EIA as a Tool to Climate-proof Projects: Rationale, Opportunities, Challenges – A Global Review

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Content

1. Weather and climate
2. Climate change and infrastructure
3. Incorporating climate change risks and adaptation in environmental impact assessments

Weather, Climate and Climate Change

Are scientists too boring?

experimentally observed time series. Hense (1987) has estimated correlation dimension of three 84 year Southern-Oscillation-related monthly time series: the precipitation at Nauru, the sea-surface temperature (SST) at Puerto Chicama and the surface pressure at Darwin. He hypothesized the existence of a strange attractor for the precipitation and SST time series with a correlation dimension between 2.5 and 6.0. Some ENSO models can also generate chaotic behaviour (Jin et al., 1994; Tziperman et al., 1994). The SOI time series itself, however, which is commonly defined as the standardized sea-level barometric pressure difference between Tahiti and Darwin, has not yet been checked in detail for chaotic characteristics; this is especially true for the noise-reduced SOI time series.

The main purpose of this paper is to find out whether the SOI time series is chaotic or not. We try to identify the essential features of the SOI when viewed as a dynamic system. Several data analysis techniques need to be combined to ascertain chaotic behaviour. In this study, three schemes are used to reduce noise in the time series and enhance its chaotic features. Then, three methods for detecting and identifying the chaotic characteristics of a time series, i.e., drawing its phase space trajectory, checking Lyapunov exponents and evaluating correlation dimension, are applied to the noise-reduced series as well as the raw data, after autocorrelation and spectral characteristics have been examined. If a time series can be identified as deterministic chaos, then the knowledge of its underlying characteristics would make short-term predictions possible (in this case of the SOI) by setting the system on a fractal trajectory (strange attractor), although chaotic systems are unpredictable in the long term (e.g., Casdagli, 1989; Sugihara and May, 1990; Jinno et al., 1995; Berndtsson et al., 1994; Kawamura et al., 1994a, b).

2. Data

Several indices have been used to monitor the Southern Oscillation. One commonly used SOI is derived from values of the monthly mean sea-level pressure difference between Papeete, Tahiti

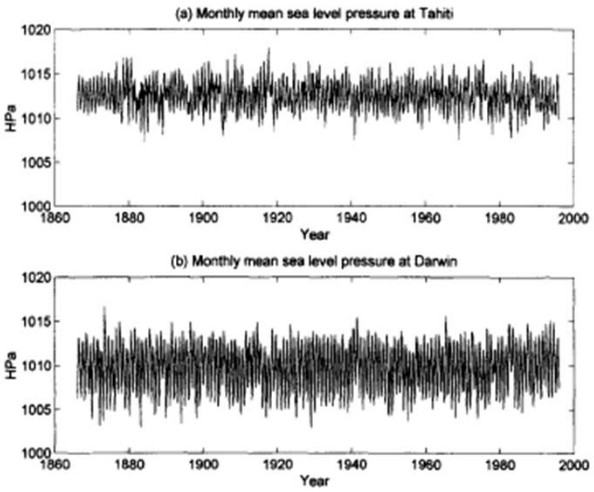


Fig. 1. Monthly mean sea-level pressure time series at (a) Tahiti and (b) Darwin.

Table 11.3. *Projected changes in New Zealand annual precipitation and mean temperature for the 2030s and 2080s, relative to 1990. The ranges are based on results from forty SRES emission scenarios and six climate models for various locations in each region (Wratt et al., 2004).*

Temperature change (°C)	2030s	2080s
Western North Island	+0.2 to 1.3	+0.3 to 4.0
Eastern North Island	+0.2 to 1.4	+0.5 to 3.8
Northern South Island	+0.1 to 1.4	+0.4 to 3.5
Western South Island	+0.1 to 1.3	+0.2 to 3.5
Eastern South Island	+0.1 to 1.4	+0.4 to 3.4
Rainfall change (%)	**2030s**	**2080s**
Western North Island	-4 to +14	-6 to +26
Eastern North Island	-19 to +7	-32 to +2
Northern South Island	-7 to +3	-7 to +5
Western South Island	-4 to +15	+1 to +40
Eastern South Island	-12 to +13	-21 to +31

Southern Alps, it is less clear whether snow will be reduced (MfE, 2004a), although snowlines are likely to be higher (Fitzharris, 2004). By 2100, there is likely to be a 5 to 20 day decrease in frosts in the lower North Island, 10 to 30 fewer frost days in the South Island, and a 5 to 70 day increase in the number of days with temperatures over 30°C (Mullan et al., 2001). The frequency of heavy rainfall is likely to increase, especially in western areas (MfE, 2004a).

In Australia, within 800 km of the coast, a mean warming of 0.1 to 1.3°C is likely by the year 2020, relative to 1990, 0.3 to 3.4°C by 2050, and 0.4 to 6.7°C by 2080 (Table 11.4). In temperate areas, this translates to 1 to 32 more days/yr over 35°C by 2020 and 3 to 84 more by 2050, with 1 to 16 fewer days/yr below 0°C by 2020 and 2 to 32 fewer by 2050 (Suppiah et al., 2007). A tendency for decreased annual rainfall is likely over most of southern and sub-tropical Australia, with a tendency for increases in Tasmania, central Northern Territory and northern NSW (Table 11.4). The 15-model average shows decreasing rainfall over the whole continent (Suppiah et al., 2007). A decline in runoff in southern and eastern Australia is also likely (see Section 11.4.1).

The area of mainland Australia with at least one day of snow cover per year is likely to shrink by 10 to 40% by 2020 and by 22 to 85% by 2050 (Hennessy et al., 2003). Increases in extreme daily rainfall are likely where average rainfall either increases or decreases slightly. For example, the intensity of the 1-in-20 year daily rainfall event is likely to increase by up to 10% in parts of South Australia by the year 2030 (McInnes et al., 2002), by 5 to 70% by the year 2050 in Victoria (Whetton et al., 2002), by up to 25% in northern Queensland by 2050 (Walsh et al., 2001) and by up to 30% by 2040 in south-east Queensland (Abbs, 2004). In NSW, the intensity of the 1-in-40 year event increases by 5 to 15% by 2070 (Hennessy et al., 2004). The frequency of severe tropical cyclones (Categories 3, 4 and 5) on the east Australian coast increases 22% for the IS92a scenario (IPCC, 1992) from 2000 to 2050, with a 200 km southward shift in the cyclone genesis region, leading to greater exposure in south-east Queensland and north-east NSW (Leslie and Karoly, 2007). For tripled pre-industrial CO_2 conditions, there is a 56% increase in the number of simulated tropical cyclones over north-eastern Australia with peak winds greater than 30 m/s (Walsh et al., 2004). Decreases in hail frequency are simulated for Melbourne and Mt. Gambier (Niall and Walsh, 2005).

Potential evaporation (or evaporative demand) is likely to increase (Jones, 2004a). Projected changes in rainfall and evaporation have been applied to water-balance models, indicating that reduced soil moisture and runoff are very likely over most of Australia and eastern New Zealand (see Section 11.4.1 and Meehl et al., 2007). Up to 20% more droughts (defined as the 1-in-10 year soil moisture deficit from 1974 to 2003) are simulated over most of Australia by 2030 and up to 80% more droughts by 2070 in south-western Australia (Mpelasoka et al., 2007). Projected increases in the Palmer Drought Severity Index for the SRES A2 scenario are indicated over much of eastern Australia between 2000 and 2046 (Burke et al., 2006). In New Zealand, severe droughts (the current 1-in-20 year soil moisture deficit) are likely to occur every 7 to 15 years by the 2030s, and every 5 to 10 years by the 2080s, in the east of both islands, and parts of Bay of Plenty and Northland (Mullan et al., 2005a). The drying of pastures in eastern New Zealand in spring is very likely to be advanced by one month, with an expansion of droughts into both spring and autumn.

An increase in fire danger in Australia is likely to be associated with a reduced interval between fires, increased fire intensity, a decrease in fire extinguishments and faster fire spread (Tapper, 2000; Williams et al., 2001; Cary, 2002). In south-east Australia, the frequency of very high and extreme fire danger days is likely to rise 4-25% by 2020 and 15-70% by 2050 (Hennessy et al., 2006). By the 2080s, 10-50% more days with very high and extreme fire danger are likely in eastern areas of New Zealand, the Bay of Plenty, Wellington and Nelson regions (Pearce et al., 2005), with increases of up to 60% in some western areas. In both Australia and New Zealand, the fire season length is likely to be extended, with the window of opportunity for controlled burning shifting toward winter.

Relative to the year 2000, the global-mean projection of sea-level rise by 2100 is 0.18 to 0.59 m, excluding uncertainties in

Table 11.4. *Projected changes in annual average rainfall and temperature for 2020, 2050 and 2080, relative to 1990, for Australia. The ranges are based on results from forty SRES emission scenarios and fifteen climate models for various locations in each region (Suppiah et al., 2007).*

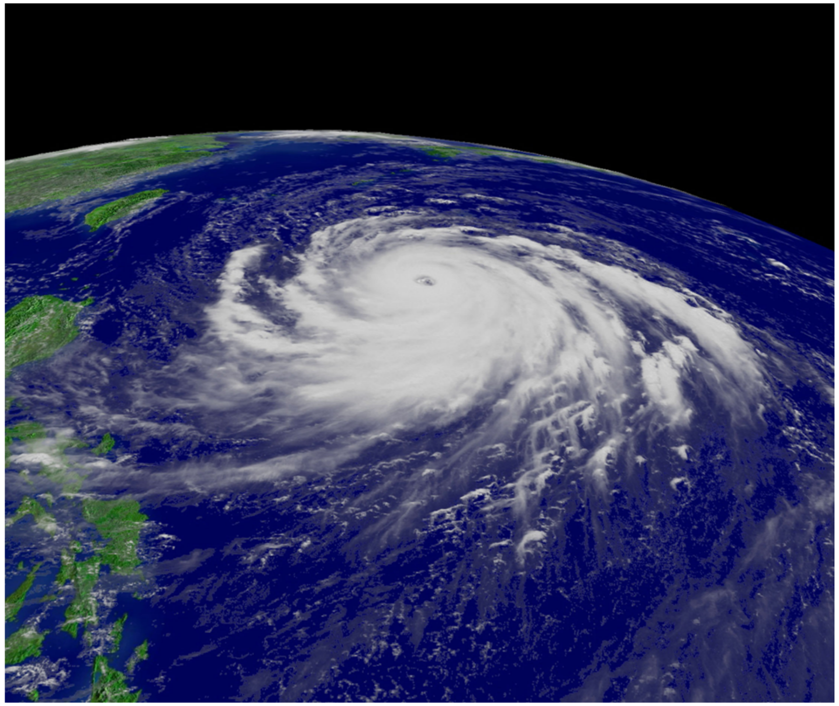
Temperature change (°C)	2020	2050	2080
0 to 400 km inland of coast	+0.1 to 1.0	+0.3 to 2.7	+0.4 to 5.4
400 to 800 km inland	+0.2 to 1.3	+0.5 to 3.4	+0.8 to 6.7
Central Australia	+0.2 to 1.5	+0.5 to 4.0	+0.8 to 8.0
Rainfall change (%)	**2020**	**2050**	**2080**
Within 400 km of western and southern coasts	-15 to 0	-40 to 0	-80 to 0
Sub-tropics (latitudes 20-28°S) except west coast and inland Queensland	-10 to +5	-27 to +13	-54 to +27
Northern NSW, Tasmania and central Northern Territory (NT)	-5 to +10	-13 to +27	-27 to +54
Central South Australia, southern NSW and north of latitude 20°S, except central NT	-5 to +5	-13 to +13	-27 to +27
Inland Queensland	-10 to +10	-27 to +27	-54 to +54

Weather

Weather is the meteorological conditions (temperature, rainfall, wind, etc.) on any day

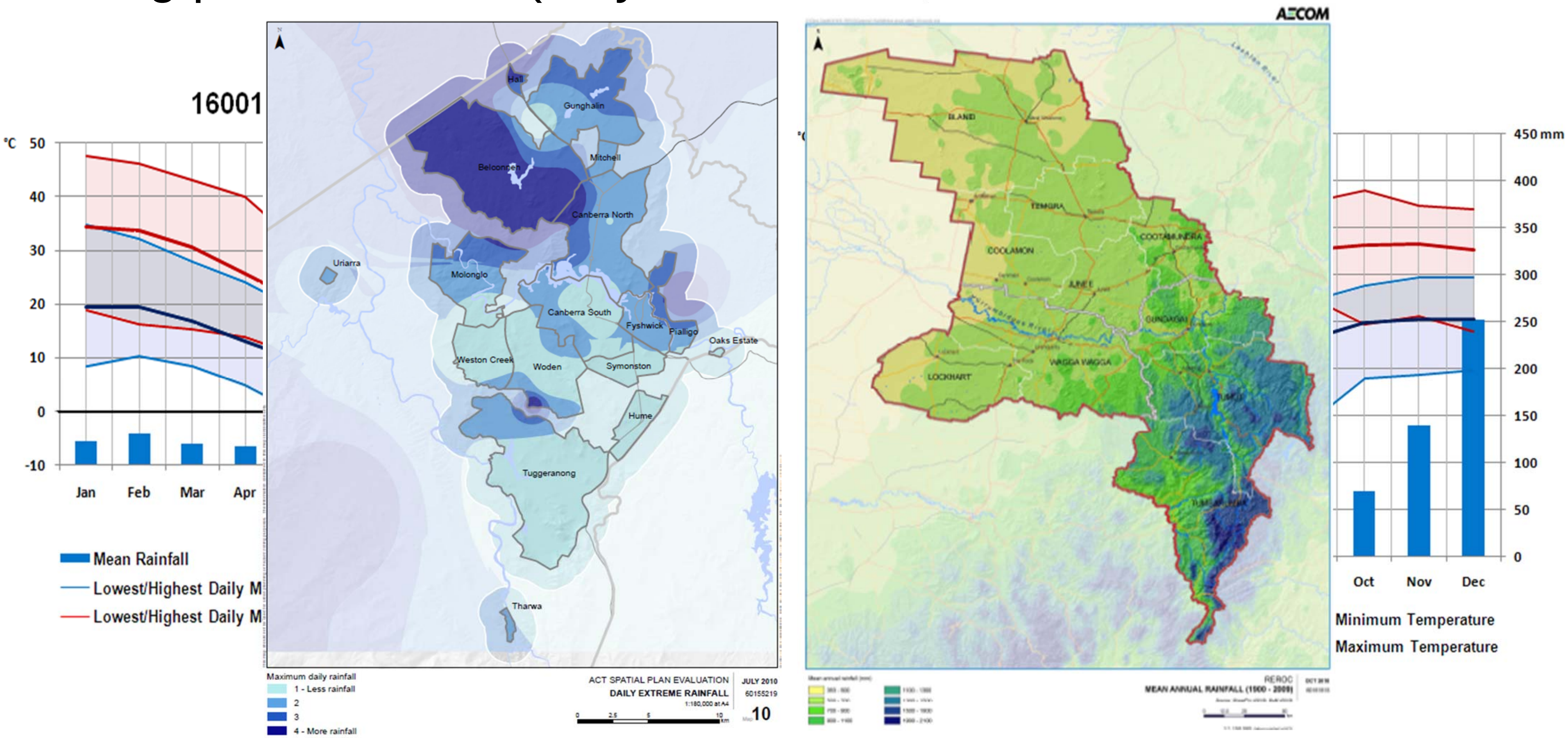
Normal

Extreme



Climate

The climate is the average of the weather conditions over a long period of time (30 years / WMO)



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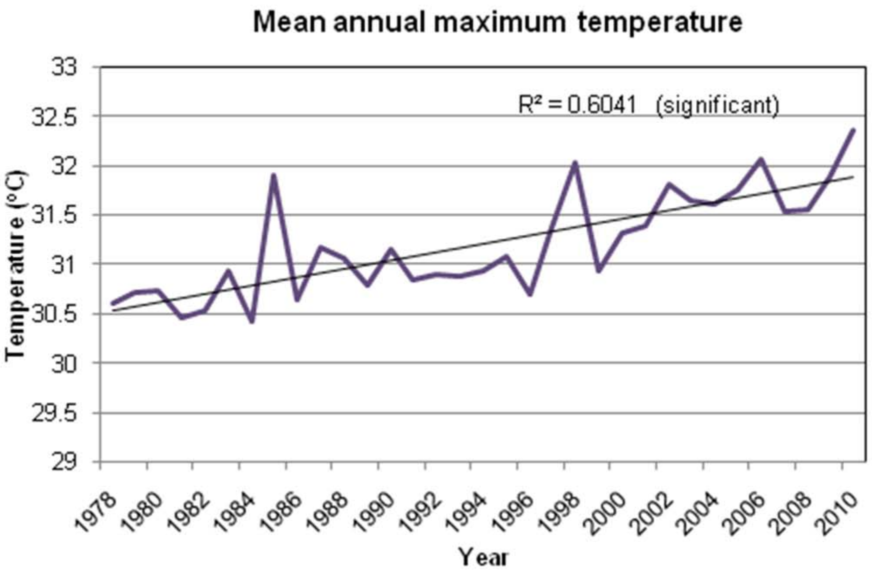
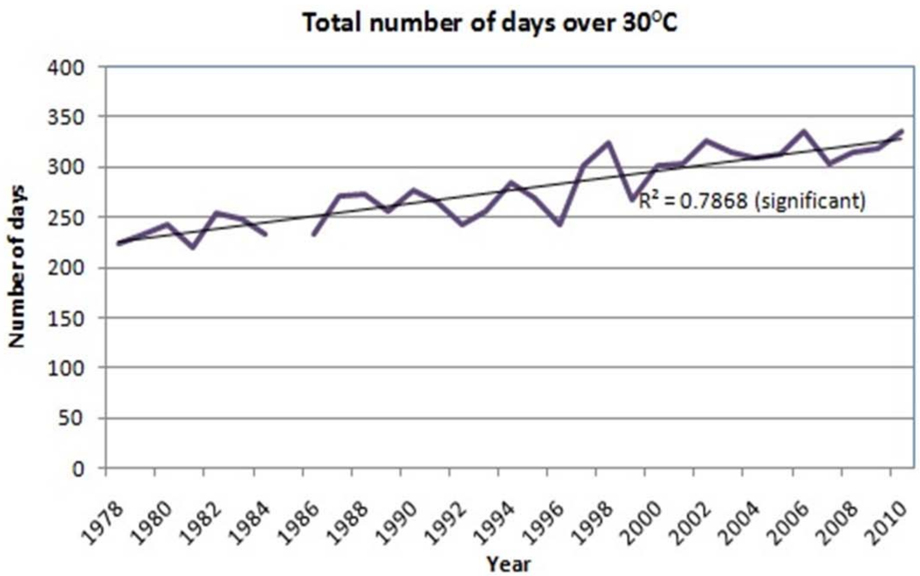
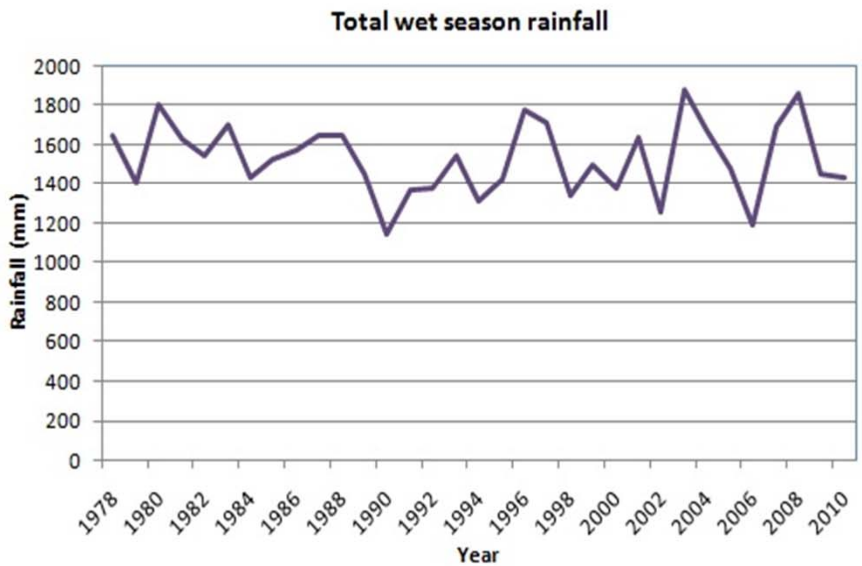
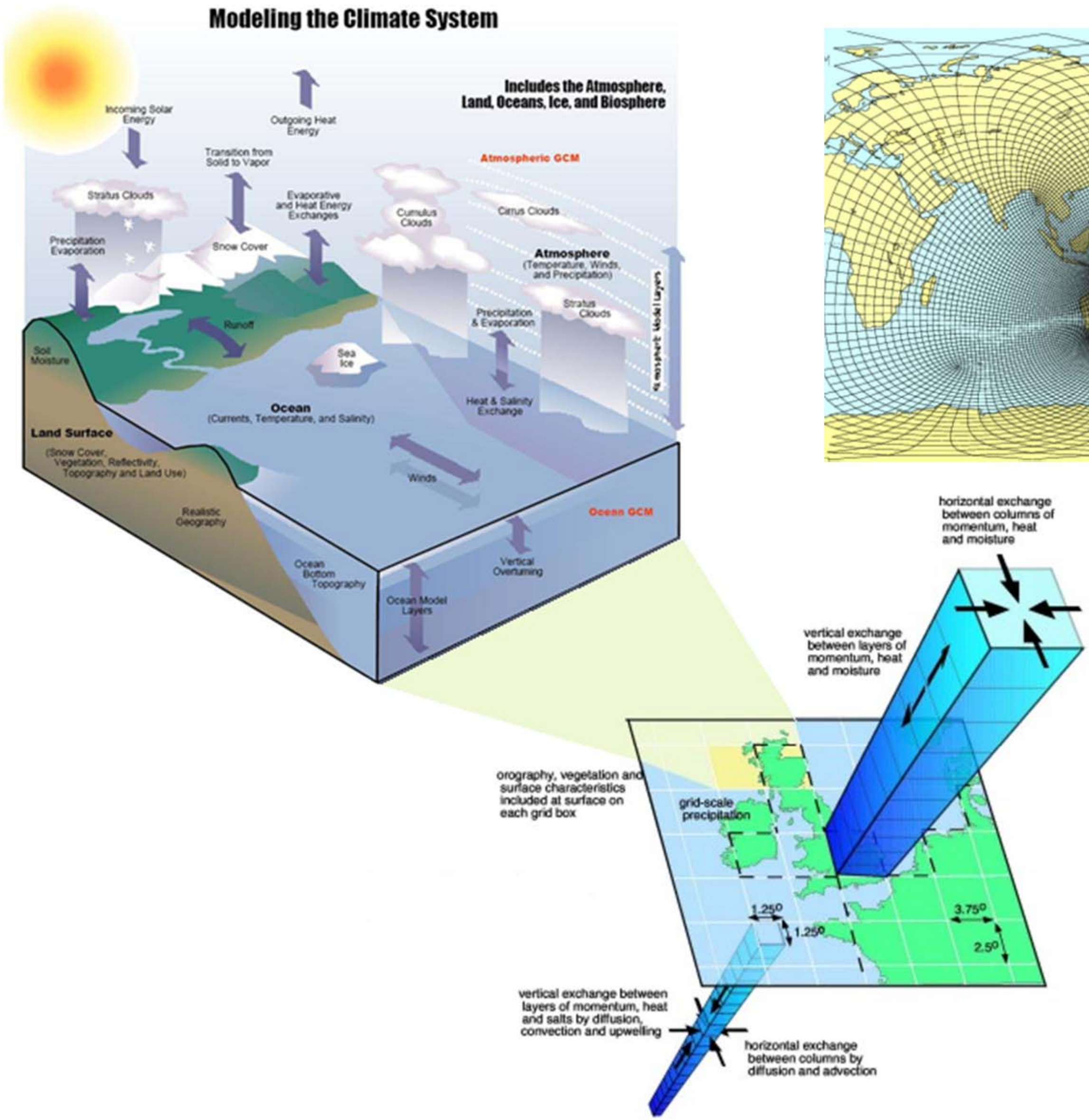
Assessing past trends

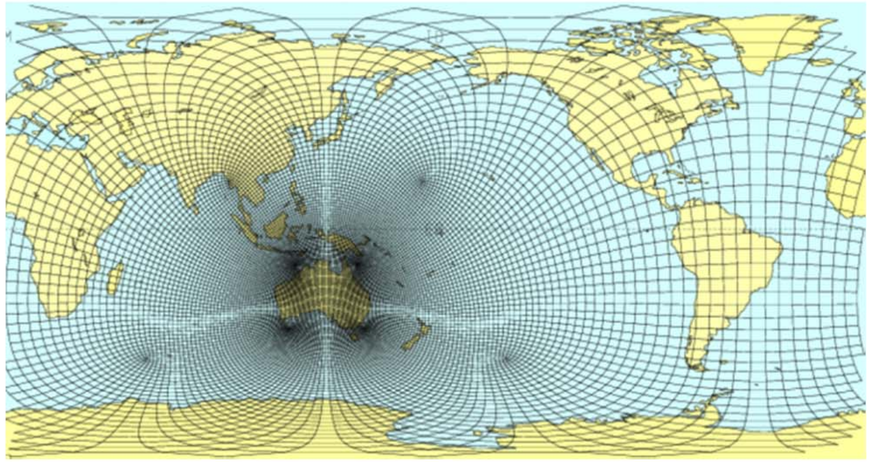




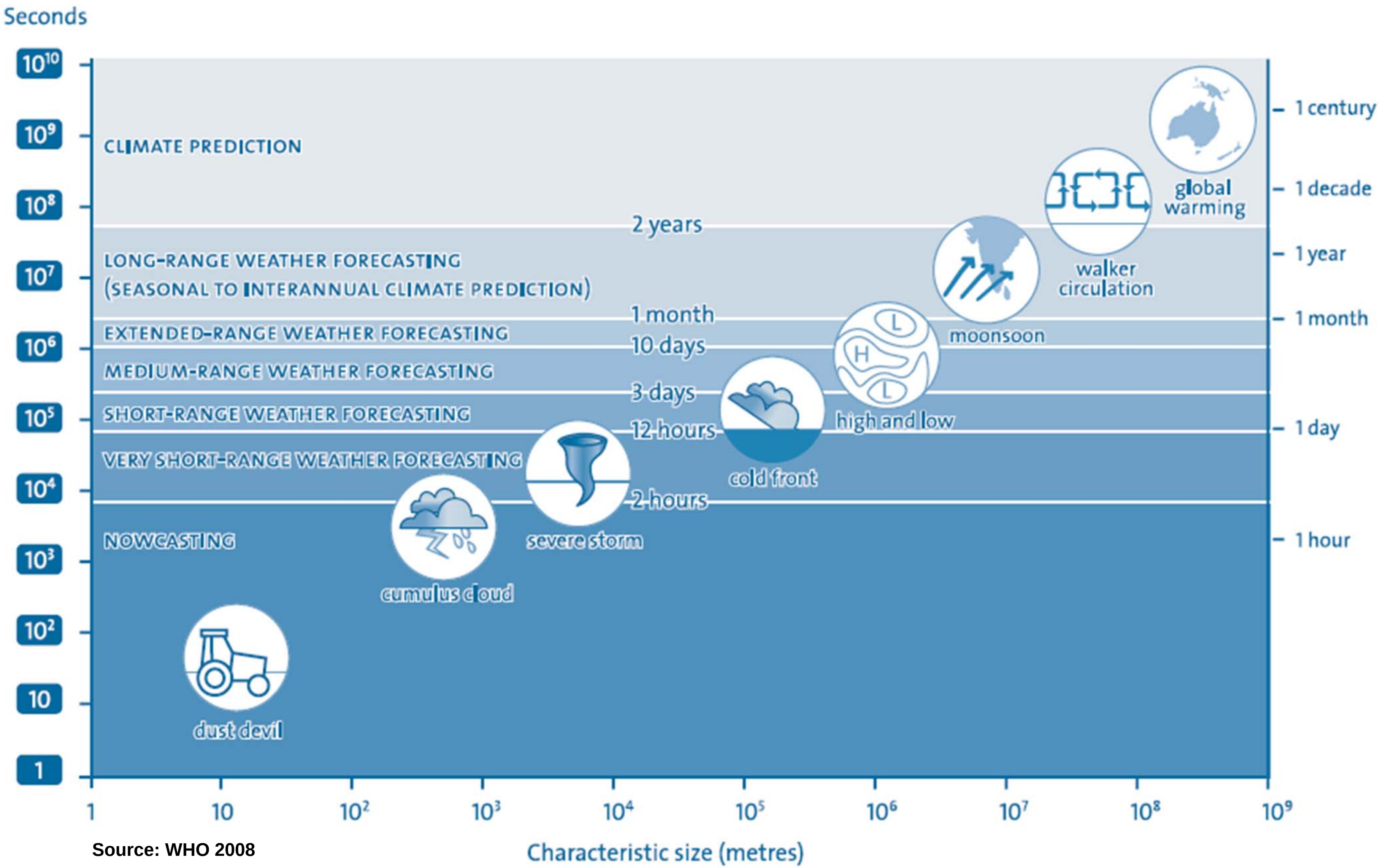


Future climate projections





Weather vs. Climate



Source: WHO 2008

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Infrastructure and climate change

Key impacts on infrastructure

Infrastructure design

- Currently infrastructure is designed based on past climate
  - The standard use to design are often out of date…
    …even more significant in developing countries
- Infrastructure are not currently designed based on future climate projections
  - Requires localised climate projections applied to current weather pattern to make it robust
  - Infrastructure design does not cope very well with uncertainties in climate modelling

Impact function

Impacts are a function of:

- Climate variables changing over time (gradual changes and extreme events)
- Life expectancy of assets (100 yrs for a bridge vs. 20 yrs for a road seal)
- Location, geomorphology and existing environment
- Critical assets chain and cascading consequences (e.g. loss of power for water distribution)
- Condition of existing assets (operation, maintenance, etc.)

Key impacts on infrastructure

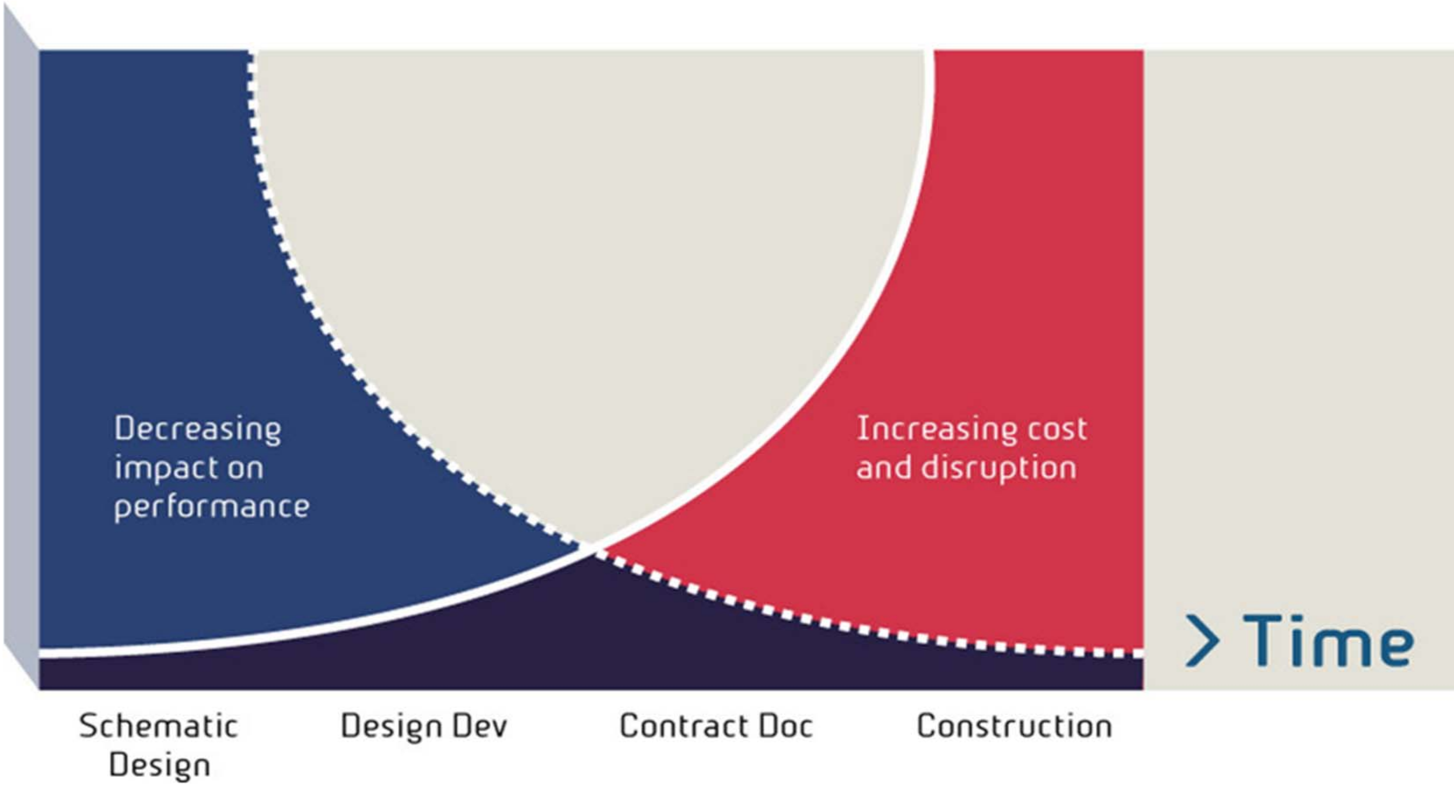
- Changes in extreme events patterns
  - Cyclones, storm surge, bushfire, heat waves, floods
- Gradual changes
  - Mean temperature, sea level rise, mean rainfall
- Degradation of materials and long terms losses
- Resource/service demand
  - Irrigation and water storage (drought)
  - Energy (heatwaves)
  - Viable agriculture (rainfall and runoff)

Impacts on materials

Material	CO_2	Cyclones, Storms	Sea Level Rise	Extreme Rainfall, Floods	Increased Annual Temp.	Increased Max Temp.	UV	Bushfire	Drought
Concrete	M	H	H	M	M	M	L	M	L-M
Metals	L	H	H	M	M	M	L	H	L
Brick, Mortar	L	M	M	M	L	L-M	L	M	H
Stone, Mortar	L	M	M	M	L	L-M	L	M	H
Timber	L	M	M	M-H	M	M	L	E	L-M
Coatings	L	M	L	M	M	M	H	E	L
Polymers	L	M	L	L	M	M	H	E	L

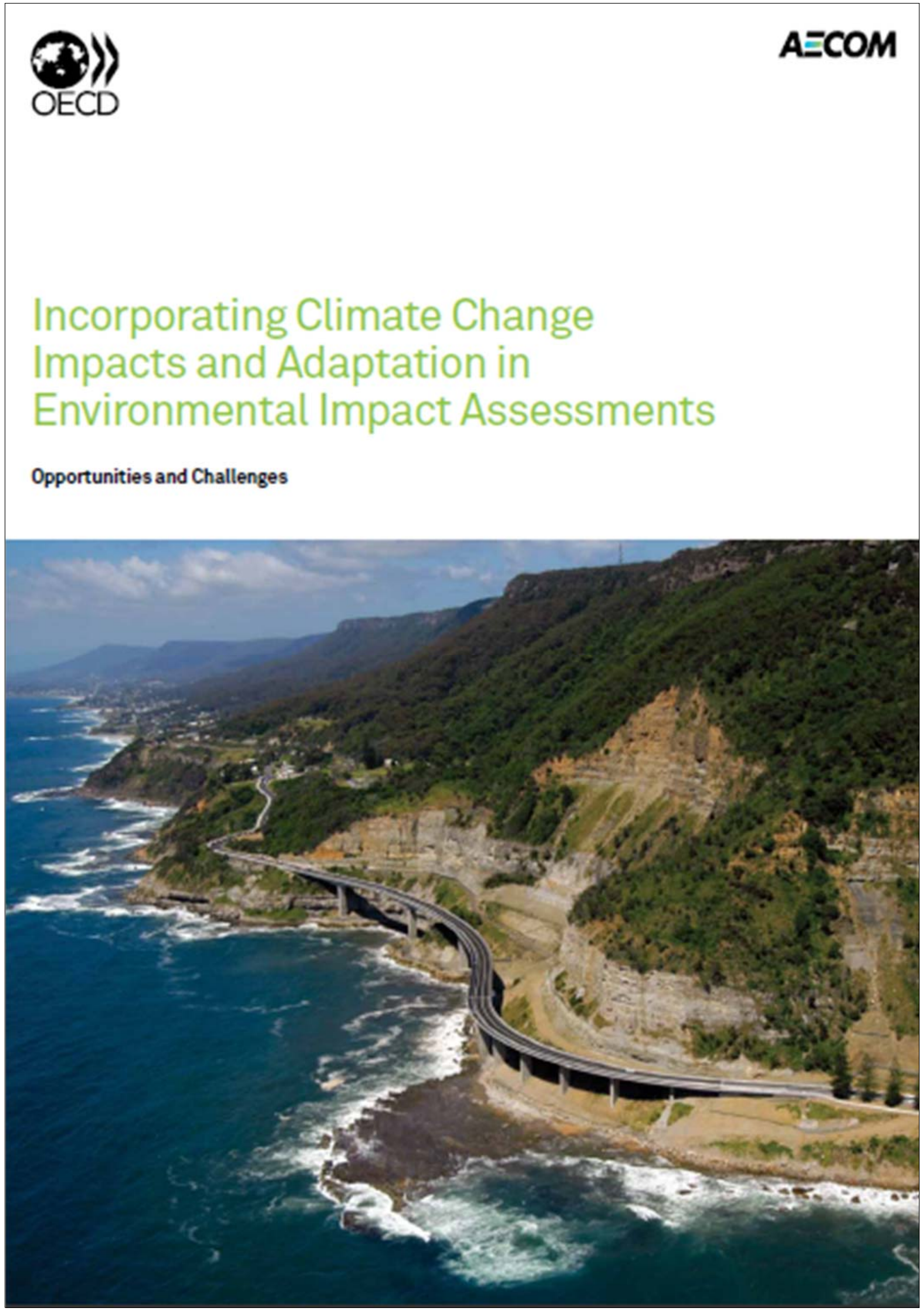
Source: Maunsell AECOM Advanced Materials 2008

What are some of the adaptation options?



Avoid / Adapt / Defend / Retreat

Climate change and environmental impact assessments


OECD

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Incorporating Climate Change Impacts and Adaptation in Environmental Impact Assessments

Opportunities and Challenges

Shardul Agrawala

Arnoldo Matus Kramer

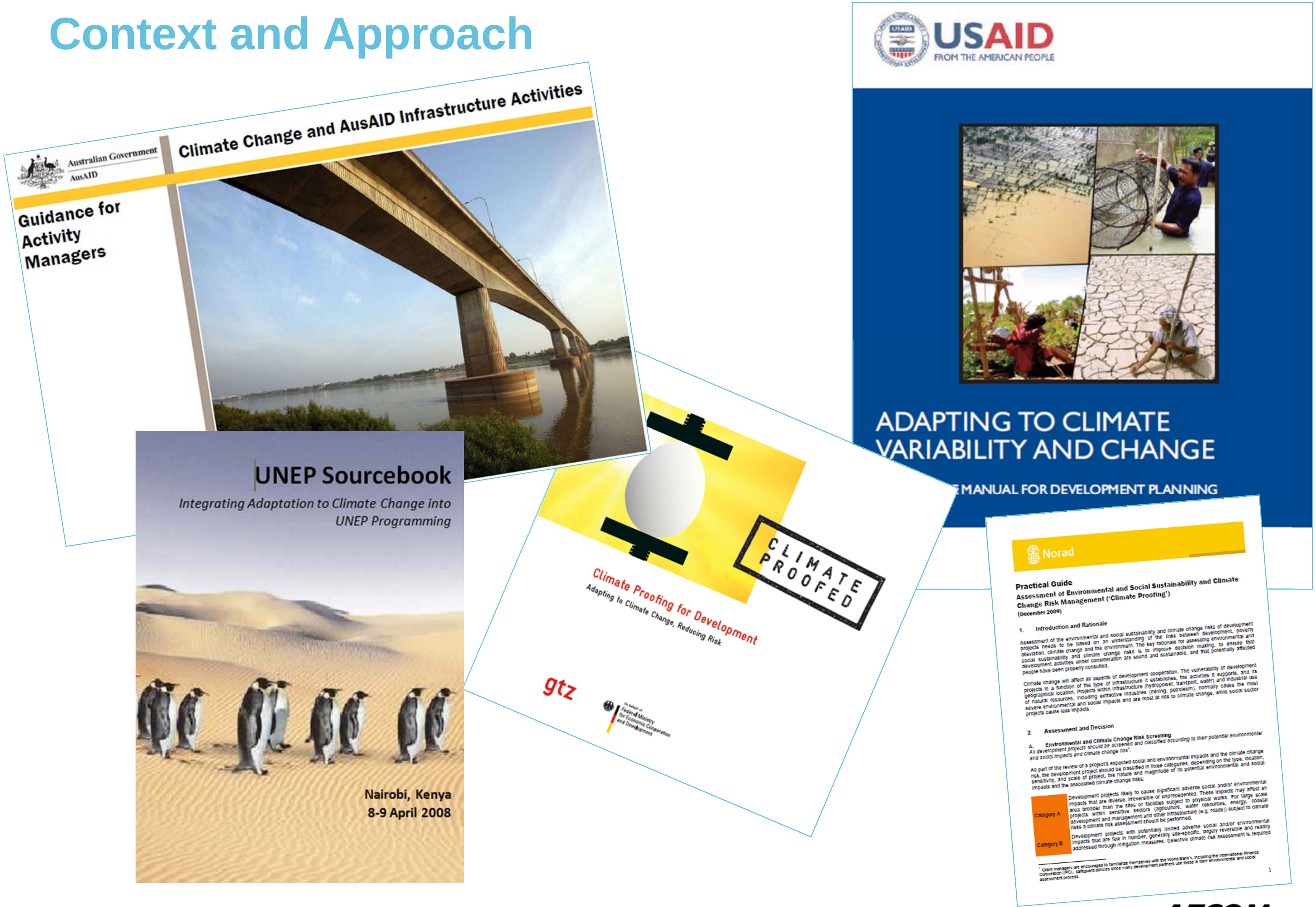
Guillaume Prudent-Richard

Marcus Sainsbury

Context and Approach

Context and Approach

Context and Approach



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Context and Approach

- Explore potential entry points to consider climate change as part of an EIA
- Review of how EIAs include climate change consideration in:
  - OECD Member Countries
  - Non-OECD Member Countries
  - Bilateral and multilateral context
- Present the results in a three-tiered framework:
  - Intention
  - Operational Guidance and Adjustment of Legal and Regulatory Framework
  - Implementation

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EIA Process and Possible Entry Points

	Strategic Phase	Concept Phase	Detailed Assessment Phase	Implementation Phase
EIA Steps	**Project Need and Justification** **Strategic Environmental Assessment**	**Project Identification** **EIA Scoping** • Determine what needs to be assessed	**Conducting EIA** • Baseline environmental characteristics • Potential impacts • Management measures **Formal Public Consultation** **Determination** • Submission • Review • Conditions	**Implementation / Monitoring** • Construction • Operation • Maintenance
Entry Points for Climate Change	**Climate Change Screening** • Does the project scope justify considering climate change? • If so what would be the broad implications?	**Scoping the Climate Change Risk Assessment and Adaptation Options** • What climate variables and elements of the project need to be assessed? • Who will conduct the assessment ?	**Conducting the Climate Change Risk Assessment and Adaptation Options** • Have climate risks and adaptation options been correctly assessed? • Is there potential for *maladaptation*?	**Implementing Climate Change Adaptation Measures** • Implementation through CMP, OMP and EMP • What KPIs can be used to monitor climate change and climate proofing over time?

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Level 1 – Intention

- Signaling the intention to integrate CC consideration in the EIA process in high level policy documents
  - Development plans
  - National and regional planning documents
- In some cases the focus is on an holistic approach combining GHG mitigation and CC adaptation (e.g. Canada)
- In other case the focus is solely on climate change adaptation and natural hazards management (e.g. Small Developing Island States)

Level 1 – Intention / Developing Countries

- Small Developing Island States have shown a strong interest in the use of EIA for climate change adaptation
  - Samoa
  - Kiribati
  - Solomon Islands
  - Vanuatu
  - Cook Islands
  - Saint Lucia
- Among the Least Developed Countries Bangladesh considers it through its National Water Management Plan and National Adaptation Program of Actions

Level 1 – Intention / Developed Countries

- Canada is furthest along in terms of considering CC in the EIA process
  - Required for any major development projects
- In 2009 the European Commission proposed to revise the European Union EIA Directive to integrate CC considerations
  - Should be revised by late 2011
  - Most EU countries except the Netherlands and Spain do not consider it currently
- In Australia, EIA provisions are contained in the *EPBC Act* which does not include CC considerations

Level 1 – Intention / Multilateral and Bilateral Agencies

- Recognised as a need and promoted by:
  - World Bank
  - Asian Development Bank
  - Caribbean Development Bank and Carribean Community
  - Inter-American Development Bank
- Bilateral agencies tend to develop “stand alone” climate change tools (AusAID, USAID, DFID, GtZ, etc.) rather than considering it through the EIA process

Level 2 – Operational Guidance and Adjustment of Legal and Regulatory Framework

- Guidance and adjustments of the legal and regulatory framework are necessary to bridge the gap between intention and action

- Relatively few countries have moved toward developing guidance and/or adjusting regulatory framework
  - Australia
  - Canada
  - Grenada
  - Guyana
  - Jamaica
  - Kiribati
  - The Netherlands
  - Trinidad and Tobago

Guidance – Canadian Environmental Assessment Agency (2003)

Step 1	Preliminary Scope for Impacts Considerations - Focus on general considerations and readily accessible information; - Are there likely impacts considerations associated with the project that should be addressed in greater detail? - Document a rationale as to why, or why not; - If there are no likely impacts considerations that should be addressed in greater detail, no further analysis is required; - Proceed to Step 2 if further analysis is required;
Step 2	Identify Impacts Considerations - Identify project sensitivity to possible changing climatic parameters; - Conduct more detailed collection of regional climate change and project specific information; - Clarify changing climatic parameters (magnitude, distribution and rate of changes);
Step 3	Assess Impacts Considerations - Assess range of possible changes to climatic parameters; - Determine the range and extent of possible impacts on the project; - Assess the potential risks to the public or environment; - Based upon the risks to the public or environment resulting from the effects of climate change on the projectt, determine whether impact management is required; - If no further action is required, document impact analysis. No impact management required; - Proceed to Step 4 if further action is required;
Step 4	Impacts Management Plans - If the project is likely to pose risks to the public or environment resulting from the effects of climate change: - Clarify mitigation measures to reduce project vulnerability; - Clarify adaptive management plan to resuce risks associated with climate change; - Incorporate ongoing information gathering and risk-assessment; - Distinguish between public and private sector risks and responsibilities;
Step 5	Monitoring, Follow-Up and Adaptive Management - If the project is likely to pose risks to the public or environment resulting form the effects of climate change; - Monitor status of project and effectiveness of mitigation measures; - Implement remedial action as necessary; - Incorporate "lessons learned' into normal procedures; - Address evolving project and climate change knowledge, technology, policy and legislation.

Source: Canadian Environmental Assessment Agency (2003)

Guidance – CARICOM (2004)

Step 1

Define Project and Alternatives
- Clearly desbribe proposed project, identify alternatives to project and to approaches to implementationt;.

Step 2

Preliminary Vulnerability Assessment
- Preliminary identification of significant hazards and hazard impacts to inform EIA screening and scoping;
- Process;
- Using existing information and expert knowledge, estimate frequency or probability of hazard events;
- Estimate severity of impacts on project components and zone of influence

Step 3

Initial Screening
- Determine, based on information provided, whether
  a) the project is likely to have a significatn effect on the environment and
  b) climate change impacts are likely to have significant effects on the project, and therefore require further study;

Step 4

Scoping
- Identify and agree upon the critical issues to be addressed in the EIA and the information and analyses required for inclusion in the environmental assessment report to determine acceptability and feasibility of the project;

Information needs:
- Baseline data on project site, existing detailed hazard maps and assessment;
- Significant hazards and potential impacts on project and zone of influence/ project boundaries identified in screening;
- Relevant legislation and insititutions;
- Climate change assessments;

Step 5

Assessment and Evaluation
- Fully assess and characterise significant natural hazards, their potential impact on the project and potential effects on those hazards introduced by the project;

Information needs:
- Baseline data, hazard studies and maps indicating past incidence, factors influencing hazard occurrence and climate change scenarioes;

Step 6

Environmental Managament Plan
- A Climate Change Adaptation Program should be developed as part of the EIA process to address significant impacts from climate change that will affect the project and define adaptation measures that will be established to address climate change impacts.

Source: CARICOM (2004)

Level 2 – Operational Guidance and Adjustment of Legal and Regulatory Framework

- Other countries/agencies propose recommendations without providing detailed guidance
  - Jamaica
  - Grenada
  - The Netherlands
  - Trinidad and Tobago
- Recent court case in NSW

Level 3 – Implementation

- This research could only identify documented experiences of implementation in three countries:
  - Australia
  - Canada
  - The Netherlands

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Level 3 – Implementation / The Netherlands

2003

2005

Level 3 – Implementation / Canada

Project	Climate Change Considerations
Cascade Power Park	Changes in hydroelectric regime potentially affecting viability of operations and fisheries.
Conferderation Bridge	Integrity of bridge structure over design life of project due to a rise of 1m in sea level, ice-out and inundation of low-lying areas near the bridge.
Diavik Mines	Permafrost, integrity and design of facilities in light of changes in air temperature, snow cover and precipitation regime.
Dredging of St. Lawrence River	Maintenance of a channel with a minimum depth of 11.3 m below low-water line which may be affected by reductions of water levels and flows in St. Lawrence River arising from lower precipitation and lower Great Lakes levels.
Little Bow Reservoir	Water supply for use in irrigation, municipal water supply and water based recreation as affected by changes to precipitation regime and demand from use of evapotranspiration.
Decommissioning of Quirke and Panel Mines	Permanent containment of tailing ponds requiring adequate supply as affected by extremes in precipitation, both excessive amounts giving rise to floods and insufficient amounts giving rise to droughts.

Source: Adapted from Lee (2001)

Level 3 – Implementation / Australia

- Australia is covered today by Marcus Sainsbury

Level 3 – Implementation / The Maldives

Wrap-up

	Level 1 Intention	Level 2 Guidance	Level 3 Implementation
Developed Countries	Canada	Australia	Australia
	Spain	Canada	Canada
	European Union	Netherlands	Netherlands
Developing Countries	Bangladesh	Grenada	
	Dominica	Kiribati	
	Kiribati	Trinidad and Tobago	
	Saint Lucia	Caribbean Community	
	Samoa		
	Soloman Islands		
	Caribbean Community		
Multilateral Organisations	Asian Development Bank		
	Inter-American Development Bank		
	Work Bank		

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Wrap-up

- Guidance and adjustments of the legal and regulatory framework are necessary to bridge the gap between intention and action

- Relatively few countries have moved toward developing guidance and/or adjusting regulatory framework
    - Australia
    - Canada
    - Grenada
    - Guyana
    - Jamaica
    - Kiribati
    - The Netherlands
    - Trinidad and Tobago

Conclusion

- There are numerous barriers and challenges
- As there are still limited methodology and guidelines published it can result in inconsistent assessments
- Availability and uncertainties of climate observations and projections at the project scale remains an obstacle
- These issues are still insufficiently understood and poorly communicated

Conclusion

- There is a lack of suitable practitioners with working experience in both EIAs and Climate Change Risk Assessments

- EIA are very often required for large infrastructure projects (or when key factors are triggered)
  - Does not cover existing assets and infrastructure
  - Does not cover non-infrastructure projects

Conclusion

- EIA can be considered as a good vehicle for climate change adaptation for new infrastructure projects
- There are a number of entry points to consider climate change during the EIA process
- This approach uses existing tools and methodology
- EIA present the advantage of being accepted and consolidated tools in many countries
- While Strategic Environmental Assessment were not part of this study, they also represent a useful tool for a more strategic approach

"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change."

Charles Darwin