Activity - Impact Linkages

4.1 Introduction

There is evidence that coral reefs are under global threat and it has been estimated that around 70% of all the world's coral reefs are degraded in some way (Zann 1995). Given that the Great Barrier Reef is the largest coral reef complex in the world, it is not surprising that there is general community concern about the possible impacts of coastal urban development adjacent to the Great Barrier Reef World Heritage Area. This is reinforced by evidence of urban run-off and wastes leading to destruction of reefs in other parts of the world (see for example, Ferguson Wood and Johannes 1975; Kinsey 1987).

The potential impacts of urban development on coastal values has emerged in recent years as an important planning issue. This is evidenced by:

- the terms of reference of the 1993 Resource Assessment Commission Coastal Zone Inquiry,
- the findings of the State of the Marine Environment Report for Australia (Zann 1995),
- the findings of the 1996 Australian Bureau of Statistics Report on 'Australians and the Environment',
- the findings of the 1996 State of the Environment Report for Australia, and
- the findings of the recent Review of the Marine Tourism Industry in the Great Barrier Reef World Heritage Area (Tourism Review Steering Committee 1997).

The purpose of this chapter is to address potential impacts associated with coastal urban development and the associated management needs of the adjacent World Heritage Area. It does this by discussing:

- the full range of impacts that need to be considered,
- available evidence of impacts, and
- implications for decision-making processes connected with coastal urban development.

In view of the relative weights that were assigned to the study outputs by the Steering Committee, this chapter does not attempt to present a detailed analysis of potential impacts arising from coastal urban development. Its primary purpose is to provide, particularly for local government, an awareness of the full range of potential impacts that need to be considered in making decisions about coastal urban development.

4.2 Impacts that need to be Considered

In a nutshell, the coastal planning and management process is all about the allocation of scarce coastal resources amongst different, and sometimes competing interest groups. Urban development encompasses a broad 'church' of interest groups and is a legitimate use of the coastal zone.

However, in areas adjacent to the Great Barrier Reef World Heritage Area, decisions to allocate coastal resources for urban purposes should only be made in the light of relevant international obligations and intergovernmental agreements. Of particular note is:

- the need to protect World Heritage values – this requires knowledge of those values and the likely effects of urban development,
- the need for sustainability, taking into account all of its ecological, economic, social and cultural dimensions, and
- the need to apply the precautionary principle which involves:
  - dealing cautiously with uncertainty,
  - shifting the burden of proof onto development proponents,
  - ensuring that environmental wellbeing is given legitimate status, and
  - developing best practice techniques in the pursuit of management excellence.

The 'correct' allocation of coastal resources requires informed and prudent decision making. In the case of coastal urban development, this implies a need to take into account:

- both the positive and negative effects of development proposals,

- all of the various biological, physical, economic, cultural, social and amenity implications over both the short and the long term, and
- all of the secondary, indirect or downstream effects of planning and development decisions.

While there is a requirement under the World Heritage Convention that 'outstanding universal values' be protected, the way in which these values are often expressed makes it difficult for them to be adequately incorporated into local government planning schemes and development control processes. For example, the assessment of the outstanding universal value of the Great Barrier Reef World Heritage Area prepared by Lucas et al. (1997) classifies values on the basis of either:

- attributes which include a mixture of organisms and features,
- processes, or
- whole of system characteristics.

These are often difficult concepts to incorporate into traditional planning and decision-making processes. From the point of view of local government planning, there may be advantages in focusing on ecosystems as the mechanism for incorporating values and management needs into local government decision making. Ecosystems include consideration of ecological communities, physical environments, biological and physical processes and they can be mapped.

The Queensland Department of Environment has already prepared a draft report on coastal ecosystems of Queensland, their values and management needs (Saenger and Pitts 1997). Extracts from this draft report are included in appendix 3. Links between urban development activities and coastal ecosystems are illustrated in table 4.1. The information contained in table 4.1 is intended to be illustrative rather than definitive. Its main purpose is to show the diverse and sometimes complex interactions between coastal urban development and coastal ecosystems.

Recreational and commercial fishers are two stakeholder groups that have played a significant role in raising awareness of the potential impacts of coastal urban development on marine and estuarine habitats. These groups have long argued that environmental degradation of fish habitats in Queensland has resulted from:

- fragmented responsibility for management of coastal resources, and
- the lack of overall strategic plans for natural resource conservation and management (Queensland Fisheries Management Authority 1996).

The 1993 State Government Inquiry into Recreational Fishing identified a number of key environmental issues that require attention. These include the following issues which are of direct relevance to coastal urban development:

- sewage discharge into aquatic environments,
- industrial and domestic run-off,
- loss of fishing amenity caused by jet skis, hovercraft and 4WD vehicles,
- loss of access to foreshores and waterways resulting from coastal development,
- siting of rubbish tips, and
- dredging and extraction of sand and gravel resources.

4.3 Evidence of Impacts

There has been no attempt to address the impacts of coastal urban development on the values of the World Heritage Area in any comprehensive or systematic manner. What does exist are:

- broad-scale assessments of total nutrient loadings over the Great Barrier Reef lagoon, and
- smaller, localised assessments of the impacts of some aspects of coastal urban development.

In so far as nutrient and sediment discharges into the Great Barrier Reef lagoon as a whole are concerned, Brodie (1995a) provides a summary of the latest findings. These show that:

- approximately 15 million tonnes of sediment, 77 thousand tonnes of nitrogen and 11 thousand tonnes of phosphorus are discharged by coastal rivers,
- the major sources of nutrients are grazing lands (80%) and areas under sugar cane (15%) – sewage discharges contribute approximately 1% of the overall flux,

Table 4.1 Changes to Coastal Ecosystems Arising from Urban Development

Nature of Change	Ecosystems Potentially Affected	Examples of Sources of Change
Changes in local drainage patterns and watershed levels	• Freshwater Streams and Stream Banks • Swamp Forests and • Woodlands • Mangroves • Seagrass Beds • Shallow Channels • Saltmarshes • Ephemeral Lakes	• Dams, weirs or other structures which modify flow regimes of rivers and creeks • Modification of natural drainage channels (e.g. channelisation) • Filling of flood plains or wetlands • Gravel extraction • Piped drainage schemes • Vegetation removal which alters run-off rates
Changes in groundwater levels or quality	• Freshwater Streams and Stream Banks • Swamp Forests and • Woodlands • Mangroves • Saltmarshes • Cays • Ephemeral and Dune Lakes	• Modification of natural drainage channels (e.g. channelisation) • Filling of flood plains or wetlands • Septic tank seepage • Piped drainage schemes • Vegetation removal which alters groundwater levels • Groundwater extraction for domestic purposes • Intrusion of saltwater
Changes in sediment deposition patterns or rates	• Freshwater Streams and Stream Banks • Mangroves • Saltmarshes • Seagrass Beds • Sandy Coasts • Fringing Reefs	• Construction of dams, weirs or other structures which modify sediment regimes • Foreshore development • Dredging and extractive operations • Clearing of stream banks
Changes in light levels due to increases in suspended solids or turbidity	• Seagrass Beds • Mangroves • Fringing Reefs • Freshwater Streams and Stream Banks	• Dredging and extraction operations • Roads, bridges and dams • Wastewater disposal • Foreshore development • Stormwater run-off
Changes to temperature regimes (thermal pollution)	• Soft Bottoms • Mudflats, Sandflats and Sandbars • Seagrass Beds • Rocky Foreshores • Mangroves • Freshwater Streams and Stream Banks • Fringing Reefs	• Power stations • Industrial cooling • Loss of Stream Bank vegetation

Changes to water quality, including nutrient and organic enrichment	• Soft Bottoms • Seagrass Beds • Rocky Foreshores • Mangroves • Freshwater Streams and Stream Banks • Fringing Reefs • Ephemeral and Dune Lakes	• Disposal of sewage and industrial effluent • Marine and recreational facilities • Disturbance of sediments • (e.g. dredging and extractive operations) • Stormwater run-off • Solid waste disposal sites • Roads, bridges and dams
Changes to salinity regimes	• Mangroves • Saltmarshes • Freshwater Streams and Stream Banks • Swamp Forests and Woodlands • Ephemeral Lakes and Dune Lakes • Rocky Foreshores	• Construction of dams, weirs and other structures which interfere with tidal levels, flood behaviour, flushing or mixing • Dredging and extractive operations • Foreshore developments • River improvement works • Stormwater run-off
Changes to tidal regimes/tidal drainage patterns	• Freshwater Streams and Stream Banks • Mangroves • Saltmarshes • Swamp Forests and Woodlands • Sandy Coasts • Mudflats, Sandflats and Sandbars • Shallow Channels • Rocky Foreshores	• Construction of dams, weirs, spits, retention walls and other structures which will influence/change natural tidal limits • Dredging and Extractive operations • Foreshore developments and reclamation • River improvement works • Clearing of intertidal vegetation
Changes in wave regimes	• Rocky Coasts • Mudflats, Sandflats and • Sandbars • Sandy Coasts	• Breakwater construction • Seawalls
Changes in sand mobility	• Sandy Coasts • Seagrass Beds • Sandy Bottoms • Mudflats, Sandflats and Sandbars	• Vegetation clearance • Offroad vehicles • Recreational activities • Bait digging
Erosion due to increased currents and wave action	• Sandy Foreshores	• Breakwater construction • Channel re-alignment
Erosion due to increased rates of surface run-off	• Swamp Forests and Woodlands	• Catchment vegetation removal • Channelisation/piped drainage schemes
Wind erosion	• Sandy Coasts • Dune Lakes	• Foreshore development • Offroad vehicles • Access tracks

Physical disturbance of substrates or shorelines	• Mudflats, Sandflats and Sandbars • Seagrass Beds • Mangroves • Sandy Bottoms • Soft Bottoms • Rocky Foreshores • Fringing Reefs	• Offroad vehicles • Bait digging • Foreshore development • Recreational usage/access • Boat landing facilities • Dredging and extraction
Changes in vegetation cover	• Sandy Coasts • Non-tidal Wetlands • Tidal Wetlands • Headland/Bluffs	• Timber removal • Frequent firing • Foreshore development • Recreational usage/access • Filling of flood plains or wetlands
Changes in species composition and biodiversity	• Sandy Coasts • Non-tidal Wetlands • Tidal Wetlands • Headland/Bluffs • Fringing Reefs • Rocky Foreshores • Soft Bottoms • Sandy Bottoms	• Weed and pest introductions • Selective removal of target organisms • Timber removal • Frequent firing • Nutrient enrichment • Ballast water discharge
Changes to fire frequency and intensity	• Swamp Forest and Woodlands • Sandy Coasts • Headland/Bluffs • Mangroves	• Visitor access • Vegetation clearance

- urban lands contribute a small but significant proportion of sediment,
- discharge of sewage effluent associated with increasing coastal population is a significant local problem in some areas, and
- urban diffuse run-off from major coastal cities is a significant, but very localised problem.

In so far as localised assessments of impacts are concerned, there are a number of reasonably well documented case studies of both positive and negative impacts available. A cross-section of these case studies is provided below. It should be noted that there is a dearth of information on social and cultural impacts of coastal urban development. These case studies deal with:

- specific examples of actual and potential impacts resulting from specific residential/resort/marina projects,
- the construction of transport infrastructure across tidal wetlands,
- the effects of urban drainage works,
- the effects of reef blasting to allow small boat access to a coral cay,
- the cumulative water quality effects of urban development around an estuarine inlet, and
- the flow on effects of coastal tourism development which leads to increased visitor pressure on offshore reefs and islands.

Case Study 1: Assessment of Likely Effects of a Proposed Resort, Residential and Marina Development

Nature of Project: Proposed mixed resort, residential and marina proposal at Rainbow Harbour, Cairns

Source of Information: Queensland Department of Environment and Heritage (1992)

The Queensland Department of Environment and Heritage prepared an assessment of the likely positive and negative impacts of this proposed major development on the coastline north of Cairns.

Positive impacts include:

- the production of high quality residential land from generally poor quality cane land and the consequent reduction in farm impacts such as pesticide spraying, the harbouring of vermin and weeds, fertiliser run-off and cane burning;
- increased housing availability for local residents and an increase in the range of available residential lifestyles;
- increased availability of water-based recreational facilities and moorings which would be a safe haven for boats;
- improved beach access for residents of the district and visitors;
- improved availability of services and possibility of increased land value for nearby communities;
- possible replenishment of local beaches at no cost to the Council;
- the prospect of increased foreign exchange from tourists attracted by the development;
- stimulation of the local economy and creation of jobs;
- possible reduction in insect problems for Yorkeys Knob residents;
- possible reduced flooding in the immediate vicinity of the development due to improved drainage although regional flooding should be unaffected;
- stabilisation of the Richters Creek/Barron River system;
- replenishment of mangroves in the Yorkeys Creek system as a result of removal of existing tide gates;
- landscaping with native species may attract native fauna displaced by farming; and
- the development would be aesthetically pleasing to some individuals.

Negative impacts include:

- some marine habitat loss, including approximately 2 ha of mangroves, mainly at the mouth of Richters Creek;
- aesthetic loss to Holloways Beach users caused by construction of Richters Creek training walls on an unspoilt beachfront;
- beach replenishment and increased coastal sand transport may increase dredging requirements at other marinas in the short term, although the long-term average will be unaffected;
- loss of some terrestrial habitat including melaleuca wetlands, mainly at the harbour entrance;
- increased boating and road traffic at the mouth of Richters Creek;
- the location of another community near the approaches to Cairns Airport could increase pressures to modify flight operations;
- possible turbidity problems during maintenance and capital dredging operations;
- possible pollution from the marina; and
- loss of productive though fairly low quality cane land.

Case Study 2: Tidal Wetland at Eimeo, Pioneer Shire

Nature of Project: Construction of causeway across a tidal wetland

Source of Information: Tidal Wetlands Information System

The tidal inundation into the upper part of the wetland has been severely impeded by the construction of a large causeway across the wetland. In addition there has been quarrying of areas that formerly would have supported tidal marsh and some mangroves at both the northern and south-eastern ends of the wetland. The site at the northern end appears to have been turned into a lake for a hotel or tourist facility. In 1991 airphotos, about 20% of the remaining mangrove forests of the wetland appear to be dead from the alterations in tidal and freshwater inputs caused by these activities (E. Hegerl, airphoto interp.).

Human-induced alterations to drainage are on a sufficiently large scale that changes to soil chemistry could be expected to adversely impact on the entire wetlands system.

Case Study 3: Magazine Creek at Bowen

Nature of Project: Marina construction

Source of Information: Tidal Wetlands Information System

In recent years there have been major alterations to the mouth of the estuary due to the construction of a marina, a causeway and pipeline across the wetland, as well as from dredging a channel through the tidal flats into the marina. A channel also has been dredged along the south-east side of the wetland. A substantial mangrove area at the mouth of the estuary has been cleared, and patchy regrowth seems to be occurring. Upstream of the causeway, the limitation on tidal inundation caused by the construction of the causeway appears to have resulted in substantial mangrove mortality in the higher (less frequently inundated) areas of mangrove forest.

While originally formed as part of the delta of the Don, human activities have drastically altered the drainage into and through this wetland.

Case Study 4: Drainage Waterways at Cairns

Nature of Project: Assessment of water quality and fisheries habitat values of urban drainage channels

Source of Information: Queensland Department of Primary Industries (1996)

Cairns is built on coastal lowlands that flood during heavy rainfall, particularly when flood rain coincides with high tides. A complex network of both natural and artificial waterways service the Cairns region.

Whilst drainage waterways are essential to prevent flooding of coastal development, fish and other aquatic life utilise the drainage waterways to disperse and as nursery and feeding habitat in the same manner as they would a creek.

Thirty species of fish and crustacea were collected and identified from the Cairns drainage waterways – seven commercial target species, nine recreational target species, eight bait species and three target aquarium species. Twenty different aquatic and riparian species, including thirteen of Queensland's 34 mangrove species, were identified.

Drainage waterways may be designed and maintained in a way that takes into account fisheries values as well as the need to reduce flooding, minimise mosquito breeding and retain water quality.

Mosquito control is a major issue that concerns the community. Potential disease carrying insects require some form of control. Many freshwater fish species actually prey on mosquito larvae and so act as a natural form of mosquito control.

Best Practice Guidelines for the maintenance of the Cairns drainage waterways have been formulated by researching existing clearing practices and technical and ecological assessment of the Cairns drainage waterways. Best practice recommendations include:

- the protection and creation of vegetated waterway buffer zones
- drainage waterway maintenance timing and techniques that are mindful of the fisheries values of the waterways
- design and layout of drainage waterways and surrounding development to decrease dredging requirements
- the rehabilitation and careful monitoring of drainage waterways.

Case Study 5: Beach Erosion on Heron Island

Nature of Project: Construction of boat harbour at Heron Island

Source of Information: Jell and Flood (1978)

The initial blasting (ca. 1945) of a gap in the reef rim to allow small boats access to the island during low tide periods. This gap was adjacent to the wreck which was positioned at this time. The gap allowed ebbing tidal currents passing around the island to be channelled in the direction of the gap rather than radially out over the reef rim. The increased velocity of the redirected tidal currents, which now moved across the area of the sand spit adjacent to the western beach, produced erosion on the spit and beach.

The management of the tourist resort attempted to protect their buildings by constructing a vertical faced retaining wall along the eroding sector of the beach. The alignment of the wall reflects waves approaching the island from the northwest or northeast and enhances the erosive capacity of such waves. This promotes erosion in the areas adjacent to the end of the wall. When erosion continued, extensions were made to the wall during 1964–65. These extensions caused further realignment of the beach.

In 1966 a channel was dredged into the reef rim and reef flat to provide boat harbour facilities for the island. During the dredging the reef was subjected to severe cyclonic activity (cyclone Dinah, February 1967) which caused infilling of the dredged area and other undocumented readjustments to the beach and sediment distribution patterns on the adjacent reef flat. Redredging of the silted harbour occurred in 1967, and the spoil was placed within the beach zone on the southwestern corner of the island forming a base for the helipad, which was built in 1968.

Sediment was prevented from entering the harbour by walls which were constructed around it approximately one metre above the level of the reef flat, nevertheless, erosion and readjustment of the beach continued, and the helipad was endangered. More retaining walls were constructed.

The harbour walls were breached and flattened during the cyclone season of 1971. Tidal currents and cyclone Emily (April 1972) produced marked changes to the beaches by infilling the boat harbour through these breaches with sediment derived from the reef flat and beach.

The boat harbour was redredged in 1972 and the spoil (approximately 20 000 m^3) placed near the northwestern beach, the area that had suffered erosion since the early 1950s. This artificially formed beach and spit experienced reorientation and migration by westward movement of sand along the beach. This sediment was able to re-enter the boat harbour through the gaps in the walls, which had not been fixed after the dredging operation. During the cyclone season of 1976 (cyclone David, January 1976) the harbour became once again sediment filled. The mound of spoil from the 1972 dredging had been totally removed by this time. Recently attempts have been made to block the gaps in the harbour walls.

Case Study 6: Water Quality Trinity Inlet, Cairns

Nature of Project: Monitoring of water quality

Source of Information: Trinity Inlet Management Program (1996)

Over the past two and a half years, Trinity Inlet has been the subject of one of the most intensive investigations of inshore water quality and tidal movements undertaken for any regional centre in Australia.

Sewage effluent discharge is a major nutrient source for Trinity Inlet as it flows regardless of river flows or the state of the tide, and is the major source of both nitrogen and phosphorus in a dry year. The discharge of sewage effluent accounts for 50 to 78 per cent of the total phosphorus load in any year and from 26 to 58 per cent of the nitrogen load in wet and dry years respectively.

Information was also obtained on licensed point-source discharges to Trinity Inlet from industrial premises. The composition of these discharges was found to be similar to that of stormwater draining from streets and other hard surfaces in industrial areas. Hence, the addition of nutrients from industrial sources is considered minor when compared to that from sewage treatment plants.

The treatment plant outfalls are in a poorly flushed section of the Inlet and monitoring has now revealed the symptoms of a classic eutrophic system. Chlorophyll measurements show phytoplankton concentrations to be continuously high, nutrient concentrations are very high, while dissolved oxygen concentrations are low near the bottom of the Inlet and the benthic communities are reduced in diversity.

The Woree plant has recently been upgraded and the Edmonton plant is currently being upgraded to improve the quality of the effluent and to enable better control of effluent standards.

Case Study 7: Impact of Tourist Pontoons on Fish Assemblages

Nature of Project: Assessment of impacts of pontoons on Agincourt and Kelso Reefs

Source of Information: Sweatman (1996)

For many tourists, observing schools of fish is an important part of the day's visit, whether it be watching the fish naturally in the water while snorkelling or diving or controlled feeding activity from the boat or pontoon. Many Reef managers have been concerned about the impacts this feeding might have on the natural regime of reefs. Concerns include possible depletion of aggregating species from other sections of the Reef and a concentration of feeding activity (and thus impact on other species) around tourist pontoons. Monitoring programs for tourist pontoons have been put in place by Reef managers based on the assumption that one or both of these impacts were occurring. For example, monitoring programs often require that fish census be taken at pontoon sites with aggregations and at control sites without aggregations.

The project has shown however, that such a monitoring system based on 'presumed change' may be inappropriate. Both these species, and many others that are found in aggregations around pontoons, naturally form aggregations at particular sites on reefs or at least spend the day time within a restricted area.

Regarding the second assumed impact of increased predatory effort around the tourist pontoons, the project has, through observation of fish behaviour and analysis of densities of likely prey, determined that this impact is minimal, probably of no consequence. Certainly for red bass, predation on natural prey is very limited. A comparatively significant but still very small subset of the spangled emperor aggregations did feed on their natural prey. The impacts of this predation are not readily detectable within the bounds of the methods available.

4.4 Implications for Coastal Urban Development

The investigation of activity–impact linkages has revealed a number of implications for the way in which information on potential impacts is incorporated into decision-making processes that affect coastal urban development. It is suggested that:

- there should be a greater awareness of coastal values and management needs on the basis of different ecosystem types,
- management needs for different ecosystem types be incorporated into planning schemes and decision-making processes,
- greater attention be given to the social, cultural and amenity implications of coastal urban development,
- greater emphasis be placed on identifying and documenting the secondary, indirect and downstream effects of coastal urban development,
- greater resources be allocated to the monitoring of impacts resulting from coastal urban development – the important point is made by Lucas et al. (1997) that the concept of monitoring lies at the very root of the World Heritage Convention, and
- greater emphasis be placed on the assessment and documentation of cumulative impacts associated with coastal urban development.

It is also important to recognise that actions aimed at protecting the World Heritage Area must be incorporated into both planning and management. Ecologically sustainable outcomes will only be achieved if appropriate management systems and 'good' planning decisions co-exist across all spheres of government.