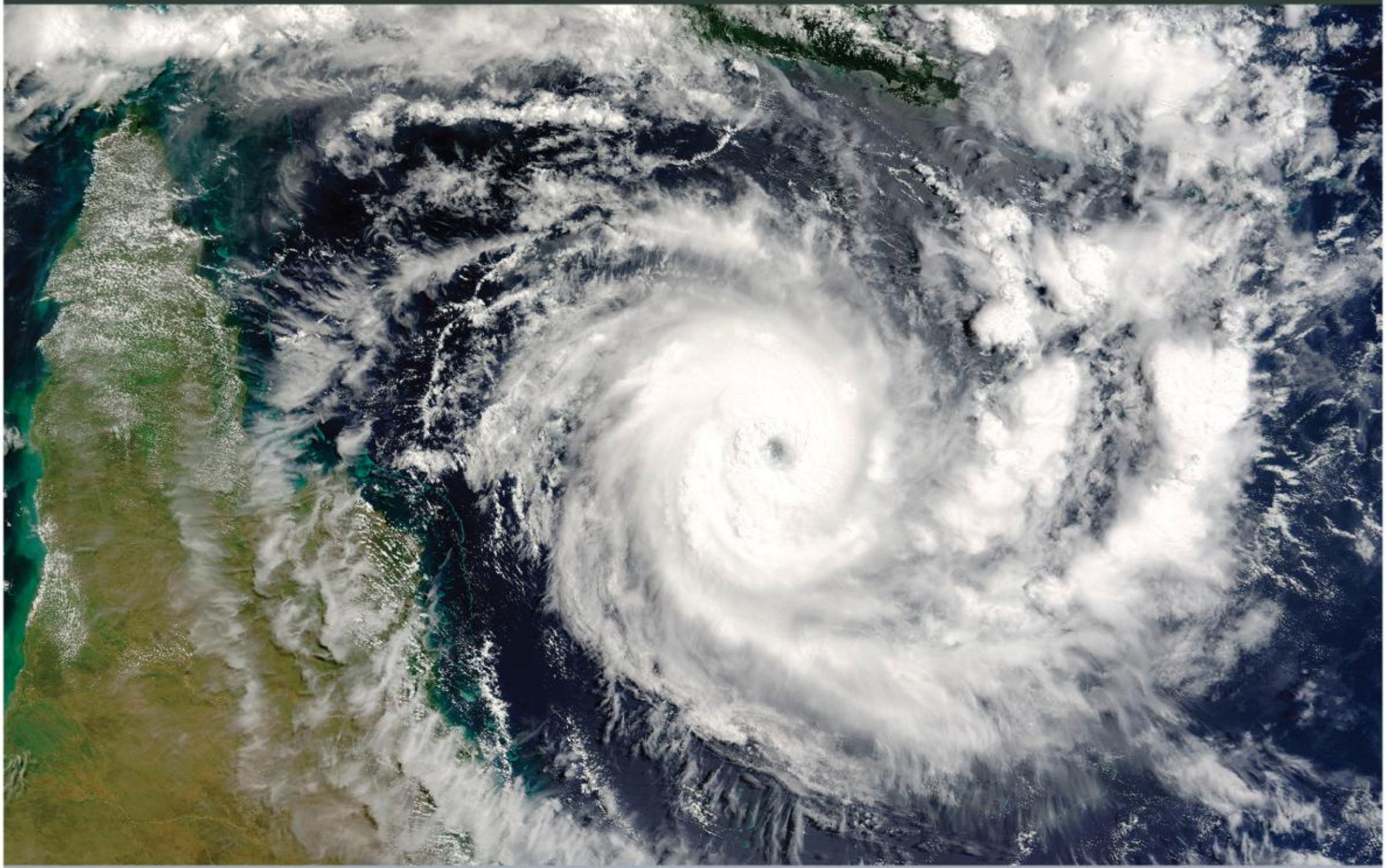
WET TROPICS
NRM CLUSTER

CLIMATE CHANGE IN AUSTRALIA

IMPACTS & ADAPTATION INFORMATION FOR AUSTRALIA'S NRM REGIONS



Adaptation Pathways and Opportunities for the Wet Tropics NRM Cluster region

Volume 1. Introduction, Biodiversity and Ecosystem services

Edited by Catherine Moran, Stephen M. Turton and Rosemary Hill

3. Ecosystem services: adaptation pathways and opportunities

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IN A NUTSHELL
• An appropriate system for payment for ecosystem services is required. • Carbon abatement projects are influenced by national and international pricing and trading schemes. Abatement projects are currently limited by frequent policy shifts, a lack of funding and complexity in approaches. Carbon plantings have the potential to mitigate CO_2 as well as to provide wildlife habitat, increase landscape functional connectivity & protect water quality. • Integrated farm management has the potential to deliver benefits for biodiversity conservation, ecosystem service provision and farm productivity.

Precis

In this chapter, we compile climate change adaptation options for ecosystem services for the Wet Tropics Cluster (WTC) region, derived from the Australian literature and elsewhere. We focus particularly on water regulation, climate regulation, carbon sequestration, agricultural production, timber production, habitat provision, erosion control, and traditional values. We also discuss emerging opportunities that may become available in WTC region in the future, bring together the limitations and constraints of current payments for carbon abatement and discuss possible ways to establish payments for ecosystem services through examination of examples from across the world that may be applied to the WTC region. Finally, we discuss the barriers to climate adaptation in regard to ecosystem services. The key messages associated with each of the topics addressed in this chapter are:

TOPIC	KEY MESSAGES
Introduction	70. Natural ecosystems have a low adaptive capacity in the face of rapid climate change. 71. Both short- and long-time planning are required.
Water regulation and water provision	72. Management practices that maintain or restore ground cover & riparian vegetation are required for protection of water quality. 73. Water sensitive design at both macro- and micro-scales is required.
Coastal protection and erosion control	74. Protection and landward facilitation of mangroves are both necessary for coastal protection from tropical cyclones, storm surges, sea-level rise and salinity intrusion. 75. Restoration of littoral forests will reduce the vulnerability of coastal communities to extreme climate events like tropical cyclones, storm surges and sea-level rise and will potentially minimise coastal erosion. 76. Coastal plantations with robust native tree species will build resilience to anticipated increases in tropical cyclone wind speeds and storm surge threats. 77. Hybrid engineering will be useful in places where natural ecosystem-based protection is not sufficient or feasible.

TOPIC	KEY MESSAGES
	78. Re-establishing native vegetation in beaches, dunes and barrier Islands will increase the climate adaptation potential of these systems.
Carbon sequestration	79. There is high potential for more carbon sequestration and storage through improved management practices, environmental planting, mixed farming and land rehabilitation. 80. Native species with relatively high wood density and slow growth rates are more likely to store carbon for a long time. 81. There should be consideration of potential limitations to C sequestration on rangelands.
Habitat provision for biodiversity	82. Integrated farm management has potential benefits for biodiversity as well as farm productivity. 83. Ongoing and enhanced invasive species management is required.
Timber provision	84. More emphasis on cyclone-resistant tree species is required. 85. Forest management practices may affect climate change resilience. 86. Opportunities to increase growth rates due to elevated CO_2 should be taken advantage of where practical.
Traditional values	87. Incorporating local and Indigenous knowledge in formal decision-making about ecosystem services and climate change adaptation is important. 88. Enhancing Indigenous adaptation options and community-based adaptation is useful. 89. Strong linkages between local knowledge and formal science are required.
Marine ecosystem services	90. Maintaining continuous native vegetation cover in the terrestrial ecosystems will reduce some stressors on the Reef and will increase its resilience to climate change.
Barriers in current mechanisms	91. Lack of sufficient funding is an ongoing concern. 92. Frequent government policy shifts are not helpful. 93. Complexity of methods and approaches is discouraging for many stakeholders. 94. Uptake of adaptation measures depend on attitudes beliefs and perceptions about climate change by members of the society and their level of exposure to mass media.
Mechanisms for establishing payments for ecosystem services	95. An appropriate process is required for payment for ecosystem services.

Introduction

Natural ecosystems have a low adaptive capacity in the face of rapid climate change.

Both short- and long-time planning are required.

Ecosystem services are the benefits people derived from ecosystems (MA 2003, 2005) including the provision of food, fibre, timber and water, climate regulation, nutrient cycling, and habitat provision for biodiversity. Ecosystem services are an essential element of community wellbeing but are under serious threat from global climate change (Stafford Smith & Ash 2011; Pert *et al*. 2014) and from the current push for economic development above social, cultural and environmental considerations by current state and federal governments (Pert *et al*. 2014). NRM managers will be required to respond at differing temporal and spatial scale to ensure the sustainable supply of ecosystem services (Lawler 2009).

Natural ecosystems have a high vulnerability to climate change because both their coping range and adaptive capacity are low. Thus even below a 2°C temperature change – relative to 1990 – there will be significant negative effects on natural ecosystems (Stafford Smith & Ash 2011). Therefore adaptation strategies should start as soon as possible. In addition to natural ecosystems, coastal communities and water security are highly vulnerable to climate change impacts (Stafford Smith & Ash 2011).

Decision making in the face of adaptation to climate change is difficult due to the uncertainty involved in the projected magnitude of climate change (Jones & McInnes 2004; Stafford Smith *et al*. 2011).It is even more difficult for the WTC region due to complex landscape features and various environmental gradients. Therefore, both short- and long-time decisions are required. For example, urgent decisions about water savings and storage measures are required, especially in northern parts of the WTC Region (Cape York and Torres Strait) that experience pronounced dry seasons. Lawler (2009) has pointed out a triage classification for ecosystems management under climate change threat considering value of ecosystems (ecological, economic and social value) and severity of climate change impacts (Figure 3.1). Some systems require immediate action otherwise they may be lost forever, for example rare systems or species, species with high interaction strength and in some systems-high priority only a few years waiting is possible before the management actions, if closely monitored. Other systems (low priority and no management) either require management actions in the long run or no management actions. These systems wouldn't be lost if there is no management actions soon. These systems require monitoring. Considering this classification, it is likely that for the WTC Region, immediate actions are required for many ecosystem services including coastal protection and erosion control due to the projected and apparent severe tropical cyclone and associated impacts (IPCC 2013; Turton 2008, 2014) and habitat provision for biodiversity for iconic species due to projected habitat loss resulting from temperature rise and seasonal rainfall variability (Hilbert *et al*. 2001; Williams *et al*. 2003).

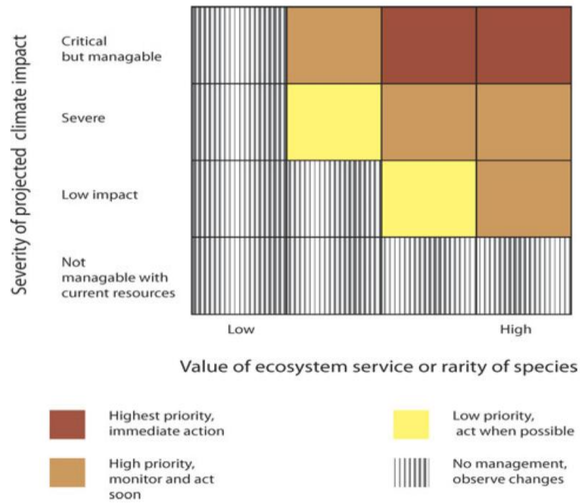

Figure 3.1 Triage classification for ecosystem services management in a changing climate

Source: adapted from Lawler (2009)

Specific ecosystem services

In this section we examine specific ecosystem services that are most relevant to the Wet Tropics Cluster region. Appendix 3.1 provides a summary for planners.

Water regulation and water provision

Management practices that maintain or restore ground cover and riparian vegetation are required for protection of water quality.

Water sensitive design at both macro- and micro-scales is required.

Both water regulation and water provisioning services are among the most important ecosystem services provided in the WTC region. It is well recognised that healthy upstream vegetation cover can deliver high quality water in downstream environments, including the Great Barrier Reef lagoon (Calder *et al*. 2007). Upstream vegetation also has profound influences on regulating runoff and flood mitigation to downstream users (Baral *et al*. 2012). Fewer disturbances to vegetation cover will also reduce outside stressors so as to increase climate resilience. Woody vegetation – including mangroves – may also remove sediment and nutrient pollutants from runoff (Baral *et al*. 2012) eventually helping to maintain water quality.

Riparian vegetation has a profound influence on maintaining water regulation, water quality and water temperature. Riparian vegetation reduces stream temperatures and creates cool water refugia (Palmer *et al*. 2008; Scott *et al*. 2008). Riparian vegetation is likely to increase the ability of cold-water micro fauna to persist in rising temperature through protecting headwaters, and identifying and protecting existing thermal refugia (Hansen *et al*. 2003; Chapter 2, this report). Riparian vegetation also provides important habitat for many terrestrial fauna and flora and may provide functional connectivity through disturbed landscapes, enabling dispersal. A healthy riparian zone filters sediments and slow down overland water flow, which subsequently provides water quality benefits to the community (Burgman *et al*. 2007). The restoration of riparian vegetation is an important option for adaptation to climate change. Selection of trees species should include consideration of resilience to cyclones; after Severe Tropical Cyclone 'Larry' it was found that trees in riparian zones were more severely damaged than those in nearby forests fragments (Bruce *et al*. 2008).

Climate change is projected to lead to increased variability in rainfall and more intense extreme rainfall events in the WTC region (Turton 2014). This will potentially mean longer dry periods as well as more frequent, prolonged and extensive freshwater inundation events. Higher rates of evapotranspiration will interact with these changes and may exacerbate water shortages, especially during the dry season. A number of management actions are available to regulate water flow in stream channels such as flood plain restoration, channel reconfiguration and bank stabilisation. Creating off-channel basins and wetlands to store water during extreme flows may prevent excessive downstream flows (Palmer *et al*. 2008). Groundwater extraction could also be an option to address water shortage in a changing climate although it is controversial (Hansen *et al*. 2003; Refer to Chapter 4, this report). During the dry season, water savings measures are essentially a good option particularly for the private use of water.

Coastal protection and erosion control

Protection and landward facilitation of mangroves are both necessary for coastal protection from tropical cyclones, storm surges, sea-level rise and salinity intrusion.

Restoration of littoral forests will reduce the vulnerability of coastal communities to extreme climate events like tropical cyclones, storm surges and sea-level rise and will potentially minimise coastal erosion.

Coastal plantations with robust native tree species will build resilience to anticipated increases in tropical cyclone wind speeds and storm surge threats.

Hybrid engineering may be a useful protective adaptation strategy in places where natural ecosystem based protection is not sufficient or feasible.

Re-establishing native vegetation on beaches, dunes and barrier Islands will increase the climate adaptation potential of these systems.

Mangroves provide coastal protection by reducing wave energy, increasing sedimentation, reducing erosion and movements of sediments, and reducing water velocities (Gedan *et al*. 2011; Shepard *et al*. 2011; Spalding *et al*. 2014). Mangroves are very efficient in trapping fine sediment particles (Wolanski 1995; Young & Harvey 1996). Mangrove roots also increase soil cohesion, and provide an important physical barrier between soil and water (Gedan *et al*. 2011). Wave heights can be reduced by 13% to 66% over 100 m of mangroves (McIvor *et al*. 2012a). Storm surge heights can be reduced between 4 to 48 cm/kilometre through provisioning of mangroves along the coast (Krauss *et al*.

2009; McIvor *et al*. 2012b; Zhang *et al*. 2012). Therefore, mangrove protection and enhancement are both necessary pathways to adaptation to sea level rise, extreme climate events like tropical cyclones and associated storm surges, and coastal erosion control in the WTC NRM region.

Mangroves move inland if the pace of sea level rise allows (Alongi 2008). It was found that mangroves nearby Key West, Florida have shifted inland by 1.5 km since the mid 1940s under a regime of sea level rise of 2.3-2.7mm/yr (Ross *et al*. 2000). In Western Australia it was found that mangroves are responding to coastal erosion and sea level rise by colonising landwards (Semeniuk 1994). If possible, mangroves in the WTC region are also likely to move landward in response to sea-level rise and coastal erosion. Facilitating this natural movement of mangroves would be a potential adaptation pathway for coastal protection in the WTC region, although many potential sites are currently used for agriculture and urban development. Mangrove movement may be facilitated through 'managed realignment', whereby coastal lands are deliberately reconnected with tidal systems by opening seawalls and filling drainage channels (Spalding *et al*. 2014). In many places across the world using this process of natural regeneration of mangroves has taken places and accretion processes have been re-established (Linham & Nicholls 2010; Luisetti *et al*. 2011). This method is being used increasingly in places where maintenance of artificial sea defence is expensive and risky (Spalding *et al*. 2014).

Littoral (coastal) forests provide a number of ecosystem services in the WTC Region (DEWHA 2009; Gallagher *et al*. 2010). They protect areas from erosion, filter sediments, nutrients and pollutants and reduce the impacts of flooding and storm surge events (Burgman *et al*. 2007; Murphy *et al*. 2012). They act as a buffer to coastal erosion and wind damage (Meier & Figgis 1985). They will also protect coastal communities, infrastructure such as roads, marinas, and agriculture and aquatic industries on floodplain areas of the WTC Region during tropical cyclones and associated storm surge, and in the face of ongoing sea level rise (Murphy *et al*. 2012; Chapters 4 & 5, this report). Severe tropical cyclones can cause major damage to littoral forests and riparian vegetation reducing their capacity to provide essential ecosystem services. For example, heavy damage of littoral rainforest with melaleuca trees occurred north of Cardwell following Category 5 Severe Tropical Cyclone 'Yasi' (Murphy *et al*. 2012). Coastal erosion can lead to seawater intrusions into wetlands negatively impacting on biodiversity, tourism and recreation (Environment Planning 2011), and leading to the loss of public assets such as beaches and protective dune systems (Bustamante *et al*. 2012; Williams *et al*. 2012). Restoration of littoral forests may help protect remaining freshwater wetlands from seawater intrusions. Therefore protection and restoration of littoral forests will have profound positive impacts on coastal communities, terrestrial ecosystems and aquatic ecosystems in the face of climate change. Protection of littoral forests is potentially one of the least cost measures for the WTC Region.

Use of coastal plantations is a well-implemented concept across the world for coastal protection and erosion control with 375,000 ha of coastal plantations having been established across the world, mainly for coastal protection (Spalding *et al*. 2010). Therefore coastal plantations comprising robust native tree species will build resilience to anticipated increases in tropical cyclone winds and ocean storm surge threats in the WTC Region. As the primary target is coastal protection and erosion control rather than production, larger plantation widths with closer tree spacing using cyclone-resistant tree species would be desirable.

Hybrid engineering is the combination of hard engineering and green engineering applications to mitigate river and coastal erosion threats (Spalding *et al*. 2014). Green engineering may not be sufficient in some areas to ensure coastal protection and hard engineering solutions may not be acceptable due to the economic and, social costs (Spalding *et al*. 2014) or biodiversity impacts. However, in some parts of the WTC NRM Region, hybrid-engineering solutions may be an adaptation pathway to provide rapid and effective protection for coastal communities and adjacent agricultural, urban and sensitive protected areas. For example the revegetation of hard engineering sites on riparian zones in the WTC Region.

Beaches, dunes and barrier islands built of sand are sediment reserves and subsequently an important component of adaptation pathways in the face of sea level rise and storm surge threats (Defeo *et al*. 2009). Dunes have significant positive impacts on reducing wave and storm surge thereby protecting coastal communities and reducing erosion during extreme events like tropical cyclones (Ba Thuy *et al*. 2009). It is necessary to ensure vegetation presence for the effective structure and stability both of dunes and barrier islands (Bhalla 2007; Feagin *et al*. 2010). Coastal protection functions of dunes and barrier islands are reduced by vegetation removal or introduction of exotic species (Bhalla 2007; Feagin *et al*. 2010), and by hard structures/coastal development that are interfering with natural coastal processes, erosion and deposition patterns.

Carbon sequestration

There is high potential for more carbon sequestration and storage through improved management practices, environmental planting, mixed farming and land rehabilitation.

Native species with relatively high wood density and slow growth rates are more likely to store carbon for a long time.

There should be consideration of potential limitations to C sequestration on rangelands.

Australia's soils and forests store large quantities of carbon; however they also emit a large quantity of carbon due to land use change, e.g. savanna burning due to both naturally caused wildfires and planned burning for pasture management (Battaglia 2011). Agroforestry is a potential adaptation option for generating multiple benefits such as carbon sequestration, watershed management and biodiversity restoration (George *et al*. 2012). Landscape rehabilitation and mixed farming - including integrating trees with farming - are likely to improve soil health, and increase carbon sequestration and storage (Battaglia 2011). Among the different planting options environmental plantings have the highest potentiality to sequester and store carbon (George *et al*. 2012). The WTC Region has the potential to increase carbon sequestration and storage in both plants and soils by forest restoration and mixed farming. Ongoing environmental plantings need to be enhanced and implemented at the landscape scale.

A study of replanted trees (Curran *et al*. 2008) found that those species with high wood density had been less damaged by cyclonic winds during cyclone 'Larry'. Higher wood density, long-lived large trees with extensive root systems are more useful to store carbon in the long term (Murphy *et al*. 2012). Scattered trees will also reduce the risk of carbon release by fire, pests and tropical cyclones, together with their secondary positive impacts on water supply (Battaglia 2011).

Rangelands emit carbon to the atmosphere mainly from three different sources- land use change and management, livestock and savanna burning (Cook *et al*. 2010). In tropical savannas fuel decomposition rates are high and equilibrium fuel loads are reached within 3-5 years (Cook *et al*. 2010; Cook 2003), therefore reducing fire frequency likely to reduce carbon emission to the atmosphere (Cook *et al*. 2010). Improved grazing management is essentially an important pathway to adapt with climate change. For improved grazing potential options could be managing shelterbelts, improving grass, time control rotational grazing and avoiding over stocking. Improved grazing will enhance carbon sequestration potentials of rangelands and will reduce carbon emissions. It will also provide other co-benefits, such as biodiversity conservation. A substantial amount of carbon is stored up to 1 m depth in the soil of rangeland and savanna soils (Baker *et al*. 2000). Harms and Dalal (2003) have reported a 7.9% decline of soil carbon stock to a depth of 0.3m after clearing of *Acacia* and *Eucalyptus* woodlands and savannas for cattle grazing in Queensland, which is nearly 260 Mt CO_2- e (National Land and Water Resources Audit 2001). A study in Bundaberg (Schulke undated) has found that thinning may increase grass production only in the short term. Woodland clearing for grazing is detrimental for the environment and in most of the cases not economically viable (Cook *et al*. 2010). Therefore, in the WTC Region, lands that are now managed for grazing could be significantly improved with better grazing management.

Habitat provision for biodiversity

Integrated farm management has potential benefits for biodiversity as well as farm productivity.

Ongoing and enhanced invasive species management is required.

Integrating trees into farming landscapes and strategically retaining strips of regrowth in pastoral landscapes, are both likely to have little impact on farm productivity (Battaglia 2011); if applied correctly the impact on farm productivity will be positive. These trees can provide habitat for wildlife (including ‘stepping stones’ to enable movement) and shelter from extreme climate events such as heat waves, floods, storm surges and tropical cyclones. These trees will also have an influence on microclimate at the local scale, thereby reducing local air temperatures. These trees can help to increase the soil fertility; more importantly nitrogen, enhanced nutrient cycling, reduced stressed on livestock, soil health (which brings in the often neglected component of microbial biodiversity). These trees are also vital in the cycling of Molybdenum a key limiting factor in Azitobacter and nitrogen fixation (G. Kay 2014, personal communication).

Some invasive species may benefit from changing temperature and rainfall patterns, as well as increased atmospheric CO_2 (Dukes & Mooney 1999; Chapter 2, this report). Invasive plants may also inhibit natural regeneration and colonisation of native species (Murphy *et al*. 2012). Disturbances also create more favourable conditions for plant invasions (Laurance 1991, 1997). Large-scale disturbances like tropical cyclones which are predicted to increase in intensity in the WTC Region (Turton 2014) may promote the recruitment and spread of invasive species (Murphy *et al*. 2012) over native taxa. These processes will likely interact with other disturbances. For example, after Tropical Cyclone ‘Larry’ in the Babinda-Tully area, it was found that woody weeds grew more quickly, showed low mortality rates and persisted over a longer time frame in the fragmented landscapes compared with intact forest areas (Murphy *et al*. 2008a, Murphy *et al*. 2010; Murphy *et al*. 2008b, Turton 2008).

Timber provision

More emphasis on cyclone-resistant tree species is required.

Forest management practices may build climate change resilience.

Opportunities to increase growth rates due to elevated CO_2 should be taken advantage of where practical.

Australian native conifers (hoop/Kauri pine) are more likely to be resistant to tropical cyclones than exotic pine species (Timber Queensland 2012). A study after Cyclone ‘Larry’ found that *Backhousia bancroftii* (Johnstone River Hardwood/ Langdon's Hardwood) was more resistant to cyclonic winds than many other tree species in the WTC Region (Metcalfe *et al*. 2008). This tree grows in a wide range of altitudes from sea level to 700m (Australian Tropical Rainforests Plants). Tree resistance to cyclones is influenced by seed provenance and seeds sourced from regions that have evolved in environments where cyclones occur frequently are likely to more resistant to strong wind events. In the areas affected by Cyclone ‘Yasi’ in 2011 it was found that the Cuban-sourced exotic pine (*Pinus caribaea*) - which is regularly subjected to strong coastal winds - was less affected than mountain Honduras-sourced exotic pine of the same species (Timber Queensland 2012).

Some forest management practices may build forest plantation resilience to climate change. For example mixed-species plantings can minimise impacts from pest outbreaks, and wide-spacing of trees may minimise impacts from forest fires (Dale *et al*. 2001; Joyce *et al*. 2008), and prescribed burning by reducing fuel loads (Spittlehouse & Stewart 2003; Scott *et al*. 2008). In the WTC Region, appropriate prescribed burning regimes and mixed plantings are potentially important adaptation pathways under climate change.

Traditional values

Incorporating local and Indigenous knowledge in formal decision-making about ecosystem services and climate change adaptation is important.

Enhancing Indigenous adaptation options and community-based adaptation is useful.

Strong linkages between local knowledge and formal science are required.

Scientists have found that local communities' knowledge is useful in climate change science and policy (Chaudhary & Bawa 2011; Chapter 6, this report). Indigenous adaptation options are usually based on long-term practice, experience and observation of communities. If there is an Indigenous adaptation option in place then government and other organisations should assist to increase their adaptive capacity, e.g., by providing training, and financial incentives to facilitate a continuous flow of ecosystem services in landscapes. Community-based adaptation is a popular concept, especially in developing countries and places where communities are dependent on forest resources. This approach is also applicable to areas in the WTC Region, especially remote areas such as Cape York (details in Chapter 6, this report). Working with Indigenous groups to manage places of particular cultural significance may be an important adaptation option in the face of climate change.

Strong linkages between local knowledge and formal science are required for successful adaptation strategies. Climate change is a long-term phenomenon and decision-making is problematic, as various uncertainties exist. Adaptation should also be placed before the more serious negative impacts take hold. Indigenous knowledge may help to identify the impacts and also to identify the areas where immediate action is needed to build resilience to climate change. Scientists have found similarities between Indigenous knowledge-based identification of climate change impacts and traditional science based identification of impacts (Chaudhary & Bawa 2011).

Marine ecosystem services

Maintaining continuous native vegetation cover in terrestrial ecosystems will reduce some stressors on the Reef and will increase its resilience to climate change.

Marine ecosystems are already under threat from climate change (Chapter 2, this report). The Great Barrier Reef's health and hence resilience are negatively impacted by terrestrial sediment runoff (Bustamante *et al*. 2012). Other stresses like nutrients and pesticides from agricultural lands, land clearing and other land uses increase the vulnerability of marine ecosystems. Sediments and nutrients load in the Great Barrier Reef due to extensive clearing of low land vegetation for agriculture, ground cover disturbances, and agricultural practices have already been reported (Murphy *et al*. 2012). So managing terrestrial catchment vegetation cover to minimise runoff is an important adaptation pathway which will increase the reef's resilience to climate change and other stressors, such as coral bleaching and rising acidity (Bustamante *et al*. 2012).

Barriers of current mechanisms for adapting to climate change

Lack of sufficient funding is an ongoing concern.

Frequent government policy shifts are not helpful.

Complexity of methods and approaches is discouraging for many stakeholders.

Uptake of adaptation measures depend on attitudes beliefs and perceptions about climate change by members of the society and their level of exposure to mass media.

Current government funding for carbon offset schemes is insufficient and the gains in protection will be outweighed by the rapid loss of biodiversity and ecosystem services. Funding cuts to regional organisations presents a great challenge to promoting adaptation mechanisms since as a result - for example - some organisations may have to reduce staff members who closely work with stakeholders in this area (van Oosterzee *et al*. 2013). One of the main barriers for current adaptation mechanisms is that regulations are often applied to promote adaptation actions but little importance is given to the fact that these regulations do not always provide enough funding to engage stakeholders in these enterprises - which in turn - has the effect of discouraging people from adopting adaptation mechanisms (van de Koppel & Reitkerk 2000).

Policy shifts are argued to be an important barrier to climate adoption since uncertainty in the direction of policies generally tends to discourage stakeholders from adopting new methodologies. In Australia there have been various shifts in policies such as the Carbon Farming Initiative (CFI), where the complex nature of the scheme discourages landholders from dealing with climate change adaptation and mitigation (van Oosterzee 2012). Current financial mechanisms of carbon offsets, such as the CFI are complex and require high financial investment for project establishment and registration (van Oosterzee 2012). Therefore non-adoption of this type of initiatives by small landholders emerges as another barrier.

Uptake of mechanisms for climate change adaptation depends on attitudes and perceptions of the general public. Akter and Bennett (2011), in a study carried out to households in New South Wales, Australia found that: (1) “willingness to pay for climate change mitigation is significantly influenced by their beliefs of future temperature rise”, (2) “perceptions of policy failure have a significant negative impact on respondents’ support for the proposed mitigation measure” (3) “preferences for the proposed policy are influenced by the possibility of reaching a global agreement on emissions reduction” and (4) “willingness to take action against climate change, both at the national and household level, is found to be influenced by their level of mass-media exposure”.

Mechanisms for establishing payments for ecosystem services

An appropriate process is required for payment for ecosystem services.

There is the need to develop appropriate mechanisms to pay for ecosystem services given that they are vital for human wellbeing, are becoming increasingly limited and that many of the key services do not have substitutes (Farley & Costanza 2010). Payment for ecosystem services (PES) is a policy instrument that aims to combine ‘market forces’ and ‘environmental protection’. Wunder (2005) provided the widely accepted definition of PES as a “voluntary transaction where a well-defined ecosystem service (or a land-use likely to secure that service) is being bought by a (minimum one) ecosystem services buyer from a (minimum one) ecosystem service provider if and only if the ecosystem service provider secures ES provision (conditionality)”. PES is structurally similar to other ‘incentive-based policies’ and the objective of this mechanism is to reward individual landholders and communities to foster the adoption of activities that enhance the continued provision of ecosystem services (Jack *et al*. 2008). The central idea of a PES is to encourage ‘external beneficiaries’ of ecosystem services to financially support - under defined contractual conditions - ‘local landholders’ in order to adopt sustainable practices, thereby securing the continued provision of the services (Wunder 2005). PES may also be of different types (Table 3.1).

The PES mechanism has developed rapidly during the last decade and has gained international attention (Perrot-Maitre 2006; Bulte *et al.* 2008). Payments from environmental services have been applied even before the term was introduced such as the case of Vittel’s private scheme developed and implemented in France, in order to protect the aquifer that provides the mineral water for the company (Perrot-Maitre 2006). Numerous PES mechanisms have been implemented or are under implementation, both in developed and developing countries. Some PESs are private initiatives, others are run by national and international NGOs or other organisations and there are also governmental administered schemes. One common characteristic of PES schemes is that they are voluntary. Some examples have been compiled in Table 3.2.

Table 3.1 Types of Payments for Ecosystem Services

SCHEME TYPES	SCHEME DETAILS
Area- vs. product-based schemes	The most common type is *area-based schemes*, where contracts stipulate land- and/or resource-use caps for a pre-agreed number of land units. *Product-based schemes* is the second most common type of PES, where consumers pay a 'green premium' on top of the market price for a production scheme that is certified to be environmentally friendly, especially vis-à-vis biodiversity (as cited in Pagiola & Ruthenberg 2002).
Public vs. private schemes	In *public schemes* the state acts on behalf of ES buyers by collecting taxes and grants and paying alleged ES providers. *Private schemes* are more locally focused and buyers pay directly. Public schemes are generally larger in scope and have the state providing legitimacy, which many private schemes struggle hard for. On the downside, public schemes can become overloaded with side objectives catering to voters rather than supplying ecological services proper, they are less flexible vis-à-vis targeting of strategic ES sellers, and they tend to be less efficient in securing additional ES provision.
Use-restricting vs. asset-building schemes	*Use-restricting PES schemes* reward providers for conservation (including natural regeneration) for capping resource extraction and land development; or for fully setting aside areas, such as for protected habitat. Here, landowners are paid for their conservation-opportunity costs, plus possibly for active protection efforts against external threats (as cited in Hardner & Rice 2002). *Asset-building schemes* PES aim to restore an area's ES, for example (re)planting trees in a treeless, degraded landscape. Conservation-opportunity and protection costs aside, PES may here also compensate the direct costs of establishing ES, often through investments within agricultural systems (as cited in Pagiola *et al*. 2004)

Source: Wunder (2005)

Table 3.2 Examples of PES schemes around the world

PES SCHEME	SHORT DESCRIPTION	COUNTRY
Vittel (Perrot-Maitre 2006)	Vittel mineral water company is providing incentives to farmers to change farming practices and technology in order to protect the aquifer to ensure water quality (reducing the risk of nitrate contamination from agricultural activities). The negotiations between the local landholders and the owners of Vittel started in 1988.	France
Conservation Reserve Program (CRP) (Farm Service Agency 2013)	The CRP is voluntary program, administered by the Farm Service Agency (FSA), which support farmers to protect "environmentally sensitive land" and enhance conservation outputs. The ES targeted are improvement of water quality, avoiding soil erosion and conserving and enhancing wildlife habitat.	USA
Proambiente Brazil (Hall 2008)	Reduction or avoidance of deforestation, carbon sequestration, recuperation of ecosystem hydrological functions, soil conservation, preservation of biodiversity and reduction of forest fire risks. The PES scheme was adopted by the Federal Government in 2003.	Brazil
The Carbon Farming Initiative (Department of Climate Change and Energy Efficiency 2012)	The Carbon Farming Initiative is a voluntary scheme that provides landholders with the opportunity to access carbon markets, presenting them with an alternative way to generate income through the adoption of activities that either sequester carbon dioxide or CO_2 equivalents (CO_2-e) from the atmosphere or reduce greenhouse gas (GHG) emissions are considered to earn carbon credits which can be later sold to businesses to offset their emissions. The CFI Act was passed in 2011.	Australia

PES SCHEME	SHORT DESCRIPTION	COUNTRY
Los Negros Valley (Asquith *et al.* 2008)	In this case the USFWS pays for the protection of the habitat for migratory birds and the Municipality of Pampagrande pays for the provision or water for irrigation during dry season, services provided by the same “upland forest and puna (native central Andean alpine grassland) vegetation”. Fundacion Natura Bolivia started PES negotiation in 2003.	Bolivia
Regional Integrated Silvopastoral Ecosystem Management Project (Pagiola *et al.* 2005)	This program was carried out from 2002 to 2008. The objectives were to demonstrate and measure a) the effects the introduction of payment incentives for environmental services to farmers to adopt integrated silvopastoral farming systems in degraded pasture lands, and b) the improvements resulting for ecosystems functioning, global environmental benefits, and local socio-economic benefits obtained through the provision of ES.	Colombia, Costa Rica and Nicaragua
Fostering Payments for Environmental Services in the Danube Basin (WWF 2012)	This PES scheme promotes the maintenance, improving or adoption of conservation friendly land uses in the Lower Danube and Danube delta. Preparations for the PES project started in 2002.	Bulgaria, Moldova, Romania and Ukraine

Waage *et al*. (2008) propose a four-step approach to develop Payments for Environmental Services that are presented in Figure 3.2. As a result of the analysis of information of a workshop held in Costa Rica, Farley and Costanza (2010) recommended measuring, bundling, scale-matching, property rights, distribution issues, sustainable funding, adaptive management, education and politics and participation and policy coherence as principles (Table 3.3) to be considered for payments for ecosystem services.

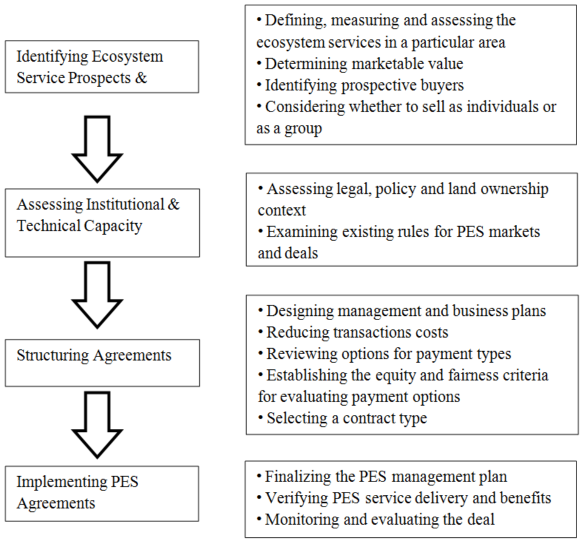

Figure 3.2 A Step-by-Step Approach to Developing PES Deals

Source: Waage *et al*. (2008).

Table 3.3 Principles concerning the use of PES systems

PRINCIPLES	DETAILS
Measuring	We need to continue to develop better methods to measure, map, model, and value ecosystem services at multiple scales. At the same time, we cannot wait for certainty and precision to act. We must synergistically continue the process of improvement of measurements with evolving institutions that can effectively utilise these measurements.
Bundling	Most ecosystem services are produced as joint products (or bundles) from intact ecosystems. The relative rates of production of each service varies from system to system and site to site, and time to time, but we must consider the full range of services and the characteristics of their bundling in order to prevent creating perverse incentives and to maximise the benefits to society.
Scale-matching	The spatial and temporal scale of the institutions to manage ecosystem services must be matched with the scales of the services themselves. Mutually reinforcing institutions at local, regional and global scales over short, medium and long time scales will be required. Institutions should be designed to ensure the flow of information between scales, to take ownership regimes, cultures, and actors into account, and to fully internalise costs and benefits.
Property rights	Establishing appropriate property rights regimes is essential for implementing PES systems. However, given the public goods nature of most ecosystem services, we can either use existing private property rights, change property rights, or develop systems that can propertise ecosystems and their services without privatising them. For example, common property asset trusts are one way to effectively do this.
Distribution issues	The distribution of costs and benefits from PES systems need to be carefully considered. Systems should be designed to ensure inclusion of the poor, since they are more dependent on common property assets like ecosystem services. In particular, wealthier nations should be prevented from free-riding, and instead pay for the services they receive from the biodiverse and ecologically productive ecosystems in less developed countries.
Sustainable funding	PES systems should link beneficiaries with producers. In order to be sustainable, fees should be collected from beneficiaries in order to pay producers to continue to provide the services — either by paying private land owners or through investments in commonly owned natural capital assets.
Adaptive management	Given that significant levels of uncertainty always exist in ecosystem service measurement, monitoring, valuation, and management, we should continuously gather and integrate appropriate information with the goal of learning and adaptive improvement. To do this we should evaluate the impacts of existing PES systems and design new systems as experiments from which we can more effectively quantify performance and learn.
Education and politics	Two key limiting factors in implementing PES systems are shared knowledge of how the systems work and political will. Both of these can be overcome with targeted educational campaigns, clear dissemination of success and failures directed at both the general public and elected officials.
Participation	All stakeholders (local, regional, and global) should be engaged in the formulation and implementation of PES systems. Full stakeholder awareness and participation contributes to credible, accepted rules that identify and assign the corresponding responsibilities appropriately, and that can be effectively enforced.
Policy coherence	PES systems will be most effective when they form part of a coherent set of policies to address ecosystem use and management. They are less likely to work when other policy instruments are providing opposing incentives (for example by subsidising the use of water, energy etc.) or when legislation controlling allocation is inflexible

Source: Farley & Constanza (2010)

What if carbon is priced much lower?

Even though the current carbon price seems to be relatively high, it may not be profitable for small landholders to implement carbon abatement projects.

The repeal of the Carbon Pricing Mechanism and the establishment of the Direct Action Plan and the Emission Reduction Plan announced by the current government may have a significant impact on the carbon price.

Volatility of carbon prices in the European Union Emissions Trading Scheme could have a huge impact in the Australian carbon market due to the proposed future linking of the markets.

Uncertainty around future carbon prices reduces the willingness of stakeholders to make long-term commitments.

Effective communication to stakeholders about additional benefits of carbon sequestration activities is needed to counteract an eventual carbon price drop.

There is the need to continue analysing the applicability of Carbon Capture and Storage which being tested in Australia as well as internationally.

The future impact of Carbon Capture and Storage on carbon prices is unclear.

There is not clear evidence in the literature about the environmental consequences of a significantly lower price of carbon. Nevertheless, as carbon sequestration and emission- avoidance projects involve high establishment costs, they are highly dependent on carbon markets and prices. In Australia, in a study carried out mostly large in properties, "several thousand hectares in area", a company estimated that the costs, associated with registering and auditing environmental planting projects are around 20,000 per property. Despite the expectation of lower costs for smaller properties, the "fixed costs related to the preliminary assessment and project management will be the same regardless of project size" (Knudsen & Putland, 2012).

Correspondingly, van Oosterzee (2012) states that the returns will not cover the costs resulting from registering the rights to the carbon and other expenses such as survey, plan preparation or forest establishment costs which contradicts "the expectation that forests deliver low-cost abatement". With carbon prices ranging from $23 a tonne in 2012 to $25.40 in 2015 (Australian Government, 2013a; Commonwealth of Australia, 2012), the expected income ranges from $160 to 345 ha/year (Knudsen & Putland, 2012). This implies that these types of plantations would only be profitable for large-scale farms. Consequently, it can be assumed that a low price of carbon in national and international markets could provoke discouragement for stakeholders to setup new GHG-abatement projects.

The European Union Emission Trading Scheme (EU ETS) is the biggest carbon market in the world, operating in the 28 EU members and three associated member states belonging to the European Economic Area (EEA) and the European free trade Association (EFTA) (European Commission 2014a). The EU ETS set prices for carbon emission of about 11,500 high-energy consuming industries, covering the 46% of European emissions, since 2005 (Alberola *et al*. 2008). The EU ETS and the Australian carbon markets are setting "the first full inter-continental linking of emission trading systems". This "full two-way link" market will start around July 2018. In the meantime, from July 2015 an "interim link" will allow Australian businesses to offset their emissions using EU ETS allowances (Australian Government 2013b; European Commission 2014b). Although, the plan to link the European and Australian carbon markets was announced in 2012 (Australian Government 2013b; European Commission 2014b), uncertainty for this to happen persists.

Fluctuations of carbon markets/prices can have important impacts on carbon abatement projects. In a study conducted on the UE ETS, Feng *et al*. (2011) state that "the carbon market is a complex volatility model" as prices can be affected by different factors such as power prices, weather and traders' behaviour. In the same context the Parliament of Australia (2012) conveys that the fluctuation of carbon prices in the EU ETS (Figure 3.3) are driven by different market factors such as offer and demand, but also economic, financial and environmental factors including: industrial production, financial markets, energy prices and weather as well as policy issues and uncertainty of policy shifts.

In Australia, since the start of the Carbon Pricing Mechanism (CPM), July 2012, the price per ton of CO_2-e, for the fixed price, was set at AU$ 23 in 2012–13, $24.15 in 2013–14, and $25.40 for 2014–15. In 2015, from the flexible period, the price will be set by the market (Australian Government, 2013a; Commonwealth of Australia, 2012). According to Commonwealth of Australia (2012), during the flexible period, 2015 to 2018, a price floor AU$ 15, and a price ceiling, AU$ 20 higher than the expected international price, were to be set. However the Australian carbon market is experiencing critical changes. On one hand, the repeal of the CPM, which will "abolish the carbon tax from 1 July 2014" and the establishment of the Direct Action Plan and Emission Reduction Plan has been announced by the current government (Australian Government 2014). Furthermore, there will not be a floor price per ton of CO_2-e due to the linking with the EU ETS (Mansell & Sopher 2014), which could have an impact on the price of carbon adding more uncertainty to the carbon market.

It is necessary to share information effectively with stakeholders about the benefits resulting from the adoption of carbon sequestration activities, which could be crucial to counteract negative impact of an eventual drop of carbon prices. Mechanisms to pay for carbon sequestration are justified because the adoption of new farming activities may present some risk to farmers. Nevertheless, there are additional important economic and environmental benefits (Table 3.4) resulting from the adoption of "conservation agricultural systems" (FAO and CTIC 2008).

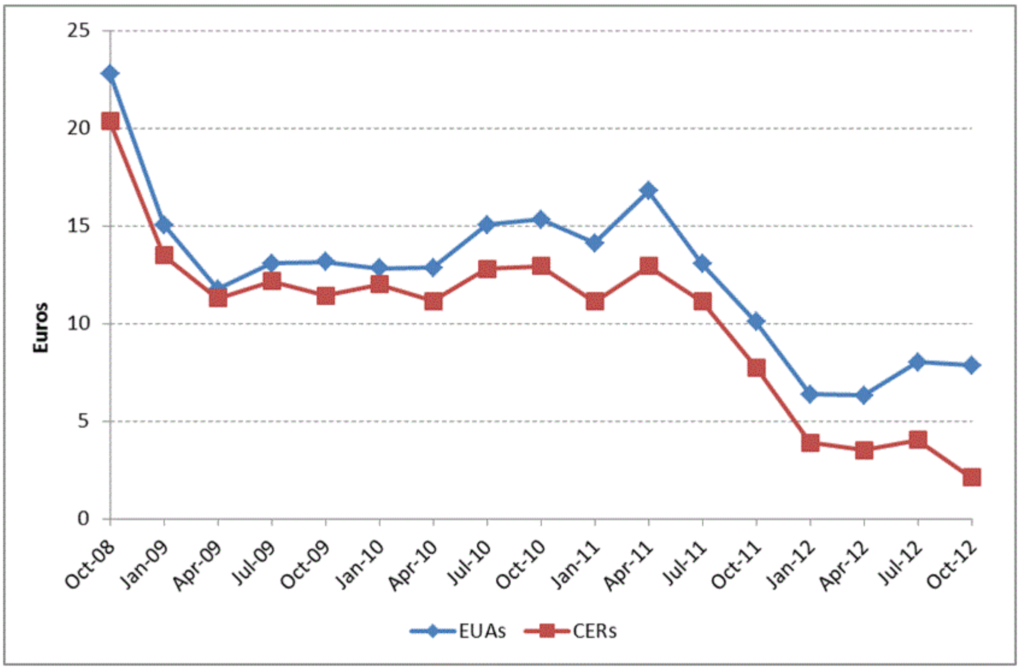

Figure 3.3 Prices of Carbon in EU ETS 2008-2012

Source: Parliament of Australia (2012).

Carbon capture and storage (CCS) also called geological sequestration or geosequestration that refers to the process of capturing carbon dioxide emitted from burning fossil fuels, which then is compressed, transported to an adequate geological formation that will be used as storage and then injected (CO2CRC 2011; Metz *et al*. 2005). Carbon capture and storage is not a new or untested technology, oil and gas industries have been using it for around forty years to improve recovery of oil and gas (New South Wales Trade and Investment 2014). CCS can be applied to industries that produce large amounts of carbon dioxide, production of natural gas, synthetic fuel production, etc. (Metz *et al*. 2005). Various demonstration projects in execution or planned in Australia, including 3 in Queensland (CO2CRC 2011) : CarbonNet Project, Victoria (CCS Flagship Project), South West Hub Project, Western Australia (CCS Flagship Project), Surat Basin Integrated CCS Project, Queensland, Callide Oxyfuel Project, Queensland, CO_2CRC Otway Project, Victoria, The Gorgon Project, Western Australia, GDF SUEZ Australian Energy Carbon Capture Plant, Victoria, AGL Loy Yang Project, Victoria, CO_2CRC UNO Mk 3 Project, Vales Point Power Station, New South Wales, CSIRO Vales Point PCC Project, CO_2CRC Membrane CO_2 Capture Facility, Tarong PCC Project, Queensland, NSW CO_2 Storage Assessment Program.

In a report about costs of CCS in EU, Zero Emissions Platform (2011) states that "Post 2020, CCS will be cost-

Table 3.4 Key environmental and economic services that can be derived from conservation agricultural systems.

FINANCIAL BENEFITS FOR FARMERS	BENEFITS TO COMMUNITIES & SOCIETY	ENVIRONMENTAL BENEFITS
Greater yields and improved yield stability invariable weather	More reliable and cleaner water supplies resulting in lower treatment costs	Favourable hydrologic balance and flows in rivers to withstand extreme weather events
Reduced fuel and labour requirements	Less flooding due to better water retention and slower runoff, resulting in less damage to roads, canals, ports and bridges	Reduced incidence and intensity of desertification
Greater resilience to drought through better water infiltration and retention	Improved air quality with less wind erosion	Increased soil biodiversity
Alleviation of labour deman at key times in the year, permitting diversification into new on-farm and off-farm enterprises	More secure food and water sources	Less soil erosion resulting in less sediment in rivers and dams
Better cycling of nutrients and avoiding nutrient losses	Economic and industrial development opportunities	Potential for reduced emissions of other greenhouse gases, including methane and nitrous oxide, if compaction is avoided
Higher profit margin with greater input-use efficiency	Improved quality of life	Reduced deforestation due to land intensification and more reliable and higher crop yield
Increasing land value due to progressive improvements in environmental quality		Less water pollution from pesticides and applied fertiliser nutrients
		Less hypoxia of coastal ecosystems

Source: FAO and CTIC 2008

competitive with other low-carbon energy technologies” and that CCS is already being considered as a crucial option to fight climate change “within a portfolio of technologies”. However, the department of Trade and Investment of New South Wales claims that internationally CCS is still being demonstrated to gain understanding and reduce costs and that commercial applications of this technology are not possible yet (New South Wales Trade and Investment 2014). There is the need to continue with the analysis of this mitigation option and the possibilities for application within the region. Since CCS is still in trial stages, the future impact of CCS on carbon prices is unclear.

Summary of adaptation options for ecosystem services

Table 3.5 Major climate change impacts and potential adaptation options for ecosystem services. Adaptation options that also potentially mitigate greenhouse gas emissions are marked **(M)**.

		EXAMPLE ADAPTATION OPTIONS		
Climate change	**Major impacts**	**Protect**	**Accommodate**	**Retreat**
Increased atmospheric CO_2	1. Exacerbate all climate change impacts	· Sequester more carbon through environmental plantings using longer-lived species with higher wood density and extensive root systems **(M)**; · Limit clearing of woodlands and savannas to protect soil carbon stocks **(M)**; · Integrate trees with farming practices **(M)**; · Reduce fire frequency in savanna systems **(M)**; · Manage shelterbelts, improve grasses, implement rotational grazing and manage stocking rates **(M);** · Improve carbon capture and storage technologies **(M)**.		
Increased temperatures	1. Increased water temperatures		· Maintain and restore riparian vegetation to create cool water refugia **(M)**	
	2. Impacts on farm productivity (e.g., livestock health)		· Integrate trees into farm landscapes, including regrowth.	
Sea level rise	1. Increased vulnerability of		· Conserve landward	

			EXAMPLE ADAPTATION OPTIONS		
	coastal communities due to inundation of mangrove systems		sea level rise refugia for coastal vegetation systems; · Facilitate landward migration of mangroves.	
	2. Sea water intrusion into freshwater wetlands		Conserve and restore littoral forests **(M)**	
Extreme events (increased occurrence of high intensity cyclones, extreme rainfall events, heatwaves)	1. Increased vulnerability of coastal communities during cyclones, especially in combination with sea level rise and storm surge.	Hybrid engineering defensive measures. (e.g., revegetation of lard engineering sites in riparian zones).	· Protect & restore mangroves, littoral forests and vegetation on dunes and barrier islands **(M)**; · Establish protective coastal tree plantations using robust species **(M)** · Managed realignment to promote natural regeneration of mangroves by reconnecting coastal areas with tidal systems.	
	2. Reduced water quality due to sediment and pollutant runoff into waterways during heavy rainfall events		Maintain or restore ground cover and woody riparian vegetation to slow overland flow and reduce soil erosion.	
	3. Flooding and erosion during heavy rainfall events		· Restoration of vegetation on floodplains **(M)**; · Off-channel basins and wetlands to store water; · Channel reconfiguration; · Bank stabilisation.	
	4. Damage to the Great Barrier Reef system		Conserve and restore native vegetation cover in reef catchment area **(M)**	

		EXAMPLE ADAPTATION OPTIONS		
	5. Damage to agroforestry		· Select more resistant species. Source seed from areas subject to cyclones; · Use mixed-species plantations to increase resilience e.g., to pest outbreaks.	
More variable rainfall	1. Reduced availability of freshwater		· Water sensitive design at micro- and macro-scales; · Groundwater extraction; · Water savings measures, esp. during the dry season.	

Barriers to potential adaptation options

Scepticism and misinformation about climate change science are an ongoing issue

There are uncertainties about the magnitude of climate change effects.

Linkages among policy-makers, researchers and landholders need to be improved.

Well-developed evaluation tools for assessing adaptation options are a priority.

There is a strong mindset that all climate adaptation options are expensive.

In Australia ongoing scepticism is a barrier for adaptation to climate change (Hennessy 2007). Scepticism is a real problem for climate change adaptation because it influences the attitude of different stakeholders to not act to deal with anticipated costs and benefits of climate change. Inadequate information flow about climate change is also a barrier to adaptation (Rodriguez *et al*. 2009).

Climate change is a very long-term phenomenon and it is also very difficult to precisely predict what the future may be. Although there is a strong consensus about the climate change impacts on different ecosystem services like water provision, carbon sequestration, agricultural production and habitat provision, uncertainty exists about the level of magnitude, which also discourages the community to act to adapt with climate change in the short term. Uncertainty in climate change projections – particularly rainfall - is a barrier to climate change adaptations in Australia (Hennessy 2007).

In Australia climate change related policy and regulations always varies with changes in government at all levels, despite the fact that long-term commitment is required from the NRM adopters to receive any incentives from governments.

The linkage among various strata of government - from national to local - regarding climate adaptation policy, plans and requirements is weak in Australia (Hennessy 2007), which hinders or delays the adaptation options in the NRM sector. Potential adopters are rarely interested to adopt something if they know little or nothing about it (Rodriguez *et al*. 2009). Lack of on-farm trials and demonstrations, and lack of sufficient institutional support, are all barriers to adaptation to climate change (Rodriguez *et al*. 2009). The effective evaluation tools for assessing planned adaptation options, such as benefit-cost analysis is currently lacking (Hennessy 2007).

In one study Rodriguez *et al*. (2009) found that the first barrier to adoption mentioned by potential adopters was the economic factor due the costs involved in the process of adoption. So community people think that most of the climate adaptation process involved a huge investment but some adaptations are based on only the 'best practice; that they are practicing now. Potential adopters are also worried about the investment return for adaptation (Rodriguez *et al*. 2009) due to the uncertainties in climate change.

Summary and conclusions

Ecosystem services are the benefits people derived from ecosystems including the provision of food, fibre, timber and water, climate regulation, nutrient cycling, and habitat provision for biodiversity. Ecosystem services are an essential element of community wellbeing, but are under serious threat from global climate change. NRM managers in the WTC Region will be required to respond at differing temporal and spatial scale to ensure the sustainable supply of ecosystem services.

The key ecosystem services that apply to the WTC Region that will require climate adaptation pathways includes: water regulation and water provision; coastal protection and erosion control; carbon sequestration; habitat provision for biodiversity; timber production; traditional values; and marine ecosystem services.

There are many barriers to current mechanisms for effective adaptation to climate change. Current government funding for carbon offset schemes is insufficient and the gains in protection will be outweighed by the rapid loss of biodiversity. Policy shifts are argued to be an important barrier to climate adoption since uncertainty in the direction of policies generally tends to discourage stakeholders from adopting new methodologies.

There is the need to develop appropriate mechanisms to pay for ecosystem services (PES) in the WTC Region given that they are vital for human wellbeing, are becoming increasingly limited and that many of the key services do not have substitutes. Various approaches for PES that may be applied within the WTC NRM Region have been presented and evaluated.

There is not clear evidence in the literature about the effects that a significantly low price of carbon could generate for the environment. Nevertheless, as carbon sequestration and emission avoidance projects involve high establishment costs, they are therefore highly dependent on carbon markets and prices.

Climate change is a very long-term phenomenon and it is also very difficult to precisely predict what the future may be. Although there is a strong consensus about the climate change impacts on different ecosystem services like water provision, carbon sequestration, agricultural production and habitat provision, uncertainty exists about the level of magnitude, which also discourages the community to act to adapt with climate change in the short term. Uncertainty in climate change projections – particularly rainfall - is a barrier to climate change adaptations in Australia, including the WTC Region.

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