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Adaptation to climate change in regional NRM plans



Guiding integration

This is a supporting document to *Guidelines for Regional Natural Resource Management Planning in Queensland*. This module addresses climate change adaptation in regional NRM plans, target setting and investment strategies. This document does not directly address reducing greenhouse gas emissions. Its purpose is to:

- help guide regional bodies in developing regional natural resource management (NRM) plans that address the following accreditation criteria relevant to climate change adaptation in NRM (see <http://www.regionalnrm.qld.gov.au/>)
 - cover the full range of NRM issues including likely climate change projections and impacts
 - are underpinned by scientific analysis of natural resource conditions, problems and priorities including climate change modelling and projections
 - include strategies to implement agreed NRM policies to protect the natural resource base
 - demonstrate consistency with other planning processes and legislative requirements applicable to the region including climate change provisions of coastal plans and local government planning schemes
 - identify strategic, prioritised and achievable actions to address the range of NRM issues and achieve the regional targets including those that address greenhouse effect outcomes
- provide direction on incorporating the best available information and advice on climate change impacts into regional planning processes and implementation of management actions
- provide a reference point for state priorities on adaptation to climate change for NRM.

Scope

Climate change will take Queenslanders outside the current range of human experience particularly in NRM, land use change and planning, and biodiversity loss/change. Past and current experience informing current planning may be less relevant. Future planning will need to be increasingly proactive and adaptive. While there is a range of possible warming projections to the year 2100, warming and attendant effects will not be felt uniformly. Importantly, more intensive extreme weather events, such as higher intensity rainfall events causing larger scale flooding events or more intensive droughts, may have dramatic impacts on natural resources. There are multiple interactions with climate variability and other environmental issues. Impacts will cross research and economic areas, and industry sectors.

No part of Queensland will be immune to its effects. Changes are and will be felt at regional and local spatial scales and have decadal variability. Impacts of climate change will be complex and to some degree uncertain. Increased foresight would enable planners to optimise the future through planned adaptation. Adaptation is essential to cope with unavoidable climate changes.

Climate change responses need to be integrated into NRM policy, targets and on-ground actions. Sectors that keep pace with or ahead of climate change issues will be better positioned in the future (environmentally, socially and economically). Policies need to facilitate adaptive management for increased landscape resilience. Policy formulation and implementation itself will need to be more responsive in a dynamic climate change regime. More effective strategic environmental assessment, NRM

planning and market based and community sourced adaptation and mitigation is required.

Queensland Government initiatives

The Queensland Government is currently working with other states and the Australian Government on the implementation of the *National Greenhouse Strategy*. The Queensland Government is introducing various policies and initiatives to deal with issues specific to the state, including the *Queensland Greenhouse Policy Framework 2001*, *Queensland Energy Policy – A Cleaner Energy Strategy 2000* and the *Queensland Greenhouse Strategy 2004*. This module is intended to encourage regional body participation in strategies that address climate change impacts. This will also assist in meeting state, national and international obligations on adaptation to climate change.

Climate change projections and impacts

While uncertainty remains with predicted climate change scenarios, more extreme weather events, higher temperatures and lower rainfall are likely to have already commenced and to continue. Predictions for Queensland by 2070 indicate mean temperature increases above 1990 levels of 0.8 to 5.0 degrees Celsius.

Rainfall projections are more uncertain though less rainfall is predicted along much of the coast, central west and northern regions (range by 2030 +5 percent to –15 percent). Rainfall variance within seasons also needs to be considered e.g. the spring average pattern of decreasing rainfall extends over the majority of Queensland, with rainfall reductions in the range of +5% to –25% by 2003. Rainfall events may be more extreme e.g. in northern Queensland, a current 1-in-40 year storm event may occur 1-in-15 years by 2050. Similarly, the future 1-in-40 rainfall event is likely to increase from 78 mm to 100 mm.

In addition, rising sea level, more severe tropical cyclones with increased intensity of oceanic storm surges and flooding are likely. A study has shown that tropical cyclone intensity around Cairns in northern Queensland could increase by 20 percent by about 2050. More severe cyclones would increase the flood level associated with a 1-in-100 year flood in Cairns from the present height of 2.3 m to 2.6 m; a rise in sea level of 0.1 m to 0.4 m would result in the flood level increasing further to 2.7 to 3.0m by 2050. This would result in flooding occurring over an area about twice that historically affected.¹

In order to achieve sustainable NRM such changes in climate and associated natural hazards must be incorporated in condition and trend studies for NRM and subsequent resource condition targets and management actions.

Foreseeable impacts of climate change, particularly relevant to the regional bodies may include:

- more extensive storm tide flooding and erosion of coastal areas and infrastructure associated with sea level rise and changes in cyclone frequency and intensity
- changes in end of system river flows as a result of reduced annual rainfall and rainfall runoff and increased rainfall intensity (flooding)
- increases in potential riverine sediment and nutrient loads due to changes in rainfall intensity and ground cover

¹ Australian Greenhouse Office 2002. *Living with Climate Change. An Overview of Potential Climate Change Impacts on Australia*.

- possible loss of wetland and mangroves as a result of increases in sea level, saltwater intrusion and coastal erosion
- increased disturbance of vegetation from more extreme wild fires and prolonged drought
- increased stress on biodiversity resulting in changes in structure and composition, possibly leading to extinctions
- reduced soil moisture due to increasing evaporation
- heat stress on livestock and wildlife
- increasing problems with pests, disease and weeds
- changes to more adaptable agricultural enterprises
- possible negative impacts on sea grasses as a result of changes to coastal turbidity and ocean temperatures
- secondary impacts on marine population dynamics i.e. changes in abundance, species dominance and recruitment.

There is a need to adopt an integrated approach to impact assessments, whereby climate change is considered in conjunction with the other socio-economic and resource issues related to NRM planning. Integrated assessments will enable possible clashes to be identified and the overall least cost and most beneficial strategies to be chosen.

Information available

For information on regional climate change scenarios and likely impacts contact CSIRO (<http://www.dar.csiro.au/impacts/future/html>) and the Queensland Climate Impacts and Natural Resource Systems Centre (<http://www.longpaddock.qld.gov.au/>).

For a recent summary, refer to the recent publication *Climate Change - An Australian Guide to the Science and Potential Impacts 2003* (<http://www.greenhouse.gov.au/science/guide>)

Further fine-scale modelling is required for improved projections to facilitate natural resources planning. Research on this topic could form part of the regional NRM plan management actions. Example research projects for natural resource climate change impacts currently underway include:

- establishing the links among climate change, salinity and water yield and optimal revegetation for sinks in two sub-catchments in the Murray-Darling Basin
- managing climate variability research and development program (www.lwa.gov.au).

Further research is necessary to reduce the uncertainties, better establish probabilities and identify the most cost-effective adaptation and mitigation options and strategies, which in most cases need to be location and sector specific.

See *References* later in this guideline for more detail.

Addressing climate change adaptation in regional NRM plans

Regional NRM plans need to take account of regional trends in climate change as such trends are likely to impact on regional natural resources and subsequently on environmental values and communities. While there may be a lack of information about the impacts of climate change on natural resources there is some relevant impact assessment work underway as pilot projects (contact state agencies). Regional bodies operate at a scale that allows observation and response to climate change as well as take account of predictive modelling results.

Climate change scenarios and predictive modelling of climate change is also currently available on a regional basis. Guidance to communities through regional planning forums can be an effective means for providing comprehensive and regional specific responses. Many (but not all) such responses to climate change can be implemented via regional NRM planning and local government planning schemes. Decisions about the future use and development of natural resources should be made in the context of expected climate change for the region.

Regional-specific risk assessments of vulnerability to climate change should be undertaken as an early step in an integrated climate change adaptation regional strategy. A suggested 50-70 year outlook should provide a reasonable guide to future climatic variations. Results from an integrated risk assessment can be considered when setting targets and developing management actions.

Regional NRM plans should be vehicles for introducing and implementing an array of climate change adaptation measures. The regional NRM plan forum allows communities to invest in climate change adaptation in an organised and effective way. Regional NRM plans can:

- take account of available climate change model predictions such as rainfall, water flows, water quality (salinity) in resource condition targets and subsequent management actions
- take account of changing land-use suitability for agriculture, industry development, nature conservation and any existing targets for land and water resources and energy use
- facilitate ways to highlight the issues and obtain community support for initiatives on adaptation to climate change.

Effective regional NRM planning for coping with climate change would generally provide an assessment of vulnerabilities to climate change and possible adaptation strategies for the region via:

- a risk assessment of how changing patterns of rainfall and hydrology, temperature and extreme weather may affect regional NRM
- outlining the preferred and alternative adaptation strategies to be initially implemented, including deliberate allowances for future NRM
- developing commitments to undertaking ongoing monitoring of climate change so as to progressively adapt as required.

In regions where NRM planning processes are underway opportunities exist for the adoption of commitments for the progressive development of adaptation measures in response to regional trends in climate change.

Regional NRM plans may address adaptation to climate change by:

- identifying vulnerable areas with the relevant likelihood and type of hazards (this may form management action involving studies/assessments)
- assessing the extent of vulnerability and potential consequences to natural resources for each vulnerable area e.g. which species/ecosystem is vulnerable
- evaluating adaptation options and implications for each vulnerable area
- selecting the adaptation options for each area and combine into a planning and management strategy for the area
- incorporating the strategy into the regional NRM plan via achievable targets and management actions with links to other measures as required (e.g. local planning schemes, local laws or other NRM instruments)
- outlining how climate change impacts and adaptation measures will be monitored through time and adjustments made to regional NRM initiatives.

The following diagram illustrates how the climate change adaptation measures can be integrated into a regional NRM plan. Following are examples of specific initiatives:

Adaptation for coastal management

To support the implementation of the *State Coastal Management Plan 2001* (SCMP) and any relevant regional coastal management plans (RCMP), regional NRM plans should identify measures relating to climate change in the region. Local governments and other relevant planning bodies are encouraged to take account of new climate change data as it becomes available to ensure the protection of human life, property and natural resources.

The *SCMP 2001* and the several existing RCMPs contain principles, policies and recommendations on planning provisions for adaptation to climate change that should be addressed by regional NRM planning (for details see Attachment 1).

Adaptation for farmland and farming

Actions in regional NRM plans can encourage the adoption of adaptation measures by the farming community. Adaptation measures for cropping to enhance landscape resilience may include:

- on-ground techniques (e.g. zero tillage)
- opportunistic cropping
- water use efficiency
- crop varieties selection and development
- maintaining riparian and other corridors
- stringent record keeping (climate, yield)
- pest control.

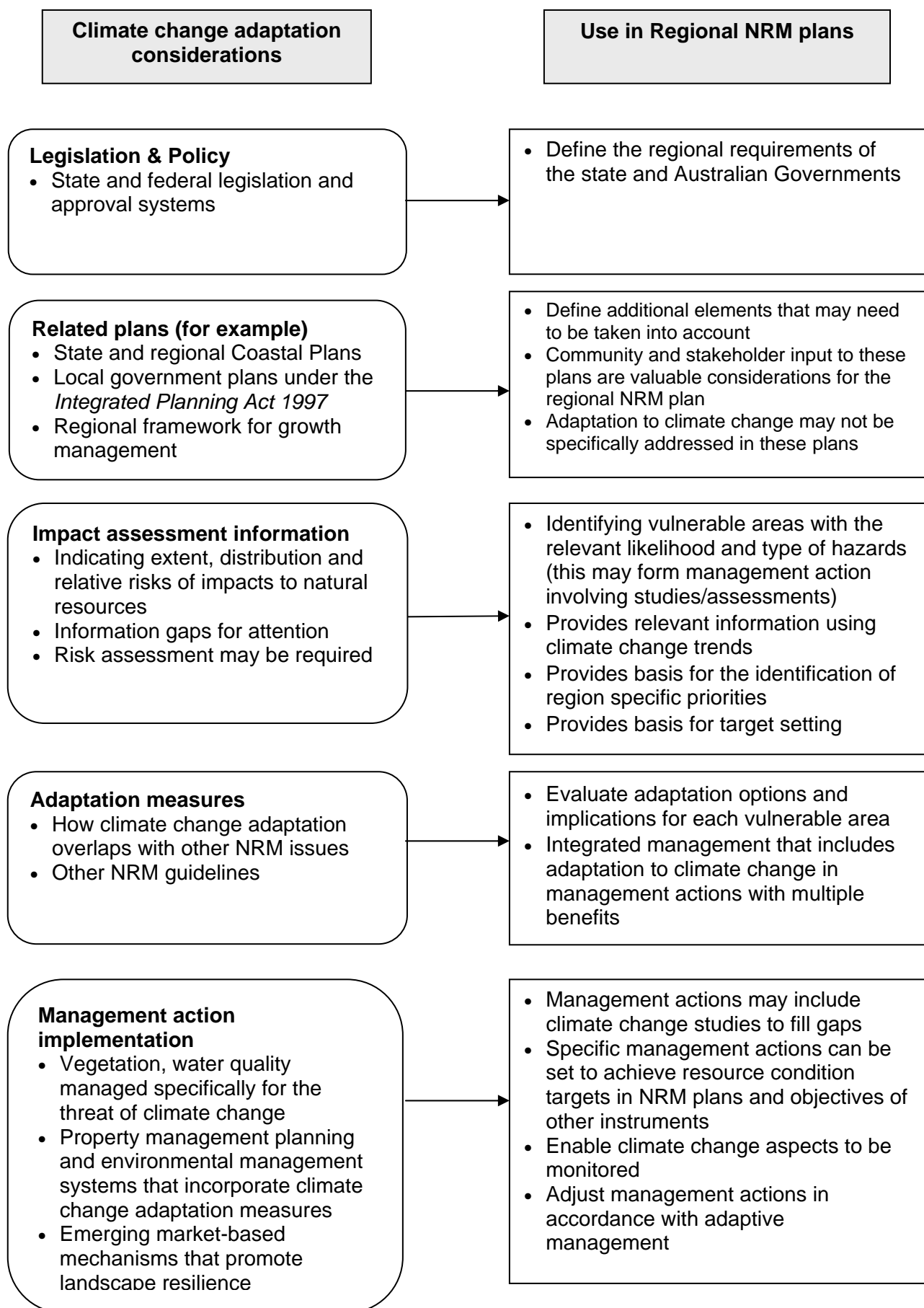
Adaptation measures for grazing to avoid possible major land degradation events include:

- maintaining access to, and using, information on climate forecasting and climate risk assessment (e.g. pasture management)
- resource monitoring and remote sensing of land cover and clearing
- implementing safe carrying capacity and drought alerts, degradation alerts
- facilitating grazer ownership of these issues as well as community engagement
- greater use of tools such as *Grazing Land Management Package* and *Australian Rainman* (see <http://www.lwa.gov.au/products.asp>)
- pest control.

Implementing NRM plans

Climate change adaptation measures identified in regional NRM plans can be implemented through a range of mechanisms including:

- through local government planning by ensuring planning scheme assessment codes, overlays and other measures include suitable provisions
- adaptive water planning under the *Water Act 2000*
- adaptive vegetation management under the *Vegetation Management Act 2001*
- agricultural industry initiatives
- using conservation agreements under the *Nature Conservation Act (1992)* to conserve biodiversity
- addressing climate change projections in property management planning.



Linkages and integrated management

Existing legislation, plans and policies contain provisions about climate change adaptation that need to be reflected in regional NRM plans. Some examples include:

Legislation

- *Coastal Protection and Management Act 1995* including state and regional coastal plans
- *Environmental Protection Act 1994* including environmental values protection measures
- *Land Act (1994)* including leasehold land conditions and vegetation clearing
- *Marine Parks Act (1982)* including zoning plans for marine parks
- *Water Act 2000* including water management plans.

Local, regional, state and national planning

- Local government planning schemes and supporting local laws and policies
<http://www.ipa.qld.gov.au/>
- State and regional coastal management plans
<http://www.epa.qld.gov.au/>
- Reef Water Quality Protection Plan, Department of the Environment and Heritage, Australian Government, October 2003
<http://www.thepremier.qld.gov.au/reefwater/downloads/rwqpp.pdf>
- Guidelines such as *Biodiversity Conservation in Regional NRM Planning*, Land and Water Australia Research, November 2003
<http://www.lwa.gov.au/sirp>

Information on climate change impacts and responses, including:

- *Queensland Greenhouse Policy Framework: A climate of change*, Environmental Protection Agency, Queensland Government, 2001
<http://www.env.qld.gov.au/publications?id=546>
- *Developing a National Biodiversity and Climate Change Action Plan*, prepared by the National Task Group on the Management of Climate Change Impacts on Biodiversity convened under the NRM Ministerial Council's Land, Water and Biodiversity Committee Department of the Environment and Heritage, September 2003
<http://www.deh.gov.au/nrm/publications/biodiversity/>
- *Climate Change in Queensland under Enhanced Greenhouse Conditions* reports on research undertaken for Queensland Departments of State Development, Main Roads, Health, Transport, Mines and Energy, Treasury, Public Works, Primary Industries and Natural Resources, CSIRO, 2002
<http://www.dar.csiro.au/impacts/future/html>.
- Climate Change impacts on Australia's Natural Resources – Conference papers, November 2003
<http://www.climateimpacts.com.au/>
- *Climate Change: An Australian Guide to the Science and Potential Impacts 2003*, edited by Barrie Pittock Australian Greenhouse Office
<http://www.greenhouse.gov.au/science/guide>
- *Environmental Crisis: Climate Change and Terrestrial Biodiversity in Queensland*, January 2004, edited by A.K. Krockenberger, R.L. Kitching, and S.M. Turton, Cooperative Research Centre for Tropical Rainforest Ecology and Management

Climate change adaptation is linked to many facets of natural resource management and this needs to be taken into account in the context of the other NRM modules.

Resources for climate change impacts and their mitigation should be addressed in regional NRM planning and any investment strategies.

Contacts, support and further information

The Environmental Protection Agency has developed the *Directory of Products and Services for regional natural resource management, planning and implementation* that provides guidance on the range of information and advice available from EPA supporting the making of NRM plans. The directory can be found at <http://www.epa.qld.gov.au/publications?id=735>

The state government contact officers listed below can assist regional NRM bodies with queries about climate change in their region.

Environmental Protection Agency (EPA)	Department of Natural Resources & Mines (NR&M)	Department of Primary Industries and Fisheries (DPI&F)
Manager (Environmental Planning) Southern Queensland Ph: (07) 3224 7049 MEP.Southern@epa.qld.gov.au	Natural Resource Sciences Indooroopilly Block A 80 Meiers Road Indooroopilly Qld 4068 Telephone: 07 3896 9523	Mr David McRae Research Scientist PO Box 102 Toowoomba Qld 4350 Phone: (07) 4688 1459 Fax: (07) 4688 1477 David.McRae@dpi.qld.gov.au
Manager (Environmental Planning) Central Queensland Ph: (07) 4936 0523 MEP.Central@epa.qld.gov.au	Attn: Mr Michael Gabriel Principal Project Officer Michael.Gabriel@nrm.qld.gov.au	Theresa Bishop Policy Officer (Policy Analysis and Industry Development) Phone: (07) 3239 3497 Fax: (07) 3239 3379 theresa.bishop@dpi.qld.gov.au
Manager (Environmental Planning) Northern Queensland Ph: (07) 4722 5240 MEP.Northern@epa.qld.gov.au	Attn: Ms Jacqui Willcocks Senior Project Officer Jacqueline.Willcocks@nrm.qld.gov.au http://www.nrm.qld.gov.au/science/climate.html http://www.longpaddock.qld.gov.au/ClimateChanges/	Theresa Bishop Policy Officer (Policy Analysis and Industry Development) Phone: (07) 3239 3497 Fax: (07) 3239 3379 theresa.bishop@dpi.qld.gov.au http://www.dpi.qld.gov.au/climate/

Glossary

Abatement	Reduction of the quantity of emissions.
Adaptability	Degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and be carried out in response to or in anticipation of changes in conditions.
Carbon sequestration	The removal of carbon dioxide from the atmosphere by storing it away in places (sinks) such as biomass (trees, soils and crops), the ocean depths, disused oil wells or suitable geological formations.
Carbon sink	See carbon sequestration.
Climate change	A change in climate, attributable directly or indirectly to human activity which alters the composition of the global atmosphere and, in addition to natural climate variability, is observed over comparable time periods. Can be caused by an increase in the atmospheric concentration of greenhouse gases that inhibits the transmission of some of the sun's energy from the Earth's surface to outer space. These gases include carbon dioxide, methane, nitrous oxide and a number of synthetic gases including perfluorocarbons, sulfur hexafluoride and hydrofluorocarbons and other chemicals. Increases in these gases arise primarily from human activities such as the burning of fossil fuels i.e. gasoline, oil, coal and natural gas, as well as deforestation.
CO₂ equivalent	The basis for comparing the warming effect of greenhouse gases such as methane, nitrous oxide and the perfluorocarbons.
EIA	Environmental impact assessment is the process in which environmental management is integrated into planning for proposals. A more detailed definition from the International Association of Impact Assessment (1999) serves equally as well - "the process of identifying, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made".
EIS	An Environmental Impact Statement is a document that assesses the potential adverse and beneficial environmental, social and economic impacts of the proposal, proposes measures to manage potential impacts, looks at alternatives to the project and provides information to decision-makers and the community.
EIS assessment report	A report from the government about a submitted EIS describing whether the EIS meets the terms of reference and making recommendations on the proposal.
Emissions	Pollutants released to air, land or waterways from industrial processes, households or transportation vehicles.
Energy efficiency	Energy efficiency is about getting the most useful work from every unit of energy consumed, or producing a product using the least amount of energy possible, without compromising quality.
Global warming	The progressive gradual rise of the Earth's surface temperature caused by the human induced rise in greenhouse gas concentrations

in the atmosphere and the consequent increased greenhouse effect responsible for changes in global climate patterns.

Greenhouse Challenge A national program established by the Australian Greenhouse Office to address greenhouse gas intensity of processes in organisations.

Greenhouse effect The progressive, gradual warming of the Earth's atmospheric temperature, caused by the insulating effect of carbon dioxide and other greenhouse gases that have proportionately increased in the atmosphere. The greenhouse effect disturbs the way the Earth's climate maintains the balance between incoming and outgoing energy by allowing short-wave radiation from the sun to penetrate through to warm the Earth, but preventing the resulting long-wave radiation from escaping back into the atmosphere.

Greenhouse gases Gases that affect the temperature of the Earth's surface. Greenhouse gases consist of the following direct and indirect* gases which influence global warming:

- carbon dioxide (CO₂)
- methane (CH₄)
- nitrous oxide (N₂O)
- perfluorocarbons (PFCs)
- sulfur hexafluoride (SF₆)
- carbon monoxide (CO)*
- oxides of nitrogen (NO_x)*
- non-methane volatile organic compounds (NMVOCs)*
- sulfur dioxide (SO₂)*
- water vapour (H₂O)
- tropospheric ozone (O₃)
- chlorofluorocarbons (CFCs).

The first three gases are the main gases reported in the national and state greenhouse gas inventories. CFCs are controlled current and past events. Regrowth on cleared lands provides a carbon sink.

The properties of these gases relate to the transmission or reflection of different types of radiation. The increase in such gases in the atmosphere, which contributes to global warming, is mainly the result of the burning of fossil fuels, the emission of pollutants into the atmosphere and deforestation.

Intergovernmental Panel on Climate Change (IPCC) An international body of scientists, jointly established by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP), which serves as a key provider of information to the Conference of Parties (CoP) to the United Nations Framework Convention on Climate Change (UNFCCC).

Kyoto Protocol An international agreement struck by 159 nations attending the Third Conference of Parties (CoP-3) to the United Nations Framework Convention on Climate Change (held in December 1997 in Kyoto, Japan) to reduce worldwide emissions of greenhouse gases.

'Annex B' countries: 38 countries agreed to limit their emissions of six greenhouse gases. Collectively, these 'Annex B' countries agreed to reduce their annual emissions by a total of 5.2 percent between 2008 and 2012 from 1990 levels.

Offsets	Activities to mitigate greenhouse gas emissions, usually implemented off site, without affecting emissions levels at the primary source.
Precautionary principle	Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation. In the context of the UNFCCC it can be expressed as that action to forestall large scale, irreversible damage from climate change is warranted even though the risks of climate change are not yet fully understood. The precautionary principle thus puts a premium on the long-term safeguarding of the world's climate system, even in the face of uncertainty about the impacts and the need to bear near-term costs of mitigation.
Proponent	The person who proposes the project.
Stakeholders	Persons or bodies affected by or interested in EIA outcomes.
Sustainable development	A broad concept referring to the need to balance the satisfaction of near-term interests with the protection of the interests of future generations, including their interests in a safe and healthy environment. As expressed in the <i>Environmental Protection Act 1994</i> , "ecologically sustainable development is protecting the environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends".
Terms of Reference	Provides advice on the structure and scope of the Environmental Impact Statement.
United Nations Framework Convention on Climate Change (UNFCCC)	The centrepiece of global efforts to combat global warming. It was adopted in June 1992 at the Rio Earth Summit, and entered into force on 21 March 1994. Australia ratified the Convention on 30 December 1992. The Convention's primary objective is the "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (man-made) interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner."

References

The following web addresses contain documents and background materials on the greenhouse issue.

International

- United Nations Framework Convention on Climate Change - <http://www.unfccc.de/>
- Intergovernmental Panel on Climate Change - <http://www.ipcc.ch/>
- IPCC (2001) *Climate Change: Impacts, Adaptation and Vulnerability - Summary for Policymakers*, Intergovernmental Panel on Climate Change <http://www.unep.ch/ipcc> and http://www.grida.no/climate/ipcc_tar/wg2/index.htm

National

- Australian Greenhouse Office, Australian Government - <http://www.greenhouse.gov.au/>
- Australian Greenhouse Office 2002, *Living with Climate Change - an overview of Potential Climate Change Impacts on Australia*.
- Australian Standard 3598:2000 Energy Audits
- Environment Australia's *Framework for Public Environmental Reporting* – www.ea.gov.au/industry/eecp/publications/pubs/per-framework.pdf
- *Climate change - An Australian Guide to the Science and Potential Impacts* - <http://www.greenhouse.gov.au/science/guide/index.html>
- CSIRO (2001), *Climate Change Projections for Australia* - <http://www.dar.csiro.au/publications/projections2001.pdf>
- CSIRO (2002), *Climate Change and Australia's Coastal Communities* - <http://www.dar.csiro.au/publications/CoastalBroch2002.pdf>
- CSIRO information on regional climate change projections – <http://www.dar.csiro.au/impacts/future.html>
- Greenhouse Friendly Certification Program – <http://www.greenhouse.gov.au/greenhousefriendly/index.html>
- Greenhouse Science – <http://www.greenhouse.gov.au/science>
- National Greenhouse Strategy – <http://www.ngs.greenhouse.gov.au/>
- National Greenhouse Gas Inventory workbooks- <http://www.greenhouse.gov.au/inventory/index.html>
- *The Greenhouse Challenge Factors and Methods Workbook* – http://www.greenhouse.gov.au/challenge/html/member-tools/fmw_v3.pdf
- Marginal emission factors for electricity use, transport, and natural gas under the Greenhouse Gas Abatement Program – <http://www.greenhouse.gov.au/ggapinternet/atc.htm>
- National Biodiversity and Climate Change Action Plan 2003 – Natural Resources Ministerial Council (NRMCC)
- Greenhouse in Agriculture and Natural Resource Systems Working Group

Queensland

- Queensland Centre for Climate Change Applications - <http://www.dnr.qld.gov.au/qcca/>
- Queensland's Department of Natural Resources and Mines web site <http://www.longpaddock.qld.gov.au/ClimateChanges/> contains useful links page.
- Queensland Environmental Protection Agency (EPA) - <http://www.env.qld.gov.au>
- Queensland EPA's site for case studies and publications on cleaner production – <http://www.epa.qld.gov.au/environment/business/production/>
- Queensland EPA's site for general information on sustainable business - www.epa.qld.gov.au/sustainable_industries
- Environmental Protection Agency (2004) *Queensland Greenhouse Strategy* - <http://www.epa.qld.gov.au/>

Other Queensland references and information sources:

- Crimp, S., Balston, J., and Ash, A. (2002) A Study to Determine the Scope and Focus of an Integrated Assessment of Climate Change Impacts and Options for Adaptation in the Cairns and Great Barrier Reef Region, Australian Greenhouse Office, Australia.
- Office of Sustainable Energy, Sustainable Industries Division, EPA
- PIA, 2003, *Climate Change*, Planning Institute of Australia (Qld)/Australian Greenhouse Office, [Online] Available at:
<http://www.planning.org.au/qld/climatechange/>
- Queensland Transport – model policies, objectives and planning provisions for integrated transport and land-use planning.
- Walsh, K., Hennessy, K., Jones, R., McInnes, K., Page, C., Pittock, B., Suppiah R and Whetton, P. (2001). *Climate Change in Queensland under enhanced conditions: Third Annual Report*. CSIRO Atmospheric Research, 108pp.

Attachment 1 Coastal management initiatives

The State Coastal Management Plan 2001 and the several existing regional coastal management plans contain principles, policies and recommendations on planning provisions for adaptation to climate change that should be addressed by regional NRM planning including:

- coastal management outcome statements such as:
 - the coast is managed to allow for natural fluctuations to occur, including any that occur as a result of climate change and sea level rise, and provide protection for life and property.
- principles such as:
 - trends in climate change including sea level rise and more extensive storm tide flooding necessitate impact and vulnerability assessments before plans for progressive adaptation can be made
 - knowledge and understanding of greenhouse issues and climate change impacts should be improved amongst the public and private sectors with the aim of setting the foundation for cost effective adaptation measures. The four target areas are:
 - avoidance of development on vulnerable areas
 - improved knowledge and understanding of climate change
 - assessments of impacts and vulnerability
 - incorporating adaptation strategies into coastal planning and management.

Climate change is having and is predicted to continue to have physical, social and economic impacts on the coastal zone and human settlements including:

- increased vulnerability of beach and dune systems to coastal erosion
- potential shoreline recession
- inundation of coastal lowlands
- higher frequency and more extensive storm tide flooding
- possibly more frequent severe storm events such as tropical cyclones
- saltwater intrusion of estuaries and aquifers
- changes in the characteristics of near-coastal surface and groundwater due to the predicted long-term changes to rainfall patterns
- reduced coastal habitats due to changes in tidal inundation
- increased reef vulnerability and mortality, including from coral bleaching
- changes to coastal and estuarine processes resulting in altered sediment deposition patterns in near shore areas
- alteration of marine biodiversity and displacement of coastal wetlands
- increased risk of damage to coastal infrastructure
- possible reduction in water quality in coastal rivers
- loss of tourism, recreation and transportation functions, and impacts on agriculture on the coast.

Planning for the coast must address the potential impacts of climate change through the following hierarchy of approaches:

- *avoid* — focus on locating new development in areas not vulnerable to the impacts of climate change
- *planned retreat* — focus on systematic abandonment of land, ecosystems and structures in vulnerable areas
- *accommodate* — focus on continued occupation of near-coastal areas but with adjustments such as altered building design
- *protect* — focus on the defence of vulnerable areas, population centres, economic activities and coastal resources.

Policies specifically targeted at avoiding development in vulnerable areas are contained in state and regional coastal plans. Many regions include low-lying areas and erosion prone areas that are susceptible to climate change trends such as sea level rise and more extensive storm tide flooding. Areas of concern are islands, estuaries, waterways and the riparian zones. Climate change has the potential to impact on Indigenous Traditional Owner cultural resources within the areas of concern identified above.

Erosion prone areas provide an indication of areas vulnerable to sea level rise. Local governments and state agencies are involved in mapping storm tide potential to identify high-risk areas, which will provide an indication of the areas vulnerable to the effects of climate change.

For more details see the coastal management plans and the module *Integrating Coastal and Marine Park Management into Regional NRM Plans*.