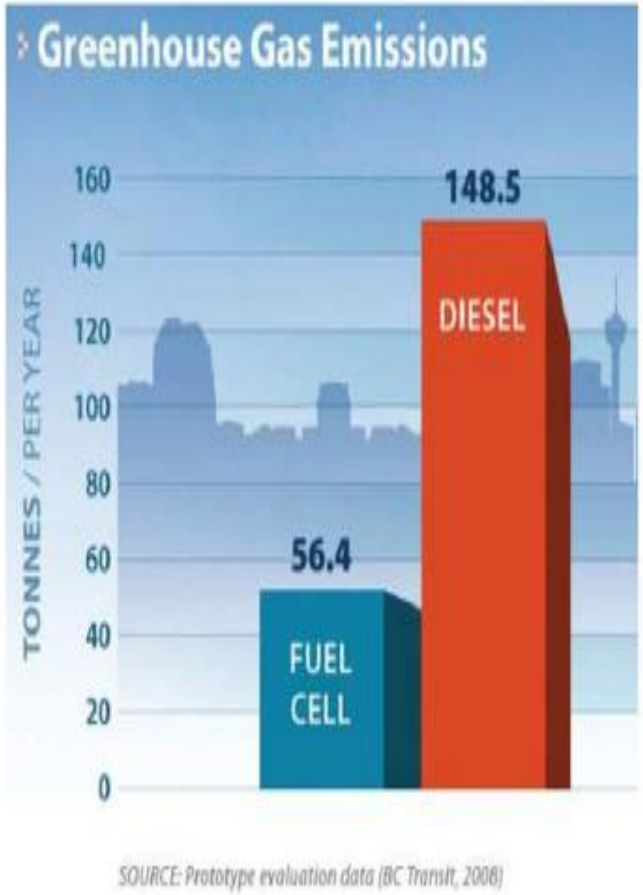
Why Fuel Cell Buses?

- **Completely eliminates tailpipe emissions**
  - Nox, Sox, PM
- **Noise reduction and comfortable ride**
- **Improved fuel efficiency**
  - 1.5-2.5x improvement over conventional diesel buses on an energy equivalent basis
- **Reduced Greenhouse Gas Emissions**
  - Demonstrated on a well to wheel basis



SOURCE: Prototype evaluation data (BC Transit, 2008)

BC Transit has calculated* a WTW reduction in CO_2 emissions of 62% for the Whistler buses

Phase IIa Verification Test Results

- **Performance:**
  - Fuel cell bus performance superior to existing diesel fleet
  - Drivers praised ease of operation & comfort
- **Fuel efficiency:**
  - Average hydrogen consumption of 13.3kg/100km, exceeding goal of 15kg/100km
- **Challenges:**
  - Some system failures due to operating environment (humidity, dust & weather conditions), to be addressed in Phase IIb

AIRSHIPS

Worldwide Aeros *Dragon Dream*

ARH-50 VariaLift Study Specifications	
Length (m)	150
Span (m)	52
Max payload (metric tonnes)	50
Cruise speed (km/hr)	190
Purchase price (Cdn $)	$30,000,000
Life of airship (years)	40
Insurance rate (Hull)	10%
Insurance rate (PL)	5%
Helium leakage (annual)	1%
Vertical take-off and landing (VTOL)	Yes
Estimated fuel consumption l/hr	900
Flight crew	2
Ground crew, mechanics, etc	4
Airdock (hangar) construction cost (Cdn $)	$58,000,000

Why did Airship Technology Stall?

- Military investment in airplanes during WW2
- Adaptation to civilian use of jet airliners
- Surplus pilots, mechanics and landing strips
- Desire for speed/Passenger focus
- Cheap oil
- No concern for air pollution or climate change
- Perceptions of safety
- No market demand for airships, beyond advertising blimps

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Table 1: Fund level impacts and outcomes of GCF projects and programmes.

Mitigation Strategic Impacts	**Adaptation Strategic Impacts**
Shifting to low-emission sustainable development pathways through: • *Low-emission energy access and power generation* • *Low-emission transport* • *Energy efficient buildings, cities and industries* • *Sustainable land use and forest management*	*Increasing climate-resilient sustainable development for:* • *Enhanced livelihoods of the most vulnerable people, communities, and regions* • *Increased health and well-being, and food and water security* • *Resilient infrastructure and built environment to climate change threats* • *Resilient ecosystems*
Mitigation Outcomes	**Adaptation Outcomes**
• Increased gender-sensitive low-emission development mainstreamed in government • More small, medium and large low-emission power suppliers • Lower country energy-intensity trajectory • Increased use of low-carbon transport • Stabilisation of forest coverage	• Strengthened government institutional and regulatory systems for climate-responsive development planning • Increased generation and use of climate information in decision-making • Strengthened adaptive capacity and reduced exposure to climate risks • Strengthened awareness of climate threats and gender-sensitive risk reduction processes

SANBI –GCF Funding Criteria 2017-2022 (Not accepting any new funding for climate change

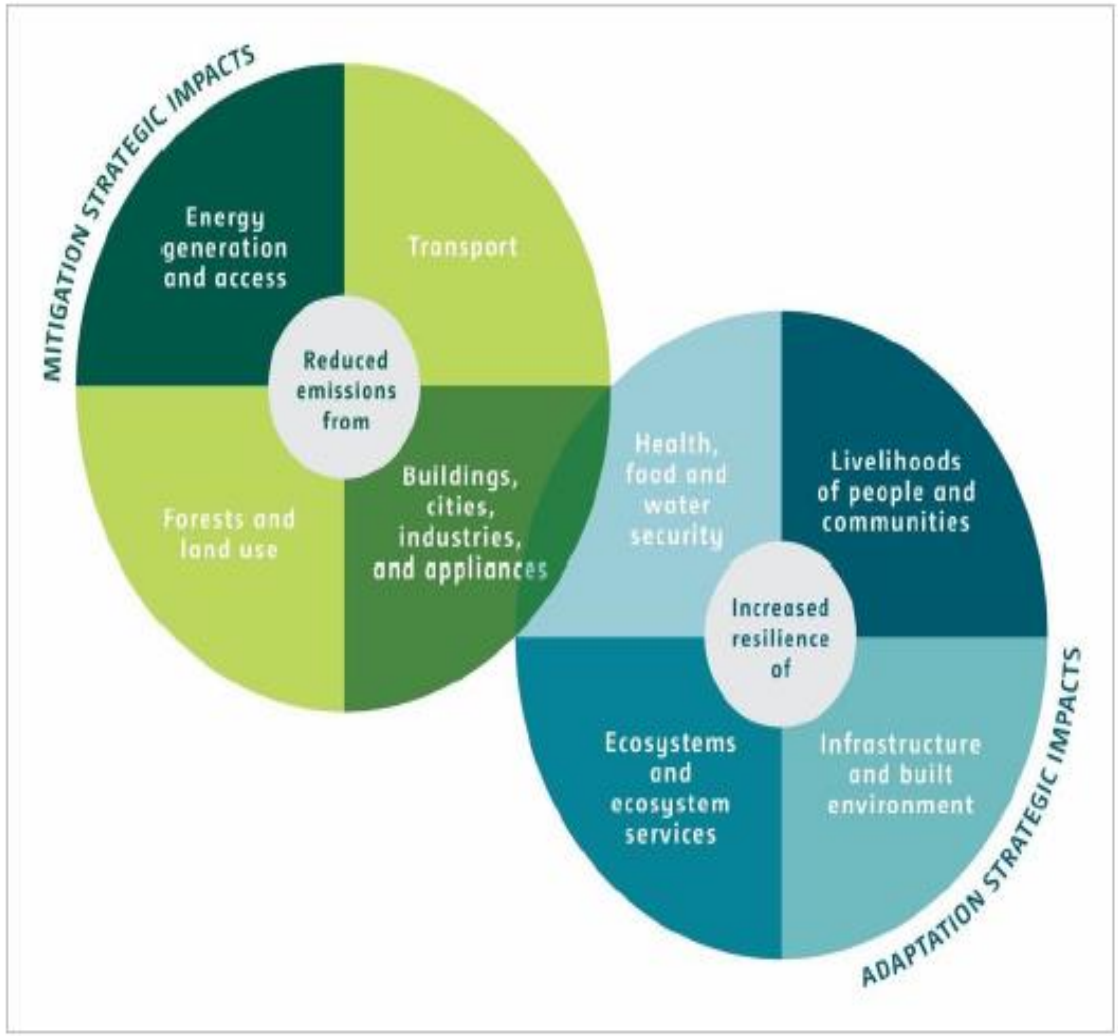


Figure 1: Sectors for climate change mitigation and adaptation (*Source: GCF we*

2. The Green Climate Fund

The Green Climate Fund was established by decision of UNFCCC COP 15 to scale up climate finance funding by raising USD 100 billion a year by 2020. To date, just under USD 9 billion has been raised by the Fund, for both mitigation adaptation activities.

At the GCF Board meeting held in Cape Town in February 2016, the Board adopted the following as the vision for the Fund:

To support the implementation of the Paris Agreement in developing countries: -

- by enhancing adaptive capacity and fostering resilience and making financial flows consistent with low greenhouse gas emission and climate resilient development; and
- by making Intended Nationally Determined Contributions (INDCs) the important reference point for the Fund's programming.

SANBI –GCF Funding Criteria 2017-2022 (Not accepting any new funding for climate change

2.2 GCF investment criteria

The GCF has six investment criteria that guide its decisions. These are as follows:

- Impact/result potential: Potential of the programme/project to contribute to the achievement of the objectives and results areas of the GCF.
- Paradigm shift potential: Degree to which GCF can achieve sustainable development impacts beyond one-off project or programme investments by replicating and scaling them up.
- Needs of the recipient: Financing needs of the beneficiary country.
- Country ownership: Beneficiary country ownership of and capacity to implement a funded project or programme (including policies, climate strategies and institutions).
- Economic efficiency: Benefit-cost ratio of activity, translated to a measure of impact per US dollar delivered by the Fund.
- Efficiency and effectiveness: Financial soundness of the activity.

Additional information about the investment criteria is available on the GCF website[2].

3. The Process for Submitting Proposals to the GCF

The GCF makes use of Accredited Entities to develop funding proposals and oversee, supervise, manage and monitor their respective GCF-approved projects and programmes, and project proposals can only be submitted to the GCF through these Accredited Entities.

CLIMATEPROOFING SOLUTIONS -Psychology

- **Factors Clarifying Stakeholder Reluctance to Prioritise Climate Change.**

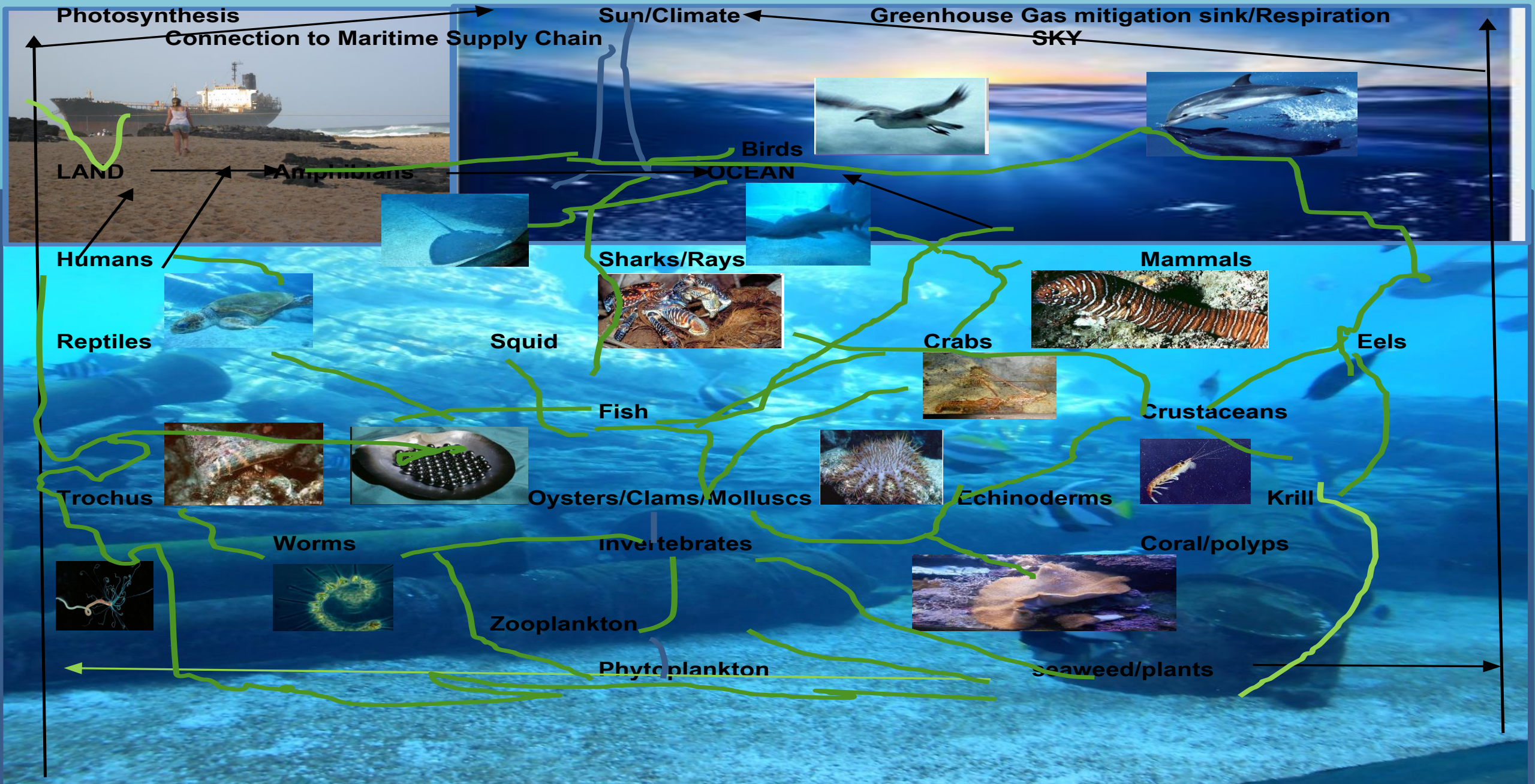
- Access to capital/finance –or awareness of options.
- Asymmetrical information/climate change uncertainty.
- Lack of concern.
- Lack of incentive/legal uncertainty.
- No investment/information criteria.
- Other priorities –finance, risks, business operations.
- Perceived relevance.
- Risk ambiguity.
- Scepticism.
- Timing.
- Uncertain short run profitability and benefits.
- Uncertainty over cost effective, sustainable adaptation responses.
- Unknown inaction, maladaptation and opportunity costs.

- **Factors Affecting Stakeholder Successful Survival/Recovery**

- Adaptation.
- Adapting to opportunity not business as usual recovery.
- Competitors versus collaboration –impact costs of competitors versus own.
- Ecosystem protection.
- Extent of aid/reserves/support/flexibility.
- Extent of organisational loss, reputation, relocation costs.
- Extent to which businesses/stakeholders have experience, overcome past-existing impacts.
- Event specific impacts/location.

- PROACTIVE RISK EXPECTATIONS THEORY

A Pacific Maritime Ecosystem/Pacific MSC' Resources



CLIMATEPROOFING SOLUTIONS -FINANCIAL

- Physical Indicators Measuring the Extent to Which an Investment is Climateproofed.

- Development of a Business Continuity Plan.
- Extent of Mitigation/Adaptation Investment.
- Extent of Globalisation, Asset Interdependency and Supply Chain Exposure.
- Future Earning Power.
- Liability.
- Projected Risk/Vulnerability –Long Run/Short Run.
- Recovery time Changes.
- Resources Allocated/Reserves.
- Resource Sustainability.
- Stakeholder Reactions/Reputation/ Requirements.

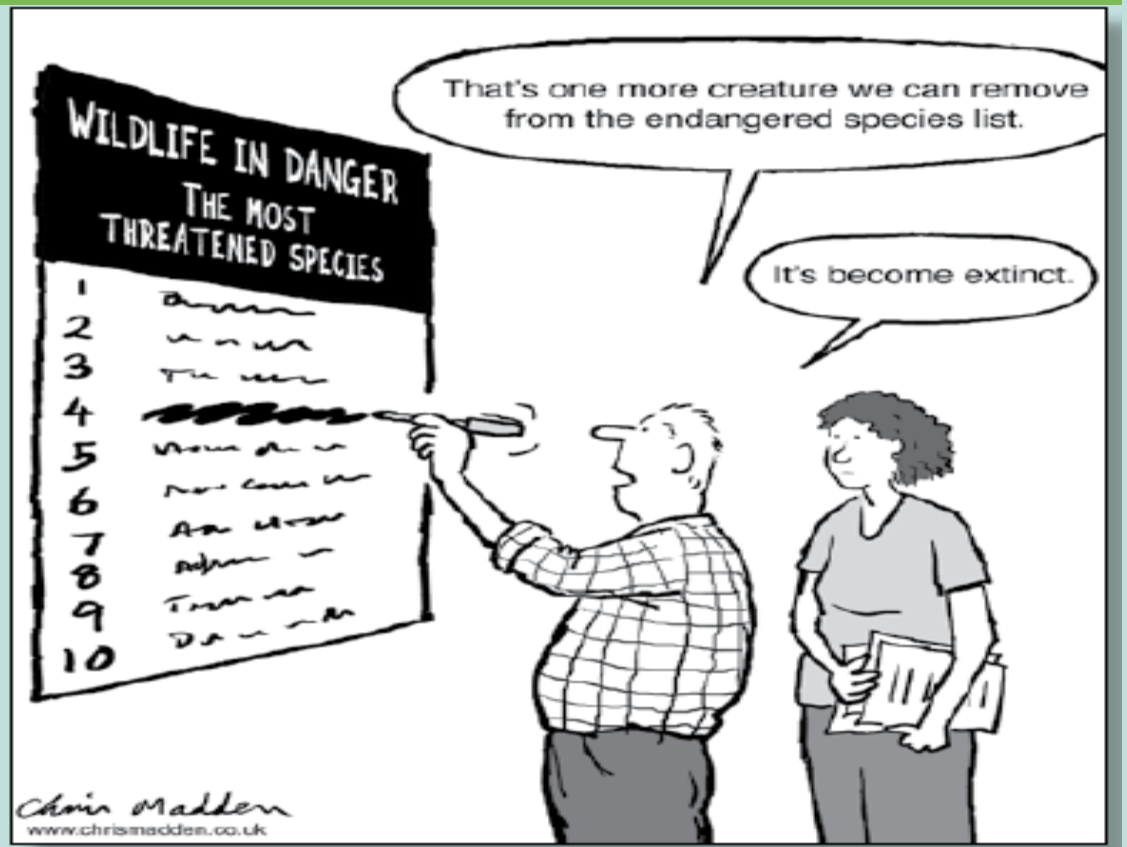
- Physical Indicators Measuring the Extent to Which an Investment is Climateproofed.

- Business Awareness over climateproofing resilience.
- Change in Asset Performance.
- Change in Conditional Probability of Asset Failure/Asset Resilience.
- Change in communication, financial, information, physical, psychological exposure and leadership.
- Change in Percentage of Assets Exposed.
- Change in Risk Perception/People trained.
- Competitors.
- Coordination/Cooperation with other stakeholders.
- Demand/Supply/Market Changes.

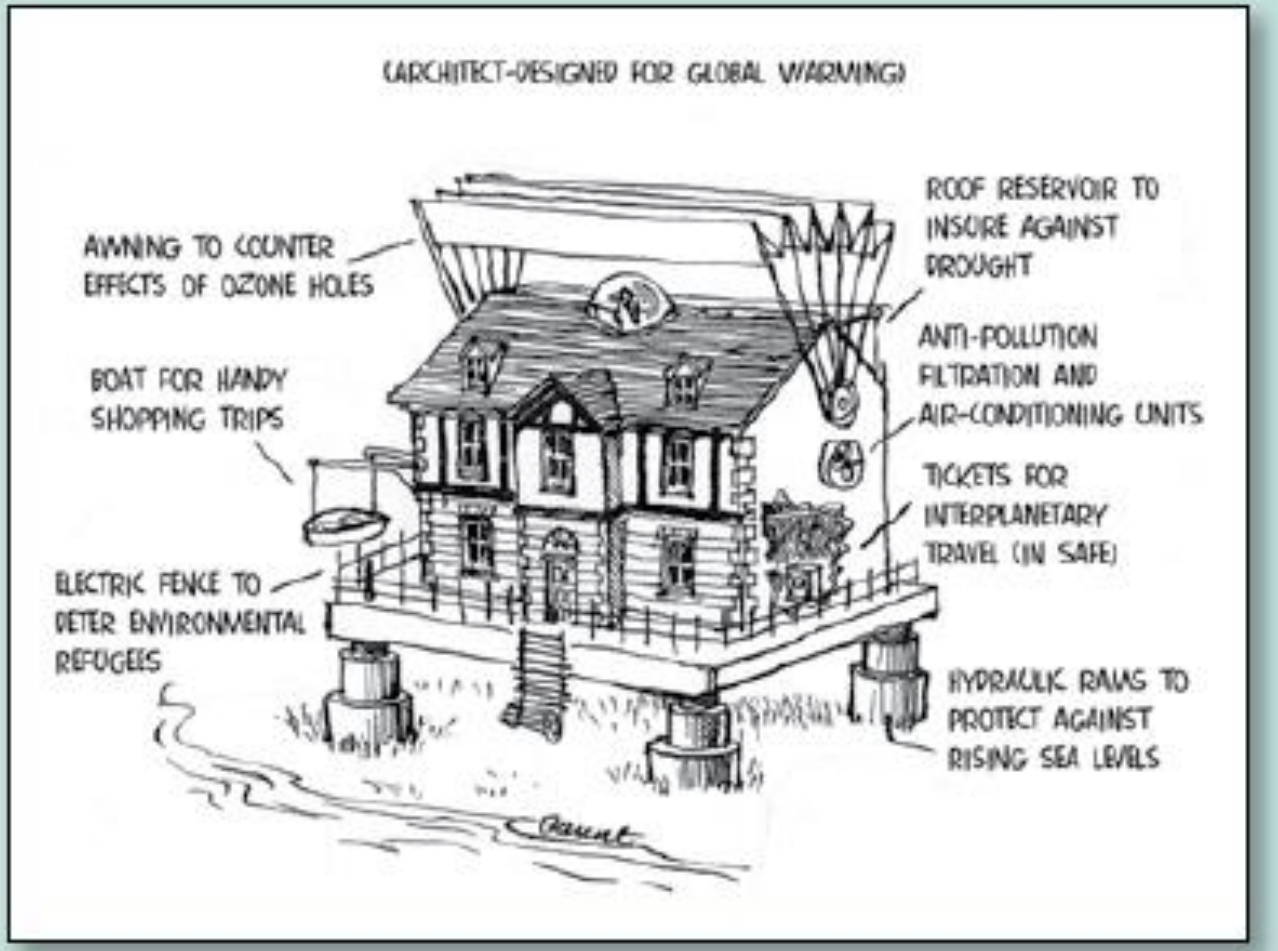
Climateproofing Supply Chain Opportunities.

- Aid/ FDI/Remittances.
- Aquaculture, aquaponics.
- Climateproofing Infrastructure and equipment investment.
- Credits for mitigation and adaptation, venture capital and incentives.
- Export/Import power.
- Experience, Psychology and Training.
- Green Economy –climate bonds, emissions credits.
- Localisation rather than globalisation.
- Pacific Ecological Capital and real estate.
- Reputation and publicity.
- Reserves.
- Technology.
- Trade diversion, continuation and creation into new markets.
- Traditional crafts, resources, products and techniques.
- The Ecological Capital Theory of Climate Change Risk Management

- “How wonderful it is that nobody need wait a single moment before starting to improve the world. "Anne *Frank*
- ” I’ve come on a special mission on behalf of my constituency, the millions of trillions of insects and other small creatures, to make a plea for them. Please keep in mind that if we would wipe out insects from this planet – which we are trying hard to do – the rest of life would disappear within a few months. *E.O. Wilson, biologist and author, at TED 2007 awards,* www.ted.com



February 2nd [2007] will be remembered as the date when uncertainty was removed as to whether humans had anything to do with climate change on this planet. The evidence is on the table, we no longer have to debate that part of it.



Working with sustainable solutions is an opportunity to embrace local craftsmanship and new technology with a human and emotional approach. Sustainable design is not about trend, but is here to stay – it's inevitable.

Thomas Lykke, designer

Education is the most powerful weapon that you can use to change the world.

Nelson Mandela

ARE YOU PREPARED?

- Ecosystem?
- Infrastructure?
- Resources/Products?
- Assets/Equipment?
- Human/Psychology?
- Financial Reserves?
- Information?
- Communication?
- Other Stakeholders?

Figure 6.1: Risk Event Disruption, Impact Cost Phases for a Pacific MSC

Temporary

Phases ···· Mitigation ···· Prediction/Anticipation ····· Disruption ·····

Opportunity ····· Adaptation ····· Recovery ····· Evacuation/Relocation ···· Permanent

ASSIGNMENTS

- **Assignment I Week 5**; Test
-
- **Assignment 2: Week 6 Poster/Presentation -Group Work (Groups of 3)**
- With reference to MDG and other core South African national/local strategic objectives; describe and effectively market how you would produce an ecologically sustainable business or service to promote green living within South Africa.

- **Assignment 3: Essay: 2500-3000 Words) Arial Narrow, Font 12, 1.5 spacing, Consistent reference Style, South African or UK English, Headings Bold. Week 12 Lecture 1**

- Identify core climate change risks and impact costs for a local company of your choice. Then create several strategies to reduce the impact within the South African logistics industry and supply chain.

Optional Additional Climate Change Sources –For Assignment Aid

- Bornors A and Zipplies R, 2011, Bending The Curve: Your Guide to Tackling Climate Change in South Africa
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- Jury M, 2013, Climate Trends in Southern Africa, *South African Journal of Science*, Volume 109 Issue (1/2), http://dx.doi.org/10.1590/sajs.2013/980
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- Mojafi T, 2014, 'Development of Policy For Climate Change Adaptation For South African Ports,' World Maritime University Master's Dissertation, Malmo.
- Nelson Mandela Bay Municipality 2015, Climate Change and Green Economy Action Plan, Nelson Mandela Bay Report, Port Elizabeth.
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Any questions
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