

Opportunities in tropical science, knowledge, research and innovation for Queensland



Dear Premier

Please find attached the Smart State Council working group report on 'Opportunities in Tropical Science, Knowledge, Research and Innovation for Queensland'. The report draws attention to emerging opportunities for knowledge-based industries focussed on the provision of food, health, building, environmental and education services to the tropical world.

The report notes that Queensland's R&D base and tropical location give us a huge competitive advantage in the development of these industries, but that capitalising on that advantage will require major efforts to coordinate and commercialise our research.

Finally, the report outlines ways in which industry, research and government can work together to capture this opportunity for Queensland.

I commend it to you.

Professor Peter Andrews

Queensland Chief Scientist and
Chair, Standing Committee
Smart State Council

© The State of Queensland (Department of the Premier and Cabinet) 2006.
Published by the Queensland Government, 9 August 2006, George Street, Brisbane. Qld. 4000.

The Queensland Government supports and encourages the dissemination and exchange of information. However, copyright protects this document. The State of Queensland has no objection to this material being reproduced, made available online or electronically but only if it is recognised as the owner of the copyright and this material remains unaltered. Copyright enquiries about this publication should be directed to the Department of the Premier and Cabinet, by email to copyright@premiers.qld.gov.au or in writing to PO Box 15185, City East Qld 4002.

Copies of this publication can be obtained at www.smartstate.qld.gov.au

WORKING GROUP

Chair

Professor Russell Reichelt, CEO, Marine and Tropical Science Research Facility

Members

Lt. General John Grey AC, Chancellor, James Cook University; Board Chair, Wet Tropics Management Authority

Mr Michael Rayner, Partner, Cox Rayner Architects

Dr Ian Gould, Chair, Australian Institute of Marine Science

Dr Stephen Prowse, CEO, Australian Biosecurity Cooperative Research Centre for Emerging Infectious Disease

Professor Lesley Johnson, Deputy Vice Chancellor, Research, Griffith University

Professor James Dale, Director, Centre for Tropical Crops and Biocommodities, Queensland University of Technology

SMART STATE COUNCIL

The Smart State Council was established in June 2005 as a central advisory body to provide high level advice to the Queensland Government on emerging Smart State issues and trends, and to propose measures to position Queensland to respond to challenges and opportunities.

The Smart State Council is chaired by the Premier of Queensland and comprises Government Ministers, the Queensland Chief Scientist and representatives from Queensland's business and research communities.

This paper was prepared by an independent working group for the Smart State Council. The views expressed in this paper are those of the group and do not represent Queensland Government policy.

Executive summary

1. *The Opportunity*

Queensland has the opportunity to become a world leader in tropical know-how by servicing the increasingly sophisticated needs of rapidly developing tropical nations, while simultaneously improving the quality of life of Queenslanders and Australians living in the tropics.

The increasing wealth and population growth in the tropical world and the likely environmental impacts of these trends is escalating demand for a range of goods and services such as health, environmental management, agriculture, urban renewal, and education.

As one of the few developed regions within the tropics, Queensland is well placed to capitalise on this emerging global demand. The State has a mega-biodiverse environment, world-class capabilities and infrastructure in tropical knowledge, a modern economy, and is close to the rapidly growing Asia-Pacific region.

Queensland has the opportunity to become an international centre in tropical research, knowledge and innovation, building industries that service the needs of tropical nations, and returning substantial economic gains to the State. Aside from the economic benefits, which would generate regional growth and employment in tropical Queensland, there would also be a range of environmental and social outcomes that would benefit Queenslanders living in the tropics and remote communities.

There are substantial opportunities for Queensland in the application of research, knowledge and innovation to the basic needs of all tropical communities, but most importantly in the areas of:

1. enhancing tropical health expertise and capacity
2. maximising value from the environmental and cultural assets of tropical Queensland
3. transforming tropical primary industries
4. promoting and capitalising on tropical living and design
5. extending tropical knowledge and influence through education and capacity-building.

Seizing these opportunities and developing a sustainable niche sector of the Queensland economy based on tropical knowledge and expertise requires:

- coordinating and building on our tropical know-how
- bringing our tropical know-how to market.

2. Coordinating and building on our tropical know-how

Queensland is recognised internationally for its tropical science skills, programs, and infrastructure. However, these resources and capabilities are fragmented, geographically dispersed and are not aligned to exploit the benefits and synergies that could be derived from critical mass. This situation could be remedied and a competitive niche advantage for Queensland could be built through coordination, networking and clustering of our capacity in the five areas of opportunity identified in the previous section.

2.1 Tropical health – There is potential to build on existing capacity in medicine, public health and veterinary science in Queensland.

Opportunities for scientific discovery and commercialisation exist at the interface of human health and medicine with emerging zoonoses (diseases transmissible from animals to man), such as BSE, avian influenza, or leptospirosis. Strong partnerships and linkages could be formed with public health researchers across northern Australia and with internationally recognised expertise in the subtropics.

2.2 Tropical environmental sciences and management – Efforts to enhance critical mass, reduce duplication of research, attract significant funding to the region, and foster the development and commercialisation of specialist research and development (R&D) services for environmental outcomes would be highly beneficial to Queensland. Strategic alignment of the significant R&D capacity in environmental science and management in the State would provide the knowledge platform to foster industry engagement in ecosystems management of the developing tropical world. Opportunities would also exist to utilise Indigenous knowledge in the development of education, ecotourism, biodiscovery, and commercial ventures.

2.3 Tropical primary industries - Potential exists to better link the technological capacity and expertise in life sciences centred in South-East Queensland with the significant network of government supported research facilities and programs based in the north of the State. By smarter integration of the innovative outputs in tropical primary industries with real-world experience and field-based industry assessment, Queensland could capitalise on its status as a significant centre for agricultural biotechnology in the Asia Pacific region.

2.4 Tropical living – There are opportunities to coordinate Queensland's capacity and scientific knowledge in tropical living across a wide range of interconnected fields, including environmental science, health, planning, urban renewal, building design, and environmental design. Such coordination could place Queensland in a unique position to encourage and promote a substantial export industry based on urban renewal of mega-cities in the developing tropical world through integrated solutions.

2.5 Tropical education - Strategic, tailored, and coordinated education services of specific interest to the tropical world could be developed by better coordination of education services in tropical science, knowledge, research and innovation. A more strategic approach to deliver Queensland-based education programs could lead to increased employment opportunities through growth of the tropical science knowledge industry, international recognition of Queensland as a centre of excellence in tropical science, and ultimately, strong ties and mutually beneficial relationships between our State and the future leaders of the tropical world.

3. *From opportunities to markets*

Queensland has a poor record in commercialising and marketing products, services and intellectual property to support the development of industries based on tropical know-how. Effective management, financing, and marketing of the areas of opportunity outlined above would create a sustainable niche sector in the Queensland economy.

Opportunity exists to establish an overarching mechanism or hub that would provide identity and global branding by marketing Queensland as a world leader in tropical science, knowledge, research and innovation. Strategic alignment of effort in tropical science would create a potent, cohesive and targeted tropical knowledge capacity that would surpass that offered by any other State or country.

Better marketing and coordination of Queensland's tropical know-how would create alliances and partnerships with researchers, investors and clients to commercialise relevant products and services at a regional and industry level, rather than at an organisational level. Anticipated outcomes from this approach are regional economic development, better coordination of scientific capacity for problem solving and application, access to greater infrastructure, as well as supporting the social and environmental objectives of local communities.

A conceptual outline of the hub mechanism is provided in **Figure 1**.

International Hub for Tropical Knowledge

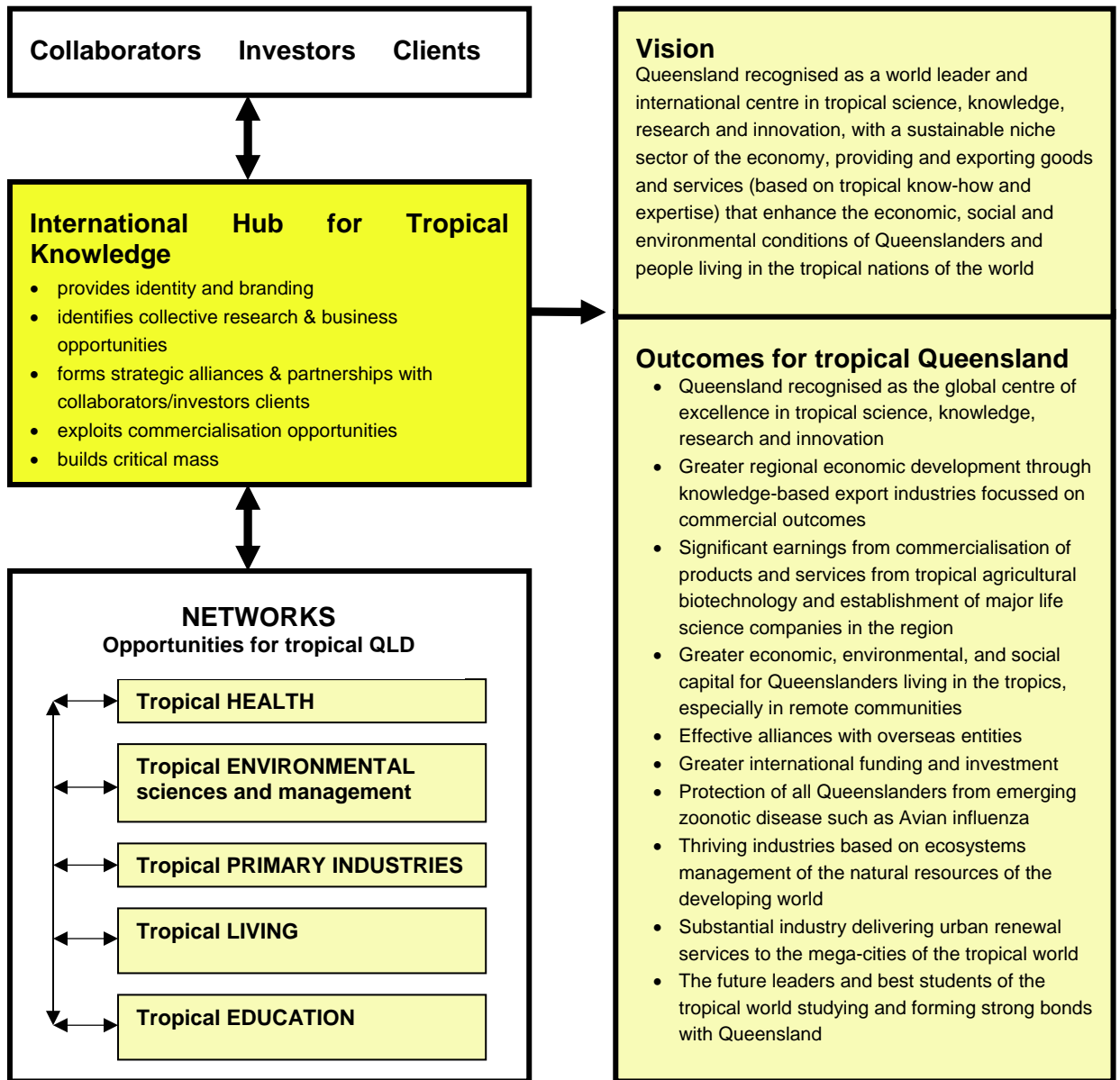


Figure 1. Hub mechanism

Table of contents

Executive summary	iii
Table of contents	vii
Abbreviations	viii
1.0 INTRODUCTION	1
2.0 ENVIRONMENTAL SCAN	1
2.1 Emerging international trends.....	1
2.2 Queensland's current position	2
2.3 A way forward.....	4
3. CREATING COMPETITIVE STRENGTH	6
3.1 Enhancing tropical health expertise and capacity	7
3.2 Maximising value from environmental and cultural assets	11
3.3 Transforming tropical primary industries	20
3.4 Promoting and capitalising on tropical living and design.....	28
3.5 Extending tropical knowledge through education.....	33
4. FROM OPPORTUNITIES TO MARKETS	37
4.1 Marketing	37
4.2 R&D intensive tropical industries.....	38
4.3 Commercialisation	38
4.4 A new approach.....	40
5. REFERENCES	42
Appendix 1. Capacity and capability	45
Appendix 2. Detailed SWOT analysis	64

Abbreviations

AAHL	Australian Animal Health Laboratory
ABCRC	Australian Biosecurity CRC for Emerging Infectious Disease
ACIAR	Australian Centre for International Agricultural Research (Australian Government)
ACITHN	Australian Centre for International & Tropical Health & Nutrition
ACTFR	Australian Centre for Tropical Freshwater Research (JCU)
AIMS	Australian Institute of Marine Science
AMPTO	Association of Marine Park Tourism Operators
ANU	Australian National University
APEC	Asia-Pacific Economic Cooperation
ARC	Australian Research Council
ASEAN	Association of Southeast Asian Nations
ATFI	Australian Tropical Forest Institute
ATSI	Aboriginal and Torres Strait Islander
ATSIC	Aboriginal and Torres Strait Islander Commission
AusAID	Australian Agency for International Development
BERD	Business expenditure on R&D
BSE	Bovine Spongiform Encephalopathy
CDU	Charles Darwin University
CERF	Commonwealth Environment Research Facilities, Department of the Environment and Heritage (Australian Government)
CQU	Central Queensland University
CRC	Cooperative Research Centre
CREDC	Cairns Region Economic Development Corporation
CRTR project	Coral Reef Targeted Research and Capacity Building for Management – Global Environment Fund (UQ)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEST	Department of Education, Science and Training (Australian Government)
DPI&F	Department of Primary Industries and Fisheries (Queensland Government)
DSDTI	Department of State Development, Trade and Innovation (Queensland Government)
EPA	Environmental Protection Agency (Queensland Government)
FRDC	Fisheries R&D Corporation
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
GBRRF	Great Barrier Reef Research Foundation
GDP	Gross Domestic Product
GU	Griffith University
ICT	Information and communication technology
IMB	Institute for Molecular Bioscience (UQ)
IWC	International Water Centre

JCU	James Cook University
L&WA	Land and Water Australia
Menzies	Menzies School of Health Research
MOU	Memorandum of understanding
MTSRF	Marine and Tropical Sciences Research Facilities
NAEIDA	Northern Australian Emerging Infectious Disease Alliance (proposed)
NCRIS	National Collaborative Research Infrastructure Strategy (Australian Government)
NCWR	National Centre for Water Resources
NHMRC	National Health and Medical Research Council (Australian Government)
NQ	North Queensland
NRM	Natural Resource Management (Australian Government)
NRMW	Department of Natural Resources, Mines and Water (Queensland Government)
NWI	National Water Initiative (Australian Government)
OECD	Organisation of Economic Co-operation and Development
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
QBP	Queensland Bioscience Precinct (UQ)
QH	Queensland Health
QIMR	Queensland Institute of Medical Research (UQ)
QPWS	Queensland Parks and Wildlife Service (Queensland Government)
QUT	Queensland University of Technology
R&D	Research and Development
SME	Small to medium-sized enterprises
SSRFF	Smart State Research Facilities Fund (Queensland Government)
STRI	Smithsonian Tropical Research Institute
SWOT	Strengths, Weaknesses, Opportunities and Threats
TAFE	Technical and Further Education
THI	Tropical Health Institute (proposed)
TPHUN	Tropical Public Health Unit Network
TRACK	Tropical Rivers and Coasts Knowledge (proposed)
TSIP	Tropical Science and Innovation Precinct (proposed)
TTNQ	Tourism Tropical North Queensland
UNSW	University of New South Wales
UN	United Nations
UQ	University of Queensland
UNESCO	United Nations Educational, Scientific and Cultural Organization
UWA	University of Western Australia
WHO	World Health Organization
WTMA	Wet Tropics Management Authority

1.0 INTRODUCTION

Queensland has substantial research infrastructure and natural resources based in the tropics that could be utilised to more fully capitalise on growing tropical markets. This paper assesses emerging trends in the tropics, Queensland's capacity and capability in tropical knowledge, and the strengths, weaknesses, opportunities, and threats associated with any move by the State to substantially increase its role in the tropical marketplace. Through this analysis, Queensland's competitive advantages are identified, along with the opportunities that could maximise our potential in tropical science, knowledge, research and innovation.

2.0 ENVIRONMENTAL SCAN

2.1 Emerging international trends

The standard of living in many tropical nations within the developing world is improving rapidly, with an associated increased need for a range of goods and services such as health, environmental management, agriculture, urban design, and education. Many tropical nations will look to developed regions to fulfil these needs. Although at a formative stage of development, these markets provide opportunities for enterprising, skilled, and prepared suppliers of relevant goods and services.

Tropical nations account for approximately one-half of the world's population and one-third of the world's landmass, but produce only one-fifth of the Gross World Product.¹ Although tropical nations are currently amongst the poorest in the world (limiting the present market for many tropical goods and services), many are developing rapidly. Three of the four most populous tropical nations – India, Indonesia and Bangladesh – recorded strong economic growth per person between 1990 and 2002 of 4.0%, 2.1%, and 3.1%, respectively.² These changes in wealth will produce an increasing demand for goods and services in these regions, while also increasing the environmental impact arising from the use of these resources. Queensland is well placed to serve these growing tropical markets.

The demand for goods and services will also increase due to rapid population growth, which is again highest in the tropics.³ Improving health and education levels has been identified as the most effective way to decrease population growth, and, for this reason, the United Nations Millennium Development Goals⁴ and many philanthropic organisations focus on these issues. In 2003, US\$77.5 billion was spent on official development assistance by international organisations and individual donor nations, up from US\$59 billion in 2001, with about one-half of this amount allocated to tropical nations.⁵ There is huge potential for coordinated proposals from Queensland to access this funding.

With declining long-term commodity prices (the average commodity in 1998 was worth only one-fifth its value 150 years earlier)⁶ and higher labour costs in Queensland than in our tropical neighbours, competitive advantage must be driven through the use of science, technology, research and innovation. The development and utilisation of knowledge has the capacity to create entirely new industries, and also maintain the competitiveness of established industries in tropical Queensland.⁷ In recognition of this potential, 'Tropical Futures' is one of the Queensland Government's six R&D Priorities.

A number of tropical nations are actively pursuing programs in science and technology. For example, Singapore has committed considerable funding in the 'One North' concept, stage one of which is 'Biopolis',⁸ a seven building, US\$300 million biomedical science complex.⁹ A number of international pharmaceutical companies have invested in Biopolis, including Novartis, which established the Novartis Institute for Tropical Diseases,¹⁰ and GlaxoSmithKline, whose investment in Singapore (their regional headquarters) exceeds US\$600 million (in manufacturing through to R&D).⁹ China and India are also committing to scientific programs, and Malaysia has invested significant funding in BioValley and the Multimedia Supercorridor, which house more than 900 information and communication technology (ICT) companies. However, much of the science investment in tropical nations is focussed on servicing the needs of the developed world. Queensland can seize the opportunity to direct research programs to address the emerging needs of developing tropical nations.

2.2 Queensland's current position

Australia is the most developed nation situated in the tropics,^{2,11} with Queensland dominating Australia's tropical population and economy (**Table 1**). Queensland has more tropical climate types than any other jurisdiction on Earth,¹² a mega-biodiverse environment, more than 13% of the world's coral reefs,^{13,14} a politically stable economy and is close to the rapidly growing Asia-Pacific region. In addition to its substantial tropical knowledge base and extensive R&D facilities, Queensland also has millennia of Indigenous tropical know-how.

Table 1. Tropical Queensland and Australia

Parameter	Tropical Queensland as a percentage of Queensland	Tropical Australia as a percentage of Australia	Tropical Queensland as a percentage of tropical Australia
Area ¹⁵	72.0	45.8	35.4
Gross Domestic Product ¹⁶ (2004-05) • Knowledge Based Industries (2004-05) ^{16,#}	23.1 18.0	N.D. [†]	N.D. [†]
Employment ^{15,16} • Knowledge Based Industries ^{16,#}	21.3 (2004-05) 17.5	5.78 (2001)	73.2 (2001)
Population ^{15,17} • Indigenous Popn (2001) ¹⁵	21.0 (2004) 55.2	5.85 (2001) 32.3	73.4 (2001) 47.0

† Not determined as gross regional product data was not available for the Kimberley and Pilbara regions of Western Australia.

Knowledge Based Industries were defined at the 3 digit ANZSIC level, and included exploration (151), high-technology and medium-high technology manufacturing (253-4, 281-6; as adapted from Statistics New Zealand (<http://www.stats.govt.nz/analytical-reports/research-development-2002/oced-tec-clas.htm>)), and communications, finance/insurance, business services, education and health and community services (711-86, 841-72; as defined by the US National Science Foundation (<http://www.nsf.gov/statistics/seind04/c6/fig06-11.xls>)).

The changing international trends outlined in Section 2.1 provide huge opportunities for Queensland to develop tropical knowledge industries, based on its substantial tropical knowledge capacity (**Appendix 1**) and significant and iconic natural features of world standing.

An analysis of the strengths, weaknesses, opportunities and threats (SWOT) of Queensland's tropical know-how (**Table 2**) highlights that realising these opportunities requires Queensland to move decisively to address our weaknesses. Much of Queensland's capacity in tropical knowledge and research is fragmented and poorly coordinated, leading to duplication of activities and resources and also limiting the formation of critical mass.

Stronger collaboration and better coordination across tropical research projects and infrastructure are vital, not only in tropical Queensland, but also in the south-east of the State, elsewhere in Australia and internationally. Together it will build a globally competitive strength, which will enable Queensland to deliver and export technologies, products, skills and services for the tropical world.

This approach is used successfully by leading research entities based outside the tropics, such as the Wellcome Trust for Tropical Clinical Medicine (with laboratories in London, Liverpool and Oxford), the Liverpool School of Tropical Medicine, the Bernard-Nocht Institute of Tropical Medicine in Germany, and the Centers for Disease Control and Prevention in the USA. A possible model that demonstrates the integration of scientific capacity across tropical and temperate climate zones is the Smithsonian Tropical Research Institution (STRI) in Panama, the only bureau of the Smithsonian Institution that is based outside of the United States.

Table 2. SWOT analysis of tropical know-how in Queensland.[#]

<p>Strengths</p> <ul style="list-style-type: none"> • Strong record of success in research • Close proximity and access (e.g. international airports) to the most populous tropical nations on earth • Developed and politically stable economy with a financial, regulatory and legal environment that supports research • The most developed tropical nation worldwide with substantial research infrastructure 	<p>Weaknesses</p> <ul style="list-style-type: none"> • Widespread poverty in the tropics limits the immediate market of goods and services • Poor record in commercialising research • Duplication and general lack of coordination in tropical research • Parochialism and lack of cooperation between tropical regions • Poor health and educational outcomes for Indigenous populations
<p>Opportunities</p> <ul style="list-style-type: none"> • Massive growth in the urban populations of tropical nations • Increasing wealth and demand for goods and services in tropical nations • Increasing focus in tropical nations on environmental sustainability • A mega-biodiverse environment that provides a range of environmental opportunities such as biodiscovery • Queensland has more tropical climate types than any other jurisdiction on Earth • Burgeoning tourism, particularly eco- and special interest tourism, is a strong determinant in Queensland's economic growth • Potential to share in a greater proportion of the global aid market 	<p>Threats</p> <ul style="list-style-type: none"> • Some of our tropical neighbours are rapidly building research and commercialisation capacity • Other regions in the world (e.g. UK and US) have a strong track record in tropical research, with a focus on commercialisation • Imported emerging diseases may threaten Queensland's tourism / travel revenue

[#]A more comprehensive analysis is available in **Appendix 2**.

2.3 A way forward

The growing dominance worldwide of knowledge-based industries, coupled with rapid changes in tropical nations, provides Queensland with the opportunity to become a world leader and an international centre in tropical science, knowledge, research and innovation. A sustainable niche sector of the State's economy could be developed based on tropical know-how and expertise, providing and exporting goods and services that would deliver substantial economic benefits to the State.

Aside from economic benefits, which would also generate regional growth and employment in tropical Queensland, there would also be a range of environmental and social benefits. These benefits may include better environmental management practices, more desirable and aesthetically pleasing living conditions, protection against emerging infectious disease, and stronger Indigenous engagement. In addition, these industries would better equip the State to address some of Queensland's most pressing social concerns with respect to Aboriginal and Torres Strait Islander (ATSI) populations.

There are substantial opportunities for Queensland in the application of tropical research, knowledge and innovation to the basic needs of people throughout the tropics, but most importantly in the areas of:

1. enhancing tropical health expertise and capacity
2. maximising value from the environmental and cultural assets of tropical Queensland
3. transforming tropical primary industries
4. promoting and capitalising on tropical living and design
5. extending tropical knowledge and influence through education and capacity-building.

Seizing these opportunities and developing a sustainable niche sector of the Queensland economy based on tropical knowledge and expertise requires:

- creating a competitive niche in tropical know-how
- bringing our tropical know-how to market.

Although there are existing world-recognised tropical science skills, programs, and infrastructure located in north Queensland, there are considerable efficiencies to be gained from the consolidation and strategic alignment of that capacity. Furthermore, engagement of more researchers based in South-East Queensland into partnerships with North Queensland would help consolidate R&D activity and create a higher level of critical mass. To better coordinate R&D efforts in tropical science in Queensland, the establishment of targeted networks that strategically align otherwise disparate initiatives and thus leverage fragmented capacity is strongly supported.

In addition, Queensland's poor performance in effectively commercialising and marketing products, services and intellectual property, particularly in tropical know-how, highlights the need to establish a mechanism that supports such activities. It would be desirable if such an initiative could be developed without being constrained by research discipline, competing interests, or parochialism.

The remainder of this paper addresses how these two issues – alignment and coordination of R&D efforts in tropical science, and commercialisation and marketing of tropical products, skills and services – may be addressed to maximise outcomes for Queensland.

3. CREATING COMPETITIVE STRENGTH

Each of Queensland's five areas of opportunity in tropical know-how (health, environmental management, primary industries, living, and education) was examined in terms of the State's capacity, capabilities, and potential and opportunity to deliver better outcomes for all Queenslanders. Greater detail of specific examples of Queensland's capacity can be found in **Appendix 1**. To determine the best way forward, consideration was given to:

- the increasing wealth, population growth, and demand for goods and services in the tropical world, and the likely concomitant environmental impacts of these trends
- the benefits to be gained from employing education as a lever for future economic growth
- the opportunity to drive the regional economic development of tropical Queensland through knowledge-based industries with an export focus
- the regional advantage created by the existence of James Cook University through its infrastructure and capacity in education and research
- the advantages in developing, retaining and attracting world class research, development, extension, innovation and commercialisation personnel to stimulate and grow critical mass in areas that build on our tropical resource endowment¹⁸
- the value of engaging more researchers based in South-East Queensland to create a higher level of critical mass into partnerships in North Queensland to help build new industry (and to support existing ones)
- the existing world-recognised tropical science skills, programs, and infrastructure located in North Queensland, particularly in environmental science and management, and the efficiencies to be gained from the consolidation and strategic alignment of that capacity
- the ability to generate economic, environmental, and social capital for Queenslanders living in the tropics, especially in remote communities
- the opportunity for better health of Queenslanders living in the tropics
- the need to position Queensland internationally and to leverage funding and investment from external sources.

The value obtained through consolidating research capacity to create synergy was a key premise in developing opportunities for this paper. The integration of partner organisations and research programs delivers much more than pooling resources and bringing complementary groups together. The process also enables networks and ongoing collaborations of partners to be connected to a common centre with potentially significant impacts and efficiencies.

3.1 Enhancing tropical health expertise and capacity

3.1.1 Background

Health is fundamental for the well-being of all people. Tropical nations have amongst the poorest levels of health worldwide, and this issue is a major focal point for international organisations. As a consequence of this attention, both the quality and market for these services are growing rapidly. Queensland will need to embrace these opportunities if it is to take advantage of this growing market.

A good health system is vital for socio-economic development, alleviating poverty, economic growth, lowering birth rates and child mortality rates and also increasing some aspects of social cohesion and political participation.¹⁹ Expenditure on health increases exponentially with increasing standards of living,²⁰ resulting in opportunities for tropical nations as they become wealthier. Increased prosperity is conditional on having a healthy local workforce to service industry. Improvement in health also leads to increasing consumption rates and demand for resources and education services, a greater awareness of issues relating to the environment and sustainability, and further improvements in living standards through augmented economic performance.

The health status of tropical nations is amongst the lowest in the world. Infant mortality rates in tropical nations are more than 11 times higher than those in Australia, and Australians can expect to live on average for about 17 years longer than people from tropical nations.¹

For these reasons, there is an increasing worldwide demand for strong health outcomes. For example, health services are the focus of three of the eight United Nations Millennium Development Goals.⁴ Many governments and philanthropic organisations have also been trying to encourage the development of pharmaceuticals for tropical diseases, which have been largely neglected by pharmaceutical companies due to their small market size.²¹

Australia's health systems and its health R&D are highly regarded internationally. In the OECD, Australia has amongst the highest life expectancy at birth, the second lowest mortality rates and the best dental health record for children.²² Recently, there has been investment by both the Australian and Queensland Governments in tropical health capacity, including the establishment of the School of Public Health, Tropical Medicine and Rehabilitation Sciences at James Cook University adjacent to the recently established Townsville Hospital. The Queensland Government has also invested in biotechnology infrastructure that has a strong tropical health and medical focus, such as the Queensland Bioscience Precinct (QBP), the Queensland Institute of Medical Research (QIMR), and the Institute for Glycomics (**Appendix 1**).

Another entity with tropical expertise is the Tropical Public Health Unit Network (TPHUN) of Queensland Health, with approximately 90 staff that specialise in disease prevention and control, population-level health service delivery systems, applied research in priority areas of tropical infectious diseases, chronic diseases, remote and Indigenous health, tourism, and public health. The TPHUN has considerable potential to export knowledge and services in infectious diseases of the tropics such as dengue fever, malaria, Japanese encephalitis and leptospirosis.

Other existing or proposed groups with significant expertise in tropical health include:

- the Australian Centre for International and Tropical Health and Nutrition (ACITHN), particularly in the Tropical Health Program and the Indigenous Health Program
- the Menzies School of Health Research in tropical and emerging infectious conditions, chronic diseases, and population health
- the Australian Biosecurity CRC for Emerging Infectious Disease (ABCRC) that seeks to detect, identify, monitor, assess, predict and respond to emerging infectious disease threats that impact on national and regional biosecurity
- the planned Northern Australian Emerging Infectious Disease Alliance (NAEIDA) that aims to protect public health through early detection and response to public health emergencies involving emerging infectious diseases
- the potential Tropical Health Institute (THI) in Cairns that would undertake targeted research, education and training to address major public health problems endemic to North Queensland, northern Australia and the Asia-Pacific region
- the proposed Queensland Tropical Disease Cluster that will seek to establish a research network to enable tropical disease surveillance and drug and vaccine development.

Northern Queensland's tropical environment, remote communities and high Indigenous population present special and unique challenges to health protection in this region, some of which have application to the developing nations of the Asia-Pacific region.

The proximity of tropical Australia to our northern neighbours, especially Papua New Guinea, Timor-Leste, and the eastern archipelago of Indonesia make the region vulnerable to a range of biosecurity threats, such as emerging infectious disease. Approximately 75% of newly recognised infectious diseases have been diseases of animals transmitted to humans under natural conditions (zoonoses) and which require a public health response closely linked to control measures in animals. Many of the recently emerged diseases, including Nipah virus, severe acute respiratory syndrome (SARS), and avian influenza, have originated in the Asia Pacific region. The shared tropical zone ecology of the Asia Pacific region places tropical Queensland at particular risk from emerging infectious disease. Furthermore, the speed and unprecedented volume of international travel and trade exacerbates that vulnerability.

In the longer-term, with global warming, the climate of North Queensland is likely to become hotter and more variable than it is today, possibly providing more favourable conditions for mosquito disease vectors and expanding their range into southern areas. It has been suggested that changes in the broad-scale climate system may already be affecting human health, including mortality and morbidity from extreme heat, drought or storms; changes in air and water quality; and changes in the ecology of infectious diseases. In a recent review paper in the journal *Nature*, it was suggested that there is growing evidence that climate–health relationships pose increasing health risks under future projections of climate change and that the warming trend over recent decades has already contributed to increased morbidity and mortality in many regions of the world.²³ The World Health Organization (WHO) estimated that climate change may have caused the death of over 150,000 people in 2000, and the death toll attributed to climate change is likely to increase in the future.²⁴

Furthermore, it has been proposed that climate change would extend the tropics to a greater proportion of the planet, increasing the range and spread of tropical diseases.^{25,26} Woodruff *et al.* (2005) projected that if greenhouse gas emissions are allowed to increase, by 2100, up to 15,000 Australians could die every year from heat related illnesses and the dengue transmission zone could reach as far south as Brisbane and Sydney.²⁷

3.1.2 Opportunities

With significant social, economic and environmental changes occurring in tropical nations, there are major opportunities for Queensland to more fully realise its international potential in tropical health. With its strong track record of excellence in health research, mega-biodiverse environment with consequent biodiscovery opportunities, and position as the most dominant tropical jurisdiction in Australia, Queensland is one of the most attractive sites worldwide for the generation of tropical know-how in health services (**Appendix 2**). The opportunities for biodiscovery and pharmaceutical development from a mega-biodiverse environment are further enhanced by an Indigenous population with a rich, underutilised knowledge of the medicinal properties of much of Australia's flora.

There is also the opportunity to address the poor health levels of Indigenous Australians, which trails behind that of the non-Indigenous population. Relative to the overall Australian population, Indigenous Australians have 17.2 years shorter life expectancy. Major contributors to this are diabetes and related conditions, such as heart and kidney disease. Indigenous people experience up to four times greater prevalence of cardiovascular disease, more than 10 times the prevalence of diabetes in the 20 to 50 years age group, and develop end-stage renal disease at up to 30 times the rate of non-Indigenous people.²⁸ These lifestyle diseases are mainly preventable.

Australia is almost unique among OECD countries in having a large population living and working in the tropics. However, northern Australia has a vast tropical ecology and border with neighbouring countries, and as such, is a major portal for entry of vector-borne infectious disease. Although important collaborations between public health professionals and their agencies and institutions in the north and nearby neighbouring countries exist, most could benefit by improved coordination.

Tropical Health Network

The opportunity exists for Queensland to develop a strategic capacity to detect, diagnose, contain and control extant and emerging infectious disease of public health importance. This can be achieved by undertaking cutting-edge research and working with our northern neighbours to improve core capabilities for health protection in our local region.

In particular, opportunities for research and commercialisation exist in Queensland at the interface of human health and medicine in diseases transferred from vertebrate animals to humans (zoonoses). Although Nipah virus, Hendra virus, and leptospirosis are associated with tropical regions, zoonoses with far greater potential impact include avian flu and bovine spongiform encephalopathy (BSE). Enhanced capacity in zoonotic research in North Queensland would complement the work of the Australian Animal Health Laboratory (AAHL) facility of CSIRO Livestock Industries at Geelong.

Worldwide, around 75% of human emerging infectious diseases are zoonoses, yet research in this area is often incomplete and sometimes contradictory.²⁹ This status is partly because zoonotic infections have traditionally spanned medical and veterinary responsibilities and have fallen into the divide between them. A multidisciplinary coordinated approach to zoonoses would enable Queensland to make major breakthroughs in this field. This model is being employed by the University of Liverpool, that has established the world's first interdisciplinary centre for zoonosis research in a joint venture with the University of Lancaster, the Health Protection Agency, and the Veterinary Laboratories Agency.²⁹ A similar multidisciplinary approach to zoonoses research would be highly complementary, particularly with a tropical focus.

Better coordination of tropical health capacity in Queensland would enable the State to become more competitive in attracting international funding grants, such as the Gates Foundation, the Wellcome Trust and the US National Institutes of Health. Opportunities would also arise for greater involvement in international health initiatives, training programs and consultancies. A critical mass of researchers in a dedicated discipline would attract high profile researchers to Queensland. Alignment of our capacity in tropical health would enable our State to more fully capitalise on competitive strengths and to be a world leader in tropical science, knowledge, research and innovation.

3.2 Maximising value from environmental and cultural assets

3.2.1 Background

An increasing population and rising standards of living in tropical regions throughout the world will impact heavily on environmental sustainability in the future.

Queensland is well placed to play a significant role in addressing this issue, with more tropical climate types than any nation on Earth, a mega-biodiverse environment, and status as a highly developed and politically-stable region in the tropics. The State also possesses significant R&D capacity and expertise in environmental management, with a number of important projects under development (**Appendix 1**), has rich cultural assets, and is home to Indigenous communities with extensive knowledge of local species, ecosystems and processes.

Much of the world's environmental biodiversity is located in the tropics. Tropical forests, which account for half of the remaining untouched forests,³⁰ cover 6% of the world's land surface, but hold 50-80% of all the terrestrial species of plants and animals.³¹ The oceanic equivalent of these forests is coral reefs, which are found predominantly in the tropics. The majority (92%) of the world's coral reefs are in the Indo-Pacific,¹³ on Australia's doorstep. Similarly, tropical Queensland has remarkable biodiversity, with one-third of Australia's marsupial species, one-quarter of the frogs and reptiles, and about 60% of the bat and butterfly species located in the Wet Tropics World Heritage Area,³² and the adjoining Great Barrier Reef constituting 13% of the world's coral reefs.^{13,14}

The rapid population growth of many tropical regions (which is almost double the population density of the rest of the world and around double the global population growth rate)^{33,34} coupled to rising consumption rates will increasingly threaten their precious ecosystems and rich biodiversity through the clearing of land, construction of towns and infrastructure, and intensified industrial activity. A global benchmarking study of environmental performance ranked Ethiopia, Mali, Mauritania, Chad, and Niger as having the world's worst pollution control and natural resource management practices.³⁵ All five countries are located in the tropics. Building the environmental management capacity of developing tropical nations must be considered a matter of urgency, especially since it is proposed that if all tropical nations today achieved a standard of living on par with that enjoyed by the most developed economies, worldwide consumption rates would increase by around 4.5 times.³³ This scenario would result in around a 4.5-fold increase in the environmental impact arising from the use of these resources.

To cope with increasing environmental pressures, sustainable development, development that “meets the needs of the present without compromising the ability of future generations to meet their own needs”,³⁶ is being promoted internationally. The World Bank acknowledges that sound environmental management is essential for the long-term growth of a society,^{37,38} and environmental sustainability is currently a Millennium Development Goal of the World Bank, with a self-imposed deadline of 2015.³⁹

Because of these developments, the global market for environmental technologies (e.g. water and soil pollution control, solid and toxic waste management, site remediation, and environmental monitoring and recycling) is considerable, estimated at US\$556 billion in 2002.⁴⁰ Market demand is likely to increase over time, with many developing countries such as China actively pursuing solutions to their increasing environmental problems.

Queensland has immense potential to capitalise on these overseas markets for environmental technologies. On a global scale, the State has developed significant knowledge and expertise relating to the planning, management, protection, monitoring and rehabilitation of environments within, and affected by, primary production, mining, industry activity, and coastal development and urbanisation. The equivalent research capacity in the United States, for example, focuses on tropical biology involving such institutions as the Smithsonian and its Smithsonian Tropical Research Institute in Panama, as well as the Organisation for Tropical Studies. That capacity is on a scale not vastly different from that of Australia – larger, but not by orders of magnitude.⁴¹

Enhancement of relevant capacity in northern Queensland may avert repetition of some of the environmental problems of the south. For example, with water resources becoming an increasingly important issue, southern regions of the State may wish to capitalise on the fact that 76% of the discharge of Queensland rivers occurs in sparsely populated catchments that drain to the Gulf of Carpentaria and the Coral Sea north of Mackay.⁴²

Within tropical Queensland, sound environmental management and sustainability is critical to the State’s growing tropical tourism industry, based largely on unique environmental and Indigenous cultural assets. Careful management of the environment also provides ecological goods and services, contributes to strong health and social outcomes for communities, and leads to economic returns to the State. The Queensland Government is highly supportive of building capacity and critical mass that delivers R&D in tropical environmental biotechnology (including bioremediation and waste/wastewater management).⁴³

3.2.2 Opportunities

The fields of endeavour in environmental management are diverse, and include terrestrial/marine/estuarine/riverine planning and management, climate change, biodiversity, biodiscovery, forest canopy processes, marine biology, control of feral organisms, taxonomy, education/training/teaching, consulting and ecotourism. Although grouping Queensland's capabilities under various environmental disciplines is fraught with complexities due to overlapping or changing circumstances, opportunities within these disciplines are explored below. For each category, opportunities exist for 'brown' or 'green' aspects of environmental management, such as developing cleaner production techniques or protection of biodiversity, respectively.

Terrestrial/riverine/estuarine

Entities or initiatives addressing some of the terrestrial/riverine/estuarine issues of relevance to tropical Queensland are diverse and geographically dispersed. Rationalisation and the formation of strategic alliances through co-location or clustering is challenged by these issues. Nevertheless, strategic alliances and co-location of significant research entities or initiatives in these fields do exist, are occurring, or are planned. An outstanding example is the Cooperative Research Centre for Tropical Rainforest Ecology and Management (Rainforest CRC) based in Cairns, with significant partnerships between research institutions (focussed on tropical rainforest science and management) and research users, including the Wet Tropics Management Authority, the tourism industry, and infrastructure agencies such as the Department of Main Roads. The new Marine and Tropical Sciences Research Facilities (MTSRF) program provides the opportunity to build on the work of the Rainforest CRC as well as the Reef CRC by providing \$40 million from 2006 to 2010.

Potential for future collaboration exists through the Australian Tropical Forest Institute (ATFI) under construction in Cairns. ATFI is envisaged to become the northern partnering centre for tropical related science effort in Queensland, with the vision to be the world-leading centre for creating innovation in sustainable use of tropical landscapes. The key partners in ATFI are JCU and CSIRO, with the joint venture expecting to attract other relevant partners and tenants, such as government departments, universities and industry. ATFI is expected to become an iconic facility.

Other examples of strategic alliances in the terrestrial/riverine/estuarine disciplines include the planned Tropical Science and Innovation Precinct (TSIP) (including a number of significant partners such as the CSIRO Davies Laboratory), and the proposed Tropical Rivers and Coasts Knowledge (TRACK) initiative that consists of about 50 partners.

Tropical Queensland is already exporting expertise in environmental management to developing tropical nations. For example, through the Lorentz Project, the Wet Tropics Management Authority is helping to build the capacity of the environmental agencies of Indonesia to manage potential world heritage tropical forests.⁴⁴

Marine

Queensland's marine science research capacity includes internationally recognised strengths in coral reef management and ocean research, and resides in several high profile research institutes located mainly in North Queensland, focussed around Townsville. Notable examples include the Australian Institute of Marine Science (AIMS), the ARC Centre of Excellence in Innovative Science for Sustainable Management of Coral Reef Biodiversity, the proposed Tropical Marine Science Centre of Excellence, and the Coral Reef Targeted Research and Capacity Building for Management project that is one of four Centres of Excellence in a global marine research program.

Excellent collaborations and partnerships in marine science in North Queensland also exist, such as the AIMS@JCU joint venture and the Tropical Marine Network, that also has links with the Global Environment Facility - Intergovernmental Oceanographic Commission of UNESCO/World Bank Coral Reef Targeted Research and Capacity Building project.

The significance of partnerships that have developed in marine science was highlighted in a review of marine research in tropical Australia by then Chief Scientist, Dr Robin Batterham.⁴⁵ Dr Batterham regarded the AIMS-JCU-GBRMPA-Queensland Government collaborations and the physical proximity of their organisations as a “model for collaboration and worthy of replication elsewhere in Australia”. The status of Townsville as a centre for marine science was consolidated by the review, with the recommendation that AIMS remain an independent organisation, and that its infrastructural refurbishment at Cape Ferguson should proceed. The review also recommended the Commonwealth Government consider the development of a long-term strategy for the refurbishment, enhancement and replacement over time of existing marine research infrastructure, possibly financed from a special fund.

Biodiscovery/biodiversity

Biodiscovery is the examination of biological resources (such as plants and animals) for characteristics that may have wider application and/or commercial value.⁴⁶

The level of return from biodiscovery is predicted to be substantial, through improvements in research capability and capacity, infrastructure, employment, knowledge, conservation initiatives, traditional knowledge documentation, community engagement, and financial returns.⁴⁶

The opportunities for biodiscovery in tropical Queensland are said to be significant, with the Great Barrier Reef and Wet Tropics World Heritage rainforests famed for their mega-diversity. Only a fraction of this diversity has been explored and considerable potential exists to find novel bioactive chemicals with commercial application.⁴⁷

Queensland has taken a lead role in pursuing these opportunities, and became the first Australian State or Territory to develop legislation pertaining to biodiscovery. The *Biodiscovery Act 2004* facilitates access to small quantities of native biological resources on or in Queensland State land or water, to encourage the development of value-added biodiscovery in the State, to ensure that Queensland obtains a fair and equitable share in the benefits of biodiscovery, and to ensure biodiscovery adds to knowledge of Queensland's biodiversity, conservation and sustainable use of native biological resources.

The rich biodiversity of tropical Queensland, coupled with the State's range of university and private sector-based research groups with high throughput screening and assaying capabilities, presents significant opportunities in this emerging sector. Several entities are successfully engaging in biodiscovery initiatives in Queensland, including private or publicly-listed companies (BioProspect Ltd, EcoBiotics Ltd, Xenome Pty Ltd), public/private partnerships (AstraZeneca/Griffith University Natural Product Discovery Program), Government-funded institutions (Queensland Museum), and universities (ARC Centre of Excellence in Innovation Science for Sustainable Management of Coral Reef Biodiversity at JCU Townsville).

The mega-biodiversity of Queensland's ecosystems underscores a need to name and describe the originating source of potential products. Funding to support taxonomic activities has suffered nationally in recent years.⁴⁸ Nevertheless, opportunities to develop the biodiscovery capacity of Queensland may exist in utilising the taxonomic and biodiversity expertise resident in the Queensland Museum, the natural product discovery expertise of the Eskitis Institute, and other knowledge existing throughout the State to help compile the proposed 'Atlas of Living Australia' (or 'Biodiversity Google'), as suggested by the PMSEIC Working Group on biodiversity.⁴⁶

Coordinating existing knowledge relating to biodiversity (e.g. taxonomic, geographic, ecosystem and Indigenous knowledge) through mechanisms such as networked databases and incorporating engagement in international programs such as the 'Barcode of Life Program' would allow easier access and utilisation of information. Such coordination would enable Queensland to benefit more fully from biodiscovery opportunities in our tropical ecosystems.

Indigenous knowledge

Indigenous communities possess an intimate knowledge of tropical environments built on experience over tens of thousands of years. This knowledge base includes a rich store of information on health, wildlife, land management and bush or native food. The local knowledge of Indigenous communities can contribute significantly to tourism, biodiscovery efforts and commercial industries. It has been suggested that traditional knowledge may help expedite the identification of biological resources and examination of organisms for commercial development,⁴⁶ such as bio-based products,⁴⁹ by saving substantially on investment in exploratory research, pre-screening and testing. The commercial potential of Indigenous knowledge was demonstrated in an international survey of 119 plant-based drugs, of which 74% had links to medicinal folklore.⁵⁰

There is widespread acceptance that Indigenous knowledge and traditions, together with commercial enterprises, can assist Australia to compete with the rapid advances being made in other countries. There is opportunity to utilise Indigenous knowledge further for a raft of environmental initiatives. Through the 'Queensland Biotechnology Code of Ethics',⁵¹ the Government requires users of traditional knowledge to negotiate reasonable benefit sharing arrangements with the providers of that knowledge.

There are also opportunities to enhance the capacity of the education system in North Queensland by developing partnerships with Indigenous communities, organisations such as the Cape York Institute for Policy and Leadership, and the ecotourism industry to make and promote the concept of using Indigenous knowledge in ecotourism ventures. The concept would benefit both the industry and Indigenous groups, and provide meaningful job creation at the community level. The initiative could take the form of new types of training, Indigenous and tourism partnerships, and education facilities located near Indigenous communities.

Ecotourism

Queensland has developed considerable expertise in tourism development and management, particularly in relation to accessing World Heritage sites and managing extremely fragile and unique eco-systems. For example, the CRC for Sustainable Tourism has developed programs dedicated to the Australian wildlife tourism industry that comprises over 1200 enterprises.⁵² The industry is also coordinating tropical tourism activities, such as the Cairns-based Australian Tourism Resources consortium, that provides professional services and total project management for new tourism ventures in any country or region seeking to develop or redevelop a tourism industry, particularly in sensitive tropical environments.

The rapid expansion of the ecotourism industry in Queensland has resulted in a commitment to develop (within the Queensland Ecotourism Plan 2003-2008) plans, policies and practices to support sustainable ecotourism.⁵³ The Ecotourism Plan aims to protect the environment, to ensure that the nature-based tourism industry is ecologically, commercially, culturally and socially sustainable, and to strengthen Queensland's competitive position. The high standard of ecotourism services and associated resource management in Queensland has been the result of a continual process of raising the best practice standards as well as a growing understanding of the nature of the ecotourism industry in the State.

Tropical regions attract millions of visitors each year. For some countries, many of which are in the developing world, tourism represents a major contributor to GDP. Poor practices in the past have jeopardised the sustainability of tourism ventures, for example in parts of Africa and Asia where poaching, poor management of national parks, drought, habitat depletion, unsustainable agricultural practices, and disease have seen a rapid drop in animal numbers (even extinction) and ecosystem degradation. There is a growing demand for the development of policies and practices to manage and protect the natural environment, whilst still gaining economic benefit. The knowledge underpinning the ecotourism industry in Queensland represents expertise that is in high demand, and can be exported to other regions of the world developing ecotourism. This demand has encouraged environmental and ecotourism organisations to develop and supply information, training and after-project services to regions seeking to develop sustainable ecotourism.

As described in the previous section, there is also the possibility to foster Indigenous engagement in the ecotourism industry, perhaps driven by the business sector and aligned with local tertiary providers such as TAFE to offer a qualification component. Engagement of island communities of the Torres Strait in Indigenous tourism is a major feature of the Cape York Tourism Development Action Plan, announced in September 2005, that seeks to stimulate sustainable tourism development in the region by providing a range of nature-based and cultural tourism experiences for the Queensland tourism market.

Climate studies

In the future, climate change may result in Queensland's climate becoming hotter and more variable and extreme, bringing more droughts, heatwaves and heavy rainfall.⁵⁴ Climate change and climate variability have been identified as some of the biggest risk factors for Queensland's economy and environment. Changing climatic conditions are predicted to fundamentally modify terrestrial and marine environments. Coral reefs and significant tropical rainforest species have been identified as particularly vulnerable to global warming, especially if the return time between extreme climatic events shortens.²⁶ Many tourism operators have experienced deterioration of the quality of reef sites due to coral bleaching, a possible consequence of global warming.⁵⁵ At a macro scale, changes in the climate of the tropics have been linked to far-reaching global effects.⁵⁶

Although there remains scientific debate about the role of human activity in driving climate change,⁵⁷ it is clear that Queensland has a highly variable climate that has changed significantly over the past century. Therefore, emphases on clean technologies and mechanisms for adaptation are warranted in view of the State's substantial revenue from the coal industry. Initiatives relevant to climate change that are in various stages of development in Queensland include the Boggo Road Ecosciences Precinct, the Centre for Disaster Studies at JCU, and the Cyclone Testing Station, also at JCU. In addition, GBRMPA monitors the Reef each summer for coral bleaching damage, a possible manifestation of climate change.

Although Queensland is currently developing capacity in technologies relevant to climate change, there is a need for a measured response. Firstly, it is necessary to understand how and why the climate is changing, determine practical measures that could slow the rate of change if appropriate, and identify how rapidly people and nature (as a dynamic system) would be affected. Secondly, measures (such as regulation) to mitigate the activities identified as causal agents for climate change, need to be considered, but in a global context. Finally, practical solutions for living with climate change must be found. These needs fall broadly into three categories; *viz.* predictive, mitigative, or adaptive, respectively. Whereas some work has been conducted on understanding the dynamics of climate change and considering mitigative policy and protocols, little has been achieved on developing technologies that would effectively turn a changing climate to our advantage.

Assuming tropical nations become increasingly vulnerable to extreme weather events and climate change, Queensland's expertise in this field would provide opportunities for the export of this knowledge and expertise to tropical nations in the developing world. Further investment in this capability would attract significant international investment, provide export opportunities as well as protect Queensland's future economic and environmental sustainability.

Tropical Environmental Sciences and Management Network

Queensland has the opportunity to capitalise on having the natural advantage as a developed region with around two-thirds of its area¹⁵ in the tropics. Although the State boasts internationally recognised expertise in natural resource planning, management and governance and world-class research capacity in environmental sciences, this capacity is undertaken in a number of significant, though disparate, research facilities. Currently, there is no mechanism within Queensland that provides a strategic, focussed, collaborative and coordinated approach to tropical environmental management, research, and application that would build on existing investment in this area and preclude any duplication of research effort in the future.

There is the opportunity to consolidate this dispersed expertise into a 'Tropical Environmental Sciences and Management Network' that would facilitate improved coordination of research capabilities in tropical environmental management and integrate research activities focussing on tropical terrestrial, coastal and marine ecosystems (**Figure 1**). The network would provide an opportunity to strengthen and develop physical and virtual associations and collaborations among researchers and environmental managers from different disciplines, organisations, sectors and jurisdictions.

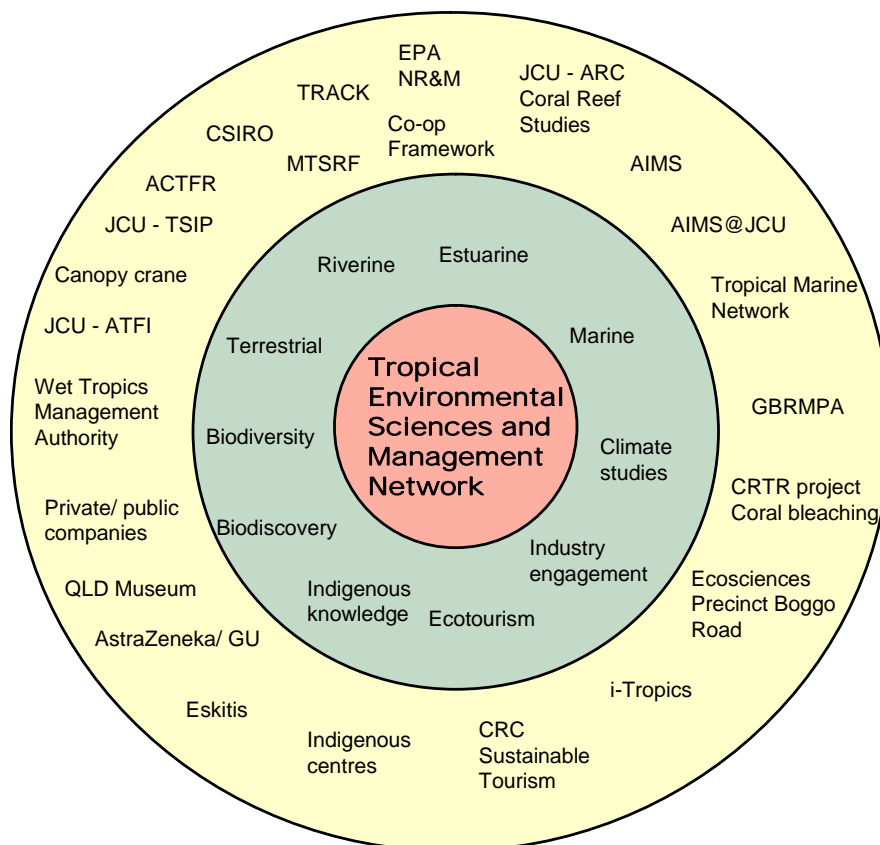


Figure 1. Integration of the tropical environmental science and management capacity of Queensland. (Refer to **Appendix 1** for more detail on entities in the outer circle).

3.3 Transforming tropical primary industries

3.3.1 Background

Primary industries, particularly mining and agriculture, are the historic basis of Queensland's economy, and these industries are far more dominant in the tropics than in the State as a whole. In 2004-05, agriculture, forestry, fishing, and mining accounted directly for about one-eighth of Queensland's economy,⁵⁸ but was one-fifth of the economy of tropical Queensland.¹⁶

Tropical Australia has some of the largest mineral deposits in the world, including copper, lead, zinc, nickel, tin, gold, manganese, uranium and magnesite. Diamonds, mineral sands, phosphate rock, kaolin, limestone and silica deposits are also mined in the tropics. In tropical Queensland, the mining industry alone directly accounts for about one-seventh of the tropical Gross Regional Product,¹⁶ and the indirect contribution of the industry is presumably far greater.

The future of primary industries in Queensland will be heavily affected by the changing global economy. Although cyclical, commodity prices are in long-term decline. At the same time, Australian producers have to compete with countries in which the cost of labour is significantly cheaper. In developed economies, changing markets and industrial structures have created a bleak future for 'commodity manufacturing' - high volume, low value-added, labour intensive, often low-skilled production.⁵⁹

Therefore, Australian producers, including those in the tropics, will need to transform their operations to deliver products with higher intrinsic value for consumers. In doing so, they would capture intellectual property and commercialise it into technologies that can be sold into a wider range of markets and meet new and emerging sources of demand. This trend may include the development of on-farm processing and packaging systems to deliver products that meet market specifications. For the mining industry, value may be added to bulk undifferentiated products through the establishment of refining processes that enable control of a greater share of the supply chain.

With advances in technology and a better understanding of biosystems, efficient and effective commercial exploitation of crops for the biotechnology, industrial, pharmaceutical, nutraceutical, renewable energy, and fibre markets are now experiencing rapid worldwide growth.⁶⁰ Such trends can be attributed to the underlying desires of consumers for better health, improved quality of life, the use of more natural products, and concerns about the sustainability of non-renewable resources.⁴⁹ These key drivers have the potential to transform the composition of primary production systems and practices for the future,⁶¹ through the development of bio-based industries.

The global biotechnology market had a compounding annual growth rate of 16% from 2000-2004, and is expected to be worth US\$185 billion by 2008.⁶² It is predicted that the world nutraceutical market will have a compounding annual growth rate of 8.1% from 2003 to 2008, worth US\$90 billion by 2008. The nutraceuticals market in the Asia-Pacific region is expected to grow more strongly still, with a compounding annual growth rate of more than 10% up to 2008.⁶³

Domestic trends may also have a substantial impact on primary industries in the future. Competition for water may become more critical, since agriculture, which accounts for 73% of the water consumption in Queensland,⁶⁴ is likely to face increasing scrutiny as competition for water is likely to intensify.⁶⁵ Growing concern for environmental sustainability also has repercussions for all primary industries. Furthermore, there may also be implications on the success of primary industries in the tropics through potential labour shortages or the provision of basic services. For example, although the population growth in tropical Queensland has exceeded that of the State as a whole over the last 10 years,⁶⁶ population growth in the zero to 40 year-old group in the tropics has been close to zero.⁶⁶ Australian rural populations have also been declining over the last 43 years, with an annual growth rate of -0.5%.³³

A transformation is occurring in the way that farming is conducted, as traditional family farms become aggregated to achieve economy of scale. It is likely that farms of the future will be larger than those of today and have corporate or shared ownership. These changes will be far-reaching and have lifestyle implications on farmers and their families. The social fabric of rural communities will ultimately change. Additionally, the non-farm population is likely to continue to increase, especially in the tropical coastal regions of North Queensland. For tropical primary industries to prosper in the future, a fair and equitable policy framework needs to be established that provides planning, regulatory and operational support.

The extensive capacity and capability of Queensland to service the needs of tropical primary industries (**Appendix 1**) is embedded in an established network of facilities and expertise, including DPI&F research stations, facilities and projects, BSES Ltd sugarcane experimental stations and laboratories, CSIRO research centres, CRC programs and projects, and university courses, expertise and infrastructure. Leading research institutes in Queensland are undertaking programs ranging from marker assisted breeding programs, genomics and gene discovery through to new transgenic varieties of crops and molecular pharming. Because of these programs and infrastructure, Queensland is acknowledged as a major centre for biotechnology in the Asia Pacific region with particular expertise in tropical agricultural biotechnology.⁴³ The State also demonstrates strengths in mineral resource assessment in the tropics (e.g. bauxite and kaolinite) as well as in applying specialist technologies for extractive industries in an environmentally sustainable manner. These technologies include designing impoundments in zinc mining in the tropics to withstand tropical events, which is a particular area of expertise in Queensland.

The capacity of Queensland in the tropical sciences provides our State with an opportunity to take the lead in developing 'new' tropical industries, such as molecular pharming, biofuel, bioplastics, functional foods, as well as building on 'established' tropical industries, such as agriculture, aquaculture, forestry, and mining (**Appendix 2**). Queensland is also seeking to apply its expertise in these areas to other developing countries in the tropics to solve food, environment, and health problems thereby ensuring the delivery of higher living standards for communities in these regions.

3.3.2 Opportunities

The economy of tropical Queensland is heavily reliant on traditional agricultural industries that are in long-term decline. The reasons for this decline are multifarious, but are intrinsically linked to the well established trend of declining commodity prices over many years and strongly subsidised, or more efficient, agricultural sectors in competing countries. While the sugar and dairy industries remain, tobacco is no longer grown commercially in North Queensland. Clearly, there needs to be a shift away from traditional primary production systems and practices towards new technologies and processes, and sustainability. Some opportunities to transform primary industries in tropical Queensland are presented below.

Biotechnology

Queensland has a number of advantages that support the development of biotechnology industries, including:

- the high targets for future growth set by the local biotechnology industry⁴³
- the significant investment made by the State Government in biotechnology infrastructure, skills and projects
- support for the national gene technology regulatory system
- a proactive role by the State Government in biotechnology issues, such as the implementation of the 'Queensland Biotechnology Code of Ethics'⁵¹ and the development of a 'Co-existence Framework for GM and non-GM crops'.⁶⁷

As large agricultural biotechnology companies are focussing on temperate crops of global importance, an opportunity exists for Queensland to target tropical crops of worldwide significance, such as banana, sugarcane, or mango. Biotechnology could be used to improve tropical crops for the benefit of the producer (e.g. resistance to herbicide) and the consumer (e.g. reduced allergens or toxins, improved shelf life), or to develop new products (e.g. nutrient-fortified bananas) or production techniques. Queensland is well positioned to become a major producer and exporter of germplasm for production elsewhere in the tropics and subtropics. However, alliances, such as with multinational firms, need to be developed or strengthened to maximise commercialisation possibilities and product potential.

Furthermore, Queensland has the opportunity to apply biotechnology in the development of functional foods; *viz.* foods or dietary components with health benefits beyond basic nutrition. It has been estimated that by 2010, the 'wellness' industry in the United States would contribute US\$1 trillion to their GDP.⁶⁸ Strategic opportunities in functional foods exist in North Queensland due to the diversity of food crops that can be grown in the tropics. The Queensland Government has committed \$3 million over four years to establish a Centre for New Foods to draw together Queensland's key players in the research, development and commercialisation of tropical and subtropical future foods. Negotiations with key stakeholders to establish this virtual centre are continuing.

Bio-based industries

Bio-based industries are premised on the synthesis of products (other than conventional foods) using plants/crops as biofactories/bioprocessors in integrated biorefinery/bioprocessing systems. In other words, the endemic natural biomass of crops is exploited to produce a diversity of products, including:

- biopharmaceuticals (vaccines, antibodies, anti-cancer agents)
- nutraceuticals (over-the-counter healthcare products)
- cosmeceuticals (personal care, skin, hair, and anti-aging products)
- biofuels (fuels for transportation such as ethanol and biodiesel)
- bioenergy (green electricity and heat derived from cogeneration)
- bioremedial agents (targeted enzymes)
- biodegradable fibres (automobile, housing, textiles and construction)
- biodegradable plastics (automobile, electronics, construction, furniture)
- industrial agents (chemicals, paints, dyes, enzymes, solvents and inks).

The central philosophy of bio-based industries is the conversion of renewable biological and agricultural resources through environmentally friendly processes to produce bio-products in a sustainable way. In an assessment of bio-based industries in tropical Queensland, Holden *et al.* (2005)⁶⁹ proposed that high technology production systems and purpose-built processing and manufacturing facilities established in rural communities would bring about new jobs and a broadening and stabilising of the region's economic profile and income base.

Tropical Queensland provides significant opportunities in bio-based industries by having a climate conducive to high biomass production and rapid growth rates of crops. Sugarcane is a highly suitable crop from an agronomic perspective. Tobacco has already been assessed for its potential for molecular pharming (transgenic crops that produce bio-molecules for scientific, medical or industrial purposes, but not for food or feed) in the Mareeba and Dimbulah irrigation area.⁷⁰ Niche markets are likely to arise from molecular pharming in the future, with participating enterprises requiring potentially small areas of land to grow products of extremely high value (e.g. vitronectin) or other pharmaceutical products in high containment.

The development of a large renewable energy and bio-fuel industry based on the considerable biomass production capacity of sugarcane in tropical coastal areas has potential to provide a significant boost in employment in many tropical areas. Increased ethanol production would provide fermentation capacity for the production of other new products, adding further value to tropical coastal farming systems. Renewable energy sources are particularly important for powering communications systems in remote regions.⁷¹ The high levels of sunlight in northern Queensland make the region an ideal testing ground for solar energy.

Biosecurity

Queensland has an impressive record of eradication and management of incursions by significant pests and disease pathogens through the actions of DPI&F Biosecurity and the coordination of Plant Health Australia, especially in North Queensland. For example:

- the detection and subsequent eradication in 2003 of black Sigatoka from the Tully Valley, Australia's largest and most concentrated banana producing region, the first time anywhere in the world that the leaf fungus had been eliminated from a major banana region
- the eradication in 1999 of the serious exotic pest Asian Papaya fruit fly from the Cairns district
- the outbreak of canker in the major citrus area of Emerald was eliminated in 2005, and required the complete destruction of all trees in the district to achieve the result
- following devastation to the banana industry from the effects of banana bunchy top virus in the 1920s, the disease has been kept in check by continual monitoring and destruction of infected plants.

This well-established capacity in tropical biosecurity and impressive record of success provides opportunities for Queensland in the development and export of biosecurity services to developing nations. An opportunity also exists to establish a tropical biosecurity facility within Queensland to complement the existing national framework for biosecurity R&D, which consists of the Perth Containment Facility, the Victorian National Biosecurity Centre, and the Australian Animal Health Laboratory, and builds on the nation's capability to protect itself from biosecurity threats.

Intellectual property and commercialisation

Opportunities exist for the development and commercialisation of knowledge-based products and services arising from research in primary industries. The Queensland Government provides a policy framework for public sector intellectual property. This framework includes a recommended practice statement for the management and commercialisation of intellectual property developed and funded by the Queensland Government.

Mining services

More than half of the revenue of the mining industry in Queensland comes from the tropics,¹⁶ which has benefited from the recent price rise of many resource commodities, especially coal. Existing mines, in addition to the establishment of new mines and future import-replacement opportunities, create the potential for continued development of internationally competitive local industries for the design, construction and maintenance of mining equipment and services for domestic and overseas markets.⁴⁷ For example, export sales in the Australian mining technology services sector have grown impressively at 19% per year over the last four years.⁷² Further opportunities might lie in providing services in tropical mining, such as whole of life planning, resource management, or high value processing.

Mining in the tropics also creates significant environmental challenges, such as the overflow of waste and contaminated water into the surrounding ecosystem, especially during the monsoon. The application of well established scientific principles and specialist techniques to the reclamation and rehabilitation of mine-sites in tropical environments after the extraction process is an opportunity for future development. Techniques such as designing impoundments in zinc mining in the tropics to withstand tropical rainfall events have been developed and used successfully in northern Australia, and this knowledge is directly transferable to other locations facing similar challenges.

Sustainable production

The rapid population growth in developing tropical nations is necessitating rising production of agricultural commodities to meet increased demand for food and fibre. A challenge for these countries is to produce commodities without degrading the natural capital of tropical systems. Queensland has significant strengths in the sustainability of primary production and in the development of agricultural systems with a small environmental footprint. There exists a significant opportunity for tropical Queensland to be a global exemplar of sustainable agricultural systems for both the dry and humid tropics. The issues of soil and water degradation, and the development of cropping/grazing management systems to minimise these problems, would be a 'saleable' product to developing tropical nations.

Tropical aquaculture

Aquaculture is the fastest growing food production sector in the world and the fastest growing primary industry in the Indo-Pacific region. The value of the Australian aquaculture industry has trebled over the past ten years and is now worth more than \$700 million.⁷³ In Queensland, the value of the aquaculture industry was estimated at \$72.5 million in 2003-04, with prawn farming the largest segment of marine waters aquaculture (mariculture), accounting for 74% of this total value.⁷⁴

There are great opportunities for aquaculture in tropical Queensland, as the demand for seafood is outstripping sustainable harvests from wild populations and there is increasing pressure on aquaculture and fishing industries to develop and adopt sustainable practices. The favourable climate, clean waters and diverse range of environments of tropical Queensland create opportunities to develop aquaculture further, particularly as the domestic and international demand for seafood grows and wild harvesting becomes increasingly regulated due to diminishing resources.

Due to environmental constraints, it is predicted that off-shore aquaculture farming will not be developed near the Great Barrier Reef in the future, leaving the Gulf of Carpentaria as the only possibility for offshore production. However, opportunities also exist for farming fresh water species in low quality water in western areas of tropical Queensland, away from the environmentally sensitive coastal zone.

Climate studies

With greater climate variability predicted in the future,⁵⁴ the potential average annual gain to the Queensland economy from the adoption of improved climate forecasts is expected to be \$38 million per year over the next 15 years.⁷⁵ Productivity improvements from these forecasts for the sugarcane and beef cattle industries were estimated at 1% and 1.2%, respectively. Increased profits would result from better risk management through improved tactical and strategic decision making (e.g. grazing management, crop variety choice and fertiliser management). In plantation forestry, improved knowledge enables risk reduction in response to drought stress, pests and diseases, improved product quality and increased harvest efficiencies.

Queensland is well positioned to undertake first-class climate change research and development projects. Both CSIRO and DPI&F have proposed that climate risk technologies need to be developed that address the broad spectrum of climate variability, from bridging the weather/climate divide, improved seasonal data, better assessment of decadal/multi-decadal climate variability to climate change. Opportunities exist in developing operational interfaces between current global climate models and agricultural systems models, although a participatory approach is required to generate high levels of interaction between climate, environment and management decisions in Queensland's tropical landscapes.

International aid funding

A considerable proportion of Queensland's research in primary industries is addressing issues in developing nations through funding grants from international aid programs, such as the Australian Centre for International Agricultural Research, The Rockefeller Foundation, and the Grand Challenges in Global Health Initiative. There is scope to develop further international research linkages and to establish and conduct training programs relevant to the needs of tropical developing nations. Additionally, there is the opportunity to develop and commercialise knowledge-based products and services arising from research in primary industries.

For example, Queensland has a unique core of scientists with considerable knowledge in the chemistry, physics and microbiology of soils in the tropics. These scientists are spread throughout the State in a number of research institutions (NRMW, DPI&F, CSIRO, BSES Ltd, UQ, JCU). The knowledge possessed by these scientists in management of tropical soils is fundamental to the development of sustainable management practices of commercial or natural tropical ecosystems. Such knowledge is highly marketable if developed appropriately, and could be sold through aid agencies for application in developing tropical countries.

Network for Transforming Tropical Primary Industries

The network of DPI&F research stations and facilities, BSES Ltd experimental stations, CSIRO and CRC centres and programs, and university courses/centres in North Queensland provide significant capacity to conduct research into agriculture, aquaculture and forestry. The field stations enable trialling and practical assessment at a local level for a range of initiatives relevant to the tropics, such as new crop development, assessment of genetic material, evaluation of agronomic practices, or appraisal of pest management/biosecurity measures. There is also an ethos of cooperation among centres, with a solid record of research projects with multi-regional input. From a community perspective, regional facilities provide a link to new technologies and act as a base from which these technologies can be extended.

Few developed countries have available such an extensive regional capacity in tropical primary production. Whereas it may be prudent to rationalise existing investments, there is clearly merit in maintaining and utilising the capacity and links to the local community. To extract greater benefits than currently exist, there needs to be better linkages between regional facilities and the technological capacity and expertise in life sciences centred in South-East Queensland. This 'Network for Transforming Tropical Primary Industries' may be fulfilled in a virtual sense, and would provide better integration of outputs in tropical primary industries with real-world experience and field-based and industry assessment.

By focussing on biotechnology in agriculture, aquaculture and forestry and on the development of bio-based industries, Queensland could capitalise on its status as a significant centre for agricultural biotechnology in the Asia Pacific region and would be more attractive to life science companies wishing to establish in the region.

3.4 Promoting and capitalising on tropical living and design

3.4.1 Background

Tropical Queensland is characterised by its climate, variable weather patterns, large Indigenous population, sparsely populated inland regions and relatively heavily populated coastal regions. The tropical climate of North Queensland is a major influence on housing design, clothing, leisure activities, and environmental management. The high temperatures and humidity, threats of cyclones, drought and bushfires create demands on emergency services and encourages communities to seek innovative responses to these climatic events.

Tropical cities are the fastest growing urban environments in the world.²⁰ This growth, coupled with increasing standards of living in tropical nations and an increasing focus on the environment and on sustainable development, has created a demand for aesthetically pleasing and community-focussed tropical living environments with a strong emphasis on integration with the surrounding environment.

All cities in Asia are undergoing massive urbanisation, many of these cities having climates akin to Queensland, from the Gold Coast to Cairns. As the only major developed Western nation in the Asian region, Australian planners, architects, engineers and environmental designers have been at the forefront of urban renewal throughout the region.

In recent years, China has been the primary focus for Australian consultants as it has numerous cities simultaneously implementing urban renewal programs. With the recent self-imposed slowdown in development in China, Australian consultancies have shifted attention to other countries, such as India, Malaysia and Vietnam. Indonesia has been largely avoided due to safety threats, and Singapore has long been a target market, although that city is already highly developed.

Despite having a tropical or subtropical environment, there is currently little research and commercialisation being undertaken within Queensland that specifically targets applied technologies for construction sustainability in the built and urban environment of such climatic zones (**Appendix 1**). Furthermore, what is undertaken tends to be carried out in isolation with virtually no coordination of effort or opportunity for synergistic collaboration (**Appendix 2**).

3.4.2 Opportunities

Opportunities to market Queensland's expertise in tropical urban living and design exist in a range of niche markets already respected internationally, but yet to be seen as coordinated. These niche markets include:

- urban waterfront renewal
- tourism development
- environmental analysis, planning and design
- health planning and design
- disaster renewal
- design for Indigenous communities.

Urban waterfront renewal

For a decade, Australian planning and architectural consultants have been at the forefront of urban waterfront design in the Asia-Pacific region. These consultants are undertaking major projects in cities such as Shanghai, Changdong, Ningbo and Yichang in China, Singapore and Auckland. Firms based in Queensland have secured a large proportion of this work.

Projects like Darling Harbour in Sydney, Melbourne Docklands, and South Bank in Brisbane, and work in the regional cities of Cairns and Newcastle have been seen as exemplars for overseas cities to follow. If this expertise could be combined more closely with the expertise outlined below, there is significantly greater potential to exploit the urban renewal market overseas, both for consultancy services and contractors.

Tourism Development – focussing on 'ecotourism' and 'cultural tourism'

A major area of demand is whole new 'resort' cities, and 'cultural tourism'. Australian consultants may be regarded as more culturally sensitive than consultants from Europe, Japan or the United States. Many Asian cities are in the process of shifting from industrial-based economies to tourism economies due to redundancy of an existing workforce, such as Yichang City in China, whose population grew from 100,000 to 5 million in 10 years to house the 'Three Dams Gorge' workforce, but now seeks to shift its economic base to tourism.

The Pacific Asia Travel Association (PATA) predicts that approximately 100 million Chinese will travel outside of China each year from 2020.⁴⁸ This emerging industry has implications on travel health (infectious disease, healthy destinations and crisis management) and travel law, but also presents considerable opportunity for Queensland. ACITHN and its partners have taken steps to bridge recognised shortfalls.⁴⁸

Environmental planning and architecture

There is a widespread belief throughout Asia that consultants from Australia, and Queensland particularly, are more attuned to appropriate environmental design than counterparts in other countries. This view is based on the climatic similarity of Queensland to many Asian cities, especially in the tropics and subtropics. It is, however, an area of discipline in which a cohesive market image has not been created that reflects the abilities of tropical living consultants from Queensland, especially with respect to coordinating engineering, planning and architecture as a 'one-stop shop' service.

Health infrastructure planning and architecture

Many Asian countries have embarked upon comprehensive redevelopment programs of hospitals and other health infrastructure, as urbanisation increases at a rate that far exceeds the capacities of existing health facilities. Australian consultants are regarded as leaders in hospital planning and design, but there is no knowledge build-up among consultants of Queensland's research in tropical sciences. Interrelation of research and design knowledge would provide Queenslanders with a significant market advantage over competition from other regions. Better connectivity between research and design knowledge could be extended into planning and design for a raft of other opportunities, such as research clusters or sustainable natural environments threatened by anthropic impacts such as coastal tourism, climate change, overdevelopment or pollution.

Health

Carefully planned living environments can bring about direct health benefits. For example, well-designed urban transport systems can reduce greenhouse gas emissions, while simultaneously reducing the major health impacts of urban air pollution and physical inactivity. Environmentally responsive housing design can cut energy consumption and associated greenhouse gas emissions, reduce deaths from heat, and in poor countries, reduce the need for burning of biomass fuels and the impacts of indoor air pollution.²⁴

Disaster renewal and climate change

Consultants from Australia and Queensland have generated a strong reputation for assisting in the planning, architecture and engineering of cities affected by environmental disasters and conflicts. An example is the recent rehabilitation of Timor-Leste. Queensland also has research capacity in technical design (Cyclone Testing Station, JCU Townsville) and in emergency management (Centre for Disaster Studies, JCU Townsville).

The Boxing Day tsunami, recent hurricanes in the United States, Central America and Southeast Asia, and Cyclone Larry, have heightened public and government awareness of the risk facing much of coastal Queensland from unpredictable weather and other phenomena. A predicted outcome of climate change in future years is more extreme occurrences of climatic conditions including more intense cyclones and more severe droughts and floods. In low lying areas such as Cairns, more severe floods would be extremely damaging to the city whereas more severe cyclones would impact negatively on the entire Queensland coastline.

There is an opportunity to combine knowledge in disaster prevention and impact minimisation with post-disaster rehabilitation using coordinated knowledge and implementation skills. This opportunity could be addressed by pooling Queensland's renowned expertise in responding to issues such as climate change, coastal environmental degradation, post-conflict urban renewal, and energy crises. Consolidation of this expertise would help establish a stronger knowledge base than currently exists to inform planning and disaster management for tropical communities and ecosystems. Research, skills and tools developed by this approach would have export potential, since many countries in the Asia-Pacific region are subject to severe environmental disasters such as cyclonic events and tsunamis.

Design

In the context of this paper, 'design' refers to the creation or fashioning of products or environments that do not necessarily meet a critical living need, but nevertheless, are in demand due to the rapidly increased standard of living in Asia. Design could translate into environmental products, medical equipment and other innovations to improve quality of living environments. Queensland designers have outstanding abilities in their trade, and the opportunity exists to market their skills and services in a more coordinated manner.

Indigenous

Indigenous people are the most disadvantaged people in tropical Australia, often living in poverty and in poor housing and in extreme environments.⁷¹ However, Indigenous Australians have become influential in the development of the tropical region, through land ownership or control over access to land, and in the regional economy. Major developments, particularly in mining, may require the approval of traditional land owners, and increasingly, their involvement. There is an opportunity to further expand the economic development opportunities for the Indigenous population within Queensland.

Tropical Living Network

Although Queensland has strengths in various disciplines that contribute to the State's expertise in the built environment for the tropics, the research in these fields tends to be undertaken in isolation with little coordination of effort or opportunity for synergistic collaboration. Furthermore, there is a lack of critical mass of research expertise in tropical living, little effort is made to link disciplines, and the structure of the industry is less coordinated than some overseas competitors.

These issues, particularly the need for greater coordination, have been recognised previously, and was a motivator for the commissioning (by the then Department of Public Works and the Department of State Development and Innovation) of a study in 2004 to determine the feasibility of establishing an innovation centre for the tropical built environment. Although the authors of that report supported the proposal,⁷⁶ the recommendation to develop the centre was not pursued.

Nevertheless, there still exists considerable opportunity to coordinate and augment Queensland's capacity and scientific knowledge in tropical living to form a 'Tropical Living Network'. There is merit in focussing on a cross-disciplinary approach to this coordination across a wide range of interconnected fields, including environmental science, health, planning, urban renewal, building design, and environmental design. Such an approach would enable the marketing of Queensland as a world centre of tropical /subtropical design.

Built design is pivotal to strategic, residential and tourist development and encompasses, for example, consideration of health, environment, and social issues with traditional planning and engineering. Coordination of effort and a pooling of expertise would enable the complexity of issues relating to tropical living issues to be addressed. Currently, no country in the world is coordinating scientific knowledge directly with planning and design to improve the living environment of tropical/subtropical cities. Furthermore, no country is translating knowledge into solutions and outcomes for cities.

Consolidation of expertise in tropical living would support the development and commercialisation of globally competitive products and services, and best practice usage in the tropical built environment. Aside from increasing the profile and competitiveness of Queensland companies, there is also an opportunity to use these skills to increase the quality of life for Queenslanders, decrease energy consumption, and potentially better integrate isolated communities.

3.5 Extending tropical knowledge through education

3.5.1 Background

Queensland is one of few regions in the tropics with a world-class education system. For example, although net primary school enrolments of tropical nations were about 82% in 2002 (compared with Australia at 97% and around 85% worldwide) a far smaller percentage of students from tropical nations finish primary school.²⁰

The low education levels of tropical nations are a major focal point for international organisations. The United Nations seeks to achieve universal primary education as the second of its eight Millennium Development Goals.⁴ The World Bank commits around US\$343 million per year on tertiary education projects, with special emphasis on education, health, and gender equity.⁷⁷ The World Bank also works with several academic institutions and multinational organisations to further its goals, including universities in the United States and the Netherlands.

The education systems in Queensland and Australia are extensively utilised by foreign students. Australian universities have the highest proportion of foreign students enrolled throughout the OECD.¹⁹ Queensland is currently educating 16% of Australia's international students⁷⁸ – less than Australia on a per capita basis. These students, of which more than 40% are studying business administration and management,⁷⁸ provided \$376 million income for Queensland universities and \$1.95 billion income for Australian universities in 2004.⁷⁹ It has been estimated that approximately 9,000 Queenslanders are employed full time in the international education and training industry (JCU, pers. comm.).

Furthermore, the intake of students into Australia from China, Afghanistan, Pakistan, India, Bangladesh, Burma, Indonesia, Vietnam and Japan to pursue undergraduate and postgraduate study may increase if the Colombo Plan 2 scholarship program is released in the future.⁸⁰

It is clear that the demand for education services in tropical regions is increasing and will continue to grow rapidly. Queensland can take advantage of this developing market by furthering the expansion of education as an export industry to tropical nations. There is also scope to address the generally low education levels of Indigenous Australians, which trails behind that of the non-Indigenous population.

3.5.2 Opportunities

Queensland's education system is well regarded overseas and is extensively accessed by students from nearby tropical nations. Tropical Australia, and especially Queensland, offers research training opportunities of high relevance to other countries in the tropics. The location of these countries include the ASEAN region, the Indian subcontinent, Oceania and Central America.⁷¹ Education services and products could be exported to the developing world for a wide range of subject matter relevant to the tropics, including tropical health and well-being, environmental management, primary production, living/design/architecture, ecotourism, and agribusiness.

The development in Queensland of world class educational capacity focussed on tropical science provides the opportunity to build on these education services. Educational products or services dedicated to tropical science, or including components relevant to this field, have been developed, including:

- a wide range of courses at UQ, ranging from veterinary science, tropical health and disease, rural and regional communities including Indigenous communities, tropical plant and livestock production, plant and animal diseases, tropical biosecurity, environmental management including tropical marine environments, and tropical soils and landscapes
- a Bachelor of Tropical Agricultural Science and a Bachelor of Biotechnology at JCU that offer the only Australian agricultural science and biotechnology courses based in the tropics, and focus on the diversity and productivity of the tropical environment and the science and practice involved in sustaining and enhancing the productivity of these complex systems, while preserving environmental integrity
- a Bachelor of Veterinary Science at JCU, that teaches students about tropical animal husbandry
- the International Water Centre, based in Brisbane, that promotes expertise in sustainable management of catchments and other water resources to communities in Australia and abroad (such as South-East Asia, Latin America, Africa, China, India and Eastern Europe) through education, training, provision of software and high-tech products, and skills transfer.

Opportunities exist in the provision of consultancies, short courses, undergraduate and postgraduate education, or other information products in specific areas of interest to the tropical world. For example, the TPHUN of Queensland Health has identified several possibilities for exporting knowledge and expertise in tropical health, including those relevant to infectious diseases in the tropics, such as management strategies for dengue, Japanese encephalitis, leptospirosis, prevention of HIV, and sexually transmitted disease.¹⁸

Expertise and information systems have also been developed to address the burden of chronic disease in the tropics. These products and services would complement the coursework and research degree courses, short courses in professional education, and training in tropical public health that are offered by ACITHN partners; viz. UQ Health Sciences and QIMR. Coordination of these activities, along with those of other groups, could provide an avenue for the creation of significant education-based knowledge industries in tropical science.

An important link exists between the delivery of quality education services and the research that informs it.⁸¹ There is the need for Queensland to maintain a solid research base to ensure education remains strong. This concept is consistent with the Queensland Government commitment to promote more students pursuing higher education study and careers in the sciences.⁸² Queensland Government initiatives such as the Biobus, Science on Saturday, and the Smart Train are helping to engender an interest in science, particularly in regional areas. It is hoped that the long-term impact of these programs will also assist in encouraging scientists to continue to work in regional areas. 'Growing our own scientists' specialising in tropical knowledge is critical to the success of Queensland as a world leader in this discipline.

The opportunity exists to develop Indigenous knowledge-based enterprises, for example, in natural medicine, bush-tucker, or tourism. Elements of the latter category are currently provided by UQ. Establishment of partnerships with Indigenous organisations such as the Cape York Institute (that supports the economic and social development of Cape York) would be fundamental to successful Indigenous engagement. The wealth of traditional knowledge needs to be captured in a way that is beneficial to Indigenous Queenslanders, is culturally sensitive, and accessible.

Tropical Education Network

Greater collaboration among tropical science, knowledge, research and innovation entities, as well as among groups located in other parts of Queensland, would enhance the development of educational programs in the tropical sciences. An outstanding example of collaboration by research and academic institutions in providing coordinated outcomes is the National Degree in Tropical Marine Science. The course is provided through the Tropical Marine Network, a collaborative program between UQ, JCU, the University of Sydney and the Australian Museum. Expertise and marine island research stations of each entity offer six courses that form part of the degree.

There is considerable potential to develop further collaboration of this kind for the expansion of the tropical knowledge industry. Moreover, development of educational and consultancy products and services tailored to meet the needs of clients could be provided, as well as better marketing and promotion of these products and services. The development of a network of institutions, a 'Tropical Education Network', capable of working together to develop strategic, tailored, and coordinated education services would be a desirable first step.

The considerable national (ACIAR, AusAID) and international funding sources available for both education programs and tertiary education projects have been widely accessed in the past, and should continue to provide support for initiatives seeking coordinated outcomes. Recent programs, such as the Australia-India Strategic Research Fund (\$20 million to increase Australia's science and technology engagement with India) and the Endeavour India Research Fellowships (\$3.5 million to provide researchers from India with the opportunity to undertake short-term postgraduate and postdoctoral research in Australia),⁸³ may also assist in delivering educational products and services. The mooted 'Colombo Plan 2' is another avenue in this regard.

Access to Queensland-based programs attracting the best students from developing tropical countries is an opportunity to form strong bonds and mutually beneficial relationships between our State and the future leaders of the tropical world.

4. FROM OPPORTUNITIES TO MARKETS

Queensland's significant capacity and expertise in tropical science, knowledge, research and innovation ranks among the most substantial worldwide. Despite this high standing, opportunities exist to better coordinate research, knowledge and action in Queensland's tropical sciences to achieve greater outcomes. Networks in Queensland's five areas of tropical expertise will develop critical mass across knowledge-intensive clusters of research organisations and industry to deliver tropical knowledge, products and services to global consumers.

However, there is also the opportunity to go one step further to strategically brand, market and commercialise our tropical know-how for the benefit of all Queenslanders. Transforming Queensland's tropical capacity into market opportunities would not only require strong marketing and commercialisation of knowledge, it would also require a greater uptake of R&D by the State's tropical industries. Ultimately, Queensland can take leadership in tropical knowledge through a greater external focus by the State's firms and research organisations in accessing global markets and investment opportunities and by better positioning the 'tropical Queensland' brand.

4.1 Marketing

Smart regions brand and promote their strengths on a global scale to attract skills and investment and compete in dynamic markets.⁸⁴ Queensland is small on a global scale, with tropical Queensland even smaller. Better marketing and coordination of Queensland's tropical know-how as a brand has the potential to deliver greater global recognition.

For Queensland to fully exploit its tropical capability across domestic and international markets, it is critical to improve branding and marketing of our competitive strengths and increase the visibility of a tropical Queensland brand. A strong tropical Queensland brand will enable the State to access and compete in new markets and to attract increased investment and lucrative international contracts.

As outlined previously, the opportunities for our knowledge exports are enormous, with the emergence of increasingly affluent global tropical markets. A further opportunity exists for Queensland in securing additional international aid funding. It has been proposed that Australian organisations could substantially increase the portion of International Development Agency funding accessed, worth in excess of US\$77.5 billion annually.^{5,18} Queensland organisations generally only win 10 to 13% of the value of Australian international aid funding.¹⁸ In addition, improved marketing and branding would increase Queensland's capacity to develop alliances with overseas research organisations, international agencies, and companies engaged in tropical knowledge.

4.2 R&D intensive tropical industries

Transforming Queensland's tropical know-how from opportunities to markets will require many of our existing industries to significantly increase their uptake of R&D to take advantage of global opportunities. Queensland industry traditionally has a low uptake of R&D, as reflected by the State's low business expenditure on R&D (BERD) at just 0.6% of GSP in 2003-04,^{85,86} well below the OECD average.⁸⁷ To develop our tropical capacity and to enter intensely competitive global markets, particular focus should be placed on increasing the uptake of R&D, not only across all tropical industries, but by SMEs which dominate Queensland's industrial structure. Improving the uptake of R&D in our tropical industries will require a collaborative approach by industry, research organisations and government to enhance their competitiveness in servicing emerging tropical markets.

4.3 Commercialisation

If the investment in tropical R&D in Queensland is to return dividends for the State, action must also be taken to improve our capacity to commercialise our research.

Queensland's commercialisation is weak by international standards, with the State receiving less than half of the Australian average in royalties and license fees per person,^{88,89} which itself is very low by international standards, ranking 21st in the world in 2003.⁹⁰ It would appear that Queensland has a poor record in commercialising and marketing new products, services and intellectual property to support the development of industries based on tropical know-how.

Firms in emerging industries, generally start-ups, possess strong R&D capabilities, but have limited managerial and business development skills that often impede their commercial success. These firms also require improved access to capital through their various stages of growth. In particular, access in Queensland to angel and later stage venture capital investment is often restricted, and this issue may be even more challenging for start-ups in tropical Queensland.

To assess the most effective strategy for commercialising Queensland's tropical R&D, three models were considered:

- by **research institute**, effectively leaving commercialisation to the organisation in which the research originated
- by **sector**, creating a separate commercialisation body for each of the five areas of opportunity identified in this paper
- by a **single over-arching hub** that assists in commercialising Queensland's tropical research across all areas of opportunity.

Table 3 highlights the advantages and disadvantages of the three models, any one of which could be used effectively. However, given the paucity of significant commercialisation skills in the region, the hub mechanism may be the simplest and most practical to implement. It would provide a strong global identity and brand by marketing Queensland as a world leader in tropical science, knowledge, research and innovation. Economies of scale would be achieved in the provision of commercialisation services, such as business planning,

intellectual property management, market research and finance sourcing. The hub concept would also provide greater opportunities for deal flow through a collaborative approach, rather than either of the other models.

Table 3. Potential models for commercialisation of tropical R&D.

Model	Advantages	Disadvantages
Institute	<ul style="list-style-type: none"> ➤ Strong collaboration possible between sectors, but at a reduced scale ➤ Smaller number of researchers would provide more individual attention ➤ Smaller organisations can be more flexible and more prepared to respond as circumstances require ➤ Institute policies and requirements exert a level of control over IP management ➤ Institutes can provide leadership and rewards for researchers' cooperation in commercialisation 	<ul style="list-style-type: none"> ➤ Collaboration between institutes may be limited ➤ Limited branding and marketing potential ➤ Highly fragmented approach which may lack direction and coordination ➤ Research organisations may have varying commercialisation capacities and drivers ➤ Research organisations may lack sufficient resources to commercialise ➤ Investor confidence in commercial expertise of smaller organisations may be low
Sector	<ul style="list-style-type: none"> ➤ Strong collaboration possible across institutes and regions ➤ A medium number of researchers would allow for more individual attention ➤ A mid-sized organisation would be relatively adaptive to changing circumstances ➤ Capability to bundle technologies for greater investment attractiveness 	<ul style="list-style-type: none"> ➤ Collaboration between sectors may be limited ➤ Branding and marketing possibilities may be limited due to lack of scale ➤ Possible problems with working with many technology transfer companies at a number of institutes ➤ Fragmented approach which may lack direction and coordination ➤ Collaboration is difficult among institutes with different reward, incentive and control structures
Hub	<ul style="list-style-type: none"> ➤ Strong collaboration possible across institutes and between sectors, thereby achieving economies of scale ➤ Excellent branding and marketing opportunities available due to large critical mass ➤ Capacity exists to contractually oblige high standards of process ➤ Ability to build larger discovery platforms (e.g. drug pipelines) ➤ Greater opportunities to leverage external funding and involve industry from the start of research ➤ Potential for high deal flow with a greater number of contracts to commercialise research ➤ Investor confidence may be higher if representatives included in governance and management of over-arching body 	<ul style="list-style-type: none"> ➤ Possible problems working with many technology transfer companies at a number of institutes ➤ Servicing such a large number of researchers may limit individual attention ➤ Management of institutional and sectoral politics ➤ Control of IP and development can be difficult through back-to-back contracts ➤ Individual institutes may seek to profit upfront via more expensive research contracts and high full-time staff costs

4.4 A new approach

The effective coordination of networks in five areas of opportunity, together with the collective marketing and commercialisation of Queensland's tropical R&D may be effectively achieved through a dedicated overarching organisation, such as an 'International Hub for Tropical Knowledge'. This body would enable strong collaboration across institutions and between industry sectors, and represent a substantial critical mass of researchers, presenting a strong brand for leveraging external funding. The hub's operations would be shaped by market forces and global demand for goods and services derived from tropical know-how. **Figure 2** shows the potential over-arching hub and associated linkages.

An integrated hub for tropical knowledge would grow Queensland's regional and State economy through the creation of new industries, jobs and an increasingly skilled workforce by:

- establishing networks in strategic areas of opportunity that align otherwise disparate initiatives
- promoting, marketing and branding Queensland as a world leader in tropical science, knowledge, research and innovation
- maximising the commercialisation of Queensland's tropical know-how and increasing the knowledge intensity of tropical industries to provide new products and services that compete globally.

Leveraging networks is considered one of the cornerstones of the global economy.⁹¹ Strategic alignment of effort in tropical science would create a potent, cohesive and targeted tropical knowledge capacity that would surpass that offered by any other global region. An integrated hub, designed to market, commercialise and brand areas of opportunity for Queensland's tropical know-how, will provide the mechanism to take our tropical capacity to global markets.

International Hub for Tropical Knowledge

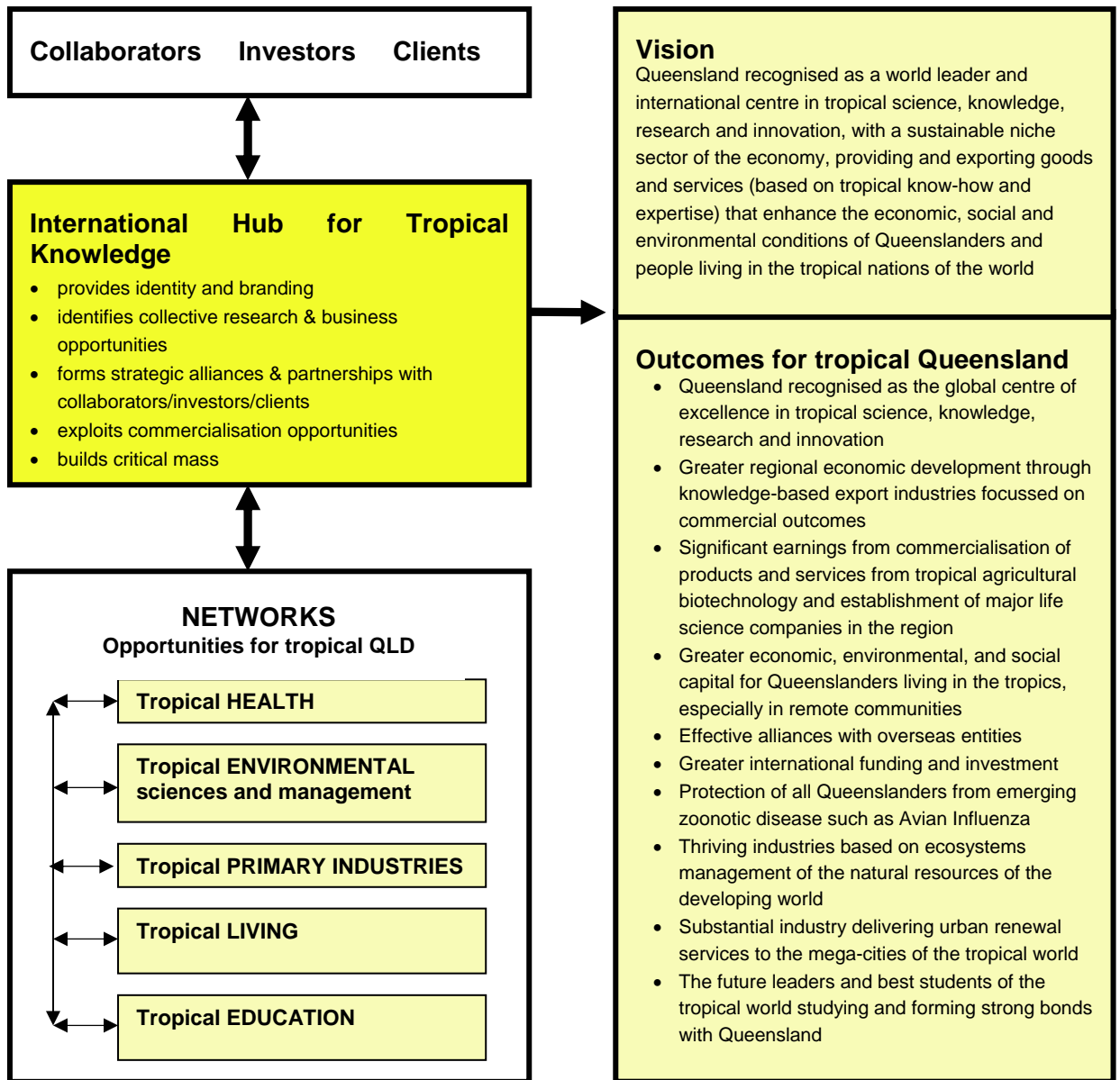


Figure 2. Hub mechanism

5. REFERENCES

- (1) *Calculations based on data available from: The World Factbook*, Central Intelligence Agency (<http://www.cia.gov/cia/publications/factbook/>), accessed April 2005.
- (2) Nations, U. *Human Development Reports*, United Nations Human Development Programme (<http://hdr.undp.org/statistics/>), accessed April 2005.
- (3) *World Population Prospects: The 2004 Revision*, Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (<http://esa.un.org/unpp/>), accessed September 2005.
- (4) *UN Millennium Development Goals*, United Nations (<http://www.un.org/millenniumgoals/>), accessed September 2005.
- (5) *Calculations available from data available at: WDI Online*, The World Bank Group (<https://publications.worldbank.org/WDI/>), accessed September 2005.
- (6) *A Raw Deal for Commodities*, The Economist, Vol. 351, Issue 8115, p75-76, April 1999.
- (7) *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine (<http://www.nap.edu>), 2005.
- (8) *One-North*, Singapore (<http://www.one-north.com>), accessed February 2006.
- (9) *GlaxoSmithKline Invests S\$62 million in Singapore's Biopolis Research Facility*, Singapore: The Biopolis of Asia (<http://www.biomed-singapore.com/>), 15th September 2004.
- (10) *Novartis Institute for Tropical Diseases*, Novartis AG (<http://www.nitd.novartis.com/>), accessed February 2006.
- (11) By Human Development Index
- (12) Based on the Koeppen Climate Classification System
- (13) Spalding, M. D.; Ravilious, C.; Green, E. P. *World Atlas of Coral Reefs*; Prepared at the UNEP World Conservation Monitoring Centre. University of California Press: Berkeley, USA, 2001.
- (14) *Great Barrier Reef*, Microsoft Encarta Online Encyclopedia (<http://encarta.msn.com/>), accessed December 2005.
- (15) *2001 Census Basic Community Profiles and Snapshots*, Australian Bureau of Statistics, 2001.
- (16) *MONASH Employment Forecasts, Version 2.75, 16/9/2005*, Centre of Policy Studies, Monash University, Australia.
- (17) *Estimated Resident Population by Statistical Division, Queensland*, Office of Economic and Statistical Research, Queensland Government (<http://www.oesr.qld.gov.au/>), accessed January 2006.
- (18) Department of Innovation and Information Economy *Tropical Science Discussion Paper*, Queensland Government, Brisbane, 2002, p 1-26.
- (19) *Education at a Glance: OECD Indicators 2005*, Organisation for Economic Co-operation and Development (OECD) (<http://www.sourceOECD.org>), 2005.
- (20) *WDI Online*, The World Bank Group (<https://publications.worldbank.org/WDI/>), accessed September 2005.
- (21) Moran, M.; Ropars, A.-L.; Guzman, J.; Diaz, J.; Garrison, C. *The New Landscape of Neglected Disease Drug Development*, London School of Economics and Political Science & The Wellcome Trust (http://www.wellcome.ac.uk/doc_WTX026606.html), London, 2005.
- (22) *Health at a Glance: OECD Indicators 2005*, Organisation for Economic Co-operation and Development (OECD) (<http://www.sourceOECD.org>), 2005.
- (23) Patz, J. A.; Campbell-Lendrum, D.; Holloway, T.; Foley, J. *Impact of Regional Climate Change on Human Health*; Nature 2005, 438, 310-17.
- (24) *Global Environmental Change - Climate and Health; Factsheet July 2005*, World Health Organization (<http://www.who.int/globalchange/news/fsclimandhealth/en/>), accessed January 2006.
- (25) *New Report Shows Climate Change Threatens Human Health*, Australian Medical Association (<http://www.ama.com.au/web.nsf/doc/WEEN-6GFAZM>), 22 September 2005.
- (26) *Climate Change Futures - Health, Ecological and Economic Dimensions*; Epstein, P. R.; Mills, E., Eds.; The Center for Health and the Global Environment, Harvard Medical School, 2005.
- (27) Woodruff, R.; Hales, S.; Butler, C.; McMichael, A. *Climate Change Health Impacts in Australia - Effects of Dramatic CO2 Emission Reductions*, Australian Conservation Foundation and Australian Medical Association ([http://www.ama.com.au/web.nsf/doc/WEEN-6HA6MS/\\$file/Climate_Change_Impacts_Health_Report.pdf](http://www.ama.com.au/web.nsf/doc/WEEN-6HA6MS/$file/Climate_Change_Impacts_Health_Report.pdf)), 2005.
- (28) *Chronic Diseases*, Menzies School of Health Research (www.menzies.edu.au/pls/portal30/url/folder/research/chronic/projects/cd/), accessed February 2006.
- (29) *University to establish world's first zoonosis centre*, The University of Liverpool (http://www.liv.ac.uk/newsroom/press_releases/2006/02/zoonosis.htm), accessed 16 March 2006.
- (30) *Fragmenting Forests: The Loss of Large Frontier Forests*, World Resources Institute (<http://earthtrends.wri.org/>), 1998.
- (31) Diamond, J. *Collapse: How Societies Choose to Fail or Survive*; Penguin Books Ltd, 2005.
- (32) *Wet Tropics*, Environmental Protection Agency, Queensland Government (http://www.epa.qld.gov.au/parks_and_forests/world_heritage_areas/wet_tropics/), accessed February 2006.
- (33) *Calculations based on statistics at: WDI Online*, The World Bank Group (<https://publications.worldbank.org/WDI/>), accessed September 2005.

- (34) CIA *Calculations based on statistics found at: The World Factbook*, Central Intelligence Agency (<http://www.cia.gov/cia/publications/factbook/>), accessed April 2005.
- (35) Esty, D. C.; Srebotnjak, T.; Kim, C. H.; Levy, M. A.; de Sherbinin, A.; Anderson, B. *Pilot 2006 Environmental Performance Index*, Yale Center for Environmental Law & Policy (<http://www.yale.edu/epi/>), New Haven, 2006.
- (36) *Report of the World Commission on Environment and Development*, United Nations (<http://www.un.org/documents/ga/res/42/ares42-187.htm>), 1987.
- (37) *World Development Report 2003: Sustainable development in a dynamic world - transforming institutions, growth, and quality of life*, The World Bank and Oxford University Press, U.S.A., 2003.
- (38) *The World Bank World Development Report: Knowledge for Development*, Oxford University Press, 1998/1999.
- (39) *UN Millennium Development Goals* (<http://www.un.org/millenniumgoals/>), accessed November 2005.
- (40) *Industry Facts*, Office of Environmental Technologies Industries (ETI), United States Government (<http://environment.ita.doc.gov/>), accessed January 2006.
- (41) Personal communication, Prof. Norman Palmer, Pro-Vice Chancellor, Research and International, James Cook University, 2006.
- (42) *State of the Environment 2003*, Environmental Protection Agency, Queensland Government (http://www.epa.qld.gov.au/environmental_management/state_of_the_environment/state_of_the_environment_2003/), 2003.
- (43) *Biotechnology - Setting New Horizons. Queensland Biotechnology Strategic Plan 2005-2015*, Department of State Development, Trade and Innovation, Queensland Government, June 2005.
- (44) Personal communication, Lieutenant General John Grey, Chancellor, James Cook University, 2006.
- (45) Batterham, R. *Review of Marine Research in Tropical Australia*, Australian Government, 2001.
- (46) *Biodiscovery*, Prime Minister's Science Engineering and Innovation Council (http://www.dest.gov.au/sectors/science_innovation/publications_resources/profiles/biodiscovery.htm), 2005.
- (47) *Investing in Northern Australia "More than Outback - More Outfront"*, Northern Australia Forum: Paper prepared for the Committee for Economic Development of Australia Seminar Series (<http://www.dotars.gov.au/>), 2001.
- (48) Personal communication, Prof Brian Kay, Director, Australian Centre for International and Tropical Health and Nutrition, 2006.
- (49) Wondur Holdings Pty Ltd *New Pharmaceutical, Nutraceutical and Industrial Products: The Potential for Australian Agriculture*, Rural Industries Research and Development Corporation (RIRDC), Australian Government. RIRDC Publication No. 00/173, Canberra, 2000.
- (50) Farnsworth, N. R. *Chapter 9: Screening Plants for New Medicines*; In *Biodiversity*; Wilson, E. O., Ed.; National Academy Press: Washington DC, USA, 1988.
- (51) *Queensland Biotechnology Code of Ethics*, Queensland Government (Department of State Development, Trade and Innovation), 2006.
- (52) Higginbottom, K. *CRC for Sustainable Tourism - Research Working in Partnership with Industry and Governments* (http://www.wildlifetourism.org.au/ppts/swtc_higginbottom_karen_plenary.pdf), accessed 7 March 2006.
- (53) *Queensland Ecotourism Plan 2003-2008: Sustainable Tourism in Queensland's Natural Areas*, Tourism Queensland, Queensland Government (<http://www.tq.com.au/>), Brisbane, 2002.
- (54) *Climate Smart Adaptation: What Does Climate Change Mean For You?* Department of Natural Resources and Mines, Queensland Government (http://www.nrm.qld.gov.au/science/pdf/climate_smart_adaptation.pdf), Brisbane, 2005.
- (55) *Climate Change and the Great Barrier Reef*, Great Barrier Reef Marine Park Authority, Australian Government (http://www.gbrmpa.gov.au/corp_site/info_services/science/climate_change/), accessed February 2006.
- (56) McClymont, E. L.; Rosell-Melé, A. *Links between the onset of modern Walker circulation and the mid-Pleistocene climate transition*; *Geology* 2005, 33, 389-92.
- (57) Kininmonth, W. *Climate Change: A Natural Hazard*; Multi-Science Publishing Co, UK, 2004.
- (58) *Australian National Accounts, State Accounts, 5220.0*, Australian Bureau of Statistics, Time Series Spreadsheets, 2004-05.
- (59) Dunnett, A. *The Changing Global Markets: A New Paradigm for Operating in the World's Knowledge-Based Economies*; In *World Knowledge Competitiveness Index 2004*; Robert Huggins Associates: Wales, 2004.
- (60) Holden, P.; Tonello, P.; Weeden, B.; Visini, J.; Smith, M. *Sowing the Seeds for an Integrated Sustainable Bioindustrial Farming System: Presenting a Case for the Future of the Mareeba-Dimbulah Region of North Queensland.*; First Australian Farming System Conference: Highfields, Toowoomba, 2003.
- (61) Gadek, P.; Holden, P.; Bitomsky, J. *Fostering Collaborative Regional Development in Biobased Industries. A Case Study - Stage 1.*, Rural Industries Research and Development Corporation (RIRDC), Australian Government. RIRDC Publication No. 05/134, Canberra, 2005.
- (62) *Industry Profile: Global Biotechnology*, Datamonitor, Reference Code 0199-0695, May 2005.
- (63) *Industry Profile: Global Nutraceuticals*, Datamonitor, Reference Code 0199-0759, November 2004.
- (64) *Water Account, Australia, 4610.0*, Australian Bureau of Statistics, 2000-01.
- (65) *Queensland Water Plan 2005-2010*, Queensland Government

- (66) (http://www.nrm.qld.gov.au/water/queensland_water_plan.html), 2005.
Calculations based on data available from: Queensland Regional Statistical Information System (QRSIS), Office of Economic and Statistical Research, Queensland Government (http://www.oesr.qld.gov.au/online_services/online_tools/index.shtml), accessed August 2005.
- (67) *Developing Strategies for GM and non-GM crops in Queensland - A Framework for Co-existence*, Queensland Government, Department of Primary Industries and Fisheries (http://www2.dpi.qld.gov.au/extra/pdf/business/coexist_strat.pdf), 2005.
- (68) Pilzer, P. Z. *The Wellness Revolution: How to Make a Fortune in the Next Trillion Dollar Industry*, John Wiley, 2002.
- (69) Holden, P.; Tonello, P.; Dillon, N. *Fostering the bio-economic revolution - the new age of agriculture in tropical north Queensland, Cairns 2020-2050 Business Research Manual*, December 2005.
- (70) Advance Consulting & Evaluation; Aoris Nova *Molecular Farming of Tobacco in the Mareeba and Dimbulah Irrigation Area, North Queensland*, Department of Primary Industries and Fisheries, Brisbane, 2003.
- (71) Australian Science and Technology Council - *Research and Technology in Tropical Australia and their Application to the Development of the Region*, Australian Government Publishing Service, 1993.
- (72) Tedesco, L.; Curtotti, R. *Mining Technology Services: A Review of the Sector in Australia*, ABARE eReport 05.5; Prepared for the Department of Industry, Tourism and Resources, Australian Government (<http://www.abareconomics.com>), Canberra, 2005.
- (73) *Marine Biotechnology Group - Tropical Aquaculture*, Australian Institute of Marine Science, Australian Government (<http://www.aims.gov.au/pages/research/research-groups/rq-marine-biotechnology-01-teams-c.html>), accessed 3 December 2005.
- (74) Lobegeiger, R.; Wingfield, M. *Report to Farmers: Aquaculture Production Survey Queensland 2003-2004*, Department of Primary Industries and Fisheries, Queensland Government (<http://www.dpi.qld.gov.au/>), 2005.
- (75) Hodges, A.; Burns, K.; Newton, P.; Goesch, T. *Global Ocean Observation System: An Economic Analysis of Australia's Contribution. ABARE Report to the Australian Academy of Technological Science and Engineering and Western Australian Global Ocean Observing System, Canberra, June*, Australian Bureau of Agricultural and Resource Economics, 2005.
- (76) *Feasibility Study - Tropical Built Environment Innovation Centre*, Capital Technic Consulting Pty Ltd; Document prepared for the Queensland Department of Public Works, September, 2004.
- (77) *Tertiary Education*, The World Bank (<http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTEDUCATION/0,contentMDK:20298183~menuPK:617592~pagePK:148956~piPK:216618~theSitePK:282386,00.html#activity>), accessed November 2005.
- (78) *International Students in Queensland*, Queensland Education and Training International; prepared by the Office of Economic and Statistical Research, Queensland Government, Brisbane, October 2005.
- (79) *Publications - Higher Education Statistics Collections*, Department of Education, Science and Training, Australian Government (http://www.dest.gov.au/sectors/higher_education/publications_resources/statistics/publications_higher_education_statistics_collections.htm), accessed October 2005.
- (80) Maiden, S., *Asian Students Scheme Grows*, The Australian, 14 December 2005.
- (81) Personal communication, Dr Ian Gould, Chair, Australian Institute of Marine Science, 2006.
- (82) *Smart Queensland - Smart State Strategy 2005-2015*, The State of Queensland (Department of Premier and Cabinet), 2005.
- (83) *Australia and India Unite Through Research Programme*, Media Release: Department of Education, Science and Training, Australian Government (<http://www.dest.gov.au/Ministers/Media/Bishop/2006/03/B001100306.asp>), 10 March 2006.
- (84) *Smart Regions Working Group Report*, Smart State Council, Queensland, 2006.
- (85) *Australian National Accounts, State Accounts, 5220.0*, Australian Bureau of Statistics, 2003-04 (Reissue).
- (86) *Research and Experimental Development, Businesses, Australia, 8104.0*, Australian Bureau of Statistics, 2003-04.
- (87) *Main Science and Technology Indicators*, Organisation for Economic Co-operation and Development (OECD) (<http://www.sourceOECD.org>), Volume 2005/1.
- (88) *Time Series Spreadsheets, Population by Age and Sex, Australian States and Territories, 3201.0*, Australian Bureau of Statistics, 2005.
- (89) *Data Cube, International Trade in Goods and Services, Australia, 5368.0*, Australian Bureau of Statistics, 2005.
- (90) *Human Development Reports*, United Nations Human Development Programme (<http://hdr.undp.org/statistics/>), accessed February 2006.
- (91) Zolli, A. *Founder, Z+Partners; Our Future, Our World - A prominent futurist's view of our world in 20 years*; Challenge your thinking, International Education Forum: Brisbane, Australia, 2006.

Appendix 1. Capacity and capability

Queensland's capacity and capability in various disciplines^{abc}

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
Tropical health and well-being					
University of Queensland Programs and Initiatives	Grand Challenges in Global Health - modifying mosquito population age structure to eliminate dengue transmission	UQ, NQ, World Tropics	2005	2010	UQ
	Burden Of Disease, Risk Factor Assessment And Cost-effectiveness Of Intervention Options: Informing Policy Choices And Health System Reform In Thailand	UQ, Thailand	2004	2009	UQ, Ministry of Public Health (Thailand)
	Investigating Kidney and other Chronic Diseases in Aboriginal People - Modelling Improved Clinical Practice and Health Services Delivery	UQ, NQ	2002	2002	

^a The information presented in this appendix is not intended to be a complete list of all of the capacity and capability in Queensland for each chosen discipline.

^b An individual entry may appear more than once if relevant to two or more disciplines.

^c Abbreviations in this appendix include: AB-CRC, Australian Biosecurity CRC for Emerging Infectious Disease; ACIAR, Australian Centre for International Agricultural Research (Australian Government); ACITHN, Australian Centre for International & Tropical Health & Nutrition; ACTFR, Australian Centre for Tropical Freshwater Research (JCU); AIMS, Australian Institute of Marine Science; AITM, Australian Institute of Tropical Medicine; AMPTO, Association of Marine Park Tourism Operators; ANU, Australian National University; ARC, Australian Research Council; ATFI, Australian Tropical Forest Institute; ATSIC, Aboriginal and Torres Strait Islander Commission; AusAID, Australian Agency for International Development; BERD, Business Expenditure on R&D; CDU, Charles Darwin University; CERF, Commonwealth Environment Research Facilities, Department of the Environment and Heritage (Australian Government); CQU, Central Queensland University; CRC, Cooperative Research Centre; CREDC, Cairns Region Economic Development Corporation; CRTR project, Coral Reef Targeted Research and Capacity Building for Management – Global Environment Fund (UQ) ; CSIRO, Commonwealth Scientific and Industrial Research Organisation; DEST, Department of Education, Science and Training (Australian Government); DPI&F, Department of Primary Industries and Fisheries (Queensland Government); DSDTI, Department of State Development, Trade and Innovation (Queensland Government); EPA, Environmental Protection Agency (Queensland Government); FRDC, Fisheries R&D Corporation; GBR, Great Barrier Reef; GBRMPA, Great Barrier Reef Marine Park Authority; GBRRF, Great Barrier Reef Research Foundation; Griffith Uni, Griffith University; IMB, Institute for Molecular Bioscience (UQ); IWC, International Water Centre; JCU, James Cook University; L&WA, Land and Water Australia; Menzies, Menzies School of Health Research; MOU, Memorandum of Understanding; MTSRF, Marine and Tropical Sciences Research Facilities; NAEIDA, Northern Australian Emerging Infectious Disease Alliance; NCWR, National Centre for Water Resources; NHMRC, National Health and Medical Research Council (Australian Government); NQ , North Queensland; NRM, Natural Resource Management (Australian Government); NRMW, Department of Natural Resources, Mines and Water (Queensland Government); NWI, National Water Initiative (Australian Government); QH, Queensland Health; QIMR, Queensland Institute of Medical Research (UQ); QPWS, Queensland Parks and Wildlife Service (Queensland Government); QUT, Queensland University of Technology; R&D, Research and Development; SSRFF, Smart State Research Facilities Fund (Queensland Government); TPHUN, Tropical Public Health Unit Network; TRACK, Tropical Rivers and Coasts Knowledge; TSIP, Tropical Science and Innovation Precinct (proposed); TTNQ, Tourism Tropical North Queensland; UNSW, University of New South Wales; UQ, University of Queensland; UNESCO, United Nations Educational, Scientific and Cultural Organization; UWA, University of Western Australia; WHO, World Health Organization; WTMA, Wet Tropics Management Authority.

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
	Attenuated West Nile virus vaccine	UQ, NQ, World Tropics	2005	2010	UQ, Sir Albert Sakzewski Virus Research Centre
	Tropical infectious diseases - pathogenesis and vaccine research	UQ, NQ, World Tropics	2004	2008	
	Dissecting Pain Pathways with Conopeptides- use of Conotoxins from Cone Shells in GBR animals	UQ, GBR	2005	2009	UQ
	Novel probes for ion channel structure and function - New Conotoxins from GBR in Queensland	UQ, GBR	2002	2006	
The Institute for Molecular Bioscience (IMB)	To undertake globally competitive research to understand the information contained in the genes and proteins of mammals and thereby to improve human and animal health through the development of new pharmaceuticals, cell therapies and diagnostics.	UQ, St Lucia			UQ, QLD Gov, ARC, Australian Genome Research Facility, Australian Phenomics Facility, CSIRO
Queensland Institute of Medical Research (QIMR)	Includes the following laboratories: Clinical Tropical Medicine, Molecular Immunology, Immunology and Infection, Molecular Parasitology, Bacterial Pathogenesis, Malaria and Scabies, Malaria Biology and Mosquito Control.	Royal Brisbane Hospital	1945	Ongoing	
Army Malaria Institute	Five Departments: Drug Resistance and Diagnostics, Drug Evaluation, Clinical Studies and Surveillance, Vector Surveillance and Control and Arbovirology.	Gallipoli Barracks, Brisbane	1996	Ongoing	Australian armed services, Cth Gov
Malaria: from target identification to therapeutics – Griffith University	To identify new targets for anti-malarial therapies or develop better methods of interfering with the function of known targets. This work will lead to the development of effective pre-clinical vaccines and new chemical entities that act against these targets, which in the longer-term will provide new approaches to the prophylaxis and treatment of this devastating disease.	Institute for Glycomics	2005	2010	Monash University, the Austin Research Institute
Australian Institute of Tropical Medicine (AITM)	Multidisciplinary group of researchers with five research clusters, including the Comparative Genomics Centre, Drug Development Design and Delivery, Health, Workforce and Education in Rural, Indigenous and Tropical Communities, the North Queensland Centre for Cancer Research and Tropical Infectious Diseases and Biosecurity. Linked to the AITM is the WHO Collaborative Centre for Lymphatic Filariasis, which seeks to assist and facilitate the global elimination of lymphatic filariasis. The centre was accorded WHO status in 1996.	JCU, Townsville			JCU, QIMR, QH and a network of national and international collaborations with research institutions and government.
Australian Centre for International and Tropical Health and Nutrition (ACITHN)	A virtual centre that includes staff at QIMR, the School of Population Health (SPH) at the University of Queensland (UQ) and informally, staff at the Army Malaria Institute. ACITHN aims to improve the health of populations in Australia and internationally through excellence in education, research and service. ACITHN has a shared commitment to a broad understanding of health and well-being through	Herston campus of UQ	1995		UQ, QIMR, Army Malaria Institute, major national and international organisations

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
	three programs in (1) Nutrition, (2) Tropical Health, and (3) Indigenous Health. Coursework and research degree courses, short courses in professional education and training in tropical public health are provided for Australian students, students from tropical developing countries and other students with a strong interest in these areas. The Centre also is committed to develop facilities for research and research training, to support international and Australian public health programs and the transfer of knowledge and technology to tropical developing countries, and to make special provision for the training of Aboriginal and Torres Strait Islander students.				
Tropical Public Health Unit Network (TPHUN)	Develop, coordinate and support public health interventions for priority health issues of State-wide and local significance (includes disease control etc). Provide expert advice to international health bodies.	Cairns, Townsville, Mackay and Mt Isa and the Gulf			QH
School of Public Health, Tropical Medicine and Rehabilitation Sciences - JCU	Focus on public health and tropical health issues relevant to tropical Australia with particular focus on rural, remote and Indigenous communities.	JCU Townsville and Cairns			JCU
Eskitis Institute for Cell & Molecular Therapies	Consists of three groups (cell biology, chemical biology, neurobiology) and two programmes (natural product discovery & tropical diseases). The natural product discovery programme is a collaboration with Astra Zeneca. Within the Institute will be the Queensland Compound Library (QCL), which will provide compounds and biota for targeting and development of new therapeutic drugs, as well as a compound storage and retrieval system and related platform technologies (Both public and private sector bioscience researchers will be able to access the library).	Griffith Uni IMB, Brisbane	2002/03, 2005 for QCL	2007	Griffith Uni, AstraZeneca
Institute for Glycomics	Focussed on the role of carbohydrates in disease and drug discovery. Profile in tropical diseases such as malaria, dengue fever, trypanosomiasis and others.	Griffith Uni, Gold Coast	2000		Griffith Uni, Qld Gov
National Research Centre for Environmental Toxicology (EnTox)	The health effects of exposure of biological systems and humans to environmental contaminants are studied.	QH labs, Brisbane	1991	Ongoing	UQ, Griffith Uni, QUT, and QH
The Australian Biosecurity CRC for Emerging Infectious Disease (ABCRC)	To detect, identify, monitor, assess, predict and response to emerging infectious disease threats that impact on national and regional biosecurity.	Headquarters at UQ, Brisbane	2003	2010	UQ, CSIRO, Qld Gov and various others
CRC for Aboriginal Health	To investigate health service delivery systems, the social determinants of health and health outcomes, reduce the burden of disease on Aboriginal communities and individuals and increase formal research training opportunities for Indigenous Australians.	Headquarters in Darwin, node in Brisbane	2003	2010	Flinders Uni, UQ, QIMR, and various others
CRC for Vaccine Technology	To develop and commercialise new vaccines, therapies and platform technologies for the benefit of human and veterinary health.	Headquartered at QIMR	1999	2006	QIMR, CSIRO and various others
Northern Australian Emerging Infectious Disease Alliance (NAEIDA)	To manage emerging infectious disease and public health issues in tropical Australia. The NAEIDA was established under the Co-operative Framework on Tropical Science, Knowledge and Innovation between the Governments of Queensland, the Northern Territory and Western Australia.	QLD, NT, WA	2005		QLD, WA and NT Governments, UQ, JCU, CDU, UWA, Menzies

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
Public Health Virology Laboratory - QH	Provides specialised arbovirus, bat borne diseases and rickettsial testing for laboratories across Australia and the Western Pacific and participates in a number of national surveillance schemes including those for influenza and Japanese.	Coopers Plains			QH
Institute for Health and Biomedical Innovation (IHBI) - QUT	To solve health problems by interfacing between traditional scientific disciplines to solve the issues affecting the well being of Australia and neighbouring communities. Staff at IHBI are expressing novel genes in tropical crops for biofortification of tropical crops to improve human nutrition, control of diseases of tropical crops through the deployment of novel resistance genes, and the use of plants to produce novel products such as medical proteins.	QUT, Kelvin Grove	To open in 2006		QUT
AIMS MOU with the US National Cancer Institute (NCI)	AIMS signed a five year MOU with the US National Cancer Institute in Washington DC in June 2003. AIMS expects to provide between 1000-5000 samples to the NCI each year under the five year agreement to test the samples of marine life against cancer.	AIMS	2003	2008	AIMS and US National Cancer Institute in Washington DC
Tropical environment and cultural assets					
Terrestrial					
Australian Tropical Forest Institute Ltd (ATFI) (under construction – JCU Cairns)	Currently under construction at the JCU Cairns campus, ATFI seeks to become the focus for Australian and international research and commercial development based on the biodiversity of tropical forests. Resilience of rainforest communities to climate change will also be studied. Key partners are the Rainforest CRC, JCU, The Wet Tropics Management Authority (WTMA), BioProspect Australia Ltd and the Australian Tropical Mycology Research Centre. ATFI is also planned to be the northern partnering centre for rainforest research conducted under the MTSRF.	JCU - Cairns Campus	Started late 2005	To be completed 2006	Rainforest CRC, JCU, Wet Tropics Management Authority (WTMA), BioProspect Australia, Australian Tropical Mycology Research Centre
Wet Tropics Management Authority (WTMA)	Management of the Wet Tropics World Heritage Area and capacity for exporting management expertise and capacity-building to developing countries.	Cairns CBD	1990		Cth Gov, Qld Gov
Cooperative Research Centre for Tropical Rainforest Ecology and Management (Rainforest CRC)	The Rainforest CRC is a research and education partnership, conducting research into environmental planning and management in rainforest regions; evaluating ecosystem goods and services; rainforest visitation, business, interpretation and presentation; managing and monitoring impacts arising from rainforest access; rehabilitation and restoration; conservation principles and management; and Aboriginal and collaborative management.	Headquartered in Cairns	1999	2006	CSIRO, WTMA, QLD Tourism Industry Corporation, Alliance for Sustainable Tourism, ATSIC, JCU, UQ, Griffith Uni, EPA, QPWS, NRMW, DPI&F Network.
CSIRO Tropical Forest Research Centre, Atherton, Far North Queensland	Includes the Atherton Herbarium (which houses the world's most comprehensive collection of Australia's tropical flora and is part of the Australian National Herbarium), as well as capacity from the Entomology and Land and Water Divisions.	Atherton			CSIRO, Rainforest CRC, Tropical Savannas CRC

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
Australian Canopy Crane Facility	Studies forest canopy processes and biodiversity. To date, this field is poorly understood.	Daintree rainforest	1998	2010	JCU, UQ, Griffith Uni, International Global Canopy programme
Centre for Forestry and Horticultural Research	CFHR undertakes research programs in sustainable forestry and horticulture to enhance the economic, environmental and social benefits of forest and horticultural ecosystems, particularly in tropical and subtropical environments. Research areas include: sustainable forest management, biogeochemical cycles of carbon and nutrients, forest nutrition and ecophysiology, soil microbiology and biochemistry, genetic control of tree nutrient and water use, wood quality, and global climate change.	Griffith Uni, Brisbane	2003	Ongoing	Griffith Uni, Qld Depts of Primary Industries and Natural Resources, Mines and Energy.
Centre for Innovative Conservation Strategies	Research focuses on conservation of biodiversity. (with most of Qld's biodiversity being in the tropics). CICS uses an integrated and diverse approach to restoration achieved through the whole-of-landscape approach, including: fire management, reserve management, species-focussed interventions and habitat reinstatement. Research programs: (1) Natural and Sustainable Ecological Processes, (2) Threats and Restoration, and (3) Conservation Management.	Griffith Uni Brisbane	2003	Ongoing	
Tropical Landscapes Joint Venture (TLJV)	Collaborative research on sustainable tropical environments.	ATFI on JCU Cairns campus			JCU & CSIRO
Boggo Road Ecosciences Precinct (proposed)	Proposed to conduct research in climate change and environmental sustainability. The precinct will bring together researchers, including those with expertise in biotechnology, from State and Commonwealth agencies and universities, to address challenges facing the State's natural resources.	Brisbane	In development – complete in 2009		DPI&F, EPA, NRMW, CSIRO and various others
Centre for Environmental Management - CQU	Focus on industrial land management, mangroves ecology, marine and freshwater ecology, koala research, and finding ways of altering the current trajectory of resource extractive industries.	CQU Gladstone (Headquarters)			CRC for Coastal Zone, Estuary and Waterway Management and various others
National Centre for Tropical Wetland Research (NCTWR), Darwin	To promote the wise use of tropical wetlands by providing information and expertise to assist managers and owners of tropical. Also involved in assessing existing and potential threats to wetlands and developing procedures and standards to sustainably use and restore wetlands.	Based in Darwin, JCU involved			JCU, CDU, UWA, Environmental Research Institute of the Supervising Scientist
University of Queensland Programs and Initiatives	Cane toad control – genomic focussed	UQ, N. Aust	In development		UQ, Aust Invasive Animal CRC
JCU School of Tropical Environment Studies and Geography	The School of Tropical Environment Studies and Geography focuses on the study of people and their environment, bringing together physical, biological and social aspects of the environment.	Cairns and Townsville campuses	Ongoing	Ongoing	JCU
Bushfire CRC	Focus on: Safe prevention, preparation and suppression; Management of fire in the landscape; Community self-sufficiency for fire safety; Protection of people and property; Education, training and communication.	Headquartered in Melbourne (Nodes in	2003	2010	Qld Fire and Rescue, CSIRO, UWA and various others

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
		Brisbane and Townsville)			
Desert Knowledge CRC	To develop thriving desert knowledge economies which sustain Australia's inland environments.	Headquartered in Alice Springs	2003	2010	CDU, ATSIC, CSIRO, Griffith Uni and various others
Environmental Biotechnology CRC	To enhance existing biologically based environmental processes as well as producing new advanced bioengineering technologies.	Headquartered at UNSW (Node in Brisbane)	2003	2010	UQ, UNSW, Orica Aust Pty Ltd and various others
MOU between the Smithsonian Institute and the Qld Government	The Smithsonian Tropical Research Institution (STRI) in Panama is dedicated to understanding biological diversity. This relationship should further collaborative research activities in tropical environmental management. A key project fostered under the MOU signed in 2000 a joint research project which aims to enable more sustainable management of coral reef fisheries. The relationship was extended for a further 5 years in June 2005.	QLD, Panama	2005	2010	Qld Gov, Smithsonian Institute
Mau Mau Native Plant Commercialisation	To domesticate selected wild plant species to produce cultivars to tap into the growing bush food market as well as therapeutic and pharmaceutical product development.				The Aboriginal community, education institutions, local government bodies and industry associations
Marine/estuarine/riverine					
Australian Institute of Marine Science (AIMS)	Has an international reputation in marine biodiversity and conservation, coastal processes and marine biotechnology. AIMS generates and transfers the knowledge needed for the sustainable use and protection of the marine environment. The facility includes a Marine Biodiversity Collection containing material from more than 17,500 marine organisms collected and isolated from over 1,500 sites around Australia including Queensland's Great Barrier Reef.	Cape Ferguson, 50 km from Townsville	1972		Cth Gov
AIMS@JCU	The AIMS@JCU joint venture between AIMS and JCU (created in 2004) aims to consolidate collaborative research activities across JCU and AIMS by improving the research capabilities and research outputs of the parent institutions, increasing research training opportunities, and increasing the research activities within identified program fields in tropical marine science (<i>viz.</i> coastal processes, aquaculture and stress in marine systems). This arrangement includes the Centre for Innovative Tropical Aquaculture.	JCU and AIMS	2004		JCU, AIMS and national and international collaborations
Cooperative Research Centre for the Great Barrier Reef (Reef CRC)	A knowledge-based partnership of coral reef managers, researchers and industry to protect, conserve and restore the coral reefs of the GBR World Heritage Area by ensuring industries and management are sustainable and that ecosystem quality is maintained.	Headquartered in Townsville	1999	2006	AMPTO, AIMS, GBRMPA, GBRRF, JCU, DPI&F, QLD Seafood Industry Association Inc, Sunfish QLD Inc, UQ, FRDC

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
ARC Centre of Excellence for Coral Reef Studies JCU	The facility has specific research expertise in biodiversity and is researching processes underlying biodiversity patterns on coral reefs, and providing the scientific knowledge necessary for managers and workers in developed and developing countries to conserve, manage and restore the world's coral reefs. The centre is seeking to: <ul style="list-style-type: none"> quantify processes underlying biodiversity patterns on coral reefs increase national capacity in coral reef science provide the scientific knowledge necessary for managers and workers in developed and developing countries to conserve, manage and restore the world's coral reefs. 	JCU, Townsville	2005	2010	JCU, UQ, ANU, AIMS, GBRMPA, and other national and international partner organisations
Tropical Marine Science Centre of Excellence	Focus on management of marine resources. Two projects are being considered by DSDTI and Qld Treasury. Centre of Excellence in Climate Change and Coastal Ecosystems	UQ, JCU	2005	Ongoing	JCU, UQ, AIMS
Centre for Marine Studies UQ	Coordinates research and teaching on the ocean, coast, estuaries and reefs of Queensland for UQ. The Centre coordinates Heron Island Research Station (the largest research station on the Great Barrier Reef), Moreton Bay Research Station, Low Isles Research Station, a suite of vessels of various capacities, and Pinjarra Aquatic Research Station. The centre undertakes marine biology and biodiscovery, coastal zone management, aquaculture, fisheries and parasitology, marine botany and coastal plant communities, climate change and coastal ecosystems.	UQ, Brisbane			UQ
Coral Reef Targeted Research and Capacity Building for Management – Global Environment Fund - UQ (CRTR Project)	UQ's Coral Reef Targeted Research and Capacity Building for Management project is one of four Centres of Excellence in a global marine research program. The CRTR Project involves four Centres of Excellence in Australasia (Heron Island, Queensland, Australia); Southeast Asia (Bolinao, Philippines); Western Caribbean (Morelos, Mexico); and Eastern Africa (Zanzibar, Tanzania). The CRTR program is working to effectively support management and policy and to better integrate resulting information with other disciplines such as economics and law.	UQ, GBRMPA			UQ, World Bank
University of Queensland Programs and Initiatives	Colour vision and photoreceptors in reef fish: a model system to discover the function of double cones.	UQ, GBRMPA	2005	2008	UQ, GBRMPA
International Water Centre (IWC) – Griffith Uni / UQ / Monash / UWA	To promote more sustainable management of catchments and other water resources through education, training, providing software and high-tech products, and transferring skills to grassroots communities. The Centre will focus on promoting expertise to nations and regions including Indonesia and other areas of South East Asia, Latin America, Africa, China, India and Eastern Europe. Therefore, the centre will be an international education and training facility.	Brisbane Headquarters. Work done in Australia and abroad	2005	2009	Healthy Waterways Partnership, International Riverfoundation
IWC – Australian Water Research Facility	Provides research and advice on water related issues for Australia's aid agency, AusAID.	Timor-Leste, Solomons and PNG			Contracted through IWC
Centre for Riverine	Conducts internationally recognised research into Water Allocation and	Griffith Uni,	2003	Ongoing	Griffith Uni,

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
Landscapes	Environmental Flows, Land Management, Biodiversity and Conversation, River and Riparian Rehabilitation, and Ecosystem Health Assessment.	Brisbane			International Water Centre, e-Water CRC, CSIRO Land & Water, Qld Dept of Natural Resources, Mines and Energy, EPA, various water instrumentalities
Centre for Aquatic Processes and Pollution	Draws together expertise in disciplines from ecology and environmental chemistry through to ecotoxicology and pollution engineering, to tackle management issues for the aquatic coastal environment. Research is conducted within 4 main programs: Ecotoxicology, Aquatic Processes, Advanced Monitoring, and Coastal Urban Ecosystems.	Griffith Uni, Gold Coast	2003	Ongoing	Griffith Uni, International Water Centre, e-Water CRC, CSIRO Land & Water, Qld Dept of Natural Resources, Mines and Energy, EPA, Gold Coast City Council, various water instrumentalities.
Catchment to Reef Project	A project between the Reef and Rainforest CRCs to identify, monitor and mitigate water quality problems and assess health of aquatic ecosystems in the Wet Tropics and Great Barrier Reef World Heritage Area. The project aims to minimise the downstream effects of agriculture, improve the health of the GBR Lagoon and provide landholders, industry and other stakeholders with the tools to monitor effects of land use change and restoration of water quality.	Wet Tropics, Great Barrier Reef World Heritage Area			CRCs for Reef and Rainforest
CSIRO Healthy Country Flagship Program – Node focussed on Great Barrier Reef	To provide R&D support in environmental science with one of its four nodes focussed on the Great Barrier Reef region. It will provide the R&D support required for the implementation of the Reef Water Quality Protection Plan, with the aim of reversing the decline of water quality delivered to the Great Barrier Reef Lagoon.	GBR			Department of the Environment and Heritage, CRC for Great Barrier Reef World Heritage Area, GBRMPA, Qld Gov and various others
Centre for Coastal Management	Coastal management, mangrove and coastal wetlands biology, crab and molluscan ecology and estuarine ecology of sea dragons and seahorses	Griffith Uni, Brisbane, Gold Coast	2003	Ongoing	Griffith Uni, Gold Coast City Council
Tropical Marine Network - Lizard (Aust Museum), Orpheus (JCU), Heron (UQ), One Tree (Uni Sydney) and North Stradbroke (UQ) Islands	The Tropical Marine Network links the tropical island research stations of JCU, UQ, the University of Sydney, and the Australian Museum to create a unique research platform for understanding biological and physical change in the GBR region. The Tropical Marine Network is also linked with significant international projects such as the Global Environment Facility - Intergovernmental Oceanographic Commission of UNESCO/World Bank Coral Reef Targeted Research and Capacity Building project. The network provides research and teaching in marine science and collaborative educational courses such as the National Degree in Tropical Marine Science. Expertise and marine island research stations of each institution are	Lizard, Orpheus, Heron, One Tree and Nth Stradbroke Islands			Includes, Australian Museum, JCU, UQ, Uni of Sydney

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
	utilised to offer six courses that form part of the degree.				
Great Barrier Reef Marine Park Authority (GBRMPA)	The management of the Great Barrier Reef Marine Park and World Heritage Area.	GBR, Townsville			Cth Gov, Qld Gov
Great Barrier Reef Research Foundation (GBRRF)	Fundraising body, founded by business leaders to raise money from the private sector to contribute to the preservation of the reef. Aims to secure a future for both the environment and sustainable industry. Philanthropic funding supports scientific efforts of Australian institutions.	Brisbane	1999	Ongoing	Various
Future Reef	A partnership between Comalco and the GBRRF to investigate effect of climate change, particular in relation to ocean acidification, on the GBR.	Comalco, GBRRF, UQ, Heron Island	Nov 2005	Oct 2009	UQ, GBRRF, Comalco
Australian Centre for Tropical Freshwater Research (ACTFR)	Acts as a research and consultancy group to promote water research, technology and information transfer to industry.	JCU, Townsville	1987		JCU, Regional NRM bodies and industry and government stakeholders
Tropical Rivers and Coasts Knowledge (TRACK)	The TRACK initiative is led by Griffith University Centre for Riverine Landscapes, Charles Darwin University, the University of Western Australia and consists of a total of about 50 partners. TRACK is a large coordinated and integrated program of R&D to underpin the sustainable management of tropical rivers and coastal environments. TRACK is focussed on 5 themes: (i) assets and values; (ii) riverscape settings; (iii) material budgets; (iv) food webs and biodiversity and (v) enterprise development. The initiative is seeking a total of \$43 million from a range of Commonwealth and jurisdictional sources.	Northern Australia	2005		Over 50 leading researchers from 15 organisations, chiefly Griffith Uni Centre for Riverine Landscapes, CDU, and UWA.
Australian Tropical Rivers Group	Independent group of Australian researchers in river ecology that will contribute to issues concerning the management of tropical rivers.	Northern Australia			Griffith Uni, NCWR, CDU, Uni Canberra, NSW Dept Env & Conservation, JCU
Cultural					
Cape York Institute for Policy and Leadership	Organisation directed by Aboriginal leader and activist Noel Pearson, with a majority-Indigenous appointed board, CYI's work supports the economic and social development of Cape York. It undertakes policy/research projects across a wide range of economic and social policy issues, including welfare, health, governance, education, economic development, land and housing, substance abuse, and social order.	Griffith Uni, Cairns	2004	Ongoing	Cth Gov, Qld Gov, Griffith Uni, Cape York communities.
General and other					
Tropical Science and Innovation Precinct (TSIP) – JCU Townsville	The TSIP is expected to create a world leading aggregation of researchers to advance sustainable living in tropical environments, with a focus on land-based research. Funds will support research programs on vegetation and ecosystems management, intensive production systems in tropical landscapes and marine and	JCU, Townsville	Proposed 2008/09	Ongoing	JCU, CSIRO, DPI&F, AIMS@JCU, ARC Centre of Excellence in Innovative Science for

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
	<p>coastal processes and production systems in six programs:</p> <ol style="list-style-type: none"> 1. ecological understandings to underpin the sustainable management of northern landscapes 2. sustainable water management 3. savannas production systems and rangelands 4. intensive production systems in tropical landscapes 5. marine and coastal processes and production systems 6. integrated approaches to managing change in tropical regional communities. <p>Current planned partners for co-location to the precinct include CSIRO (relocation of Davies Laboratory and several marina and aquaculture activities), AIMS@JCU (research joint venture between JCU and AIMS), and DPI&F (through repositioning its rangelands management and marine science activities). It is proposed that the TSIP become the major administrative centre for the MTSRF.</p>				Sustainable Management of Coral Reef Biodiversity, MTSRF
TSIP Joint Venture - JCU	As the research arm of TSIP, the TSIP Joint Venture will bring together researchers from CSIRO and JCU to create a new research collaborative partnership focussing on regional sustainability and development.	JCU, Townsville			JCU, CSIRO and a network of national and international collaborations
Marine and Tropical Sciences Research Facility (MTSRF)	<p>To enable the work of the CRC Reef and CRC Rainforest to continue, while also presenting a significant opportunity to build on this scientific foundation to create the world's largest cluster of tropical sciences expertise and infrastructure.</p> <p>Five key priority areas have been identified:</p> <ol style="list-style-type: none"> 1. Understanding the condition and trends of North Queensland's environmental assets. 2. Risks and threats to North Queensland's environmental assets. 3. Water quality and water resources of reef catchments. 4. Catchment and coastal land use planning and management. 5. Sustainable use and management of natural resources. 	NQ, based at JCU Townsville and Cairns	2005	2010	JCU – Cairns
Cairns Node of CRC Sustainable Tourism	To provide research across a range of disciplines relevant to the Far North Queensland tourism industry.	JCU, Cairns	2003	2010	JCU, CRC Tourism, TTNQ, Alliance of Sustainable Tourism & AMPTO
International Centre for Ecotourism Research	ICER's interest are international and cover the environmental impacts and management of tourism, the management of visitors and resources in protected areas, the economics of ecotourism and a range of related issues.	Griffith Uni, Gold Coast	1993	Ongoing	Griffith Uni, Tourism Qld, Australian Heritage Commission, EPA, Qld Dept of Natural Resources, Mines & Energy, EPA, Wilderness Foundation, CRC Sustainable Tourism
Queensland Museum & Museum of Tropical	Research strengths in taxonomy, biogeography and evolution of certain marine taxa. The Queensland Museum has a particular focus on the biodiversity of sessile marine	Brisbane, Townsville			Qld Gov

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
Queensland	invertebrates and bioprospecting for natural therapeutic compounds as sources of potential pharmaceuticals.				
CSIRO Davies Laboratory	Research on tropical and subtropical fisheries and ecology, sustainable aquaculture and multiple use management of Northern Australia. Also includes research on Sustainable Ecosystems, Land and Water, and Plant Industry.	Townsville			CSIRO
Environmental Protection Agency (EPA)	Coastal planning and management and for conservation and management of protected species and habitats.	EPA, QLD	Ongoing	Ongoing	NRM bodies, primary industries, conservation groups, general community
Department of Natural Resources, Mines and Water (NRMW)	To enhance community benefit through sustainable natural resource management and plays a critical role in stewardship of Queensland's natural resources. The department manages and allocates the State's land, water, mineral and petroleum resources, and manages native vegetation and the control of pest plants and animals.	NRMW, QLD	Ongoing	Ongoing	NRM bodies, primary industries, conservation groups, general community
Co-operative Framework on Tropical Science, Knowledge and Innovation (NT, Qld, WA)	Established to address tropical science issues including the management of northern Australia's tropical environment. One proposal under development aims to maintain tropical coastal and riverine ecosystems while encouraging enterprise development amongst local communities. The project is known as Tropical Rivers and Coasts Knowledge (TRACK). The Senior Officers' Group of the Co-operative Framework is also seeking information about cane toad management in northern Australia.	QLD, NT, WA	2004	2004	Government of QLD, WA, NT, Griffith Uni, UQ, JCU, CDU, UWA, and supporting funding bodies
Centre for Environmental Systems Research	Researches impact of urban population centres on surrounding environment. Research focuses on: (1) Impacts on Environmental Systems, (2) Preventing the Release of Pollutants, (3) Managing Contaminants in Urban Systems, and (4) Modelling, Management and Stakeholders.	Griffith Uni, Brisbane	2003	Ongoing	
Xenome Pty Ltd	A biotechnology spin-off company from the University of Queensland, that is developing pharmaceuticals from snake venom and toxins of Australian animals, including cone shell snails from the Great Barrier Reef. The synthetic drug XEN2014 is modelled on a peptide isolated from cone shell snails that is in clinical development for managing severe protracted pain.	Brisbane			UQ
AstraZeneca/Griffith University (AZ/GU) Natural Product Discovery Program of the Eskitis Institute for Cell & Molecular Therapies	Australia's leading bioactive compound screening facility, located in Brisbane. The AZ/GU collaboration has realized around \$100M investment by AstraZeneca over the past ten years. Currently the AZ/Griffith Uni program has approximately 700 bioactive compounds from its library of over 35,000 specimens many of which were sourced in Queensland's tropical region.	Griffith Uni, IMB, Brisbane	2002/03	2007	Griffith Uni, AstraZeneca
BioProspect Ltd	Listed on the Australian Stock Exchange, has leading natural product discovery expertise that has made several important discoveries including the development of a natural insecticide from the leaves of a Eucalyptus species found only in Northern Queensland. The company has recently formalised a partnership with Diversa, an American company, which gives Diversa the right to discover genes from collections of Australian biological material supplied by BioProspect.	Brisbane	1998		Shareholders, Diversa Corp; Centre for Phytochemistry, SCU; Uni of Western Sydney
EcoBiotics Ltd	Discovering and commercialising new pharmaceuticals and agrochemicals from tropical rainforests.	NQ			QIMR, Microbial Screening Technologies

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
Pty Ltd					
Climate studies					
Centre for Disaster Studies JCU	Queensland's only disaster research unit, is a multi disciplinary research group in the School of Tropical Environment Studies and Geography with a focus on the fields of emergency management and meteorology.	JCU Townsville and Cairns campuses	1979		JCU, City Councils, QLD Dept Emergency Services, CRC Tourism, CRC Bushfire
Marine Modelling Unit JCU	Undertakes research and consultancy on modelling tropical cyclone waves in the Great Barrier Reef, mooring design for tourist pontoons in the GBR World Heritage Area, and 3-D modelling of pollutant transport in harbours.	JCU, Townsville			JCU & Australian Maritime College
Cyclone Testing Station JCU	Researching, testing and advising industry and governments on building practices which minimise loss and suffering as a result of severe wind events. The Station delivers quality testing and technical advice to manufacturers, building associations and governments.	JCU, Townsville	1977		JCU
Centre of Excellence in Climate Change and Coastal Ecosystems - part of the Tropical Marine Science Centre of Excellence	A large component of the proposed Centre of Excellence in Climate Change and Coastal Ecosystems research group of the Tropical Marine Science Centre of Excellence will focus on the remote sensing of biological communities to monitor change that is occurring within them.	JCU, UQ, AIMS	2005	Ongoing	JCU, UQ, AIMS
Ecosciences Precinct Boggo Road	Establishment of an Ecosciences Precinct. It will include the formation of a modelling and climate change cluster.	Brisbane	In developm ent – to be complete d in 2009		NRMW, DPI&F, EPA, CSIRO
Climate Change Response Program (GBRMPA)	Climate change vulnerability assessment on the GBR ecosystem, which includes coral bleaching, ecosystem vulnerability and socio-ecological vulnerability studies. This work will lead to the formation of a climate change action plan for the GBR.	GBRMPA	Dec 2004	Dec 2008	GBRMPA and various others
Queensland Centre for Climate Applications DPI&F/NRMW	Is a partnership between DPI&F and NRMW that uses computer modelling to allow the simulation of grassland sustainability, remotely sense grassland and rangeland condition, remotely sense the presence and impact of fire, assess the impact of climate change on rural industries, develop methods to further model the effects of drought policy, assess the utility of seasonal forecasting in the water resource industries and develop enhanced agro-meteorological data systems.	NRMW, DPI&F HQ at Toowoomba, also unit at Indooroopilly			DPI&F, NRMW
Tropical primary industries					
Agriculture/Land Management					
DPI&F Research Facilities/Stations in North Queensland	Projects span issues relating to tropical horticulture, beef, fisheries and broad-acre agriculture.	Includes Southedge, Walkamin,	Ongoing	Ongoing	Qld Gov, primary industries, local communities

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
		Kairi, Mareeba, Oonoonba, South Johnstone, Ayr, Bowen, Rockhampton, Emerald			
Centre for Tropical Agriculture (DPI&F)	To conduct and support a range of research, development and extension activities for field crops industries growing mainly on the Atherton Tablelands, North Queensland. The work is primarily focussed on the peanut, maize, tobacco and sugarcane industries.	Mareeba, Kairi, Southedge, Walkamin, Atherton Tablelands, South Johnstone	Ongoing	Ongoing	Peanut, maize, tobacco and sugarcane industries on the Atherton Tableland
University of Queensland Programs and Initiatives	Control of ripening in papaya and mango by genetic engineering	UQ, NQ	1997	2005	UQ, NQ
	Increased Productivity of Rice-Based Cropping Systems in Lao PDR, Cambodia and Australia	UQ, NQ, Cambodia	2000	2006	UQ, NQ, Cambodia
	Integrated manure nutrient management in soybean/wheat cropping systems on vertisols in Madhya Pradesh and Queensland	UQ, NQ, Asia	2004	2008	UQ, NQ, Asia
	Improving drought resistance in rainfed lowland rice for the Mekong Region - use of new conventional approaches and molecular tools	UQ, NQ, Mekong	2003	2006	UQ, NQ, Mekong
	Mixed species plantations of high-value trees for timber production and enhanced community services in Vietnam and Australia	UQ, NQ, Vietnam	2002	2006	UQ, NQ, Vietnam
	Diagnosis and management of wilt diseases of banana in Indonesia	UQ, NQ, Indonesia	2005	2008	UQ, NQ, Indonesia
Griffith Uni Programs and Initiatives	International Fruit Fly Research Centre - Works to improve food security and nutrition, reduce poverty and facilitate international trade within the Australian-Asian region. Research areas include Fruit fly diagnostics for quarantine and SPS compliance; Environmentally safe field pest management; Quarantine surveillance and fruit fly incursion management; Market access technologies to facilitate international trade; Socio-economic impacts; Fruit fly eradication; Pest risk analyses.	Griffith Uni, Brisbane, Kuala Lumpur	2003	Ongoing	Griffith Uni, Qld Dept of Primary Industries, Government of Malaysia, ASEAN Plant Health Coordination Network
	Centre for Forestry and Horticultural Research - CFHR undertakes research programs in sustainable forestry and horticulture to enhance the economic,	Griffith Uni, Brisbane	2003	Ongoing	Griffith Uni, Qld Depts of Primary Industries

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
	environmental and social benefits of forest and horticultural ecosystems, particularly in tropical and subtropical environments. Research includes Plant Science and Plant Biotechnology with interests in tropical and subtropical species; Plant biotechnology; Selection and clonal propagation of superior genotypes for commercial production; Tropical fruit crops; Virus elimination and virus resistance.				and Natural Resources, Mines and Energy.
QUT Programs and Initiatives	Project on the bio-fortification of Ugandan bananas - to bio-fortify the local Ugandan bananas with beta-carotene and iron to reduce the nutrient deficiencies in these bananas. The scientists will be looking for genes from other varieties of bananas first and trying to put them into Australian Cavendish bananas. Ugandan scientists will then transfer this to local varieties.	QUT	2005		University (Uganda) and QUT
	Queensland Crop Development Facilities – establishment by QUT of secure glasshouse facilities and growing rooms in Brisbane and Ormiston that will support the development of future tropical and subtropical crops through biotechnology, especially to accelerate advances in new plant bio-industries such as molecular pharming and DNA-based plant breeding.	Ormiston and QUT Gardens Point campus in Brisbane			QUT, DSDTI, DPI&F
The Centre for Tropical Agri-Tech Research (CTAR) at JCU's School of Tropical Biology	CTAR provides the key link between research, economic expertise and agri- and bio-industries. The following research units report to CTAR: <ol style="list-style-type: none"> 1. Regional Bio-industries Unit (RBU) 2. Rapid Assessment Unit (RAU) 3. Agro-forestry and Novel Crops Unit 4. Molecular Farming Unit 	JCU Cairns campus			JCU, CSIRO, DPI&F, EPA, industry and various others
	The <i>Regional Bio-industries Unit</i> (RBU) provides opportunities for R&D collaboration and commercialisation. Research and industry is linked through BioNQ , an industry cluster, focussed on sustaining investment and innovation outcomes. Bio-industry development is a powerful catalyst for tropical agricultural diversification and is also synergistic with other industries by promoting environmental sustainability and growth in IT, environmental management, tourism and education industries.	JCU Cairns campus			JCU, CSIRO, Qld Gov, Cth Gov, Cairns Regional Economic Development Corporation
	The <i>Rapid Assessment Unit</i> (RAU), established in conjunction with DPI&F, undertakes research in rapid non-invasive assessment of food safety and quality. The commercialisation of these technologies is pursued with a focus on near infra-red technology and emerging technologies such as Nuclear Magnetic Resonance, microwave, bioelectrical impedance, biosensors and acoustic techniques.	JCU Cairns campus			JCU, DPI&F, horticultural industries
	The <i>Agro-forestry and Novel Crops Unit</i> undertakes research into tropical tree domestication and the development of novel crops, agro-forestry, agro-ecosystem function and the development of sustainable and profitable land use systems, processing and commercialisation of agro-forestry tree products, and clonal approaches to tree improvement and production.	JCU Cairns campus			JCU

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
	The <i>Molecular Farming Unit</i> develops research opportunities in a field where the practice of using plants to produce non-food/fibre commodities has already extended to product development of human and veterinary therapeutic proteins, vaccines, diagnostic proteins, industrial proteins and other industrial products.	JCU Cairns campus			JCU, QUT, DPI&F, Southern Cross Uni, Australian Plant DNA Bank
Queensland Crop Development Facilities – DPI&F and QUT	To construct the first module of a secure (PC2) glasshouse facility at the DPI&F research station at Ormiston at Redland Bay. Re-furbish and expand secure (PC2) in vitro growth facilities adjacent to the molecular biology laboratories in QUT's Life Sciences Building.	Ormiston at Redland Bay, QUT Gardens Point			DPI&F, QUT and DSDTI
Centre for Native Floriculture	To help create an internationally competitive and environmentally sustainable native floriculture industry that provides significant employment opportunities in Queensland.	UQ, NQ	2003	2006	UQ, DSDTI, DPI&F and floriculture industry
MOU between JCU and DPI&F	A broad ranging collaboration across a range of fields linked to JCU's and DPI&F's facilities and programs in tropical Queensland.	JCU	2004		JCU/DPI&F by MoU
Construction of a Veterinary Science School at JCU, Townsville (proposed)	The veterinary science school to be established in the facility will have a unique focus on tropical animal husbandry and diseases and zoonoses - tropical diseases, the development of new diseases to humans and livestock and the economic importance of Australia's livestock industry.	JCU Townsville, Cairns	2006	2008	JCU and the Cth Gov
Economic Geology Research Unit (EGRU) - JCU	Facilitate knowledge transfer in the field of economic geology between public sector researchers, industry professionals and companies.	JCU Townsville campus	1982		JCU and longstanding network of industry members in Australia
Undergraduate courses in Bachelor of Tropical Agricultural Science and Bachelor of Biotechnology - JCU	These JCU courses are the only Australian agricultural science and biotechnology courses based in the tropics. The programs focus on the diversity and productivity of the tropical environment and the science and practice involved in sustaining and enhancing the productivity of these complex systems, while preserving environmental integrity.	JCU Townsville Campus	2006		JCU, Cth Gov
BSES Limited	The principal provider of research, development and extension to the Australian sugar industry and has seven Sugar Experiment Stations, five of which are located in tropical Queensland namely Meringa, Tully, Ingham (Herbert), Brandon (Burdekin), and Mackay (Central). Major laboratories are located in Brisbane.	Meringa, Tully, Ingham (Herbert), Brandon (Burdekin), Mackay (Central)	Ongoing		Qld sugar industry
CRC for Sugar Industry Innovation through Biotechnology (CRC SIIB)	Three main programs of work (1) Increased and environmentally sustainable sugarcane productivity, (2) Developing the sugarcane biofactory for high-value biomaterials, and (3) Education.	Headquartered at UQ, node in Townsville	2003	2010	UQ, Southern Cross Uni, CSIRO and various others
Australian Invasive Animal CRC (Invasive Animals CRC)	To counteract the impact of invasive animals through the development and application of new technologies and by integrating approaches across agencies and jurisdictions. Replaced the Pest Animal Control CRC in July 2005.	Headquartered in Canberra	2005	2012	ANU, UQ, NRMW, DPI&F, CSIRO and various others
CRC for Tropical Savannas Management	Ensure the tropical savanna of Australia is healthy and managed to provide long - term benefits (economic, aesthetic, social and cultural) to those who use them and to	Headquartered at CDU, nodes	2001	2008	CDU, JCU, UQ, CSIRO, DPI&F and

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
(Tropical Savannas CRC)	sustain the biodiversity and habitat endemic to them.	in Cairns, Charters Towers and Townsville			various others
CRC for Australian Weed Management (Weeds CRC)	To reduce the risks facing the environment, agriculture and rural sectors across all of Australia from current weeds and an increasing number of weed incursions from overseas.	Headquartered at NRMW	2001	2008	NRMW, CSIRO, Uni of Adelaide and various others.
CRC for Tropical Plant Protection	Reducing losses caused by diseases and pests in Northern Australia through the discovery, development and delivery of innovative technologies, based on world-class research and education programs.	Headquartered at UQ, node in Townsville	1999	2006	UQ, DPI&F, CDU, ANU, RhoBio, Bureau of Sugar Experiment Stations and various others.
CSIRO Sustainable Ecosystems	Production Systems: Sustainable agricultural systems. Resilient agri-industry supply chains. Globally adaptive rural enterprises. Sustainable urbanisation.	Staff based in Mossman, Townsville, Ayr, Toowoomba, Brisbane	Ongoing	Ongoing	Qld sugar industry & other agri-industries, Cth Gov, Local Gov, Regional NRM Boards
Primary Industries Research Centre - CQU	Covers research interests which include agricultural (horticulture, broad acre, grazing, beef), extractive (coal, magnesite) and processing (alumina smelting, bulk materials handling) industries.	CQU Rockhampton			DPI&F, CSIRO, Cth Gov
Centre of Excellence for Risk Analysis – Commonwealth Government	To build on and strengthen the integrity of Australia's import risk analysis process. The Centre will conduct research and develop state-of-the-art risk analysis methods for use by the Australian Government. The initial focus of the Centre will be on tools for the agricultural industry. It is envisaged that the Centre will be a small operation established in an existing independent research organisation.	Yet to be determined	2005	2009	Cth Gov
Agricultural Production Systems Research Unit (APSRU)	APSRU is an unincorporated joint venture between the State of Queensland (DPI&F and NRMW), CSIRO, and UQ. Its mission is to benefit rural industries and the environment through innovative systems approaches to research and development. There are five key result areas at which APSRU's farming systems R&D project activities are targeted, including: <ol style="list-style-type: none"> 1. Sustainable Agricultural Systems 2. Sustainable Catchments and Landscapes 3. Improved Crop Design 4. Modelling Tools and Methods 5. Communication and Collaboration. 	DPI&F, NRMW, CSIRO, UQ Toowoomba	2005	2010	Rural industries
Animal industries					
JM Rendel Laboratory CSIRO Division of Livestock	Research into livestock production in northern Australia.	CSIRO Rockhampton	1981		CSIRO Beef industry

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
Industries'					
Aquaculture					
Australian Institute of Marine Science (AIMS)	To develop the technology to establish a new aquaculture industry based around one of Australia's most valuable wild fishery exports, the tropical rock lobster. To understand the process required to rear black tiger prawn broodstock in captivity on a commercial scale.	Cape Ferguson, 50 km from Townsville			Industry partners in the prawn and seafood industry, DPI&F and CSIRO
CRC for Sustainable Aquaculture and Finfish	Critical technologies for rapid and sustainable growth of finfish aquaculture in Australia.	Headquartered at South Australian R&D Institute, nodes in Brisbane and Townsville	2001	2008	South Australian R&D Institute, DPI&F, CSIRO, JCU, UQ and various others
Mining					
CRC for Predictive Mineral Discovery	Four main work programs: 1) Understanding the processes controlling the formation of superior ore deposits, 2) Developing techniques and tools to directly date ore systems and specific events in their evolution, 3) Understand the role of fluids in the formation of ore deposits, 4) Developing a modelling platform to simulate and visualise earth processes and target giant ore systems.	Headquartered at the Uni of Melbourne, node at JCU Townsville	2001	2008	Uni of Melbourne, JCU, CSIRO, Aust Mineral Industries Research Assoc and various others.
Tropical living and design					
QLD Dept Public Works (Built Environment Research Unit)	Targets sustainability in the built environment, particularly that in tropical and subtropical climate zones. Outcomes of this work include reduced greenhouse gas emissions, reductions in damage due to severe storms and other weather conditions, improved resistance to termites, and the conservation of energy and water.	State-wide			Qld Gov
Institute for Sustainable Regional Development (ISR D) CQU	To provide new options for the creation of a sustainable regional Australia through innovative research and teaching programs and strong community engagement. Formed following widespread acknowledgment that integrated, multi- and inter-disciplinary efforts provide the most effective means of bringing about desirable environmental and socio-economic change in regional Australia.	CQU Rockhampton	1997	Ongoing	CQU, Qld Gov
Centre for Excellence in Tropical Design (CETD) Townsville	A virtual Centre founded on an alliance between State and Local Government and centres of learning in the Townsville region to support sustainable tropical construction and community building. The aim of the CETD is to position North Queensland at the forefront of design and promotion of 'sustainability and innovation' in tropical environments and to expand knowledge relating to the products, principles and practices important to successful, sustainable design for the tropical climate. The CETD involves the development and sharing of information and expertise to achieve sustainable design and living in the tropics. Its roles include:	NQ, Townsville	2004	Ongoing	Qld Gov, local councils, universities, CSIRO and various industry

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
	<ul style="list-style-type: none"> • collaborating on practical solutions to issues of sustainability • applying innovative techniques across industry and community • encouraging application of innovative design strategies • supporting knowledge transfer between organisations. 				
Centre for Subtropical Design QUT/Brisbane City Council	A partnership between the Brisbane City Council and QUT that aims to stimulate design solutions which strengthen the subtropical identity of Brisbane City and surrounds. The Centre researches and promotes high quality planning, design and development in the built environment to respond to Brisbane and South East Queensland region's cultural, landscape and climatic characteristics.	Brisbane City Council, QUT Gardens Point Campus	2005		Brisbane City Council, QUT
Cyclone Testing Station JCU	Researching, testing and advising industry and governments on building practices which minimise loss and suffering as a result of severe wind events. The Station delivers quality testing and technical advice to manufacturers, building associations and governments.	JCU Townsville	1977		JCU
Centre for Disaster Studies JCU	Queensland's only disaster research unit, is a multi disciplinary research group in the School of Tropical Environment Studies and Geography with a focus on the fields of emergency management, meteorology, disaster integrated landuse planning, understanding communities and fire, natural hazards, dam break, vulnerability indicators, disaster medicine, natural hazard mitigation, awareness and preparedness, cyclones and floods, GIS applications, community vulnerability and resilience, women and disasters, tourism and disasters, natural hazard education and impact on Indigenous and remote communities.	JCU Townsville and Cairns campuses	1979		JCU, City Councils, QLD Dept Emergency Services, CRC Tourism, CRC Bushfire
Urban Research Program Griffith University	URP focuses on strategically important research issues: governance, infrastructure, ecology, economy and health, to support the development and implementation of local, regional, state and national policies that will improve the efficiency, sustainability and liveability of Australian cities including in tropical regions. It engages community, government, institutions, and policy makers in collaboration with university researchers and resources.	Griffith Uni Brisbane	2003	Ongoing	Griffith Uni, Qld Transport, Brisbane, Gold Coast and other Qld City Councils
Griffith Schools of Environmental Studies, Environmental Planning and Environmental Engineering	Comprehensive interdisciplinary teaching and research aimed at maximising social and economic benefit in context of sustainable use of natural resources and maintenance of biodiversity.	Griffith Uni, Brisbane, Gold Coast			
Griffith Centre for Coastal Management	Enhancing the sustainability of coastal regions through targeted research leading to improved coastal management outcomes. Research areas include: coastlines, water futures, urban catchments & waterways, infrastructure and technology.	Griffith Uni, Gold Coast	2003	Ongoing	Griffith Uni, Gold Coast City Council
CRC for Railway Engineering and Technologies	To develop world-standard railway systems.	Headquartered at CQU Rockhampton	2001	2008	CQU, UQ, QUT, Qld Rail, and various others.
People, Identity and Place JCU	Trans-disciplinary research grouping within JCU, bringing together researchers in the humanities, arts and social sciences, to address the educational, economic and social needs of tropical Queensland.	JCU Cairns and Townsville			Growing network of national and international collaborations.

Capacity or capability	Objectives/Proposed Outcomes	Led by/ location	Start Date	Finish Date	Stakeholders
JCU Departments and Schools	Areas include: School of Anthropology, Archaeology and Sociology and the School of Social Work and Community Welfare.	JCU Townsville, Cairns	2000		JCU and other national and international collaborators
Centre for Native Title Research	Strong focus on research and practical engagement with communities.	JCU Cairns	2002		JCU, State of Queensland, National Native Title Tribunal, Indigenous community
General					
JCU Departments and Schools	Areas include: High Performance Computing, School of Engineering, School of Information Technology, School of Mathematical and Physical Sciences and the School of Business, School of Earth Sciences, School of Medicine, School of Pharmacy and Molecular Sciences, School of Marine Biology and Aquaculture, School of Tropical Biology, School of Tropical Environmental Studies and Geography, and the School of Veterinary and Biomedical Sciences.	JCU Townsville, Cairns			JCU and other national and international collaborators
UQ Departments and Schools	A wide range of courses at UQ, ranging from Veterinary Science, tropical health and disease, rural and regional communities including Indigenous communities, tropical plant and livestock production, plant and animal diseases, tropical biosecurity, environmental management including tropical marine environments, and tropical soils and landscapes.	UQ			UQ and other national and international collaborators
i-Tropics	Linked to i-Lab in Brisbane, it will support up to four companies on site and provide others with virtual incubator services.				State & local Gov, CREDC, Atherton Sustainable regions, Cairns Chamber of Commerce, JCU
Advanced Analytical Centre	Provides instrumental analysis to the university and analytical and consulting services to external customers. Houses a comprehensive equipment base including X-ray diffractometers, X-ray fluorescence spectrometers, electron microscopes, an electron microprobe, confocal microscope and, genetic analysis equipment.	JCU Townsville, Cairns	1995/96		Industry

Appendix 2. Detailed SWOT analysis

SWOT analysis for each discipline in Queensland

Strengths	Weaknesses	Opportunities	Threats
General			
<ul style="list-style-type: none"> Substantial R&D capacity in the tropics across a wide range of fields, particularly in environmental science and management Significant facilities and skills located in North Queensland, such as James Cook University, DPI&F Research Stations, AIMS, CSIRO Two centuries of tropical know-how applying and modifying western science Millennia of Indigenous knowledge A developed and politically stable economy Financial, regulatory and legal environment that supports research excellence (e.g. Biodiscovery Act 2004; Code of Ethical Practice for Biotechnology in Queensland; Co-existence Framework 2005) Significant population living in the tropics Diverse ethnic mixture in our educational institutions Access to tropical markets via international airports located in North Queensland A willingness to explore options, as evidenced by joint forums in tropical knowledge held in Cairns and Townsville in 2005 	<ul style="list-style-type: none"> Fragmented research facilities and a limited critical mass of researchers making it difficult to attract staff Lack of funding, partly due to a poorly developed investment pipeline Limited coordination of tropical initiatives Skills shortage in applied sciences, such as taxonomic capacity, that impedes the delivery of required services⁴⁶ Limited international profile/recognition Widespread poverty in the tropical world limits the immediate market potential of knowledge-based products Potential logistical and application difficulties from exporting practices from a high-technology country to a low-technology country Centralised decision making and a need for greater decision making power to the regions Fractured social structure leads to problems when confronted with change (e.g. between urban and rural communities, Indigenous and non-Indigenous populations) Some duplication of activities/resources in the State that could be used more efficiently A need for regional centres to focus on collaboration to maximise opportunities Lack of pure, undirected R&D 	<ul style="list-style-type: none"> The close proximity of Queensland to: <ul style="list-style-type: none"> tropical nations the most populous nations on Earth (China, Indonesia and India) Queensland's mega-biodiverse ecosystems to develop industries/initiatives/ventures based on: <ul style="list-style-type: none"> bioprospecting developing exportable environmental practices other commercial ventures Rationalising and clustering to provide increasing opportunities through critical mass in R&D Increasing philanthropic funding directed towards tropical nations Increasing demand for goods and services in tropical nations through growing populations and higher living standards. This demand also makes tropical nations more vulnerable to climate change and to extreme weather events Exporting services in tropical knowledge Massive growth in the urban population of tropical countries will have cultural ramifications and present opportunities Increased focus in developing nations on environmental sustainability A focus on education and training are common to all opportunities 	<ul style="list-style-type: none"> A lack of management of population growth in tropical nations is compromising the environment A number of other locations have excellent capacity in tropical research, although many are not located in the tropics Development of a strategic and coordinated tropical science capacity in other regions of the world

Strengths	Weaknesses	Opportunities	Threats
		<ul style="list-style-type: none"> • Opportunities through increased on-line learning • More opportunities for universities to interact directly with small to medium enterprises are needed • Burgeoning tourism as a strong determinant in Queensland's economic growth 	
Tropical health and well-being			
<ul style="list-style-type: none"> • Strong track record of excellence in health research in Queensland • Mega-biodiverse environment provides substantial opportunities for biodiscovery • Strong Indigenous knowledge of the medicinal properties of Australian flora 	<ul style="list-style-type: none"> • The poor health and education records of Aboriginal and Torres Strait Islanders (ATSI) compared with non-ATSI Australians • Lack of vision, parochialism, fragmentation 	<ul style="list-style-type: none"> • Integrated education environment for tropical nations – combining land management know-how etc with health and education • Developing exportable expertise in two major emerging areas in health: emerging infectious diseases and chronic lifestyle diseases • Developing middle class in tropical nations have an increase capacity to purchase goods and services • Low investment in drugs for use in developing countries • Opportunities at the interface of human health and medicine with veterinary science • Biosecurity and surveillance technologies are a major emerging issue and opportunity • Integrating fragmented health network – develop virtual health networks? • Public health services are in the north, diagnostic capacity is in the south 	<ul style="list-style-type: none"> • Emerging infectious diseases • Spread of infectious diseases through increased travel and climate change • Torres Strait is the portal of entry into Queensland • Increasing rates of chronic lifestyle diseases, especially among Indigenous communities • Whereas Queensland has strengths in tropical medicine, research doesn't have to occur in the tropics • Failure to protect the tourism/travel revenue in Queensland from imported emerging disease
Tropical environmental and cultural assets			
<ul style="list-style-type: none"> • Environment and biodiversity <ul style="list-style-type: none"> ◦ Mega-biodiverse ecosystems ◦ More than 13% of the world's coral reefs ◦ More tropical climate types than any other nation (all of which can be found 	<ul style="list-style-type: none"> • Land management standards are fragmented • Need to better market our current capabilities • Poor environmental management in 	<ul style="list-style-type: none"> • Expanding opportunities in tourism in tropical Queensland (e.g. ecotourism) <ul style="list-style-type: none"> ◦ There is a need to know how to make a place special without making it like something else overseas (tourism research etc) 	<ul style="list-style-type: none"> • Emerging environmental pressures (e.g. feral animals, the development of water resources) • Developing the water resources of Northern Australia without creating the

Strengths	Weaknesses	Opportunities	Threats
<p>in Queensland)</p> <ul style="list-style-type: none"> • Great Barrier Reef and Wet Tropics World Heritage Areas <ul style="list-style-type: none"> ○ Major strengths in resource management • Substantial research infrastructure present working on Queensland's environment • Strict quarantine practices 	<p>some sectors</p> <ul style="list-style-type: none"> • The non-involvement of the Indigenous community in land management • A brain drain of environmental researchers overseas and to new technologies • Skills shortage in applied sciences, such as taxonomic capacity, that impedes the delivery of required services⁴⁶ 	<ul style="list-style-type: none"> ○ Potential to export knowledge products to developing tropical nations wanting to expand their tourism industry • Sustainable use of tropical rivers and groundwater systems that contain roughly 70% of Australia's fresh water resources <ul style="list-style-type: none"> ○ Demands and pressures on water resources are a major driver in Australia and also for tropical neighbours • Techniques for the conservation of biodiversity – growing in importance overseas • Education of water scientists – currently mostly done by UNESCO – by the Dutch Government • The development of partnerships with Indigenous people <ul style="list-style-type: none"> ○ Combine western science with Indigenous knowledge (major opportunities include biodiscovery and land management) ○ Opportunities for tourism, cultural sites, commercialising bush tucker, Indigenous food • Education of water scientists – currently mostly done by UNESCO – by the Dutch Government • Trading around carbon dioxide, water etc. • Increasing need for environmental services from developing tropical nations • Building export industry in environmental research (marine and terrestrial) No serious competitors, but need to better market our capabilities and increase communication between scientists 	<p>problems of Southern Australia</p> <ul style="list-style-type: none"> • Inappropriate development, lack of adequate infrastructure and loss of unique image • High demand for coastal settlement, leading to coastal urbanisation
Climate change			
<ul style="list-style-type: none"> • More tropical climate types in Queensland than anywhere else in the 	<ul style="list-style-type: none"> • Queensland has relatively high emissions of carbon dioxide on a per capita basis 	<ul style="list-style-type: none"> • Using tropical Australian weather and climate research to provide valuable 	<ul style="list-style-type: none"> • Climate change will have a big impact on

Strengths	Weaknesses	Opportunities	Threats
<ul style="list-style-type: none"> world One of the most variable climates in the world 	<ul style="list-style-type: none"> Climate change will have differential effects on the economies of North Queensland 	<p>information for:</p> <ul style="list-style-type: none"> Investment and management decisions Improved accuracy in extreme weather event warnings – leading to economic savings Improved infrastructure and engineering design <ul style="list-style-type: none"> Major opportunities in: <ul style="list-style-type: none"> Risk Management Using a changing climate to our advantage (new crop strains etc) Heightened awareness of climate change due to links made to recent hurricane disasters in the United States 	<p>energy intensive industries</p>
<p>Tropical primary industries</p>			
<ul style="list-style-type: none"> Historically, Queensland’s economy has been built on primary industries, and these industries have remained a focal point for research Rehabilitation and reclamation techniques have been developed by the mining industry Strict quarantine practices Expertise and track record in biosecurity No moratorium on genetically-modified food crops The capacity of Queensland in tropical sciences, including a network of DPI&F research facilities at key centres throughout North Queensland Excellent capacity in tropical aquaculture through the DPI&F, CSIRO, JCU, and the AIMS Tropical Aquaculture Team Core of expertise in management of tropical soils through soil chemists, physicists and microbiologists based in NRMW, DPI&F, CSIRO, BSES Ltd, UQ, and JCU 	<ul style="list-style-type: none"> Local environmental problems stemming from the rapid intrusion into the tropics of temperate zone agricultural and mining technologies Poor history of developing and commercialising research outputs in primary industries 	<ul style="list-style-type: none"> Aquaculture is a major growing industry Developing ‘new’ tropical industries, such as molecular pharming, biofuel, bioplastics, functional foods using tropical crops/organisms as biofactories Consumers desire for better health, improved quality of life, the use of more natural products, and concerns about the sustainability of non-renewable resources⁴⁹ Increased use of knowledge-based products to transform Queensland’s primary industries, such as agriculture, aquaculture, forestry, and mining Increasing demand for biofuels worldwide Increased biomass as a consequence of climate change 	<ul style="list-style-type: none"> Tropical Queensland is prone to climate extremes. Effects due to climate change could affect the viability of industries operating under more marginal conditions. Tropical nations are much poorer than Australia, and possibly have less stringent trade barriers than our own. Therefore, Queensland may have trouble competing for non-knowledge based bulk commodity exports

Strengths	Weaknesses	Opportunities	Threats
Tropical living			
<ul style="list-style-type: none"> • Extensive planning, urban design, architectural, engineering and environmental design abilities in Queensland relevant to the subtropics and tropics • Generally high respect for Australian, including Queensland, consultants based upon integrity and long-term commitment, contrasting with often poor trust in some other countries' consultants • Strong relevance of our cities to many Asian, including tropical and subtropical, cities in confronting similar issues and needs • The Australian tropical built environment market exhibits a value of \$1.8 billion per annum (residential \$1.2 billion, 3% of Australia) and has potential for improvements in cost and performance 	<ul style="list-style-type: none"> • Tropical and non-metropolitan Queensland research facilities are geographically isolated and have limited critical mass and momentum as regards to built environment research⁷⁶ • Scant coordinated effort between disciplines to offer integrated processes of planning and urban renewal – no collective strategies • Little awareness by the urban and environmental consultancy disciplines of scientific research and knowledge in Queensland, and vice versa • Lack of critical mass - research expertise in tropical living previously based at the former JCU UNESCO-funded Institute for Tropical Architecture has not been replaced⁷⁶ • The Australian tropical built environment market is relatively small (approximately 7% of the Australian market in terms of both size and value). Even if the Australian tropical residential market were more aware of best practice, innovations and existing new built environment technologies, demand appears to be highly price-inelastic, resulting in a price barrier to implementation⁷⁶ • Lack of Government support compared with other countries to assist consultants to win work overseas • Some stigma related to previous political and social trends • Concerns over health and welfare of indigenous communities • Overseas impression of our own city planning/design is deteriorating especially with respect to poor public transport innovation, our increase in 	<ul style="list-style-type: none"> • Very high urbanisation rates and increasing city densities overseas provide a strong market potential for Queensland consultancies in urban planning and engineering, architecture and environmental planning • Ability to utilise our strong reputation in certain fields of expertise to introduce other areas of expertise into overseas markets • Coordination of disciplines, and between Government and private sector, could significantly increase demand for services in areas of expertise already highly regarded overseas • Potential to market Queensland as a world centre of tropical/subtropical design across a wide range of interconnected disciplines – science, health, planning, urban renewal, building design, and environmental design • No country in the world is coordinating scientific knowledge directly with planning and design to improve the living environment of tropical/subtropical cities. No country is translating knowledge into solutions and outcomes for cities. A 'centre' such as the 'Global Centre of Tropical Development' could be the fulcrum for such an endeavour • There is also an opportunity to benefit from Queensland's expertise in responding to issues such as climate change, coastal environmental degradation, post-conflict urban renewal, or energy crises 	<ul style="list-style-type: none"> • Overseas Governments strongly back their private sector consultants to win work in Asia • There is a need to 'sieve' down to particular niche markets of which we can realistically tap with our expertise, rather than to take on the world with broad targets

Strengths	Weaknesses	Opportunities	Threats
	conventional car infrastructure (such as tunnels) <ul style="list-style-type: none"> Lack of a coordinated knowledge industry structure when compared with, for example, Singapore 		
Education			
<ul style="list-style-type: none"> Queensland educational institutions are internationally recognised to be of a very high quality in niche areas People with skills and expertise in tropical science disciplines Strong record of attracting international tertiary students to tropical Queensland universities 	<ul style="list-style-type: none"> Large geographical distance between centres of learning in NQ Ability of developing nations to pay for services Relatively lower educational standards in some Aboriginal and Torres Strait Islander communities than in the general population Difficulty in accessing the market for primary school education 	<ul style="list-style-type: none"> Developing better links with international funding organisations Developing services for the major market of primary school education in developing countries Providing an integrated education environment for tropical nations – combining land management know-how etc with health and education Developing education pathways to industry for the various educational sectors, including secondary, tertiary and TAFE. For example, special courses in Years 11 and 12 that link to TAFE and tertiary courses Developing middle class in tropical nations have an increasing capacity to purchase goods and services, and an increasing demand for an education. Integration of much of our research efforts in other areas provides an opportunity to build a one-stop-shop for training in all tropical areas Combining/overlapping tourism and education opportunities, other than English courses 	<ul style="list-style-type: none"> Universities in Asian nations are developing strongly, and it appears that they are increasingly staying at home. However, strict visa requirements for students to enter the US have increased the number of students coming to Australia Education relevant to the tropics doesn't have to occur in tropical regions. However, in specific areas such as environmental science, it is beneficial Speed with which education systems are established in developing countries such as China and India that can provide and export education services in competition with tropical Queensland