Options for Understanding Regional Dynamics in Northern Australia

Tropical Savannas CRC
Regional Modelling Scoping Study
Project Final Report

July 2003

Mark Stafford Smith¹, Daniel Walker ², Yiheyis Marui, Natalie Stoeckl ², Alexander Herr ³, Joseph Breen and Romy Greiner ²

1. CSIRO Sustainable Ecosystems, Centre for Arid Zone Research
2. CSIRO Sustainable Ecosystems

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We are grateful to the workshop participants:

**Project team (CSIRO):**

- Mark Stafford Smith
- Daniel Walker
- Romy Greiner
- Natalie Stoeckl
- Yiheyis Maru
- Joe Breen

**Present throughout:**

- John Holmes (UQ)
- Roy Powell (Private)
- Ben Smith (CAEPR, ANU)
- Ryan McAllister (UQ/CSIRO)
- Andrew Ash (CSIRO)
- Franzi Poldy (CSIRO)

**Available Thursday only:**

- Martin Bell (am only) (UQ)
- Gerard Byrne (all day) (QDPI)
- Martin Bell (am only) (UQ)
- Gerard Byrne (all day) (QDPI)
- John Holmes (UQ)
- Roy Powell (Private)
- Ben Smith (CAEPR, ANU)
- Ryan McAllister (UQ/CSIRO)
- Andrew Ash (CSIRO)
- Franzi Poldy (CSIRO)

**Contributing author information**

- **Mark Stafford Smith**
  - CSIRO Sustainable Ecosystems, Centre for Arid Zone Research,
  - Heath Road, PO Box 2111, Alice Springs, NT 0871, Australia.
  - Tel: (08) 8950 7100 Fax: (08) 8950 7187
  - Email: mark.staffordsmith@csiro.au

- **Daniel Walker**
  - Davies Laboratory, University Drive, Douglas, Townsville
  - Tel: (07) 4753 8580 Fax: (07) 4753 8650
  - Email: Daniel.Walker@csiro.au

- **Romy Greiner**
  - Private Mail Bag PO Aitkenvale QLD 4814
  - Tel: (07) 4753 8580 Fax: (07) 4753 8650
  - Email: Romy.Greiner@csiro.au

- **Natalie Stoeckl**
  - James Cook University
  - School of Business, Economics Program
  - Tel: (07) 4781 4868 Fax: (07) 4781 4019
  - Email: natalie.stoeckl@jcu.edu.au

The Cooperative Research Centre for Tropical Savannas Management is focused on the sustainable use and conservation of Australia’s tropical savannas, the landscapes that dominate the north of the continent.

For more information: Tropical Savannas CRC

Charles Darwin University Darwin NT 0909
Tel: (08) 8946 6834 Fax: (08) 8946 7107
Email: <savanna@cedu.edu.au> Web: <http://savanna.cdu.edu.au>

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Summary
This report is the outcome of a Regional Dynamics Scoping Study project carried out for the Tropical Savannas CRC in 2002–03. The project encompassed a substantial literature survey, a workshop of experts with knowledge of the north, several different exploratory model developments, and a collation of basic profiling data for savannas.

This project explored the justification for investigating savanna regions as dynamics systems. It considered the characteristics of savanna regions that make them different behaviourally from more densely settled regions and the implications of these differences for applying methods to exploring regional dynamics in northern Australia.

The report explores the tension between ‘productivist’ and post productivist views of savanna regions and explores the structural issues that lie at this interface, including:
- intrinsic biophysical and socio-economic structural constraints
- extrinsic forces at work which limit options
- tendencies towards agglomeration and
- political trends towards de-centralisation and local empowerment.

On the basis of these considerations, we explore approaches to modelling and analysis of regional dynamics. The research suggested that any such approach needs to deal with:
- population dynamics in lightly populated regions
- multiple values (for example, using the five capitals of the sustainable rural livelihoods approach to encompass the diversity of non-market values regarded as important in savanna regions)
- the diversity of actors or sectors within savanna communities
- the ways in which different actors affect the different capitals
- The effects of agglomerating influences of globalisation in financial, social and institutional terms.

We concluded that key socio-economic health indicators that integrate these considerations are needed for savanna regions are needed.

Explorations into several of these areas are reported here. On the basis of these explorations (based on literature review, workshop discussion and trial model development) we propose an integrated research framework, which will not answer all questions but seeks to target those critical elements of the understanding needed to deal with issues that are unlikely to be dealt with by researchers working outside the remotest regions of Australia.

The framework encompasses:
- establishing some basic datasets and community-based priorities
- focusing research on key areas of enabling knowledge, the need for which emerges from the discussion summarised above and
- developing a suite of tools with greater predictive or explanatory power for planning effective investment in remote regions.
1. Introduction and project formulation

Mark Stafford Smith and Daniel Walker

This report is the principal product of a scoping study into the possible approaches and value of developing the ability to model regional dynamics in savanna regions, carried out for the Tropical Savannas Cooperative Research Centre (TS–CRC) during October 2002 – June 2003. The remaining products are in electronic form, available on CD, and constitute the application of the some of the framework ideas proposed in this report to a preliminary profile of socio-economic health across savanna regions.

1.1 Project background

The Australian policy environment is changing as federal and state governments devolve responsibilities to regional communities for the management and administration of regional issues, specifically natural resource and development matters. Knowledge and understanding of regional systems are fundamental requirements for effective decision making for ecologically sustainable regional development by regional communities.

 Communities in Australia’s tropical savannas are ‘under siege’ from a variety of processes and circumstances, some of which are generic issues in regional Australia, but many of which are restricted to sparsely populated rangeland areas. For example, throughout the savannas, primary industries have traditionally provided the major source of regional income and employment, but increasingly there is an explicit ‘uncoupling’ of grazing, agriculture and mining from regional economies such that communities have become more dependent on welfare payments.

However, the existing infrastructure for understanding regional dynamics is predominantly Canberra-based and has relatively limited investment in the specifics of savanna regions. In order to maximise the Tropical Savannas CRC’s contributions in regional planning and management, a core capacity in regional analysis and modelling that encompasses economic, social, natural resource and institutional dimensions was proposed. One of the aims of the TS–CRC’s research theme, Regional Planning and Management¹, is therefore to develop a sustained capacity in state-of-the-art regional-scale systems analysis to support communities and decision makers in implementing ecologically sustainable regional development in the savannas. None of the partners to the CRC currently have this capacity. Nor does it exist elsewhere in a form tailored to the needs of remote Australia. However, some of the partners to the CRC would be core contributors to development. Furthermore, there is an opportunity for strategic alliance in such investment with other R&D providers, such as the developing Desert Knowledge CRC.

This scoping project sought to reflect the approaches that could be taken to a systems analysis of savanna regions which goes beyond traditional sectoral models, whether economic input-output models, resource-driven limits models or demography driven paradigms, to a genuinely integrated systems view. A few other modellers have taken this approach (e.g. IMAGE model, Leemans et al), but none have emphasised the special features of rangelands regions, nor have they incorporated more than a superficial treatment of social capital.

The expectation is that in the longer term the TS–CRC would need a strategic investment in a research consortium to develop and apply appropriate modelling infrastructure and approaches and to develop the partnerships with decision-makers to ensure relevance to regional planning policy, practice and implementation. This one-year scoping study is thus intended to lay the groundwork for such a longer-term investment. The project contributes to the TS–CRC objectives ‘Viable and socially desirable regions’ and ‘productive and capable people’².

1.2 Project process and implementation

In order to reflect on approaches to regional modelling that may be most appropriate for lightly populated regions, the project established a small coordinating team with systems analysis skills. This team met once in person to refine the scope and focus of core issues in the project, and from this created a series of general conceptual models of the system being debated. The team then assembled some literature (extended in Section 5) and ideas for a second larger workshop (see Appendix A: Project workshop, Toowong, November 2002).

¹ The TS–CRC has four research themes, see <http://savanna.cdu.ntu.edu.au/research/themes.html>
² For more information on TS–CRC objectives and key result areas, see <http://savanna.cdu.edu.au/research/key_result_areas_s.html>
In this second workshop 14 experts were assembled for two days, bringing a diversity of sectoral and disciplinary expertise to bear for a systems workshop. This crucial workshop resulted in a series of issues which form the basis for this report (Section 3). It also identified a number of areas that could be and were further explored in the timeframe of the project (Sections 4 and 5). These efforts provided a framework to prioritise research, monitoring and capacity building needs in regions of different types. The final step of the project was to document these findings and discuss (i) whether the approach is worth pursuing; if so, (ii) what types of partners and who are needed for the pursuit, and (iii) what research is next most critically needed in terms of the most sensitive parts of the models. These issues are discussed (after a summary of the rest of the reasoning) in Section 6 of this report, which is designed to be able to stand on its own if so required. An ancillary product is a preliminary database of savanna regional profiles.

The intended project outcomes were:

i. Informed investment by the TS–CRC in the development of integrated, multi-agency modelling and analysis infrastructure clearly based on client needs

ii. Investment in TS–CRC regional case studies informed by a preliminary analysis of the social, economic and environmental status and trajectories of all the regions in the savannas.

iii. As a result of i) and ii), build up regional development and policy choices regarding resource use in the savannas based on best available information and knowledge.

The project outputs from which these outcomes should eventually emerge were:

i. A report profiling the savanna regions in terms of their economic, social and natural resource status and trajectory, with conceptual and coded models of the process links between these factors.

ii. A report assessing options for strategic R&D and infrastructure investment to build a state-of-the-art regional modelling capacity for the savannas.

These outputs are largely combined in this one report, although a number of very preliminary models have been developed as software or Excel spreadsheet, emerging from the exercises described in Section 4, and the data underlying the profile reports in Section 5 is available again in preliminary form on a CD–ROM.

The project began in earnest in August 2002 and was completed with this report in June 2003.
2. Regional profile of the tropical savannas
Alexander Herr and Natalie Stoeckl

This chapter presents information from currently available datasets that provide regional information on biophysical, economic and social aspects of the savannas. After discussing issues associated with scale and data availability, it identifies some of the similarities and differences between the savannas and the rest of Australia, and some of the similarities and differences between regions within the savannas. Here, the savanna region is defined on the basis of the bioregionalisation of Australia (Thackway & Cresswell 1995), the borders of which are shown in black in Figure 2.1.

![Figure 2.1 The savanna region (defined by the interim bioregionalisation of Australia boundaries)](image)

2.1 Preliminary data issues

Although there are numerous sources of data describing the savanna region, this analysis relies solely on data from the Australian Bureau of Statistics (ABS 2002), Healthwiz (Prometheus Information 2002), and the National Land and Water Resources Audit (2001), courtesy of the Bureau of Rural Sciences (BRS 1999).

There are differences in the spatial and temporal resolution of the datasets. These differences are largely attributable to differences in data collection methods, aggregation processes and collection/aggregation boundaries. As illustrated in Figure 2.1, biophysical data are frequently collected for bioregions. In contrast, population and economic statistics are more frequently collected within defined administrative and/or statistical areas such as local government areas (details of which are given in Appendix B). These boundaries rarely coincide with biophysical boundaries—this is evident in the maps of Section 2.3, where biophysical boundaries of the tropical savannas (overlaid on the maps) cross over many statistical boundaries.

The issue of mismatching biophysical and social area definitions is further complicated by differences in data collection boundaries of different collection agencies. For example, tourism data is collected by ‘tourism regions’, which do not always coincide with the statistical divisions of the ABS. Employment data is often collected and reported for ‘employment regions’. Political decision-making processes at state and federal levels further complicate the issue as state and federal electorates show little consistency between political levels or with statistical and administrative area boundaries.

The problem of area incompatibility is common in catchment or bioregionally based resource management and is a major issue for planning processes and research based on natural boundaries and communities within them. This poses a significant challenge for those interested in developing an integrated regional dynamic models that use data from multiple sources (with multiple spatial and temporal scales).
Solving such issues is beyond the scope of this report, so the following pages present data that are inconsistent spatially and temporally. We attempt to limit temporal inconsistencies by only using data from a five-year time period (1996–2001), but spatial inconsistencies abound. When presenting data spatially different boundaries are used for different data sources: biophysical data uses IRBA and NLWRA boundaries; socio-economic data uses the ABS’s 1996 Statistical Local Areas. In all cases, data are presented for the entire Australian continent. Where possible, ‘boundaries’ are drawn around the outside of the savanna region, derived from IBRA regions. This allows observations on biophysical, social and economic differences between the savannas and the rest of Australia, and between regions within the savannas.

2.2 Biophysical data and conservation in the savanna region

Land use and land tenure varies significantly across Australia, as depicted in Figure 2.2. Land use in the savanna region (adjusted from BRS 1999), Figure 2.3, and Figure 2.4.

In the savannas, most areas are used for grazing—although some parts are managed for resource protection and nature conservation. Areas managed for resource protection coincide largely with Aboriginal freehold. The tenure of most savanna areas is leasehold and freehold. Land use of the non-Aboriginal leasehold and freehold areas is grazing, with most freehold areas occurring in western Queensland.

This contrasts with other outback areas, like those in the eastern parts of Western Australia, where there are significant tracts of vacant Crown land (used ‘minimally’); and significant areas of Aboriginal freehold and conservation land, managed for protection. It also contrasts with more populated, southern areas of Australia where a larger proportion of land is freehold, used relatively intensively (be it for irrigated pasture, irrigated agriculture, or residential areas).

![Figure 2.2 Land use in the savanna region (adjusted from BRS 1999)](image)
Although there are several large nature conservation areas in the savannas, the protection of the bioregions (as represented in sub-regions) is variable. Grazing is the main land use in areas with a low representation of sub-regions in protected areas (0–5%) (Figure 2.4 and Figure 2.2). Queensland and the area of the eastern Kimberley to Darwin show the highest representation of sub-regions in protected areas with some parts protecting more than 30% of the sub-regions (Figure 2.4).

Despite the relatively low levels of protection, most areas within the savannas have only medium or low levels of landscape stress (a cumulative and integrative measure describing the landscape health, discussed in NRWLA, 2001) as depicted in Figure 2.5. This contrasts markedly with parts of southern Australia (showing extremely high levels of landscape stress) and with the desert/outback regions of Australia (only showing low levels of stress).
2.3 Socio-economic data describing the savanna region

Most of the data shown in this section is displayed spatially, using the ABS’s 1996 SLA boundaries. Most of the data were taken from the ABS’s 1996 census, although some data is more recent, and some is from other sources (e.g. information on health is from the years 1996–98, taken from Prometheus Information 2002).
2.3.1 Remoteness

The concept of remoteness was developed to provide a measure of not only the geographical distance of people and communities from metropolitan centres, but also their difficulty in accessing services to meet their needs (Public Health Information Development Unit, 1999). The indicator for remoteness is termed Accessibility/Remoteness Index of Australia (ARIA).

ARIA measures access in terms of remoteness along a road network to service centres of various sizes. Index values for individual localities range from 0 (high accessibility) to 12 (high remoteness). With the exception of areas around Darwin, Mount Isa and the eastern Coast, most centres within the savannas have very high ARIA values (Figure 2.7).

![Figure 2.7 ARIA values based on distance to service centres for populated localities in Australia](image)

2.3.2 Population/demographics

Population density in the savanna regions is very low with mostly fewer than six people per 100 km². Exceptions occur in Arnhem Land and in five areas near Broome, Darwin, Cairns, on the Queensland and Northern Territory border and the western part of the top end in Queensland (Figure 2.8). These areas are in proximity of regional centres or mines.
Some of the areas in the savannas are faced with falling populations, but many others (like Broome) have rapidly rising populations (Figure 2.9). Many of these changes appear to reflect migration patterns (Figure 2.10) as evidenced by the high net migration figures in Weipa, Port Douglas, and the Kimberley (matched by relatively high rates of population growth). Again, the key point seems to be that parts of the savannas have negative net migration while other parts (predominantly coastal) are making net gains.
As shown in Figure 2.11, a significantly higher proportion of the population in the savannas (and in the Outback in general) is indigenous as compared with southern parts of Australia. The savannas have a larger proportion of males than in less remote parts of Australia (Figure 2.12), a lower proportion of individuals aged more than 64 years (Figure 2.13), and a higher proportion of children under 15 years (Figure 2.14).
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Figure 2.12 Proportion of males (Prometheus Information 2002)

Figure 2.13 Proportion of persons aged more than 64 years (Prometheus Information 2002)
2.3.3 Health/causes of death

An investigation into causes of death reveals a relatively low death rate throughout the savannas when compared with the more populated east coast (Figure 2.15), presumably reflecting the lower average age. However, people of the savanna region commit proportionally more suicide than in the more populated areas (Figure 2.16); homicides and accidental deaths are also more prevalent (Figure 2.17 and Figure 2.18). In general, the savannas have relatively low rates of death due to circulatory diseases, heart disease and cancer, again presumably reflecting the lower average age, although the Dalrymple Shire (inland from Townsville) stands out as a marked exception (Figure 2.19 and Figure 2.20).
Deaths 1998-99 - Total - Rate per 100,000 (Crude)

- 949.8 and above
- from 814.3 to 949.7
- from 696.4 to 814.2
- from 567.6 to 696.3
- from 383.6 to 567.5
- 383.5 and below
- No data

HealthWIZ Statistical Areas 1995-96 (NT grouped)

Figure 2.15 Death rate (Prometheus Information 2002)

Deaths 1998-99 - Suicide - Rate per 100,000 (Crude) (Subtotal)

- 21.7 and above
- from 17.3 to 21.6
- from 14.7 to 17.2
- from 11.9 to 14.6
- from 9.1 to 11.8
- 9.0 and below
- No data

HealthWIZ Statistical Areas 1995-96 (NT grouped)

Figure 2.16 Suicide rate (Prometheus Information 2002)
Deaths 1996-98 - Homicide - Rate per 100,000 (Crude)
- 7.8 and above
- from 3.7 to 7.7
- from 2.3 to 3.6
- from 1.6 to 2.2
- from 0.7 to 1.5
- 0.6 and below
- No data

HealthWIZ Statistical Areas 1995-96 (NT grouped)

Figure 2.17 Homicide rate (Prometheus Information 2002)

Deaths 1996-98 - Accident motor vehicle - Rate per 100,000 (Crude) (Subtotal)
- 20.1 and above
- from 13.9 to 20.0
- from 10.3 to 13.8
- from 8.2 to 10.2
- from 5.5 to 8.1
- 5.4 and below
- No data

HealthWIZ Statistical Areas 1995-96 (NT grouped)

Figure 2.18 Death rate, accidental causes (Prometheus Information 2002)
2.3.4 Labour force

Labour force data across Australia is perhaps best described as extremely variable and the savannas are no exception. As shown in Figure 2.21, unemployment in the savannas is generally lower than in other parts of Australia—although there are significant patches with relatively high unemployment rates (the area around Cairns, parts of the Gulf, and areas in and around Tennant Creek and Darwin).
Low unemployment rates do not, however, necessarily indicate a healthy labour market. First, it is not clear if these figures include, or exclude members of the indigenous population engaged in the Commonwealth Development Employment Program (CDEP). In some areas, this is simply a ‘substitute’ for unemployment benefits; in some areas it offers genuine employment. Second, when there are few employment opportunities, ‘discouraged workers’ tend to withdraw from the labour market (rather than registering as unemployed). This empirically observable phenomena is particularly evident among women and indigenous peoples. It is, therefore, important to consider labour force participation rates\(^3\). In the savannas, these are generally quite low, particularly in the Northern Territory, and in the Gulf (Figure 2.22). To the extent that low participation rates are associated with low employment opportunities, this indicates that large parts of the savannas may have relatively ‘unhealthy’ labour markets.

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\(^3\) Calculated as the number of people who are either employed or unemployed, divided by the number of individuals who could, potentially, join the labour force.
2.3.5 Socio-economic ‘ranking’: the SEIFA Indices

The ABS census collects information on the social and economic dimensions of the life of individuals such as employment, education and income. The analysis of these variables allows spatial and longitudinal comparisons at various aggregate levels but, in isolation, these variables do not tell us much about communities.

To gain a better understanding of communities, the ABS has developed a series of indexes that summarise different aspects of the socio-economic conditions of communities. Each Socio-Economic Index for Areas (SEIFA) summarises a different mix of census variables for a specified area, the full details of which are given in Appendix C: Details of SEIFA Indices. The five indices are:

- Index of Education and Occupation
- Index of Economic Resources
- Index of Relative Socio-Economic Disadvantage
- The Urban Index of Relative Socio-Economic Advantage, and
- The Rural Index of Relative Socio-Economic Advantage.

To allow for easy recognition of high and low scores, the raw index scores the SEIFA are standardised. Each index has a mean of 1000 and a standard deviation of 100 across all collection districts in Australia. This means that around 95% of index scores are between 800 and 1200. This standardisation allows for easy geographical comparisons and relative assessment of a particular community in relation to a chosen reference point. At the same time the method poses a problem for temporal comparison in that the absolute SEIFA values are not comparable between census years. Yearly comparisons are restricted to the relative score of an index in relation to determined percentiles.

Common to all indices is that regions with relatively low values, are at a relative disadvantage. In the maps that follow, the absolute value of each SLAs index is ranked relative to all Australian SLAs. Areas performing in the lowest decile (or, more precisely at 9% and below) are shown in red; those in the lower quartile (but above the lowest decile) are shown in orange; and so on, up to those in the highest decile (white).

Figure 2.23 shows the relative ‘ranking’ of SLAs on the index of education and occupation. The Index of Education and Occupation is designed to reflect the educational and occupational structure of communities. The education variables in this index show either the level of qualification achieved or whether further education is being undertaken. The occupation variables classify the workforce into the Australian Standard Classification...
Regional profile of the tropical savannas

of Occupation (ASCO) major groups and the unemployed. This index does not include any income variables. A low score indicates an area with concentrations of either persons with low educational attainment or unskilled or unemployed people. Much of Cape York Peninsula, outback Queensland and Northern Territory is red. This indicates that a large proportion of individuals living in these areas have relatively low education levels and/or are unemployed, and/or are working in unskilled jobs. In contrast, many of the more ‘urban’ areas—near Darwin, Townsville, Cairns, Kununurra and Broome—rank well on this index.

Figure 2.23 Index of education and occupation in the savanna region (adapted from ABS 1996)

Figure 2.24 shows the percentile rankings of SLAs on the Index of Economic Resources. This index reflects the profile of the economic resources of families within the areas. The Census variables that are summarised by this index measure, for example, income, rent and home ownership. Additionally, variables that reflect non-income assets, such as dwelling size and number of cars, are also included. Income variables are specified by family structure, since this affects disposable income. A low score indicates the area has relatively large proportions of households on low incomes and living in small dwellings.

As per the previous index, it is evident that a large part of the savannas is at a relative disadvantage; evidently many of the households in this area have little in the way of ‘economic resources’. Interestingly, there are fewer exceptions here (only the area around Townsville and Mount Isa), than in the case of education and occupation.
The index of relative socio-economic disadvantage tells a similar story (Figure 2.25). This index summarises the information available from variables related to education, occupation, income, family structure, race, ethnicity and housing. It reflects the extent of disadvantage represented by, for example, high unemployment. It is important to note that the scores for this index are counterintuitive as high index values represent low disadvantage to maintain consistency with the indices: the higher an area’s index value, the less disadvantaged that area is. As per previous indices, large tracts of the savannas (with few exceptions) are shown to be at a relative socio-economic disadvantage. The story is similar for both the rural and the urban indices of socio-economic advantage (Figure 2.26 and Figure 2.27)—see Appendix C: Details of SEIFA Indices for details or the variables included here.
2.4 Summary
The biophysical analysis highlights the fact that most land within the savannas is used for grazing. Small areas are set aside for conservation (with some forestry along the higher rainfall east coast of Queensland), most of which is Aboriginal freehold or within Aboriginal reserves. Protection of sub-bioregions is highly variable, with an under-representation in most of the grazing areas. Landscape stress and hydrological change is generally medium-low (compared with other parts of Australia) with considerable regional variation.
The demographic and ARIA analysis highlights some obvious points—namely that most areas within the savannas are sparsely populated and ‘remote’. Exceptions to this include areas around Darwin, Mount Isa and on the east coast. Many regions within the savannas are faced with falling populations—largely attributable to migration. Important exceptions include Broome, and some coastal areas. Generally, the savannas have a higher proportion of indigenous peoples, a larger proportion of males, a lower proportion of individuals aged more than 64 and a higher proportion of children under 15 than other parts of Australia. East coast areas are ‘closer’ to the Australian norm (for indigenous and age distributions).

The overall death rate (total per 100,000) in the savannas is generally lower than in most of south-east Australia; but significant differences in the causes of death are apparent. Suicides, homicides and accidental deaths are generally more prevalent in the savannas than elsewhere, whereas deaths due to circulatory diseases, heart disease and cancer are less prevalent (with the notable exception of Dalrymple shire).

From a socio-economic perspective, many regions within the savannas appear to be at a relative disadvantage (compared with other regions within Australia), however significant regional variability is evident. Specifically, unemployment rates across the savannas are generally low (with the exception of Cairns). Labour force participation rates are low around Broome, throughout most of the Northern Territory (except the area around Darwin and Tennant Creek), and through large tracts of the Gulf Country. Many areas of the savannas perform poorly on the SEIFA indices, with the exception of areas around Darwin and Blackall (education and income), areas inland from Rockhampton and at Threeways (economic resources, and socio-economic disadvantage).

The socio-economic data presented in this section is mostly at the finest scale available for the savanna region (and Australia). The ABS supplies these data progressively updated after each census. However, future modelling will require finer-scale data. Such future data requirements to feed into the social, economic and ecological modelling of savanna dynamics may include:

- Analysis of existing fine-scale studies for data compatibility and appropriate time frame (i.e. assess spatial and temporal compatibility)
- Integration of specific future studies into the wider modelling framework to achieve forward compatibility
- Field data collection at finer (point) scale and
- Modelling of point source data for extrapolation to and overlay with specific Savanna areas.

This analysis contains two key messages for those wishing to develop an integrated regional dynamic model: there are significant differences between the savannas and other parts of Australia; and there is significant inter-regional variation. The first point implies that existing models that have been developed in more densely populated and less remote parts of the world, should only be applied in the tropical savannas after careful scrutiny. The second point implies that a regional dynamic model may need to be developed at a relatively fine scale—certainly no larger than that of SLAs (and preferably smaller). Fine-scale data on a broad range of variables is not generally available across all of the savannas. Hence, modellers may need to look at ways of ‘scaling down’, ‘scaling up’ (using data from select studies such as that of Colin Macgregor), or some combination thereof. These approaches are not particularly satisfactory, but neither is the alternative—postponing the development of a regional model until fine-scale data is available across the whole of the savannas.
3. Tropical savannas: towards an integrated framework for regional dynamics

Mark Stafford Smith

This section sets out a general overview of the issues that need to be considered in any approach to analysing and modelling regional dynamics in the savannas, and a general framework for analysis, which emerges from this overview. It is sourced from a mixture of literature review, opinions and debate which emerged at the main project workshop in November 2002 (see Appendix A: Project workshop, Toowong, November 2002), and subsequent development of ideas by the project team. The way in which these ideas might be used to frame a research program is discussed in Section 8.

3.1 Features of the savannas

The tropical savannas of Australia are characterised by a broad suite of generally typical features (Table 3.1), of which the biophysical component has been well studied by the Tropical Savannas CRC for many years. In establishing the concept of landscape health (Whitehead et al. 2000), the TS–CRC has progressed the study of this biophysical environment substantially. However, a similar understanding of socio-economic and cultural dimensions of savanna landscapes is lacking. The present series of research developments are intended to move towards an equivalent understanding of the socio-economic health of tropical savanna regions.

Some social and economic features have been looked at over the years. ABARE updates and releases statistics on financial and social characteristics of grazing enterprises on an annual basis, based on its farm survey. Those data are available online for multiple regions and zones within the savannas. ABARE also provides forecasts of farm and mining commodities. Some of this data is presented at (regional) Outlook conferences. The Social Atlas of Australia (BRS 1999) provided a snapshot of population, income and some other characteristics, based on the 1996 ABS census, and showed some changes since the previous census in 1991.

From this, Stafford Smith (2000) suggested there were three quite distinct sets of characteristics which described the regions of the savannas—those which were:

- more-or-less uniformly shared with all of rural Australia (compared to peri-urban areas),
- more-or-less uniformly shared by regions in the north but distinct from rural regions in southern Australia, and
- differed distinctively across regions in northern Australia.

Any attempt to consider the socio-economic health of regions in northern Australia would naturally need to take account of all of these factors, but might need to be aware that different priority would need to be given to (ii) because they distinguished what was going on in northern Australia from that occurring elsewhere; and to (iii) in order to understand the drivers of differential trajectories of regions in the north.

It is clear that aspects of remoteness, costly transport, low and sparse populations, significant mobility among people both within, between and outside the regions, the substantial indigenous population, the distant nature of government, and a high reliance on public investment are all factors that mitigate against any hope of simply transferring analyses from more heavily populated regions of south-eastern Australia where most of the continent’s policy is formulated. The fact that the north is facing numerous pressures for development and a strong debate about the values of this highlights the need for a savanna-centric approach to regional dynamics.

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4 ABARE: <http://agsurf.abareconomics.com/cqbin/abare.pl?_PROGRAM=ags4Home&wh=ter&pr=agsurf>
Table 3.1 Some key features of savanna regions in Australia (sourced from a summary of workshop members’ comments)

<table>
<thead>
<tr>
<th>General category of issue</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Trees and grass (rather than shrubs, etc)</td>
</tr>
<tr>
<td></td>
<td>Attractive landscapes</td>
</tr>
<tr>
<td></td>
<td>High seasonality of climate (variable rainfall, but relatively reliable wet and dry seasons)</td>
</tr>
<tr>
<td></td>
<td>Biosecurity concerns (relatively unaltered environments to date under greatly increasing pressure)</td>
</tr>
<tr>
<td></td>
<td>Generally low landscape productivity, but pockets that are ‘rich’ and subject to intensification</td>
</tr>
<tr>
<td>Social</td>
<td>Significant proportion of population that is indigenous</td>
</tr>
<tr>
<td></td>
<td>Growing indigenous population, declining non-indigenous population</td>
</tr>
<tr>
<td></td>
<td>Disadvantages faced by the indigenous population but also their ties with the non-indigenous population in places</td>
</tr>
<tr>
<td></td>
<td>Lack of regional coherence</td>
</tr>
<tr>
<td></td>
<td>Openness and frankness in people, and strong sense of community</td>
</tr>
<tr>
<td></td>
<td>Multiculturalism in places</td>
</tr>
<tr>
<td>Institutional</td>
<td>Government as a key deliver, despite a relatively light presence</td>
</tr>
<tr>
<td></td>
<td>Distant policy making processes</td>
</tr>
<tr>
<td></td>
<td>Different needs and aspirations of indigenous compared to the non-indigenous population, under the same governments</td>
</tr>
<tr>
<td></td>
<td>Notable differences between jurisdictions—WA, NT, Qld</td>
</tr>
<tr>
<td>Human</td>
<td>The need for people to cope with extremes</td>
</tr>
<tr>
<td>Industry</td>
<td>Tourism focus (but not the ‘saviour’)</td>
</tr>
<tr>
<td></td>
<td>Most economic activities linked to natural resource base directly</td>
</tr>
<tr>
<td></td>
<td>Long distances to markets</td>
</tr>
<tr>
<td>Geographic</td>
<td>Settlement sparsity, and distances between communities</td>
</tr>
<tr>
<td></td>
<td>High turnover of some of the population</td>
</tr>
<tr>
<td></td>
<td>Tenuousness of non-indigenous occupancy</td>
</tr>
<tr>
<td></td>
<td>Remoteness and access difficulties</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Limited physical infrastructure</td>
</tr>
<tr>
<td>Future</td>
<td>On the cusp of particularly unpredictable levels of change</td>
</tr>
<tr>
<td></td>
<td>Data limitations</td>
</tr>
</tbody>
</table>

3.2 World views on change

There are a number of approaches to considering regional dynamics, which emerge from different world views on the relative primacy of different driving forces. In the human dimension, the first port of call for policy is usually the population data and projections provided by the Australian Bureau of Statistics, providing an understanding of population dynamics based on the current trends in different regions. The ABS uses its own census data to provide these projections, which help inform government investment and planning in different regions in a broad sense. It is possible to pick many holes in the way in which these statistics are collected and modelled in remote areas with small and mobile populations, which are greatly affected by what would be relatively small perturbations in more heavily populated areas (e.g. Taylor 2002). As a consequence, increasing effort has been put into refining our understanding of those statistics, and of their application to modelling demographics in areas with sparse populations (Bell 2001; Bell & Ward 1998). Even with these (as yet imperfect) corrections, however, the question immediately arises as to what drives change in the different population growth parameters, particularly mortality, birth rates, and net migration (Taylor & Bell 2002). In northern Australia, it is evident that these parameters not only differ dramatically between the indigenous and the non-indigenous population, but also that the factors driving change in the parameters are themselves changing in ways, which are poorly understood.

One world view to help determine what might drive regional development is that of economic development. Economists use a variety of techniques, such as shift-share models, input-output models, computable general equilibrium models, demo-economic models, non-linear models, and gravity and spatial interaction models to try to explain internal and external drivers of change over time and how population change and economic
activity are related. Business activity and public sector investment determine regional income levels, levels of employment and potentially other factors such as workforce participation. These types of approaches typically try to understand past developments and tend to handle relatively small additional impacts of other factors based on an incremental change rather than dramatic switches among different states. In regions with a large population this gradual evolution of the economic development paradigm serves reasonably well in continuing to provide valuable insights into regional development. In northern Australia, however, it is greatly challenged by small sample populations, again hugely impacted by what would be small changes in business balance in a more populous region (e.g., the introduction of a single new mine), and is also widely criticised for failing to deal with a very large proportion of the regional economy that falls into outside the normal market context.

These approaches provide significant and useful insights into issues that must be dealt with in remote regions since the costs of providing services and of accessing markets, and movements of financial capital are still fundamental forces in socio-economic ‘health’.

- For example, input-output analysis (IOA) is commonly used to measure the impact of changing demand in any industry throughout the (regional) economy. It reveals interdependence between various sectors of the economy or the effects of government spending by identifying monetary and employment multipliers as well as leakage out of the regional economy. Leakage for remote regional economies tends to be high, as for example analysis for the Kimberley region has shown (Greiner et al. 2001; Johnson 2001) The general tendency is that the smaller and less diversified a regional economy, the higher the leakage as more input goods and services need to be bought in and less value-adding to outputs happens regionally. This information can assist the process of prioritising alternative directions of development for regional communities as it shows which development options provide the greater local benefits however attractive they appear superficially.

- An important issue of peripheral regions such as the savannas relates to the financial trail of gross-operating surplus (profits) from business activity. It would be true to say that the more owner-operated businesses there are in a region, the more the profit is used as income for families living locally and therefore gets spent and re-invested locally. The more absentee owners there are, the greater the leakage of gross operating surplus out of the regional economy.

- Closely allied to this issue is the fact that not all businesses are equal in terms of impact on the remainder of the regional economy. Expansion in some kinds of businesses drags along other businesses that service their activities; others have no such leading effects even though their immediate activity may increase just as much. Again, conventional economic analyses can play a useful role in identifying such leading (as opposed to following) activities.

- Related to both the previous points is the global issue of agglomeration. Ever since settlements began, activities involving relationships and transactions (in the most general sense) have benefited from critical mass and economies of scale in their transaction costs. Basically, as soon as the benefits from agglomerating activity outstrip the costs of delivering the results to a remote locality, that activity will move out of the remote location and deliver from a distance. This is true for vegetable production as much as banking and government services. Even for activities which appear to have to be locally delivered, like supermarkets, certain activities such as ordering can be centralised profitably at some stage, resulting in the development of supermarket chains. As globalisation proceeds, the reduction of deliberate barriers to such remote delivery (such as border trade tariffs) or the reduction of costs (cheaper transport, increasing economies of scale with technology, or electronic delivery) means that the pace of agglomeration is speeding up. The result is that more and more economic activity in remote regions is actually channelled through centralised entities, like banking online, government services from capital cities readily accessed by phone, and even centralised delivery of activities like tourism which otherwise appear to be place-based. Even remote area supermarkets may be overtaken by online ordering and delivery systems. All these trends contribute to the problem of ‘fugitive capital’ and low regional multipliers. The counter to this trend is to promote business development that has a competitive advantage by virtue of being present in the remote community. While there are some examples of services that must be delivered locally, these are generally few and small in scale. This points to the need to focus on values and products that can only be delivered from that locality. Place-based tourism is a partial example, but the move to create centres of recognition in tropical or desert knowledge are others that are less likely to be captured by temperate urban centres.

Regional communities will have to address these concerns that are driven by economic forces, so any framework needs to be able to analyse them. Notwithstanding these important insights, though, there are fundamental forces at work in outback Australia which may argue for a different world view on regional dynamics. One is the worldwide political trend to devolving power to regions, and building self-determination in local communities (and minority groups, such as indigenous people). There is an increasing body of
literature supporting the empowerment of local communities within some sort of institutional superstructure that connects them to each other and to ‘higher’ institutional levels such as national governments and international organisations. The work of Ostrom, for example, makes a strong case for “polythetic governance systems” which can self-organise at the local level to respond most effectively to local conditions but within some framework, which enables those polythetic local solutions to interact at the next scale up (Ostrom 1999, 2001). At the same time as these theoretical advances, national policy in Australia (as in many other places in the world) has been moving in this direction anyway. The community development literature increasingly sees this as an essential aspect of creating demand-driven (rather than supply-driven) modes of service delivery; as ever, this is important everywhere but particularly critical in remote regions where service delivery is expensive and least subject to the forces of competition, at least locally. This ideological and pragmatic trend towards local empowerment remains in direct conflict with the forces of agglomeration mentioned above, so there is a continual tension between the intended and implemented regional devolution of the three R’s: responsibilities, rights and resources. Responsibilities tend to be devolved more readily than either the matching rights or the necessary human, information and financial resources to meet those responsibilities. This tension will inevitably be felt most acutely in the more remote regions. Indeed, this project and others in the TS–CRC aim to be an important part of improving the information resources available to remote regional communities that are taking greater responsibility for their futures.

There are other profound drivers at work. Holmes (2002) observes that non-market values are a very significant element in these regions, to a degree far outstripping their relative influence in more populated regions, and hence more substantially confounding a simple economic analysis. Non-market values encompass not only non-use values but also some use values (Table 3.2). These values are difficult to deal with because a primary principle in conventional development decisions is one of economic efficiency and market values of commodities (tradeable outputs and services).

Table 3.2 Key elements of market and non-market economic value

<table>
<thead>
<tr>
<th>Aesthetic/educational use value</th>
<th>Non-consumptive use value</th>
<th>Direct use value</th>
<th>USE value</th>
<th>Total economic value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distant use value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumptive use value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect use value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quasi option value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existence value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bequest value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philanthropic value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From an analysis informed by global rural and social geography world views (and derived from a long period of observation and analysis—e.g. Holmes 1990, 1997), Holmes (2002) has identified the interplay of a productivist agricultural occupancy with that of an increasingly dominant multi-functional rural occupancy, resulting in the growing importance of a ‘post-productivist’ paradigm. His analysis suggests (by comparison with international trends) that the transition is associated with:

- agricultural overcapacity which results in declining terms of trade for less competitive regions, coupled with…
- the emergence of alternative amenity-oriented uses, some of which (the most dynamic) are market-driven (e.g. tourism) but many of which incorporate non-market values (e.g. conservation, indigenous traditional attachments to land). Many of these are particularly location-oriented and therefore have an inalienable competitive advantage, out of proportion to their apparent economic market appeal, especially in the context of…
- changing societal values, such as ecological sustainability, biodiversity conservation and social justice, which must often be pursued in rural contexts.

Holmes (1997, 2002) has applied this analysis to examine the current trends in different inland regions, and has begun to explore some of the contextual factors about those regions which might constrain the options that are most likely to be open to them in the future. It helps to further highlight the likelihood of transient modes of consumption and exploitation in remote regions, through fly-in/fly-out mining, corporate empires and ‘safari’ tourism, contrasting strongly with the resident indigenous population and its services. Despite its powerful explanatory strength, however, and its huge value in focusing attention on the significance of non-market values—often with “more value but less cash” (Holmes 2002)—the approach must be integrated with more
quantified approaches to provide a greater predictive capacity about regional dynamics and about whether and why different balances of productivist and post-productivist forces may emerge in different regions.

A world view that can shed light on this issue is that of social anthropology, which places a much greater emphasis on understanding the role of different actors, the systems of meaning and value in which they are embedded and the consequent actions which arise from these systems. One advantage of such an approach is that it can bring into focus shared values among actors who might otherwise be classified differently (e.g. pastoralists and indigenous people, cf. Smith 2002a, 2003), challenge presumptions of shared interests between different actors (e.g. Aboriginal people and environmentalists, cf. Smith 2002b), and reveal differences within apparently homogenous categories (e.g. ‘(indigenous) traditional owners’, cf. Smith 2000).

Table 3.3 Some values or disciplinary frameworks that can be deeply held and paradigmatically prejudice the judgement of different players (and researchers). Each of these has a valid literature backing its view.

| Balanced sustainable livelihoods | Nature/Society/Economy/Wellbeing (NSEW) balance |
| Economic development | Physical accounting and total materials throughput, the ecological footprint |
| Entitlement-centred views | Resilience as a fundamental system goal |
| Equality/equity as an end, to reduce social tensions | Sustainability of natural resource use |
| Human health and welfare, human development | The primacy of institutional arrangements |
| Learning organisations and the need for adaptive change | Vulnerability |

This is most obviously useful in revealing and analysing differences between indigenous and non-indigenous views of life in savannas, but in truth is as big an issue between pastoral families with a long attachment to land compared to pastoral companies, and people in more remote areas compared to the main coastal urban centres of Darwin, Cairns and Townsville. It demonstrates forms of agency that ‘cross-cut’ ethnicised identities (e.g. the close ties and shared world views apparent between some Aboriginal people and non-indigenous pastoralists on Cape York Peninsula – cf. Smith 2003) and in various other ways within communities across the wider tropical savanna region, and others involved with the region elsewhere. Thus individuals must be understood as playing out roles in different communities of interest at different times. For example, an understanding of how these roles may overlap in powerful or weak individuals can retrospectively explain why different regions have apparently ‘happened’ to follow different trajectories thanks to issues such as leadership and family, other social network relationships, or values and interests that cut across what may seem, at first glance, to be homogenous groups.

Anthropology as an approach places an emphasis on understanding how different actors play their roles, but also struggles to provide great predictive power into the future. Mathematical concerns over what is identified as the “middle order number problem”—too few individuals to predict their behaviour statistically, but too many to be able to predict their behaviour and particularly their exponential number of interactions analytically—might arguably be raised here, but the increasing sophistication of qualitative analysis, presuming a comprehensive range of primary data drawn from field-based studies, should allow modelling of the current situation and allow the development of predictive accounts based in a combination of actors’ exegesis and observation and analysis by researchers. At the very least, such approaches provide a powerful corrective to the potential flaws of crass definitions of actors and presumptions of their interests, which might otherwise lead to fundamentally misaligned models that skew predictive analyses.

3.3 Approaches to integrated regional modelling

Before addressing the challenge posed at the end of the previous section, we must ask whether there are existing approaches to be applied, and what lessons may be learned from these. Section 5 outlines a wide-ranging literature review in this regard, as a key resource for future work. This section summarises some key ideas and concepts from that literature review on broad and specific approaches, and on monitoring and modelling frameworks relevant to the regional dynamics in northern Australia. It also outlines lessons learned from the review.

3.3.1 Broad approaches

Some of the perspectives and approaches useful to understanding change in northern Australia are already discussed in Section 3.1. To recap:
• remote area demographic changes from demography
• regional transitions from social geography (Holmes 2002)
• regional economic dynamics from conventional economics, and
• actor-specific narratives of change from anthropology.

There are other relevant approaches that can provide more insights to modelling the dynamics in the tropical savannas. They broadly frame the structural problems of centralising (the phenomena of relocating resources, income, services and decision making out of the periphery) of tropical savannas and provide mechanisms of dealing with these problems. These approaches are the:

• theory of adaptive cycle (Gunderson et al. 1995; Holling et al. 2002a), and a Trigger–Transfer–Reserve–Pulse analysis framework (Ludwig et al. 1997) from ecology
• examination of core-periphery relationships from political ecology (M’Gonigle 1999; Peterson 2000; Blaikie & Brookfield 1987),
• common resource pool governance as complex adaptive systems (Ostrom 1999) from political economics.

The adaptive cycle is a heuristic theory of change that views ecosystems as passing through stages of growth (exploitation), maturation (conservation), death (release) and birth (renewal). This theory of change is expanded to account for changes in economic and social systems (Holling et al. 2002a; Holling et al. 2002b; Westley et al. 2002) or linked social-economic-ecological systems such as the rangelands (Walker & Abel 2002). The theory identifies three limiting factors that shape the adaptive change of a system. These are the potential (capital) of the system that limits the options possible; the system’s connectedness that dictates its degree of flexibility of internal controls and processes; and its resilience—a measure of the capacity of the system to buffer disturbance without flipping into another state.

Walker and Abel (2002) found the adaptive cycle a useful approach to understanding the dynamics in the Australian rangelands and tropical savannas. Holling and Gunderson (2002) conclude that currently the tropical savannas tend to stay in the renewal and exploitation phases of the adaptive cycle. In both phases, potential (nutrient and biomass) accumulation is low and also connectivity of internal controlling variables is very low, exposing the systems to be more or less controlled by external variables. In contrast resilience is high.

Abel (1999) proposed that it is an opportune time to leverage for extensive desired change because “rigidity is causing structural cracks” in the rangeland systems. Similarly, Holmes (2002) claimed that there was an extensive but varied transition from production-based to amenity-based land use and occupancy accompanying the re-valuation of resources (accumulation of potential). To understand changes in regions of the tropical savannas, it may be useful to explore these broad hypotheses using the theory of adaptive cycle.

Both the old and new modes of rural and remote occupation suffer from a structural problem of centralisation (Holmes 2002). Political ecology provides a broad approach of core–periphery power relationship to frame this structural problem of fugitive income from the peripheries to the centres and ‘more value and less cash’ nature of the emerging amenities of post-productivist occupancy. Institutions (both markets and governments) facilitate the net resources flow from the territory to the core and promote decision making in the centre that has significant impact in shaping the future of the periphery (M’Gonigle 1999). With these centralising properties, M’Gonigle (1999) raises serious doubts on the will of government organisations at the centre to genuinely protect the interest of the periphery and the market to promote non-market values.

The rangelands and tropical savannas face tragedies similar to common pool resources. Ostrom (1999, 2001) challenges conventional economic assumptions on the cause of ‘tragedies of the commons’ and the simple policy prescriptions given by policy makers located at a distance. According to Ostrom (1999) the basic assumptions are: (a) resource users are competitive, norm-free maximisers of immediate gains and (b) designing rules to change incentives of participants is simple, requiring central direction. She suggests an alternative paradigm, promoting the evolution of polycentric governance systems that is based on the assumption that resource users do cooperate to overcome the tragedies they face.

Her suggestion for polycentric governance and cooperative resource use can be a basis for countervailing force that can maintain a healthy tension between the centre and periphery. Simulation modelling can allow virtual experiments to test assumptions and rules based on polycentric governance theories.
The perspectives and approaches explored raise issues and provide largely complementary insights for integrated regional dynamics modelling of the savannas. The framework of choice has to account for these insights and issues to articulate its emphasis on monitoring socio-economic health.

3.3.2 The health metaphor and the purpose of modelling

Choosing a specific modelling framework requires defining the purpose of modelling dynamics of the regions of the tropical savannas.

The purpose is to understand changes in order to monitor the health of the regions. There is already a program in place that monitors the ecosystem health. Monitoring ecosystem health involves “assessing current status, monitoring trends, diagnosing likely causes of change, or providing early warning of adverse change” (Whitehead et al. 2000). Although the focus is on ecosystem, the aspirations of the different stakeholders of the savannas are considered in the monitoring framework.

The current effort is to develop a modelling framework for monitoring social system health of the regions. It is a counterpart to the ecosystem health monitoring. The modelling framework of choice is that which provides emphasis on socio-economic health but sufficiently comprehensive to consider the ecosystem.

Here, human health can be the metaphorical guide for monitoring the socio-economic system of the tropical savannas as it is for ecosystems (Elmer et al. 2002; Whitehead et al. 2000; Bradley 1994; Costanza 1992; Mageau; Costanza, and Ulanowicz 1998). As Childs et al. (2002) put it “the appeal for human health metaphor for the ecosystem arises from our experience of the benefit of preventing and curing the causes of ill-health.”

Exploring what it means to employ the human health analogy to the social system raises issues that can lead to research questions relevant to regional dynamic modelling. This is further developed in the last part of this section in conjunction with lessons learned from the review of broad approaches and the chosen framework.

3.3.3 Specific approaches and modelling frameworks

Several monitoring frameworks are outlined in the literature, including the Quality of Life (Nussbaum & Sen 1993; Maxneef 1991; Rawls 1971); Human Development Index (UNDP 1991); Genuine Saving (Pearce & Atkinson 1993); Genuine Progress Indicator (GPI) (Cobb, Halstead & Rowe 1995; Daly & Cobb 1989; Hamilton 1999); Pressure–State–Impact–Response (PSIR) (OECD 1994; Lowe 1996); and Driving force State Response for monitoring sustainable development (DSR) (Mortensen 1997).

Some of these are one-dimensional in scope, and most provide highly aggregated figures that may fail to show much about the dynamics of the highly variable regions of tropical savannas. Both PSR and DSR frameworks are best perceived as a useful taxonomy for organising indicators without implying an underlying functional causality (Gallopin 1997). All can provide variables and indicators that we need to consider in our modelling exercise. However we found them less relevant than other trans-dimensional frameworks.

In trans-dimensional frameworks the social (socio-economic) system and the ecosystem (biophysical system) are integrated in different ways: coupling, merging and nesting one in the other system or recognising aspects and properties shared between them.

Institutions are often used as a medium to couple the socio-economic and biophysical systems (Low et al. 1999; Berkes & Folke 1998; Leach et al. 1997; Abel et al. 2001; Dodds 1999; Lawn 1999). The roles of institutions in reducing social dilemma and dealing with ecological uncertainty mediate the relationship between the social and ecological systems.

The Forest Land Oriented Resource Envisioning System (FLORES) is a model developed by the Centre for International Forestry Research (CIFOR) that couples the social and biophysical systems using tenure as intermediary sub model (Haggith et al. 2002; Vancly et al. 2000). Haggith et al. (2002) note that modelling institutions as intermediary between the systems to represent multiple and overlapping rights is a significant enhancement over most land-use models. The model also integrates ‘the five capitals’ (natural, physical, human, social and financial assets) in one model and allows the dynamic interactions between them to be explored. FLORES uses the SIMILES modelling environment and has been applied in different contexts such as in Mafungautsi in Zimbabwe, Cameroon and Bogor in Indonesia. FLORES has FLAC (the FLORES Adaptation and Calibration package) for adaptation in different contexts.

Merging the social and ecological systems involves re-envisioning the social and ecological systems as complex adaptive systems (Holland 1995; Gunderson et al. 1995; Ostrom 1999). Rangelands regions are re-conceptualised as complex adaptive systems where humans are considered as adaptive agents within an

Multi-agent based modelling, informed by concepts of complex adaptive systems, is increasingly used in exploring the likely impacts of different management strategies on natural resources (Janssen 2002; Janssen & Carpenter 1999; Carpenter et al. 1999), and the dynamics of the rangelands under different policy and institutional regimes (Janssen et al. 2000).

In a nested approach, the socio-economic system is considered as a subsystem of the overall ecosystem. This integration highlights that there are socio-ethical and biophysical limits to the socio-economic activities that cannot be ignored, particularly when these activities grow large relative to the host ecosystem (Daly 1996; Bell & Morse 1999; Bossel 1998; Peet & Bossel 1999). Nesting is the basis for Bossel’s orientor monitoring framework that considers the effects of subsystems on one another and each on the host system. Nesting can also inform modelling the dynamics of detailed socio-economic activities.

The sustainable rural livelihood framework (Scoones 1998; UK Department for International Development (DFID) 1999; Woodhouse et al. 2000) is a potential framework for modelling the dynamics of tropical savanna regions. The framework is integrative in the sense that it considers shared aspects and properties of the socio-economic and biophysical systems. Its main focus on livelihood provides the emphases required for socio-economic health.

The five capitals or the asset pentagon (Figure 3.1,Table 3.4) lies at the core of the sustainable livelihood framework. People as actors and their livelihood activities are also considered in the framework. Institutions as underlying context mesh the different subsystems of capital, actors and their livelihood activities. This allows us to develop modelling issues from three corresponding perspectives. The capitals provide a checklist for system dynamics modelling of regions. There are already capital-based modelling approaches to exploring the socio-economic dynamics of regions and to selecting indicators of system performance (e.g. Gustavson et al. 1999; Campbell et al. 2001). Actor-based modelling approaches can also benefit from the established experiences of multi-agent based modelling (Janssen 2002). Industries as livelihood activities (old and emerging) can provide a basis for detailed socio-economic activity modelling (Greiner et al. 2002). Some preliminary efforts in each of these are reported in subsequent sections.

Figure 3.1  The five types of capital discussed in the sustainable rural livelihoods literature (modified from Campbell et al. 2001, Figure 3)
Table 3.4  Some suggested principles for each of the capital assets, with examples of criteria for each of the principles, from Campbell et al. (2001, Table 2). They note that the example is for illustrative purposes only and that the principles should not be seen as definitive.

<table>
<thead>
<tr>
<th>Capital asset</th>
<th>Principle</th>
<th>Example criterion for each principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural capital</td>
<td>Options for future use are maintained</td>
<td>Processes that maintain biodiversity are conserved</td>
</tr>
<tr>
<td></td>
<td>Yield and quality of natural resource goods and services are maintained or improved</td>
<td>Ecosystem function is maintained</td>
</tr>
<tr>
<td>Financial capital</td>
<td>Financial capital is circulated within the system</td>
<td>Service and commodity outlets expand in the local and district centres</td>
</tr>
<tr>
<td></td>
<td>Financial capital grows and is equitably distributed</td>
<td>Residents have reasonable share in economic benefits derived from resource use</td>
</tr>
<tr>
<td>Physical capital</td>
<td>Physical capital is maintained or improved over time</td>
<td>Housing physical status is maintained or improved</td>
</tr>
<tr>
<td>Human capital</td>
<td>Ability to provide added value is improved over time</td>
<td>Greater array of value-added products are produced locally</td>
</tr>
<tr>
<td></td>
<td>Improved and equitable distribution of human capital</td>
<td>Level of skills with respect to running committees and organisations is improved</td>
</tr>
<tr>
<td>Social capital</td>
<td>Maintenance of systems of social reciprocity</td>
<td>Economic and other shocks are buffered by systems of social reciprocity</td>
</tr>
<tr>
<td></td>
<td>Maintenance of a set of dynamic rules and norms</td>
<td>Local rules are effective in controlling access to resources</td>
</tr>
</tbody>
</table>

It is also possible to consider institutions as a separate capital, making an asset hexagon at the core of the regional dynamics modelling for tropical savannas. The distinction between social and institutional capital is useful because the latter is expected to have a significant role not only reducing social dilemmas but also in dealing with the high environmental uncertainty characteristic of Australia’s north. The distinction is reflected in the type of social interactions (as horizontal, informal associations and networks versus hierarchical, formal associations and organisations) and major forms of externality-generating and maintaining mechanisms (trust and norms of reciprocity versus rules and formal sanctions) predominant in social and institutional capital respectively.

3.4 Towards an integrated framework

As noted above, it is always necessary to ask, “towards an integrated framework for what?” The introduction identified the broadbrush goals identified for this research area, which provided a good rationale for beginning to understand the core aspects of regional dynamics that should be common to any questions being asked about the long-term implications of regional investment decisions in the savannas. However, the discussion above enables us to be a little sharper about the reasons why regional communities in tropical savannas might be concerned about these issues, and thereby to further focus the priorities of any framework.

3.4.1 What issues must be encompassed?

From the analysis in Section 3.2, it is clear that debate about future directions in the savannas is going to be polarised between productivist and post-productivist value systems; this is increasingly true worldwide, but the much higher relative significance of the post-productivist values in remote areas in Australia emphasises this debate much more than elsewhere. In a practical sense this jargon emerges in two different types of questions already being widely asked:

- On the one hand, a (somewhat) productivist viewpoint asks how can we promote economic development in northern Australia most effectively (with its attendant implications for populating the north)? For example, through agricultural intensification and new irrigation schemes as well as railways, spaceports and more mines.

5 Note that the term ‘investment’ is used here in the broadest of senses: in any form of capital, but also, for example, into designing institutional arrangements of particular types.
On the other hand, a (more) post-productivist viewpoint asks how we can sustain the non-market values of the north, particularly Aboriginal culture and welfare, and the conservation of its relatively less impacted resources, and seeks to justify public investment to do so.

By the nature of the debate, each viewpoint is challenged in their question by the other:

- The proponents of economic development are increasingly challenged to ensure that the impacts on non-market values are understood and managed (a triple or integrated bottom line view), including impacts on the environment, community development, governance processes and education and training.
- The proponents of sustaining non-market values are challenged with not being able to do so at all costs, so that there is an increasing emphasis on cost-effective, demand-driven service delivery to remote communities, and towards seeking ways of converting some of the non-market values into a form that can capture market income (nature tourism, ‘green’ grazing, marketing of Aboriginal culture and cultural products).

Additionally, it seems clear that there are some structural issues, which underlie the interplay of these viewpoints. Whether recognised by the communities yet or not (and often they are), the following issues will play a major role in the outcomes of any investments:

- There are intrinsic biophysical and socio-economic structural constraints on what options are open to different regions; these need to be understood to allow regional communities to be realistic about what they can control or change.
- There are extrinsic forces at work that also limit options or demand special design consideration; by and large these are common to most regions, like changing international market prices, energy costs and labour costs. However, particular attention must be paid to the net effects of these on terms of trade in remote areas (costs of inputs and costs of transporting outputs), and on investment strategies in affecting these relationships.
- Emerging from the previous point, remote areas have the potential to be on the receiving end of the tendencies towards agglomeration driven by critical mass and economies of scale. Given that globalisation forces are clearly speeding up this effect, investment decisions need to be made in full awareness of the degree to which they may be mitigating (or exaggerating) the rate at which this pressure to agglomerate proceeds, with its attendant implications for ‘fugitive’ capital of all kinds.
- These economic forces are interacting also with ideological and political forces towards decentralisation and local empowerment, with the potential for some serious conundrums in terms of conflicts between economic and social efficiency if the drivers of each are not understood. Understanding the conflict will steer regions away from some sterile lobbying (where economics will eventually crush action) and enable them to focus on capturing opportunities (where real competitive advantages exist).

Any useful integrated framework for understanding regional dynamics therefore needs to be able to encompass these issues in one or more linked conceptual models, which contribute to decision making without being driven solely by one world view which would then be disbelieved or ignored by others in any debates using the model results.

3.4.2 What general approach could encompass the issues?

The problem that emerges from balancing the market and non-market values in a dynamic view of where a region might be headed is not just one of outputs—that is, it is necessary but not sufficient to simply ensure that a triple or integrated bottom line accounting of impacts is included. This is hard enough and has been the subject of a number of other studies aimed at an integrated basket of indicators. The problem is that different actors in the regional community (and outside it) respond differently as a result of their belief systems, so that a dynamic view (which has feedbacks over time) must take some account of this. This general dilemma lay behind numerous specific expressions of the problem in seeking to move towards an integrated approach at the study’s workshop. It leads one directly towards having to reconcile one of the most difficult problems in studying integrated human/environment systems today. This points, naively, towards exhilarating cutting-edge research, appropriate to the TS–CRC’s strategic role; but also more soberly to the need to break it down in to some achievable chunks which can provide useful contributions while the whole is being developed.

An anthropological view on change is at the opposite extreme to the conventional economist. It contrasts the singular differences between individual actors and their changing views over time with a simplistic monolithic
rational economic decision maker. The individualistic actor defies generalisation and prediction, while the monolithic *Homo economicus* obscures differentiated action. Naturally, any realistic approach to regional dynamics must come to some (or several) compromise between these views. Tropical savanna regions challenge the monolithic economist view (challenged today in any case) more than usual because of the highly differentiated non-market economy; while extensions to the classical analysis techniques can help, they are still grounded in incremental changes to market-linked behaviour. At the same time, an extreme anthropological view does not hold out any hope for predictability; given the increasing responsibility being placed on regional groups to envision their own futures, this condemns them to a continued inability to assimilate an understanding of regional dynamics which could contribute to their deliberations. This leaves them subject to the same past dominance by the most effective lobby groups. The insight of the workshop was, of course, to seek a well-structured integration between some level of understanding individual actors which is tailored to savanna conditions, and applying some tried and tested analytical techniques.

The discourse in this scoping study leads to the following propositions, evolved from the discussion at this study’s workshop:

i. **One core element of an integrated model must be population dynamics.** Since this (unlike the needs of economic-only models) is at the core of understanding service needs and social structure. For the savannas, it seems this must be segregated somewhat, minimally to track indigenous and non-indigenous populations separately, and must deal with the spatial demography of the populations, specifically where and why people move around. In a predictive rather than descriptive mode, the question is then what factors drive the intrinsic (births and deaths) and extrinsic (net immigration) parameters of the model, and what are the implications of different resulting populations on the regions’ resources.

ii. **In order to obtain a more integrated view on a region’s resources, some framework is needed to ensure that multiple values are considered.** There is a diversity of alternatives approaches here and we have adopted the five capitals of the sustainable rural livelihoods approach plus institutional processes, mainly as a mnemonic device to ensure we are continually considering a diversity of domains. We acknowledge that some people would add cultural capital, and potentially others, and stress the purpose is to ensure diversity of viewpoints not to constrain content. Ultimately it is necessary to specify more detailed key characteristics that span the range of values anyway (see below).

iii. **Next the diversity of actors must be considered.** The challenge here is to seek a minimum, ‘necessary but sufficient’ set of actor groups for the purpose in hand, recalling the regional scale. This set is to be resolved in terms of syndromes of significantly different impacts on the key characteristics of the region, and responses to changes in those values.

iv. **The next question is how different actors affect the different capitals, and how changes in those capitals feedback on the actions of the actors themselves.** Conventional economic approaches are quite appropriate to analysing how some of the actors operate, and these can be undertaken usefully with some caution in terms of their interactive effects on the other actors. Clearly, though, an additional effort is needed to understand the goals and the actions of other actors, particularly in regard to non-market values. The role of the state in supporting these also needs clarification. In principle, however, we now have a structure for analysing the integrated responses of the region.

v. **We have noted the importance of the agglomerating influences of globalisation in financial and institutional terms, and a specific effort is needed to ensure that these are considered in the analyses referred to under (iv).** Most actors in the regional community (all those directly or indirectly concerned with staying in the region, in fact) will need to understand the implications of any investments in this regard.

vi. **With these concepts in place, we are finally in a position, in principle, to identify a useful set of key socio-economic health indicators for savanna regions.** The variables in the dynamic regional model should be specified as a ‘necessary and sufficient’ set of criteria that determine the responses of the regional population through its various actors and specify any changes in the external environment. Some of them may be of interest to those actors in their role in engaging in decision-making in the region; others may be critical in the processes that lead to the outcomes that they are concerned about. Variables that might actually be measured across a series of regions to determine how the region is travelling would be only the subset that provides critical and non-redundant input to the dynamics. Whether these can be measured directly or must be obtained through indirect measures, this group would then constitute a set of indicators of regional socio-economic health, comparable to the landscape health variables.
measures of the TS–CRC and, like them, encompassing the diversity of values of important to different stakeholders. Figure 3.2 attempts to capture this draft conceptual framework in a single diagram. However, noting the experiences of other studies, this is not to suggest that goal should be to set up one process model to capture all of this. It may be a useful exercise to establish such a framework to help with prioritising the need for knowledge in different components of the framework, but the majority of effort should undoubtedly go into those components of the framework which are most poorly known and yet important. The following sections begin to unpick each step and examine where these critical components may be.

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6 Research work may need to measure more items in order to demonstrate that the intended causal relationship between indicator and underlying variable really exists; this is a separate issue to monitoring progress itself.
4. Economic research elements and their implications

Natalie Stoeckl and Romy Greiner

Much of the current economic research on regional dynamic models is based on the ‘merged’ result of past research in several, relatively distinct sub-branches of economic modelling: those concerned with regional economic issues, those concerned with determinants of economic growth and development and those concerned with the way in which sectors of entire economies operate (macro-economics).

To be more specific, regional economists have, historically, used techniques such as input–output and shift-share analysis to consider links within and between regional economies. These techniques generally require partially aggregated (e.g. all-of-industry output), cross-sectional data (i.e. taken at one point in time) and provide information about the sectoral composition and inter-sectoral linkages of regional economies at one point in time. In contrast, development economists have tended to work with highly aggregated data seeking to determine the way in which different ‘quantities’ of land, labour, technology and capital affect economic growth (by, for example, regressing 100 years of data on gross domestic product against measures of land, labour and capital). Macroeconomists have also generally looked at highly aggregated data; the challenge being to determine how different parts of the system (prices, employment, output) interact with each other, and/or change over the course of five to 10-year periods in response to exogenous ‘shocks’.

Nowadays the sub-branches have much more in common—at least partially because of significant advances in technology, in econometrics/statistics and in economic (and other disciplinary) theory which has facilitated the merging of previously disparate approaches. For instance, one of the first macro-economic models, the Klein model, was developed in the 1950s. It contained 22 structural equations, solved simultaneously (Thomas 1993). Nowadays, macro-economic models contain hundreds—sometimes thousands—of equations, allowing researchers to consider many variables (and their interactions) simultaneously, and across multiple regions. In the 1960s, business cycle researchers could use error correction models to estimate both the short-run and the long-run impact on single variables of ‘shocks’. Nowadays, vector auto regressions allow researchers to estimate both the short-run and long-run relationship between sets of simultaneous equations (a macro economy), generating entire sets of ‘impulse response functions’ (functions which show how a particular variable, say unemployment, responds to a particular ‘shock’, say a fall in business confidence, over the next 10 to 20 years). Researchers who have access to large time—series databases are no longer required to determine a priori whether they wish to focus on the next five years, or the next 20 years—modern econometric modelling approaches allow them to consider both.

Much work has also been done on the way in which expectations (about prices, future incomes, etc.) influence final outcomes, and many techniques for modelling expectations endogenously have been developed. Here too, there has been a merging of approaches, albeit across several disciplines (psychology, economics and econometrics), with some exciting new research on topics like Rational Irrationality (Tirole 2002). Developments in game theory have provided researchers with new ways of considering and modelling interactive outcomes, and techniques such as overlapping generations models have given researchers new methods of considering future generations. Even Chaos theory has been recognised as having an important contribution to make to the regional dynamic modelling literature. The end result, is a collection of sophisticated models that are capable of examining multiple impacts of multiple changes over multiple time-frames in multiple regions using ideas from more than one discipline. Not surprisingly, there is now an extensive body of literature focusing on issues of dynamic modelling. Indeed entire journals are devoted to the topic (the Review of Economic Dynamics, Structural Change and Economic Dynamics; the Journal of Economic Dynamics and Control to name just three).

Importantly, many (but not all) of the economic models are mathematically computable. Complex models require complex mathematics, so over the years it has become the habit of many economists to adopt simplifying assumptions about the value of parameters, the relationship between variables, the relationship between agents, etc. Ideally, these assumptions ensure that the models are analytically and mathematically tractable, but do not ‘distort’ empirically observable behaviour. In most cases, the law of large numbers works to the economists’ favour—extreme observations in some parts of the population being counteracted by extreme observations in another part, with the ‘average’ observation following predictable patterns. However, when working with small samples, as is the case in the savannas, such practices may be difficult to defend. For example, an assumption frequently adopted in economic models is that agents ‘optimise’: businesses are assumed to maximise profits and consumers are assumed to maximise utility. While this makes it relatively

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7 Rasmussen
easy to develop mathematical equations for ‘agents’ within an economic model, the validity of the approach has been questioned (e.g. the work of Herb Simon on ‘satisficing behaviour’ and ‘bounded rationality’).

The most important point to be made here is that the results of dynamic models can be very sensitive to underlying assumptions. If those assumptions do not validly describe the people and the region one wishes to model, then one cannot expect the model to provide practical, useable information to stakeholders, regardless of how sophisticated such models are. Yet this does not mean that economic models have little to offer those in the savannas. Rather, it means that assumptions underlying potential models should be carefully scrutinised. Some models may need to be discarded, some may need to be adjusted before application, and some may be able to be used as is.

Research into the suitability of a range of different models/approaches to the regional dynamics project, may thus have much to offer. This defines the central role of the first part of this section, namely to provide a very general overview of the types of models/approaches that are in use today, and to give readers a feel for the implications/importance of some of the assumptions typically adopted in economic models. More specifically, Section 4.1 gives a broad overview of a range of economic models/approaches that are relevant to the current research. It is not a definitive review and does not seek to give details of techniques or results (that task stands as an important one for future research). Rather it aims to provide readers (generally assumed to be non-economists) with an overall feel for: the breadth and depth of currently available models, the types of assumptions commonly adopted, and the importance/implications of some of those assumptions.

Section 4.2 discusses the relevance of some of the modelling approaches, and their underlying assumptions to the regional dynamic modelling project in the Australian savannas.

4.1 An introduction (for non-economists) to areas of economics that are relevant to regional dynamic modelling

4.1.1 Macro-economic theory and associated models
At the broadest level, macro-economic models can be categorised according to the time period they aim to describe: the short-run (loosely defined as the period of time during which businesses can change some, but not all factors of production); and the long-run (loosely defined as the period of time during which businesses can change all factors of production). In some sense, therefore, one of the first things one should scrutinise when considering macro-economic models are the underlying assumptions regarding production technology.

This issue is important, since production technology describes the relationship between inputs and outputs, allowing one to make predictions about the way in which changes in one market affect other markets. Suppose, for example, that businesses are facing a decrease in the availability of one input. If inputs are used in fixed proportions (the one bicycle frame, two-wheel case of Leontief technologies), and if less of one input is available, then businesses must produce less. However, if inputs can be substituted then businesses may not need to cut production, and instead can use other similar inputs (e.g. different brands of paint).

It is also important to look at underlying assumptions about the overall availability of resources. This issue is important since it determines the way in which different sectors of the economy inter-relate. If, for example, one assumes that there are fixed quantities of inputs available (population, capital, etc.)5, and that all inputs are fully employed (no land, labour or capital lying idle) then, by definition, the expansion of one sector can only occur at the expense of another. If this is not so, then expansion can occur at lesser opportunity cost—until resources are ‘fully employed’.

Finally, it is important to look at the assumptions about market structure, price flexibility, and price expectations. Many short-run macro-economic models assume that prices (both input and output) and price expectations are constant (or ‘sticky’), the argument being that quantity adjusts more readily to changes in demand than does price. If prices cannot change, they cannot act as shock absorbers. Hence, changes to the system (e.g. a fall in demand for a particular product) must be absorbed by changes in quantity (e.g. a fall in the number of people employed to produce the unpopular product). The sticky price assumptions therefore force the models to predict that there will be relatively large quantity responses to exogenous changes.

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8 e.g. Using a Lagragian equation to depict the consumers problem of attempting to maximise utility subject to a budget constraint.
9 As is the case for most short-run macro-economic models.
At the other extreme is the assumption of ‘perfect competition’ in all markets with no ‘market distortions’ (such as taxes, regulations etc.) and perfectly flexible prices (output prices, input prices, interest rates, exchange rates, etc.). If all prices within an economy are perfectly flexible (i.e. can change instantaneously, as needed), then price changes will absorb all shocks to the economy. If, for example, there is an across-the-board increase in demand, there will be an across-the-board increase in prices, and an across-the-board increase in wages and rents. There will not, however, be any change to the aggregate number of goods and services produced (or the number of workers employed)—i.e. the ‘real’ economy will not be affected. Hence, flexible price assumptions almost force the models to predict that there will be relatively large price responses to exogenous changes (with minimal quantity responses).

In the middle of the two extremes are models which allow for imperfect competition in at least some markets, and/or models which allow prices to change—albeit slowly (e.g. one or two periods after the initial shock). The ‘slow’ price-change issue is frequently handled by modelling expectations endogenously (in these models, differences arise via different assumptions regarding how expectations are formed and changed). Models which assume both perfectly flexible prices and rational expectations generally predict that shocks will impact upon prices only. Models which assume perfectly flexible prices and adaptive expectations predict that ‘shocks’ may have an initial impact upon quantity, but that expectations will subsequently change, altering prices, and returning the economy to its original (pre-shock) quantity (albeit at different prices)—the bridge between short-run and long-run models.

Like the short-run macro-economic models, when working with long-run models it is important to consider whether the underlying assumptions regarding production technologies, the availability of resources, market structure, price and wage flexibility, and expectations are valid. In most cases, long-run models allow for more price/wage flexibility than short-run models, stickiness only persisting in the presence of irremovable structural, institutional or market distortions. Like the short run models, stickiness implies that the real economy will feel shocks for longer than it would if all prices were perfectly flexible.

Some long-run macro-economic models are, in essence, collections of equations describing different sectors of an economy, which are solved simultaneously. In many cases, the simultaneous solutions assume that all prices in all markets have adjusted to ensure that all markets clear (hence the term ‘general equilibrium’ models). As at September 2000, there were four CGE models of the Australian economy, two of which make simplifying assumptions about exchange rates and international flows of goods and assets but report results for different regions in Australia, and two of which are models of the entire world economy with all of Australia’s data aggregated. (Pezzey & Lambie 2001).

Methodologically, CGE/AGE models are based on a more restrictive set of assumptions than input–output models (discussed in Section 4.1.3), in that they typically assume optimising behaviour and that the economy is at equilibrium. They require an IO model of sectoral interdependency as part of their theoretical core and to make them operational. “Most CBE analyses have a thin empirical base, and modellers are forced to make heroic assumptions regarding trans-boundary flows, production structure, and household behaviour” (Rose 1995:301).

Most important here, is the concept of ‘general equilibrium’: a state in which all markets clear (first postulated by Walras in the 1930s). It is an extremely important idea, the acceptance of which necessitates the acceptance of many other ‘sub-assumptions’ about the way in which markets within the economy operate:

According to Walras’s law, excess demands in some markets must be matched by excess supplies in other markets so that prices rise and fall in each type of market in order to move it towards market-clearing equilibrium. The (Walrasian) auctioneer keeps on trying different sets of relative prices in this way until he finds one set at which all markets are cleared. It is only then that trading actually occurs. The process by which the auctioneer gropes towards the equilibrium set of prices and quantities is known as tatonnement (or groping). In the Walrasian system trade only occurs when prices are at their market-clearing values.

Leveric and Rebman (1988: 297)

Historically, general equilibrium models were thus unable to deal with ‘non-market clearing equilibriums”—situations like that of the Great Depression where unemployment persisted for many years. As noted by Pezzey and Lambie (2001:2), however, “the boundary between CGE and macro-economic models is not rigid. Nowadays, computable general equilibrium models can, in practice, have non-equilibrium features (such as involuntary unemployment)”. In the past, general equilibrium models provided useful information about long-run equilibriums, but were unable to provide much information about short-run adjustment processes. Yet,

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10 ‘Shocks’ are partially absorbed by changes in price, and partially absorbed by changes in quantity.
when combined with other techniques, the models can do both: technological, statistical/econometric and theoretical advances have enabled researchers to develop sophisticated general equilibrium models capable of modelling short-run and long effects of multiple changes across multiple sectors using a variety of different ‘internal’ assumptions about prices, production technologies, etc. (Rose 1995).

For example, Pakko (2002) uses a general equilibrium framework that incorporates stochastic technology trends to look at transition paths (from one, long-run equilibrium to another) following changes in technology. Maffezzoli (2001) uses a stochastic version of a dynamic general equilibrium model, to consider impulse response functions in Italy and in the United States (referring to the approach as one which incorporates non-Walrasian features). Beaudry and Green (2002) present a mathematical (rather than computable) general equilibrium model, the aim of which is to explore links between population growth, the price of technology, and employment; and Giesecke (2000) uses a CGE model to investigate why the Tasmanian economy was growing slower than the rest of the Australian economy.

4.1.2 Growth theory and associated models

In the past, growth models all but ignored short to medium-term fluctuations (e.g. recessions and booms), instead concentrating on determinants of (very) long-run economic growth. These models often focus on issues like population, capital accumulation and technological change, examining how changes in such inputs affect economic growth. Some also explicitly model/consider globalisation, trade and trade barriers, changes to human capital, natural capital, etc. Johnson and Lenartowicz (1998), for example, ask the question: “Do cultural values explain economic growth?”

Using data from the ‘index of economic freedom’, and two different measures of national culture, they compare economic growth across 38 countries, finding statistical evidence to suggest that culture does matter. Findings such as this could be very important to savannas where ‘culture’ is somewhat different to that of more urban environments (not just due to indigenous/non-indigenous differences but also because of differences between rural and urban cultures).

The older, neoclassical growth models, like that developed by Solow in the 1950s/1960s, typically assumed that the long-run growth rate was determined exogenously (by the rate of technological advancement); economic policy was considered irrelevant (Mattalia 2000). Such an approach is, by and large, simply another version of the short-run/long-run distinctions often made in macro-economics (i.e. that many shocks to the economy have only a short-run impact once prices, and expectations have adapted, the real economy will return to its ‘natural’ state, or growth path).

More recently, however, neoclassical growth models have been challenged by Endogenous Growth Theory. It has been shown, for example, that permanent changes in capital (Romer 1986), human capital (Lucas 1988), and in economic policy (Barro 1990, Rebelo 1991) can have a permanent effect on the rate of economic growth. If true, this implies that it is no longer enough to simply examine steady-state equilibria—researchers working in this area need to use tools like those of transition dynamics to explore ‘transition paths’ from one growth path to another. Again, technological, statistical and theoretical advances have allowed for the merging of disparate approaches (short-run, long-run and very long-run).

Examples of merged approaches to investigations into determinants of economic growth are numerous. Hugget (2003), for example, develops a theoretical model of monotone comparative dynamics, identifying conditions that are necessary and sufficient for determining whether an increase in a parameter (say, the discount rate) will generate a permanent increase in future dynamics (e.g. increase the capital stock for all future periods). Mateos-Planas (2002) uses a neoclassical growth model with dynastic preferences, but with endogenous fertility to examine the link between mortality changes, technological progress, and the evolution of the cost of children. Hendricks (2001) urges the use of overlapping generations’ models (as is done in Rasmussen 2003), and Bellettini and Ceron (1999) use a game-theoretic approach in an overlapping generations model with endogenous growth to investigate the joint determination of social security, public investment and growth. It has also been noted (Ghiglino 2002) that growth rates are affected by the accumulation of capital, and the accumulation of knowledge—both of which are affected by a variety of factors including the costs and benefits of innovation, discount rates, uncertainty, attitudes toward uncertainty, development of financial and insurance markets and socio-economic conditions, etc. That the factors are so interwoven, and complex, means that endogenous growth theorists may need to use general equilibrium models—despite the fact that “The complete integration of endogenous growth theory into general equilibrium theory is a daunting task” (Ghiglino: 2).

4.1.3 Regional (or ‘geographical’) economics and associated models

Regional economics tends to focus on the importance of space. Rather than looking at the way in which economies change over time (as per the macro-economists and development economists), this branch of economics has, traditionally, examined the way in which economies differ across space and across sectors.
Input–output analysis is, perhaps, the most well known tool of regional economists. First used in the former USSR, it allowed analysts to examine industry links within an economy. To manufacture seven million pairs of brown leather shoes, for example, one needs leather, glue and rubber. To manufacture leather, one needs hides and chemicals. To manufacture hides, one needs cattle and fodder. If one collects such data for all final goods and services (or outputs) within a regional economy, one can construct a transactions table which describes how much of each type of input (or input category) is used in the production of each type of output (or output category). As a descriptive technique it has much to offer. To use it as a predictive model, however, requires one to adopt several assumptions—that inputs are used in fixed proportions, that neither technology nor the structure of the economy will change over time, and that the input-output model describes a general equilibrium (to name a few). In some cases (as when one is making predictions about the impact of marginal changes), such assumptions are justifiable. In other cases they are not and, of late, traditional IO analysis has been all but discarded from mainstream economics (for example, Glaeser 1998; Hawdon & Pearson 1995; and Wang 2001).

This is not to say that the methodology is of no use to those interested in regional dynamic modelling. The traditional approach to IO analysis has been adapted to allow for dynamic relationships (Leontief & Duchin 1986; Robinson & Duffy-Deno 1996). It has also been adapted to allow for non-linear relationships between inputs and outputs (Wang 2001), and to allow for economy–environment interactions (Cumberland 1966; Huang et al. 1994; Hawdon & Pearson 1995; Gustavson et al. 1999; Eder & Narodoslawsky 1999). Liew (2000) describes a dynamic version of the ‘original’ Leontief input-output model. Rather than using Leontief production technology, it uses Cobb-Douglas production functions, thereby allowing for input substitutability. It also allows for dependence between price and output (including prices in the technical coefficients); and for the dynamic effects of factor adjustments that incorporate inter-regional migration. The model allows one to consider both short-run and long-run multipliers (although Liew notes that the model could be improved by relaxing some of the assumptions about the production technology and/or resource abundance and by including a spatial dimension). In some sense, therefore, the dynamic variable IO model is but one version of a computable general equilibrium model—yet another example of the merging of disparate, yet compatible approaches.

Regional economists have also developed techniques such as structural decomposition analysis, multi-sectoral qualitative analysis and shift-share analysis to understand underlying factors that influence the physical flows and the geographic dispersion of economic activity (Hoekstra & Van Den Bergh 2002; Knudsen 2000; Roberts & Stimson 1998). A sophisticated example of this is given by Murata (2003) who considers determinants of the geographic distribution of economic activities, noting the importance of both market and non-market factors (e.g. quality of life, weather, etc.). He develops a model that looks at forces of agglomeration (rising population leading to increased product variety, lower prices and higher wages) and forces of dispersion (taste heterogeneity), arguing that the equilibrium geographic dispersion will depend on size of agglomeration forces relative to taste heterogeneity.

Rather than looking at the physical distribution of economic activity, Abraham (1996) uses a multi-region, multi-sector Dixit-Stiglitz model to investigate regional wage and employment determination across Europe, while Partridge and Rickman (2002) use structural VARs to investigate the relative importance of labour demand versus migration to regional labour markets. Both of these investigations are essentially macro-economic investigations of regional economies. The main point here, again, is that much of the recent work of regional economists employs techniques, approaches and theoretical ideas developed in other sub-fields.

In 1991 Paul Krugman published a short text and series of articles on what he termed ‘geographical economics’. In his own words, the point of these incursions was to prove first that “space matters” to the study of economic activity (Krugman 1991: 8) and second that “it is now time to attempt to incorporate insights of the long but informal tradition in this area into formal models” (Krugman 1999: 484)\(^1\).

4.1.4 Emerging approaches to modelling regional dynamics: those using significant contributions from other disciplines

As is evident from the foregoing discussion, much of the recent research on modelling regional dynamics combines theory, modelling approaches, and ‘solvers’ from disciplinary branches which were, in the past, quite separate. But the merging of approaches has not simply been within the economics discipline. Many recent innovations have developed from ideas that were, historically, in the realm of other disciplines.

Nijkamp and Reggiani (1995), for example, list several broad research areas where Chaos Theory has been incorporated into economics. They specifically review much of the regional science literature, investigating the

\(^1\) As reported in Olsen (2002)
relevance of Chaos Theory for spatial economics. Not surprisingly, leaders in this area of research are frequently found at the Sante Fe Institute (one of the founding institutions of Chaos Theory). Sometimes termed ‘evolutionary dynamics’, much of this research combines insights from ecology, chaos, psychology, econometrics, growth theory, business cycles, the theory of structural change and game theory into dynamic models that can deal with problems of ‘bounded rationality’, endogeneity, transition paths, etc. (for example, Ponti 2000; Darley & Kauffman 1996; Arthur et al. 1996; and Forst et al. 1995).

Janssen and Vries (1998) used both simulations and optimisation for a multi-agent model with adaptive responses to climate change. The models were run in parallel – passing information back and forward interactively with each model ‘building’ upon output from the other. Other innovative approaches to modelling regional dynamics use ‘systems dynamics’ (time-step simulations) with multiple modules allowing both within-module and across-module interactions. The journal *Ecological Modelling* presented a special section on modelling ecological and economic systems with STELLA, a time–step simulator with modules for the economy and the environment (Costanza & Gottlieb 1998; Woodwell 1998; and Grasso 1998). “Because of the ease with which [STELLA] can be modified and run, the model is especially useful for testing assumptions about the connections. It can also be used to show how models of this type are sensitive to changes in parameters and specification, especially in the case of the technology term” (Costanza & Gottlieb 1998: 232).

In Australia, Queensland’s Department of Natural Resources & Mines, Department of Primary Industries, and CSIRO have developed an Agricultural Production Systems Simulator (APSIM) along similar lines (multiple, complex modules, which interact—or share variables—at the end of each simulated time–step). In other parts of the world, Perez-Trego et al. (1993) suggest a modularised spatial dynamic modelling framework (there are rural and urban modules across the agricultural, industrial and service sectors for demand, incomes, population movements and the environment). Guo et al. (2001) use eight different sub-systems (modules) in a time–step simulation that include population, agriculture, industry, tourism, water resources, pollution control for water quality and forests. Costanza et al. (1990) modelled sustainable development at the regional scale using a set of system dynamics modules that were interconnected to a geographical information and Hall et al. (2000) did likewise in their Costa Rican study. “The integration of spatio-temporal processes by interfacing dynamic modelling with GIS represents the cutting edge of modelling” (Moffatt & Hanley 2001:546).

### 4.1.5 Valuing non-priced ‘goods’

Some computable economic models require one to be able to identify, include, and measure (in common units, preferably dollars) all important elements of the model. If interested in considering environmental issues, this may require one to place dollar denominated estimates on the value of typically non-priced goods.

Typically, the environment is not traded in the market place. Hence, it does not usually command a ‘price’, a characteristic that is occasionally interpreted as indicating that environmental services have no market value. Yet economists have long known that value is not synonymous with price—hence the importance of concepts like ‘consumer surplus’ (the benefit a consumer derives from the consumption of a good), ‘producer surplus’ (the benefit a producer derives from producing a good), ‘net social benefits’ (the sum of consumer and producer surplus) and ‘allocative efficiency’ (the quantity of goods and services which maximises net benefits).

Economists have also long acknowledged that the environment generates economic benefits. Although exact classifications vary, these benefits are often divided into the broad categories of ‘use’ and ‘non-use’ benefits as shown in Figure 4.1. ‘Use’ benefits are those that are derived from direct use of the environment. Examples of these include the benefits of recreation and tourism, the value of goods produced, the value of maintaining and/or improving environmental quality, the value of biodiversity, educational and research values. Non-use benefits are those that are derived from the environment without actually using it. Examples of these include the benefit of preserving the environment for future use (the option value), the satisfaction derived from being able to pass the area on to other generations (the bequest value) and the benefit of simply ‘knowing that the area is there’, even if there is no intention of ever using it (the existence value).
Over the years, many methods of quantifying the benefits (in monetary terms) have been developed and tested. Gregerson et al. (1987, pp. 60–61) tabulate the most common valuation methods, dividing them into three categories as follows:

1. **Valuation techniques using market prices** (including changes in the value of output, loss of earnings, preventive expenditure, replacement cost and cost effectiveness analysis)

2. **Valuation techniques using surrogate market prices** (including property or land value approach; travel cost approach, wage differential approach, acceptance of compensation)

3. **Hypothetical valuation methods** (including direct questioning of willingness to pay—or willingness to accept compensation—and trade-off games).

The final set of methods, which uses hypothetical valuations, is theoretically capable of measuring either a subset, or the entire economic value of environmental goods and services—depending upon the way in which the hypothetical market is constructed. In contrast, the first group of methods essentially relies on comparing the market value of items that are associated with the environment before and after a change in its state. They therefore measure only a subset of total value—typically different ‘use values’. Instead of using actual market prices (or costs) the second set of methods estimates inferred prices through actual market behaviour. As per the previous set of methods, these also estimate only a portion of total value.

Some valuation techniques are more robust than others. The more robust techniques are frequently those which measure only a subset of economic value. All techniques have their limitations. The choice of evaluation technique, therefore, needs to be based, inter alia, on the question to be answered and the data that are available.

In many cases, choice of valuation technique is limited by lack of knowledge/data. Suppose, for example, that one wished to ‘value’ the damage currently occurring on the Great Barrier Reef, that results from excessive fertiliser use on adjacent agricultural land. If one wanted to use valuation method 1(a)—that which considers changes in the value of output (say, tourism revenues) that would result from changes in management (say, increased fertiliser use)—then one would need to establish that:

\[
\begin{align*}
&'x' \text{ amounts of nitrogen are associated with reefs of quality } 'x_a', \text{ and tourism revenues of } 'x_b', \\
&\text{and} \\
&'y' \text{ amounts of nitrogen are associated with reefs of quality } 'y_a' \text{ and tourism revenues of } 'y_b'.
\end{align*}
\]

If one could not estimate the nitrogen/reef quality relationship and/or the reef quality/tourism revenue relationship, then one could not use that method for this particular problem.

Importantly, it is not always necessary to estimate the total value of a landscape or a region to make good management decisions. If, for example, one can establish that the net present value of a mine is $24 million,
and that the recreation use value of the area which would be destroyed by the mine is $30 million, then one
need not complicate the issue by attempting to estimate total economic value. Total economic value is greater
than or equal to recreation use value, and must, therefore, be greater than or equal to the value of the mine.
Similarly, some management and development recommendations can be drawn from price elasticities (the
sensitivity of demand to changes in price) and many valuation techniques are good at estimating those.

In summary, techniques for estimating the economic value of environmental goods and services are far from
perfect. Yet that does not mean that they have nothing to offer. Most can do a reasonable job of estimating price
elasticities (the sensitivity of demand to changes in price), and many are good at estimating a subset of total
economic value (if not the entire economic value). In the tropical savannas, this leaves several avenues for
further research:

i. Look at ways of improving existing valuation techniques. One particularly problematic issue is that of
the value that indigenous peoples place on the environment. In theory, a properly constructed
contingent valuation study could elicit information about this, but particular care must be taken when
dealing with the problem of willingness to pay (WTP) or willingness to accept compensation (WTA)
for changes to the environment. These are inextricably linked to the ability to pay, and acceptance of
these (or any current price for that matter) implies acceptance of the current income distribution as
‘optimal’.

ii. Look at developing new ways of valuing environmental services in the savannas.

iii. Look at ways of using existing techniques more imaginatively. An economically optimal world
requires that the marginal value of each and every commodity is set equal to its marginal cost. If the
condition does not hold in all cases, then one must look to the theory of second best. In tropical
savannas market distortions are the norm, rather than the exception (thin markets and the tyranny of
distance are such that even ‘normal’ markets cannot operate effectively). Hence, one must analyse all
in a ‘second-best’ world. Rather than deciding what is optimal and working towards it, this approach
often requires one to consider the impact of changes to the current situation, selecting that which is
most likely to improve existing conditions. This may not require a complete valuation in all instances,
as per the preceding mining example. In other words, several of the existing valuation techniques
could be used, each providing different ‘bits’ of information for use in different situations.

Crucially, the regional dynamic modelling project will not necessarily need to value all (or any?) of the non-
priced goods in the tropical savannas to generate quality information for management. It depends on the
information requirements of the chosen regional dynamic model. Before spending too much time on any of the
points above it is, therefore, essential to consider the dynamic modelling aspect of the project.

4.2 Regional dynamic modelling: the savanna challenge

As evidenced by the foregoing discussion, there is an extensive body of research focusing on issues of dynamic
modelling. Development of new methods to predict regional dynamics in the Savannas is clearly inappropriate
if we can use and/or adapt one or more of the many methods that are currently available. Before doing so,
however, it is important to assess whether such methods or models are suitable in this context. While such an
assessment is beyond the scope of this study, it would provide invaluable information to those looking to
develop a fully integrated model in the Australian tropical savannas.

First, it is important to consider the outputs, timeframe and scale of a model. What information, provided over
which time frame at what regional scale is most useful to stakeholders? Which models are capable of providing
that?

Second, one needs to consider data requirements. What data do the models require? Is that data available, at an
appropriate temporal and regional scale? If not, is it feasible to collect such data? As noted in Section 2, data—
like population—is relatively sparse in the Australian savannas. Where data is available, there are significant
spatial and temporal inconsistencies, largely because the data is collected by different agencies, at different
times.

Third, one must carefully scrutinise assumptions underlying the models. This is because output/results of
dynamic models are generally very sensitive to underlying assumptions—assumptions about the value of
parameters, the relationship between variables, the relationship between agents, etc. If those assumptions do not
validly describe the region one wishes to model, then one cannot expect the model to provide practical, useable
information to stakeholders. Specific examples of assumptions that need to be scrutinised include:
i. Behavioural assumptions. Does the model require ‘rationality’? Are agents assumed to ‘optimise’? What goals are agents assumed to have? What assumptions are made about the way in which expectations are formed, and how are these integrated into the model?

ii. The law of large numbers does not apply in the Australian savannas. Hence one cannot assume that ‘unusual’ behaviour at one end of the spectrum will be balanced (empirically) by unusual behaviour at the other. Similarly, many of the goals traditionally used in economic models (such as that of profit maximisation) may not apply to those living in Australia’s savannas (particularly in indigenous communities).

iii. Assumptions about inputs into the production process (factors). Does the model assume that all factors of production are fully utilised or does some form of un(der) employment exist? Does the model assume that changes in the availability of factors of production (e.g. population growth rates, the accumulation of physical, institutional, social and/or human capital, etc.), is exogenously given, or determined endogenously.

iv. The relatively low labour force participation rates that are evident in the savannas (Figure 2.22 Labour force participation rate based on the 1996 Census (calculated from total number of people answering the employment question)), indicate that at least one factor of production (labour) is not fully employed. This may not be a problem, but one should, at the very least, determine whether failure to meet such assumptions affects the accuracy of the model’s predictions.

v. Similarly, migration patterns in the savannas (and in other rural areas throughout Australia) suggest that population is not exogenously determined. Population contributes to economic growth, but economic growth influences migration, which in turn influences population. It is therefore, important to, at the very least, note, and consider each models assumptions vis-à-vis the interactions between changes in the factors of production and changes in the final output.

vi. Assumptions about production technology. What assumptions are made about the way in which various inputs (including physical, human, social, institutional, environmental, etc.) combine to make various outputs? How are these assumed to change over time?

vii. The savannas are characterised by remoteness. Hence transport—or inputs and/or outputs—is a more significant factor of production in the savannas than in other, less remote, areas. Further, many traditional industries in the savannas, have strong links with the natural resource base (pastoralism, mining, tourism, fishing, etc.) in contrast to other areas with more manufacturing, property services, etc. It may not, therefore, be appropriate to simply transfer ‘stylised’, aggregate, models of production from an urban area to the savannas—adjustments may be necessary.

viii. Assumptions about market structure (e.g. whether they are perfectly competitive, monopoly, or somewhere in between).

ix. Small, rural towns often have just one store, one service station, etc. Those wishing to shop elsewhere must travel hundreds of kilometres to do so. Hence, at least some local markets are best characterised as a (near) monopoly. In contrast, much of what is produced in the savannas (beef, minerals, tourism, etc.) is sold on the world market where ‘perfectly competitive’ models apply. That there is such diversity of market structure within such (economically) ‘small’ regions may pose some modelling challenges.

x. Assumptions about market distortions (e.g. taxes, regulations, externalities, etc).

xi. Perhaps one of the most important market distortions in the Australian savannas is that of externalities. Few market interactions occur in that area without having some side-effect on the environment, or the community. It is, therefore, important to ensure that the models are able to handle such distortions (even if they are dealt with externally, e.g. via a different, parallel, module). Related to this are issues of valuation; some economic models require one to consider non-market goods in dollar terms. But it may not be necessary to do so. Rather, it may be possible (and even more appropriate) to explicitly allow for such goods in a separate, parallel module (as above). Either way, such possibilities need to be explored.

Finally—and perhaps most importantly—one needs to consider whether existing models are amenable to integration with other disciplinary perspectives. Those which can only consider economic issues may provide valuable insights into methods of handling regional dynamics, but by themselves, are clearly unsuitable to the goal of developing an integrative model.
5. Review of regional modelling and monitoring approaches

Yiheyis Maru

5.1 Introduction

This review progressed iteratively, starting with searches for integrated regional modelling frameworks, models and sustainable indicators relevant to monitoring in the tropical savannas. The initial review helped in tuning the workshop and provided background information on various integrated modelling and indicator development frameworks. Three areas of modelling emerged through examination of literature on sustainable livelihoods. These are:

- Capital-based regional dynamics modelling,
- Multi-actor based modelling, and
- Detailed livelihood activities (socio-economic and demographic) modelling.

In turn, the workshop then provided direction for a further review of the literature which is detailed in this chapter. The chapter has six sections, the first of which covers approaches and metaphors to regional dynamics. The second section deals with trans-dimensional modelling and monitoring frameworks. The third covers the use of a sustainable livelihood approach to provide a framework of choices for modelling and monitoring regional health in tropical savannas. The fourth section presents selection criteria and an initial compilation of indicators for regional health monitoring. In the fifth section a conclusion is presented.

5.2 Approaches and metaphors to regional dynamics

In our review we found at least four broad approaches relevant to the dynamics in the Australian north. These approaches are occupancy transition, adaptive cycle, core–periphery tension and the metaphor of savanna health.

5.2.1 Regional dynamics in terms of occupancy transitions

Holmes (2002) claims that there is an extensive transition from production-based to amenity-based land use and occupancy. It varies from one region to another and is more prominent in the most marginal lands where post-productivist rural occupancy for multiple use is displacing a “flimsy mode of pastoral occupation” to where pastoralism still dominates. Holmes has produced a map of commodity-oriented regions and emerging amenity oriented regions.

Holmes (2002) notes three interdependent drivers of the transition in the rangelands. These drivers are failures in achieving productivist goals, the emergence of amenity-oriented uses, and changing societal values concerning the preservation of biodiversity, scenery, and Aboriginal land rights.

Holmes (2002) also recognises a growing identification and accumulation of potential for a new phase of exploitation that facilitates the transition from commodity-based productivist occupancy to amenity-based post-productivist occupancy. The post-productivist occupancy displays multi-functional use (indigenous occupancy, tourism and conservation). Although diminishing in overall hegemony in some parts of the rangelands, productivist rural occupancy is slowly refashioning itself through intensification, perhaps by adjusting to growing demands for clean and green products.

Holmes (2002) identifies two structural problems. The first is fugitive income, the transfer of income from the peripheries to the centres, which both types of rural occupancy face. The second problem is what he calls the “more value and less cash” nature of the emerging amenities of post-productivist occupancy of the rangelands.

5.2.2 Regional dynamics in terms of adaptive cycle

The release of resources previously used for pastoralism and subsequent revaluation for multiple uses captured in the occupancy transition, seems to reflect phases of the adaptive cycle of the theory of change (Gunderson & Holling 2002).
The adaptive cycle is a heuristic theory of change that views ecosystems as passing through stages of growth (exploitation), maturation (conservation), death (release) and birth (renewal). This theory of change is expanded to account for changes in economic and social systems (Holling et al. 2002a; Holling et al. 2002b; Westley et al. 2002) or linked social-economic-ecological systems such as the rangelands (Walker & Abel 2002).

The theory identifies three limiting factors that shape the adaptive change of a system. These are the potential (capital) of the system that limits possible options; the connectedness of the system, that is, the degree of flexibility in its internal controls and processes; and resilience—a measure of the system’s capacity to buffer disturbance without flipping into another state.

A complex adaptive system such as a tropical savanna region, nests subsystems with each undergoing adaptive changes at different temporal and spatial scales. The larger and slower levels constrain the behaviour of the smaller and faster levels. However, Holling et al. (2002) also proposed that at the transition from growth to collapse and from reorganisation to rapid growth, the large and slow entities become sensitive to changes from the small and fast ones.

Systems shift when external conditions change sufficiently so as to pervade the system’s internal flexibility and resilience or when capital accumulation exceeds a critical threshold, making the system rigid and vulnerable.

Holling and Gunderson (2002) conclude that the tropical savannas currently tend to stay in the renewal and exploitation phases of the adaptive cycle. In both phases, potential (nutrient and biomass) accumulation is low and connectivity of internal controlling variables is very low. This exposes systems to the control of external variables. In contrast resilience is high. But they also add that this cycle of continual adaptation to external variability in the savannas can collapse due to human over-use and misuse (e.g. continued overgrazing) resulting in a more impoverished state with lower capital, connectedness and resilience which in turn creates an ecological ‘poverty trap’.

Walker and Abel (2002) found the adaptive cycle a useful approach for exploring the dynamics in Australian rangelands and tropical savannas. However, they noted the following:

- Significant aspects of the changes would be irreversible, setting the system in a spiral of progression instead of cyclical recurrence of states.
- Resilience of the semi-arid savannas was at its maximum somewhere in between fast growth and maturation phases instead of its exploitative phase.
- Regions were at different stages of the adaptive cycle. For instance, the cattle industry of the Northern Territory was in a phase with low connectivity and hence high flexibility, while the New South Wales rangelands had accumulated rigidity in their social structures and are expected to experience significant changes in institutions and policies.

Abel (1999) proposed that it is an opportune time to leverage for desired changes because “rigidity is causing structural cracks” in the rangeland systems.

### 5.2.3 Regional dynamics from the perspective of core-periphery tension

From political ecology these structural problems which play significant role in regional dynamics are cast in a broader core-periphery power relationship. Peterson (2000) argues for political ecology as a powerful approach in understanding coupled dynamic of human–ecological systems. However, Peterson warns against framing the core–periphery tension only in terms of political and socio-economic dynamics. He adds there is a need to consider an ecosystem as an active agent in explaining ecological dynamics that can influence the type and extent of conflict over ecological resources and services.

The core–periphery tension is the result of the net resource flow to the centre of economic and political activities. M’Gonigle (1999) raises an issue with centralising tendency of both the market and the state in decision making and resource flows and up the socio-economic hierarchy. He asserts that this centralising tendency erodes the self-maintaining physical environment in the peripheries together with the complex communities that have long stewarded these environments. He then questions the reliance on these agglomerating institutions for the interest of the periphery and the promotion of non-market values. This approach to regional dynamics basically challenges neoclassical economic assumptions of the neutral market mechanisms and resource management assumptions of efficiency of centrally directed regulation.

Advances in political ecological economy also challenge related assumptions based on emerging empirical findings from studies of common pool resources. According to Ostrom (1999) the basic assumptions are: (a) resource users are competitive norm-free maximisers of immediate gains and (b) designing rules to change the
Review of regional modelling and monitoring approaches

incentives of participants is simple, requiring central direction. These assumptions often underpin simple policy
prescriptions by distantly located policy makers to resolve tragedies of the commons. One set of findings is that
resource users do cooperate to overcome the challenges and problems they face. Another set of findings is that
government agencies are rarely successful in designing simple but effective instruments that regulate common
pool resources. Based on these findings Ostrom (1999) calls for an alternative political context that promotes
the evolution of a polycentric governance system based on cooperation and recognition of the complexity of
effective rule making.

If this alternative solution works it can be a formidable countervailing force to the centring effect of market and
government instruments. This less hierarchical polycentric organisational and institutional arrangement could
provide effective sanctioning of rules, with substantial cost saving and a more flexible response to the
management needs of complex dynamic ecosystems. Subsidiarity shifts responsibility and rights from
centralised bureaucracy to those who have the most interest in an efficient outcome as major players in the
design of the rules. If this was to be administered from one centre and from a distance, the benefit of free riding
may be high and the cost of doing so low (fine in a court versus punishment by a community) and the chances
of being detected low (Ostrom 1999; Swift 1996; Johnson 1997). Subsidiarity internalises and hence reduces
transaction costs which otherwise are very high because of the great variability and unpredictability in the
tropical savannas.

This may in turn encourage local wealth generation and autonomous decision making that have contextual
relevance. At a global scale several authors have recommended similar strategies for income re-circulation to
generate small-scale economic synergy (Chambers & Conway 1992), subsidiarity to devolve institutional
development and administration to the lowest level of organisation consistent with assuring accountability and
effectiveness (Swift 1996; Chambers 1993; Thompson & Scoones 1994).

5.2.4 Health metaphors and modelling

The purpose of the Regional Dynamics Scoping Study is to develop integrated modelling frameworks for
understanding how regions in the tropical savannas are likely to evolve. This objective of integrated modelling
as further specified in the workshop is to monitor the health of tropical savanna regions. There are already well-
developed frameworks for monitoring regional ecosystem (biophysical) health. As a counterpart, the focus of
this study is to develop an integrated framework for modelling and monitoring the health the socio-economic
system.

**Healthy regions**

Health is considered as metaphorical reference for monitoring ecosystem dynamics and social system
development (Whitehead et al. 2000). In their review of the literature, Costanza (1992) noted that ecosystem
health is defined as homeostasis, absence of disease, as stability or resilience, as vigour or scope for growth and
as balance between system components. He described a healthy ecosystem as one with its inherent potential
realised, its conditions stable, its capacity for self-repair preserved, and minimal external support for
management needed. He then proposed vigour, organisation and resilience as excellent measures of ecosystem
health. Vigour is a measure of a system’s activity, metabolism or production. Organisation is a measure of the
number and diversity of interactions between system components, and resilience refers to the system’s ability to
maintain its structure and function in the presence of stress.

Bossel (1998) equates a system’s viability (sustainability) to its health. He defines health in terms of a system’s
ability to satisfy its basic needs continually. Both social systems and ecosystems share the same fundamental
needs identified as basic orientors for viability or health (Bossel 1999). He also identified some needs specific
to humans including psychological needs because they are sentient beings and ethical reference because they
are conscious beings capable of reflexivity. However, to attain health in a social system the requirements of an
ecosystem has also to be considered because the latter plays a vital role in the health of the former (Bradley
1994).

**Pathology of regions**

The syndrome concept is another health-related metaphor, and is prominent in modelling and monitoring
dynamics of the interactions in human–natural systems. This approach focuses on human–natural system
interactions because the dynamics of the latter is not independent of the former (Potsdam Institute for Climate

The rationale of the approach is that there are series of signs or multiple parallel symptoms that characterise a
key pattern of harmful human–environment interactions (Petschel-Held et al. 1999; Ludeke & Petschel-Held
Multiple indicators are required to identify conditions under which the syndrome specific mechanisms may become active. The diagnosis of a syndrome should be based on a convergence of evidence from different indicators (Lambin et al. 2002) and the prognosis by modelling the dynamic evolution of the syndrome’s specific mechanisms (Luecke & Petschel-Held 1997; Petschel-Held et al. 1999).

The syndrome metaphor can be helpful for diagnosing regional ill-health which manifests itself in multiple domains. Any specific syndrome relevant to a region in the tropical savannas may also correspond to unfavourable shifts in an adaptive cycle. Gunderson, et al. (1995) have identified general regional development and resource management pathology which can be described as a syndrome. They claim that this syndrome follows a general pattern of initially successful management policy or development that leads to complacent, rigid and myopic agencies, increasingly dependent economic activities, more fragile ecosystems and a public which distrusts its governance.

Still another health metaphor is the search for an analogy between a managed ecological system and an immune system (Janssen 2001, 2002; Allen 2001; Walker 2001). This approach studies whether there are analogous disease prevention processes such as invasion detection, response, memory and maintenance in managed ecological systems.

Health metaphors can help us monitor and model the dynamics of socio-economic systems in terms of essential properties similar to features of the human body. However, we also need to consider the essential differences. Ignoring the differences can lead to harmful oversights, while carefully studying them can provide useful insights. Considering people as if they are machines, and the social system as if it is a biological system, are familiar overstretched metaphors that have been harmful (Ackoff 1991; Ulrich 1983).

As Whitehead et al. (2000) noted, the strong appeal for health metaphors lies in our “experience of the benefit of preventing and curing the causes of ill-health.” However, we must explore the differences to gain insight into the needs of a socio-economic system in the savannas to maintain health or to understand what it means to have a healthy socio-economic system. A simple observation of the differences is that while the influence of external temperature is regulated by tight internal controls in the body, similar attempts at control in a socio-economic system could be extremely costly and may not be a sign of health.

Another point on the medical metaphors is choice. Monitoring illness is not exactly the same as monitoring wellness in terms of its implication for action, raising the question of priority given to prevention or treatment. Although both prevention and treatment are interlinked and essential, emphasis on ill-health may focus the attention of monitoring on failure instead of success. Self-referentiality of systems including systems of monitoring has been amply recorded (Ulrich 1983; Davis 1996; Ackoff & Pordenhand 2001; Bell & Rose 1999). Attention to syndromes may favour the construction of syndromes. A focus for pathology in monitoring may lead to handling the socio-economic system of a region as a passive patient for diagnosis.

5.3 Monitoring and modelling frameworks

5.3.1 One-dimensional or inter-dimensional frameworks

There are several monitoring frameworks such as the quality of life (Nussbaum & Sen 1993; Maxneef 1991; Rawls 1971); Human Development Index (UNDP 1991); Genuine Saving (Pearce & Atkinson 1993). Genuine Progress Indicator (GPI) (Cobb et al. 1995; Daly & Cobb 1989; Hamilton 1999); Pressure-State-Impact-Response (PSIR) (OECD 1994; Lowe 1996); and Driving Force State Response for monitoring sustainable development (DSR) (Mortensen 1997).

Some of these are one-dimensional in scope, and most provide highly aggregated measures of a state. If adopted, these one-dimensional or aggregated measures may fail to show much about the dynamics of highly variable regions in the tropical savannas. Both PSIR and DSR frameworks are best perceived as a useful taxonomy for organising indicators without implying an underlying functional causality (Gallopín 1997). All can provide variables and indicators that we need to consider in our modelling exercise. However, we found them less relevant than other trans-dimensional frameworks.

5.3.2 Trans-dimensional frameworks

The remainder of this section focuses on trans-dimensional frameworks. But first it makes the case for narrative modelling from anthropology and briefly introduces limited literature from recent advances on demographic
and extended Input-Output (IO) modelling. These are explored for their potentially useful role in monitoring important drivers (such as population and economic activities) on regional dynamics.

5.3.3 Narrative anthropology
Modelling need not always be mathematical or quantitative. It can usefully be qualitative (Potsdam Institute for Climate Impact Research 1998; Campbell et al. 2001; Bossel 1999; Hodge et al. 1999). Anthropological and historical records can be the basis of carefully narrated expositions of possible changes (Bradbury 2002). Defined as such, anthropological modelling can help us understand some changes otherwise often perceived as surprises or apparently as sudden (Campbell et al. 2001; Nussbaum 1993).

5.3.4 Input-Output modelling
Developed by Leontief in the early 1940s, the IO model is currently widely used for economic interactions of industries at a national level (Mohr 1999; Hoekstra & Van Den Bergh 2002) and at a regional level (Robinson & Duffy-Deno 1996). Conventional IO analysis is static. It assumes a constant relationship between inputs and outputs of an economic system (Hawdon & Pearson 1995; Wang 2001).

The IO model is modified to account for dynamic relationships (Leontief & Duchin 1986; Robinson & Duffy-Deno 1996); and to include interaction between economic activities, energy and the environment (Hawdon & Pearson 1995). The modifications are: a) the consideration of lags or rates of change overtime and b) the inclusion of entries for pollutants, abatement activities and the interactions between systems.

Hawdon and Pearson (1995) argue that modified IO analysis goes some way towards meeting the need for systems modelling in the area of complex economic and physical interaction. It enables production of hybrid unit IO tables that capture monetary and physical flows of the economic system. There are also associated methods such as structural decomposition analysis developed to understand underlying factors that influence the physical flows in an economy (Hoekstra & Van Den Bergh 2002). The IO technique can be used to trace linkages between economic and ecological indicators (Gustavson et al. 1999) and contributions and multiplier effects of industries to the regional economy (Greiner et al. 2002).

Wang (2001) notes a shared limitation of IO variants in representing the non-linear dynamics of economic activities. This limitation assumes that the final demand for a product is given and its relationship with product output constant—hence the use of linear equations.

A neural network model-based IO has been to alleviate the limitation of representing non-linear relationships between inputs and outputs and/or final demands (Wang 2001). To overcome the limitations in IO analysis, alternative analytic techniques have also been developed. Examples of alternative methods include shift-share analysis and multi-sectoral qualitative analysis (Knudsen 2000; Roberts & Stimson 1998).

5.3.5 Demographic modelling
Changes in populations have a significant bearing on a nation’s society, economic activities and the environment and visa versa (Foran & Poldy 2002). Spurred by changing migration, fertility and mortality rates populations in the regions of northern Australian is highly dynamic (Bell & Ward 1998; Bell & Taylor 2002).

Forecasting based on census data and fixed growth rates are inadequate in capturing such population behaviour (Bell 2001; Schoen 2002). Rogerson (1997) suggested more frequent monitoring of the factors of population dynamics (migration, fertility and mortality) and better understanding of the linkages of the factors with technological and socio-economic development. Schoen (2002) proposed a dynamic demographic model that captures the implication of varying population growth rates.

Researchers are developing decomposition algorithms for aggregated measures (Das Gupta 1999; Shkolnikov et al. 2001). Decomposition helps to analyse the contribution of differences in elementary demographic events such as age, births, causes of death or population group to changes in aggregate demographic measures (Andreew et al. 2002; Shkolnikov et al. 2001).

Advances in IO analysis, demography and case studies from anthropology can contribute significantly to monitoring regional dynamics. However, we need to choose a trans-dimensional framework that integrates modelling from different perspectives. In trans-dimensional frameworks the social (socio-economic) and the natural (biophysical) systems are integrated in different ways: coupling, merging and nesting one in the other system or recognising interactions and properties shared between them.
5.3.6 Integrated modelling

Institutions are often used as a medium to couple socio-economic and biophysical systems (Berkes & Folke 1998; Leach et al. 1997; Abel et al. 2001; Dodds 1999; Lawn 1999). The roles of institutions in reducing social dilemma and dealing with ecological uncertainty mediate the relationship between the social and ecological systems (Maru 2001).

Forest Land Oriented Resource Envisioning System (FLORES) is a model developed by the Centre for International Forestry Research (CIFOR) that couples the social and biophysical systems using tenure as intermediary sub model (Haggith et al. 2002; Vanclay et al. 2000). Haggith et al. (2002) note, modelling institutions as intermediary between the systems to represent multiple and overlapping rights is a significant enhancement over most land-use models. The model also integrates the five capitals (natural, physical, human, social and financial assets) in one model and allows the dynamic interactions between them to be explored. FLORES uses SIMILES modelling environment and it is applied in different contexts such as in Mafungautsi Zimbabwe, Cameroon and Bogor Indonesia. FLORES has FLAC (FLORES Adaptation and Calibration package) for adaptation in different contexts.

Merging involves re-envisioning the social and ecological systems as complex adaptive system (Holland 1995; Gunderson & Holling 1995; Ostrom 1999). Rangelands regions are re-conceptualised as complex adaptive system where humans are considered as elements of the adaptive components within integrated socio-economic-biophysical system that displays multiple interactions, non-linear dynamics, panarchy and resilience (Abel 1999; Walker & Abel 2002; Janssen 2002).

Multi-agent adaptive modelling, informed by concepts of complex adaptive system, is increasingly used in exploring the likely impacts of different management strategies on natural resources (Janssen 2002; Janssen & Carpenter 1999; Carpenter et al. 1999), and the dynamics of the rangelands under different policy and institutional regimes (Janssen et al. 2000). Multiple actors are recognised to account for adaptive human and ecological agents and essential heterogeneity within the later. This contrasts with the assumption of a universal economic actor that underlies mainstream economics (Janssen 2000). For modelling purposes categorisation of actors is based on collective world views (Thompson et al. 1990; Janssen & De Vries 1998; Janssen & Carpenter 1999), mental models, and roles (Janssen 2000; Carpenter et al. 1999).

In nesting, the socio-economic system is considered as a subsystem of the overall ecosystem. This integration highlights that there are socio-ethical and biophysical limits to the socio-economic activities that cannot be ignored, particularly when these activities grows large relative to the nesting ecosystem (Daly 1996; Bell & Morse 1999). Nesting is the basis for Bossel’s orientor monitoring framework that considers effects of subsystems on one another and each on the containing system. Nesting can also inform modelling the dynamics of detailed socio-economic activities.

In shared properties, common characteristic and interactions of the socio-economic and biophysical systems are emphasised (Low et al. 1999; Bossel 1998; Peet & Bossel 1999). Characteristics unique to each system are also recognised (Ulrich 1983). Westely et al. (2002) explored the key differences between the ecosystem and the social system and what it means in terms of an adaptive cycle. Both are organised and can be understood in terms of time and space. But the social system has a structure of signification that is captured in what Ulrich (1983) called the pragmatic dimension. This dimension locates dynamics in terms of their meaning: the practical difference they make to those concerned. This third dimension plays a significant role and clearly set social systems apart from ecosystems. It confers the capacity for a hierarchy of abstraction that permits a higher level of self-organisation than that found in ecosystems. This intentional ability (reflexivity, foresight and creating technologies) allows human systems to transiently divorce themselves from space and time, the critical organising dimensions of ecosystems.

5.4 Sustainable livelihood: the framework of choice

The sustainable livelihood (SL) framework (Scoones 1998; UK Department for International Development (DFID) 1999; Woodhouse et al. 2000) is considered as a guide for modelling regional dynamics in the tropical savannas. Its focus on livelihood provides the emphases required for socio-economic health. The framework is integrative in that it considers shared aspects and properties of the socio-economic and biophysical systems.

The capitals provide a checklist for modelling regional system dynamics. The framework also considers people as actors as well as their livelihood activities. This allows us to model from three corresponding perspectives. An activities’ perspective involves monitoring the state and changes of resource and non-resource based livelihood activities and modelling their socio-economic effects. Actors’ perspectives include exploring the
actor group’s mental models, behaviour and decisions and their effect on the management of capital assets. Regional system dynamics are explored from the capital perspective.

Modelling exercises based on these perspectives can benefit from recent advances in methodologies for their integration. There is already capital-based modelling for exploring regional socio-economic dynamics and selecting indicators of systems’ performance (Gustavson et al. 1999; Campbell et al. 2001). Actor-based modelling can benefit from established multi-agent modelling (Janssen 2002). Industries as livelihood activities (existing and emerging) can provide a basis for detailed socio-economic activity modelling (Greiner et al. 2001). The preliminary efforts for actor-based and detailed socio-economic activities modelling are covered elsewhere in this report. Here we focus on capital-based monitoring.

5.4.1 Capital-based modelling

The five capitals or the asset pentagon lies at the core of the SL framework. Institutions are considered as separate capital, making an asset hexagon at the core of the regional dynamics modelling for the tropical savannas. Institutions as an underlying context mesh the different subsystems of capital, actors and their livelihood activities. We found it necessary to treat institutional capital separate to social capital because the former is expected to have a significant role not only in reducing social dilemmas, but also in dealing with high environmental uncertainty which is characteristic of the Australia’s North.

The capitals

Each of the capitals can be considered as sub-systems of economic, social and ecological systems (Bossel 1999). Although the minimum stock is not known, each of the capitals is vital for sustainable development (Bossel 2001; Serageldin 1996). Sustainability is defined as bequeathing “future generation as many if not more options (total capital per capita) than we have had ourselves” (Serageldin 1996; Walker 2002). The list of capitals as vital components helps develop a comprehensive consideration in monitoring models of regional health.

In the hexagon-asset framework considered here, the capitals are natural, physical, financial, human, institutional and social. Social capital is chosen for wider treatment than the others. The reasons are twofold. Social capital has gained prominence relatively late and confusion surrounds its definition and measurement (Stone & Hughes 2000). We have recognised institutional capital as closely related but separate from social capital because of its significant relevance to the resource use and management in the tropical savannas. This is also consistent with the treatment of institutions in institutional economics (North 1990; Bate 1997).

Social capital

Since the late 1980s the concept of social capital has been gaining prominence in development work. The notion of social capital is also recognised in current Australian government policies related to communities, small businesses and families (Howard & Newman 2000). However there is limited empirical work and literature (Stone & Hughes 2000) and this review depends heavily on international literature. Under its Social Capital Initiative, the World Bank is generating a series of working papers which can be accessed from its website12.

Definitions of social capital

Social capital is important to development because it is the ‘glue’ that holds societies together and provides a sense of belonging and shared behavioural norms (Serageldin 1996; Onyx & Bullen 2000). It is the basis for a truly civil society and a measure of satisfaction about our interaction (Cox 1995). It captures the way human agents interact, organise and reorganise for information sharing, decision-making and collective action (Grootaert & Van Bastelaer 2001).

Feldman and Assaf (1999) note that the definitions of social capital are multiple but differ according to a) manifestation or forms emphasised and b) scopes covered.

Forms: cognitive and structural social capital

Following Coleman (1988) or Bourdieu’s (1986) original works, theoretical advances and measurements of social capital have emphasised on either its cognitive or structural manifestation (Putnam 1993; Grootaert & Van Bastelaer 2001).

Structural social capital focuses on the roles, network, associations and other socio-economic structures that facilitate social capital outcomes. Cognitive social capital refers to norms, trust, values and attitudes (Uphoff 2000). Attempts to measure social capital, including those in Australia, have tended to favour indicators of the cognitive form of social capital. Measurements based only on cognitive forms of social capital have been criticised for failing to account for the structures and power relations that underlie the dynamics of social capital formation and its outcomes (Pope 2001).

The focus on either structural or cognitive social capital is also captured in two widely proposed pathways to health gradients in regions around the world (Glover et al. 1999; Pope 2001). These are:

- Structural (uneven distribution and access to resources and service leads to health inequality) or
- Psychosocial pathways (low status in the social hierarchy causes stress, low self-esteem, lack of social support and social exclusion, leading to ill-health)

In recent years, social health studies in Australia have also consistently shown a strong correlation between socio-economic inequalities and ill health, although the causal pathway(s) are not determined (Glover et al. 1999).

**Scope covered: micro, meso or macro social capital**

The narrow (micro) definition of social capital refers to horizontal associations between people that foster coordination and cooperation for the mutual benefits of the community (Putnam 1990; Cox 1995). Put differently, it is the networks, norms, and trust that increase a society’s productive potential (Putnam 1993). The focus of the definition is with voluntary associations that are built on trust and norms of reciprocity.

The broad (meso) definition of social capital includes horizontal as well as vertical associations that are characterised by hierarchical relationships with unequal power distribution among members (Coleman 1988). Relations among groups rather than between individuals are emphasised.

The broadest (macro) definition of social capital further includes the social and political environment that shape social structure and enable norms to develop. In addition to the largely informal, and often local, horizontal and hierarchical relationship of the first two definitions, this macro definition includes most formalised institutions and structures such as political regimes, the rule of law, the court system and civic and political liberties.

This addition is equivalent to definitions and use of institutional concepts (Scott 1995; Nugent 1998; Abel 1999; Maru 2001). Onyx and Bullen (2000) relate social capital to immediate and personal relationships rather than distant and formal relationships with institutions. Institutions are of significant interest because they are expected to deal with uncertainty, a characteristic of the tropical savannas. The social capital of networks and associations and the institutional capital of formal organisations and rules are mainly complementary, and as such need separate treatment (Bates 1996).

**Properties of social capital**

Like other forms of capital, social capital is productive, making it possible to achieve certain ends unattainable in its absence (Coleman 1990). It requires investment as an input and generates a stream of benefits as an output. The benefits can flow to communities, households or to individuals or may have externalities to other scales. It is fungible with respect to specific activities. It requires an investment in time and effort, and there is often a lengthy period before benefits are accrued. However, benefits can be less obvious to those who generate social capital as they may only capture part of its benefits. These are sufficient reasons for under-investment in social capital (Coleman 1988; Collier 1998). However, those who organise it can capture the process of social capital formation. When this happens it is possible that individuals in the network or association can be forced to pursue norms that are not in their interest (Johnson 1997).

Social capital is more easily destroyed than re-built. As with any other capital, it can be damaging if it is misused (Collier 1998).

Unlike other capital forms social capital is inherent in the structure of relations between persons and among groups of people. It is lodged neither in individuals nor in physical implements of production (Coleman 1990). It is collectively owned capital that can be summoned upon by its members (Bourdieu 1986).

Further, social capital accumulates as a result of its use. It has the characteristics of public good because it requires cooperation between at least two individuals. Closure and internal morality are two relevant concepts in social capital formation. Closure implies that individuals are interdependent in some way: culture, shared resources, common hardship and proximity of habitation etc. Closure facilitates the norms of reciprocity (Johnson 1997).
Social capital is a medium for social exchange that cannot be facilitated by money. In its absence social exchange will tend to be inefficient, as does the barter economy (Coleman 1990).

As economic development proceeds and markets develop, substitution takes place within types of social capital and in particular between social and institutional capital. The absence of constructive interactions between social and institutional capital can result in significant breakdowns of trust. Social capital can vary significantly in a region through the role of influential figures and the dynamics of a community.

From an economic perspective, Collier (1998) examined the make-up of social capital. He refers to social capital as repeated social interaction with persistence effects and externalities. These externalities could be unintended economic effects incidental to the purpose of social interaction such as reduced opportunistic behaviour; or intended effects from purpose-designed social interaction such as household, firms and government organisations.

Persistent social interactions are expressed in the form of:
- Networks (free spontaneous relationships)
- Associations (horizontal informal relationships)
- Reciprocal formal organisations
- Vertical formal organisations.

Durability of the effects of social interactions includes trust, reputation, and norms of reciprocity. Collier (1998) identifies three types of externalities and six mechanisms by which social interactions generate these externalities. The externalities are knowledge generation, information sharing about agents to reduce opportunism and facilitation of collective action. The mechanisms are copying and pooling to share information and knowledge; trust and reputation to reduce costs of transaction; and norms of expectations and sanction to act collectively.

Measuring social capital

In both international and Australian literature, measurements have been identified for several broad aspects of social capital. The challenge is to find a set of indicators relevant to the context of northern Australia.

Stone and Hughes (2000) argue that there is a gulf between social capital theory and empirical understanding and measurement in Australia. They suggested a measurement framework that considers network, trust and reciprocity as key dimensions of social capital.

Recent empirical studies in five communities in NSW identified aspects to social capital and some of which are suggested as measurable generic variables (Bullen & Onyx (1998, 1999). They are:
- Participation in a local community
- Proactivity in a social context
- Feelings of trust and safety
- Neighbourhood connections
- Family and friends connections
- Tolerance of diversity
- Value of life, and
- Work connections

Each aspect is probed using a set of questions. Findings of the studies relevant to this review included a) a minimum level of economic well-being as a prerequisite to access and accumulate social capital; and b) beyond a certain minimum, material conditions, particularly income and education, are irrelevant to forming social capital.

Based on a review of the international literature, Grootaert and Van Bastelaer (2001) suggested indicators from three vantage points: input, content and output of social capital. These indicators directly measure or proxy:
- Membership in local association and networks (an input indicator). This includes examining the number of associations and members; aspects of membership such as the association’s heterogeneity and functioning, e.g. the extent of democratic decision making.
- Trust and adherence to norms (as an input, direct or output indicator). This involves asking respondents about their expectations and experience with trust: e.g. the extent to which a household received or would receive assistance from members of the community or networks in case of various emergencies (loss of a job, illness).
Options for understanding regional dynamics in northern Australia

- **Collective action** (output indicator): the extent of collective actions based on voluntary and durable cooperation as an indicator of underlying social cohesion.

However, some authors argue that collective actions must not be considered as indicators of social capital as they confound its measurement (Stone & Hughes 2000).

Collier (1998) suggested the measurement of social capital (trust) as a function of:

- civil liberty
- ethno-linguistic fractionalisation (ethnic diversity)
- telephone density (proxying communication), and
- population density (proxying the distance between agents).

Civil liberties, population density and telephone density together are a proxy for the cost of repeated social interactions. Currently in Australia there seems no direct political penalty associated with having repeated social interaction. However, distance and access to communication services may be significant in forming social capital in northern Australia.

Based on this review and knowledge of the Australian north, a preliminary list of aspects of social capital considered relevant includes:

- trust
- networks and voluntary associations
- unique culture—strong intra-cultural bonding but possible inter-cultural cleavage
- Equity—socio-economic and social health inequalities; basic capability equality, access to public services, and
- Liveability—safety, access to a range of services and leisure time, valued occupation community interaction and cohesion, horizontal integration, tolerance for social diversity and a variety of lifestyles.

**Institutional capital**

Institutions are treated as separate capital because of their significance as mechanisms for buffering variability. For better or worse, they are often an enduring link in coupling human and natural systems.

Economically, institutions are meant to facilitate exchange relations but often end up mediating power relations due to capture by some interest groups (Johnson 1997). Capture and path dependence can lead to accumulation but poorly distributed institutional capital that in the long term can endanger the health of a region (Olson 1996; North 1997; Bates 1997). The ability to provide fairly a distributed collective good at lower cost underlies the economic justification for growing institutional capital (Chhibber 1998).

Politically, improvements in institutional capital are associated with decentralising governance, which creates an institutional environment for autonomy and empowerment (Shah 1998). A measure of decentralisations is subsidiarity. It refers to the rights and resources local institutions have that match the responsibility for self-governance (Swift 1996; Bossel 1999). Capable local governance systems can play a positive role in centre-periphery tension.

At any scale, institutions are meant to reduce uncertainty but at times they themselves can be unpredictable. Political stability, predictability of rule making, the types of incentives or behaviour promoted are other aspects of institutional capability (Chhibber 1998; Pradhan 1998). Measurements of institutional capital and accountability include the responsibility of political authorities and civil servants to communities together with freedom from corruption. Crime against persons and property are used as proxies for the reliability of judicial enforcement (Shah 1998; Chhibber 1998).

Variables selected for monitoring are:

- Institutional capability – flexibility and foresight of rules and sanctions
- Institutional capacity – ability of communities for self-governance, accountability and transparency of organisation.

**Natural capital**

Natural capital is the valued and productive potential component of the natural system. It is the natural asset from which renewable and non-renewable products are extracted; market and non-market values flow, and services useful for livelihood are derived.
Change in societal values is one reason for change in valued natural capital. Post-productivist perspectives re-value land and as such is a relatively new frontier for potential accumulation. An area of interest for investigation is the interaction between these relatively new frontiers of use with conventional pastoralist use.

Stocks of interest that can be considered for monitoring natural capital are:
- aesthetic values
- conservation values
- spiritual values
- minerals
- resource productivity for pastoralism and agriculture.

**Financial capital**

Financial capital covers stocks of monetary funds, savings and investment. Aspects that can be considered for modelling are:
- local saving
- family real income
- local attractiveness for investment.

**Human capital**

Human capital refers to the stock of labour, knowledge, skills, experience and health that make people productive (Hamilton 1999). Aspects of human capital that can be considered for modelling are:
- employable skills
- personal health.

**Physical capital**

Physical capital includes buildings, physical machinery, roads, and other communication infrastructures. Physical capital considered for monitoring is:
- transport
- communication networks.

**Asset-attribute matrix**

The asset framework described above is based on capital as essential components of economic, social and ecological domains. Maintenance and accumulation of these capitals are assumed to be vital to the health and sustainability of a region (Bossel 2001; Walker 2002).

The asset framework can be modified based upon the lessons learned from the review of regional development paradigms and metaphors of change. Institutions here are treated as separate capital, making a hexagon asset framework. Each capital accounts for products and values of interest for productivist — post-productivist development paradigms. They also capture issues of concern to indigenous and non-indigenous communities. The relationship of health and accumulation of stocks is revisited from the theory of adaptive cycle.

A matrix of capital and attributes can then be developed to capture these lessons. The matrix can be used to organise regional health indicators. The matrix shown in Table 5.1 has specific and common attributes of interest for monitoring regional health. The first column identifies types and specific attributes of each capital. The first row lists attributes of interest in all capitals.

According to the theory of adaptive cycle the systems to which each capital belongs can deteriorate to an extent that it has no more capacity to reorganise (poverty trap) or accumulates and interconnects to the point that it resists change (rigidity trap). Similarly, from an ecological economics point of view, Daly (1996) argues for limiting the scale of accumulation of capital beyond which the throughput cost is higher than the service benefits. Increasing accumulation of capital that is accompanied with increasing interconnectedness may not be good for the health of a region. This requires the investigation of other attributes such as distribution of the increasing potential, its resilience and effect on other capitals and the region as a whole. The last attribute, effects, also evokes the issue of scale.

The scale in focus and its relationship with other relevant scales play a significant role in monitoring health or sustainable development. In monitoring, misperception of the interaction of scales could lead to serious management problems (Wilson et al. 1999). Indeed what distinguishes sustainable development from other forms of development approaches is its explicit treatment of scales. The frequently cited principles of sustainable development attempt to address intra and inter-scalar issues. The concern for future generations (long temporal scales), intra-generation issue (pragmatic scales) biodiversity and landscape integrity (large
spatial scales). From a systems perspective sustainable development can be redefined as a secure trans-scalar improvement (Maru 2001). In monitoring the effects within a scale, and to or from a larger system, need to be explicitly considered (Bossel 2001; Maru 2001).

Focus on a single scale may obscure important variables that only become apparent at other scales (Lovell et al. 2002). The theory of hierarchy tells us to consider at least one scale in each direction (Allen & Starr 1982). In this report, the focus is regional modelling. If the region is equivalent to a province two scales of interest are the district and the state. However, it is important to trace and explore effects that may require considerations to scales beyond (Maru 2001).

Selection criteria such as representativeness, validity, diagnostic and prognostic abilities may need special support. Representative indicators can be selected using correlation studies. Validity and diagnostic abilities depend on the extent an indicator reflects underlying causal relationships. Regression studies can help to determine validity of indicators, which can be modelled in a simulated environment to explore their capacities.

The next step is to select or/and construct indicators that measure the level and rate of changes of each capital with regard to specific and common attributes. The dynamics of the capital can be monitored and explored by modelling the indicators (Gustavson et al. 1999; Campbell et al. 2001).

Table 5.1 Asset–attribute matrix for organising regional health indicators

<table>
<thead>
<tr>
<th>Assets/Attributes</th>
<th>Accumulation</th>
<th>Distribution</th>
<th>Resilience</th>
<th>Effects</th>
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<tbody>
<tr>
<td>1. Natural</td>
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<tr>
<td>Primary productivity</td>
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<td>Minerals</td>
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<td>Aesthetic value</td>
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<td>Conservation value</td>
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<td>Cultural value</td>
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<td>2. Physical</td>
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<td>Transport network</td>
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<td>Communication network</td>
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<td>3. Financial</td>
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<td>Local saving</td>
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<td>Family real income</td>
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<td>Investment attractiveness</td>
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<td>4. Human</td>
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<td>Employable skills</td>
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<td>Personal health</td>
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<tr>
<td>5. Social</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trust</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Network/association Density</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unique culture</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Equity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liveability</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>6. Institutional</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Institutional Capability</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Institutional Capacity</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

5.5 Regional health indicators

5.5.1 Selecting indicators

There have been many efforts to construct indicators particularly since the popularisation of the concept of sustainable development (WCED 1987). These efforts have generated several potentially useful indicators. The difficult task is to select a set of indicators relevant to monitoring and exploring regional health.

Similar general selection criteria and processes are suggested in the literature (Childs et al. 2002; IISD 2000; Maclaren 1996; Mitchel et al. 1995; Bossel 1999; Gustavson et al. 1999). Indicator selection criteria are qualities we look for in indicators so we can choose some over others. Selection processes vary with the main
purpose of the indicators and the target users (Braat 1991; Mitchel et al. 1995). Relevant selection criteria include:

- **Relevance** to the attributes of regional health and indicator users to motivate decision and action.
- **Simplicity**: as simple as possible to use and understandable to target audience users.
- **Representativeness** that provides reliable information on the characteristics of a capital.
- **Validity**: scientifically defensible measures that provide a correct reflection of the state and changes in the capital.
- **Reliability**: providing the same measurements when taken by different people.
- **Sensitivity** to small but relevant changes in time, space or/and system as a whole.
- **Comparability**, with thresholds, and similar indicators used elsewhere for the same purpose.
- **Data availability and accessibility**: a measure to which data—preferably time-serious data—is available, accessible, and affordable.
- **Diagnostic ability** to identify the causes of the state and change of the attributes measured.
- **Prognostic ability** to explore future conditions of the measured attributes.

### 5.5.2 Combining indicators

Indicators can be combined to provide concise information about the state and changes of the system monitored. However, streamlining has to be achieved without losing comprehensive coverage of vital components. Indices or composite indicators can be constructed by combining indicators. These indices can be derived through aggregation, principal component analysis or other multivariate analysis techniques (Campbell et al. 2001; Bossel 2001).

To aggregate indicators four issues need to be addressed (Maclaren 1996; Hodge et al. 1999). The first issue is aggregating indicators with different units of measurement. The solution suggested includes standardising indicators with respect to percentage achievement in values such as targets, goals, standards or thresholds (Opschoor & Reijinders 1991) or assigning other dimensionless values on a scale of say, one to 1000 (Hodge et al. 1999). The second issue is weighting the contribution of indicators in the index. Some value judgements are required to do this, and it may vary with who does the weighting. The third issue is the methods of aggregation used: simple linear addition, weighted linear sum, root mean square, or a variety of multiplicative forms (Maclaren 1996). The fourth issue is that variations in individual measures can be hidden or eclipsed. Exceeding scale in some indicators can hide serious deficits in others and it remains a serious problem in highly aggregated indices.

The capitals we have considered here are essential components in a regional system. We are assuming the maintenance and improvement of each is vital to the health of a region. Therefore, the capitals are predominantly complementary. Additive aggregation of indicators of each capital is based on the assumption that they are substitutable. Therefore, aggregation to develop an index of indicators of the capital can hide vital signs of ill-health. Even for each capital the attributes identified (accumulation, distribution, resilience and effects) may not be substitutable.

Hence when using aggregation to streamline indicators, several inessential individual indicators should be considered which are assumed to give vital signs when combined. The aggregation could be done in a variety of multiplicative forms. When there is a high degree of substitutability of the components measured, additive aggregation can be used.

### 5.5.3 Modelling indicators

The intention with asset framework modelling is not to develop detailed models of each capital but to use indicators. Indicators of level and change in stock accumulation, distribution, resilience and effects are needed (Bossel 1999). A set of forward-looking (projective) and causally linked indicators is required to model the dynamics of capitals in a region (Campbell et al. 2001; Gustavson et al. 1999; Maclaren 1996).

A model that is constructed using indicators of each capital can be used explore the likely impact of different sets of derivers on regional health. It also helps to explore the impact of climatic variability on the health of a
region (Campbell et al. 2001; Gustavson et al. 1999). Table 5.2 contains a preliminary list of relevant indices and indicators compiled from various sources.
<table>
<thead>
<tr>
<th>Asset</th>
<th>Indicator/ Index</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>Index of likely regional resilience to grazing:</td>
<td>(Stafford Smith 2000; Stafford Smith et al. 2000)</td>
</tr>
<tr>
<td>Capital</td>
<td>• Resilience of soils- ability to tolerate pressure on land units</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Landscape complexity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Climatic predictability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Index of potential pastoral productivity:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Land productivity in terms of mean rainfall and fertility for grazing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Climatic predictability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Distance to market as a surrogate for the overall costs of production and net</td>
<td></td>
</tr>
<tr>
<td></td>
<td>value of sales</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Landscape resilience</td>
<td>(Peterson 2002)</td>
</tr>
<tr>
<td></td>
<td>• Probabilistic resilience</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cross scale edge</td>
<td></td>
</tr>
<tr>
<td>Human</td>
<td>Index of Education and occupation</td>
<td>(ABS: Socio-Economic Indexes for Areas 1996)</td>
</tr>
<tr>
<td>Capital</td>
<td>Index of Relative Socio-Economic Disadvantage (major no or low qualification,</td>
<td>Can provide indication the condition of human capital in communities</td>
</tr>
<tr>
<td></td>
<td>educational attainment, unemployment, skilled occupation and family income)</td>
<td>educational</td>
</tr>
<tr>
<td></td>
<td>Index of Economic resources</td>
<td>Provides profiles of disadvantage in human and financial capital of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>communities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Data availability</td>
</tr>
<tr>
<td></td>
<td>Capability Poverty Measure –designed to monitor human deprivation (lack of</td>
<td>(McKinley 1997)</td>
</tr>
<tr>
<td></td>
<td>essential capabilities)</td>
<td>Measures of lack of basic capabilities (in contrast to lack of access) :</td>
</tr>
<tr>
<td></td>
<td>• adult illiteracy and percentage of children aged 6–11 not enrolled in primary</td>
<td>Living a healthy and well nourished life</td>
</tr>
<tr>
<td></td>
<td>school</td>
<td>Being literate acknowledgeable</td>
</tr>
<tr>
<td></td>
<td>• percentage of children who are stunted</td>
<td>Having the capability of safe and healthy reproduction</td>
</tr>
<tr>
<td></td>
<td>• percentage of babies who have low birth weights and expectant mothers who are</td>
<td></td>
</tr>
<tr>
<td></td>
<td>anaemic (or rates of immunisation or % immunisation level against preventable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>diseases)</td>
<td></td>
</tr>
</tbody>
</table>
Table 5.2  A list of relevant indices and indicators compiled from different sources

<table>
<thead>
<tr>
<th>Asset</th>
<th>Indicator/ Index</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contribution to Regional total income factor</td>
<td>Contribution to regional Employment Input-output analysis Industries monetary (for income, output, investment, value added) and employment multiplier effects leakage.</td>
<td></td>
</tr>
<tr>
<td>Social Capital</td>
<td>Life expectancy at birth Morbidity rate Mortality rate Distribution of major causes of morbidity mortality Use of health services preventive curative Age dependency ratio Youth migration Number and type of local horizontal associations Number and extent of participation in local voluntary organisation</td>
<td>(Glover; Harris, and Tennant S. 1999) et al. 1999) Mapped and highly positively correlated with distribution of socio economic disadvantage; but identification of causal pathways remains. (Haberkorn et al. 2001) Indicators chosen for their relevance to community’s capacity to change to monitor socio-demographic and economic conditions in the rangelands</td>
</tr>
<tr>
<td>Physical Capital</td>
<td>Accessibility/Remoteness Index of Australia (ARIA)</td>
<td>Remoteness refers to lack of accessibility to services. Five categories of ARIA Index (Very accessible, Accessible, Moderately accessible, Remote, Very remote) constructed that reflect distance to four categories of service centres. Resident population number is the basis for these categories of service centres.</td>
</tr>
<tr>
<td>Financial capital</td>
<td>Economic Vulnerability Index • Exposure to foreign economic conditions • Remoteness and insularity (because they introduce uncertainties, delays an inaccessibility to service centres) Remoteness indicator considered is the ratio of transport and freight costs to export proceeds • Disaster proneness</td>
<td>(Briguglio 1995) Developed for Small Island Developing States</td>
</tr>
</tbody>
</table>
Table 5.2  A list of relevant indices and indicators compiled from different sources

<table>
<thead>
<tr>
<th>Asset</th>
<th>Indicator/ Index</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutional Capital</td>
<td>Institutional capacity</td>
<td>• Institutional flexibility refers to the degree of freedom institutions allow members to cope with perturbations. • Institutional morality refers to the degree to which individuals can choose to uphold or challenge institutions. It also refers to the degree to which institutions prevent free riding and externalities. • Institutional agency is the level of involvement of community members in institution making and changing. • Institutional learning refers to a process of gaining knowledge that enhances the capacity for efficient and effective adaptation. Type and rate of learning can be enhanced through conscious self or collective reflection • Relative amount time devoted to collective reflection (vs. action) with the intent of enhancing adaptation collective reflection allows critical learning. This means questioning assumptions, which were formerly taken for granted, with the intent of rethinking and changing underlying institutions. A relevant indicator is how discordant views on institutions are treated during collective reflection</td>
</tr>
</tbody>
</table>
5.6 Conclusions

The review led us to consider the livelihood approaches as an organising framework. The sustainable livelihood approach focuses on people. This allows the emphasis required to develop socio-economic health monitoring that complements ecosystem health programs already in place.

Capital assets are at the core of livelihood approach. They are the vital components that must be maintained and improved for sustainable livelihoods. The approach also deals with human actors and what activities they do for a living. The framework encourages modelling from three focal points. These are capital-, actor- and activities-based modelling to monitor regional health in the tropical savannas. The modelling exercise can benefit from recent advances in system dynamics, multi-agent, detailed economic and demographic modelling.

Systems modelling, aimed at exploring regional dynamics, is based on indicators for the state and change in the attributes of the six capitals. A capital-attribute matrix is developed that attempts to capture the lessons learned from the review of the different perspectives on change and health metaphors. There are six capitals because we recognised institutions as separate from social capital. The attributes are not only accumulation of the stocks of each capital but also its distribution, resilience and effects. Exploring effects could help to address the issue of scale explicitly.
6. Actors, actions and impacts: an agent-based simulation approach to exploring regional dynamics

Daniel Walker

One of the approaches to conceiving and modelling regional dynamics explored at the Brisbane workshop was based on considering differing behaviours of different sectors of savanna to communities and the impact of these differences on development trajectories. These different sectors can be envisaged as ‘agents’ and their behaviour, and the aggregate outcome of agent decisions modelled.

Many agent-based models have been developed over the last decade, with multiple applications in the area of how individual decisions impact on the state of the natural environment (natural capital). Some address the problem in a very theoretical way (Epstein & Axtell 1996) with the objective of emphasising the potential of multi-agent systems (MAS) to study coordination between agents and the impact on system dynamics. Bousquet et al. (2001) highlight the relevance of agent-based models or MAS in the analysis of natural resource management issues as common property management issues.

Applied models have been developed to specific problems (e.g. Bousquet 1994; Lansing & Kremer 1994). These models are used to generate a better understanding of environmental problems. Such models typically establish linkages between a dynamic resource and a society of interacting agents, which have to coordinate to manage it. These models are particularly suited for exploring the aggregate outcomes of individuals’ choices in using common property resources (Ostrom 1998) and have also been used to explore the optimal configuration of institutional characteristics to achieve optimal group-level outcomes (Deadman et al. 2000).

The intention of this review was to explore the features and implications of regional dynamics and function that distinguish savanna/outback regions from others. As discussed in Section 3, these features include fugitive capital, demand-driven services, productivist and non-productivist paradigms for resource use, global tendencies to agglomeration undermining remote economies, and contrasting motivations between indigenous and non-indigenous populations in resource use.

Discussion of the impact of these factors on savanna regions revolved around both what makes savanna and outback regions as a group different from more densely populated regions of Australia and on the marked contrasts between the history and development of different savanna regions (Holmes 1997). It was agreed that both sets of differences were usefully explored by considering different mixes of decision-making agents within regions, and the ways in which their attributes (values, aspirations, resources, relationships with others and skills) and the actions available to them impact on regional trajectories. Implementation of this type of approach to conceptualising and simulating regional dynamics falls into the broad category of agent-based simulation models (Hare et al. 2001).

As a consequence of these deliberations, a qualitative conceptual framework for an agent-based simulation of savanna regions was developed and a series of questions pertaining to further development explored.

6.1.1 Overview of the conceptual model

At its simplest, the conceptual model asserts that the state of the six capitals in a region determine the state of different sectors with a potential in the region and that, given that these sectors are key agents of planning and action, this determines the decisions/actions that those agents undertake. This in turn influences the state of the capitals (Figure 6.1). The complexity of outcomes associated with this very simple core model is a consequence of the heterogeneity of the group of agents, their actions and the impact these have on different capitals. The condition and trends of the capitals also influence the status of the groups of agents and actions differently. Moreover, there is interaction within the components of the framework: agent, actions and capitals that differ with time, space, and social setting.
Underpinning assumptions

A series of underpinning assumptions were defined that build on the core model outlined above. These were as follows.

- Regional dynamics and change are determined by the actions of key agents.
- These agents can be classified into three categories: sectors of the regional community, institutions operating in or on the region and non-human agents of change e.g. weather, pests and diseases.
- These agents can be classified as endogenous (i.e. where the agents themselves are impacted by change within the region e.g. indigenous communities, family grazing enterprises etc.) and exogenous (i.e. where they impact on the region but are not significantly impacted by the region e.g. state agencies and international markets etc.).
- The impact of these agents of change needs to be understood in an integrated fashion as the behaviour of each is impacted by that of others, both through impact on the state of the five capitals and through direct relationships.
- Consideration of changes to indicators of the state of the six capitals (natural, physical, financial, human, social and institutional) provides an appropriate vehicle to do this.
- The impact of change on endogenous agents also needs to be understood.
- The agents may interact with each other indirectly through impacts on capitals that determine the status of endogenous agents or directly through interactions such as competition, alliances etc.
- The capitals may have a direct influence on each other as well as the influence they have on each other through changing the actions of agents.

Structure

On the basis of the assumptions outlined, the structure of the conceptual model comprises:

- definition of the set of agents of decision-making that impact on the development of a savanna region
- definition of the key attributes/states of those agents
- definition of the actions available to agents in response to their circumstances
- identification of an set of indicators of the state of the six capitals that provide useful insight into the state and trajectory of the region in response to the actions undertaken by agents, and
- using the above, develop matrices of relationships that capture the relationships which determine the impact of each agent on each indicator as mediated through the agent’s action, the impact of the state of each indicator on the state and behaviour of each agent, the relationship between each pair of agents and the relationship between each pair of indicators/capitals.
6.1.2 Illustrative definition of agents, actions and indicators

Having defined the core assumptions and structure of the potential model, the practicality and insightfulness of defining the key agents and their attributes in a hypothetical ‘typical’ savanna region was explored. In this section we present a resulting partial set of sectors within savanna regions that operate as different agents of activity within those regions. The definitions are qualitative and incomplete. This exercise was based on the views of the workshop participants and extended by the research team. Neither systematic literature review or empirical or survey approaches to data collection were used. The material produced should therefore only be viewed as an illustrative ‘proof of concept’ exercise.

These sectors are categorised as organisations, individuals and emergent communities that have characteristics as a set of individuals that are distinct from the generic characteristics of members of the community.

The description of each group (i.e. agent) is essentially a set of assertions that need to be treated as hypotheses for characterising key distinguishing attributes—i.e. what is important about each sector in relation to their implications for the future of a region. The actions attributed to each agent are broad categories of activity, with the attributes indicating the status of the agent in the region. In selecting attributes, we were interested in areas that had regional implications rather than indicators of the health of that sector.
### Table 6.1 Agents, actions and attributes

**Organisations**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Description</th>
<th>Summary actions</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGOs</td>
<td>As a group NGOs represent a diverse range of interests. They play an important role in advocacy for their particular agendas and thereby have a potential impact across all five capitals. They may also potentially invest significant resources in a region in operations or capital purchase. Their presence in a region may play a significant but localised role in building / maintaining social and human capital.</td>
<td>Political representation, service delivery, resource management, investment</td>
<td>Presence / absence</td>
</tr>
<tr>
<td>Companies</td>
<td>Publicly listed companies can be key drivers of regional infrastructure and function. Particularly in remote regions they may replace the function of government in infrastructure and institutional provision. There may be substantial investment but it is targeted at a return on investment to the company. Companies in savanna regions exploit natural capital but are generally more accountable for the manner in which they do so than other sectors. They invest significant financial capital into regions but often with comparatively low multipliers for the regions. They are a key contributor to physical capital through infrastructure development and to human capital through employment and training but a minor contributor to regional social capital.</td>
<td>Invest, employ, produce, trade</td>
<td>Profits, equity, return on investment, net flows of investment, number of employees etc.</td>
</tr>
<tr>
<td>Owner/operator businesses</td>
<td>Owner operated businesses in savanna regions make variable direct use of natural capital but generally have a lower accountability for their use than companies. They make relatively low financial investment in regions compared to other sectors but with high multipliers. They are key contributors to regional social capital.</td>
<td>Invest, employ, produce, trade</td>
<td>Profits, equity, return on investment, net flows of investment, number of employees etc.</td>
</tr>
<tr>
<td>Govt sector (in region)</td>
<td>As in other areas, the government sector has enormous influence on activities in the savannas. It is, however, generally more distant than in other more closely settled regions. Nevertheless, it is the biggest investor in savanna regions with high multipliers. It makes key contributions to physical capital and is, directly or indirectly, a large investor in human and social capital through investment in other sectors.</td>
<td>Invest, employ, consume, deliver services, manage resources, enforce</td>
<td>Location, trends in services</td>
</tr>
<tr>
<td>External markets</td>
<td>External markets are key drivers of economic activity within savanna regions and are generally not impacted on by activities within those regions</td>
<td>Drive price, define products</td>
<td></td>
</tr>
<tr>
<td>Media</td>
<td>The media informs, shapes agendas and debate within communities, and entertains.</td>
<td>Inform, shape agendas, entertain</td>
<td></td>
</tr>
</tbody>
</table>
Table 6.1  Agents, actions and attributes

**Individuals**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Description</th>
<th>Summary actions</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member of local Community</td>
<td>Members of the local community are a region's human capital. They are users of regional natural resources and physical infrastructure and make critical contributions to social capital.</td>
<td>Consumption (services / commodities), stay / move, reproduce, be a member of community</td>
<td>Numbers, age profile, ethnic profile, skills, economic status, trends</td>
</tr>
</tbody>
</table>

**Emergent communities**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Description</th>
<th>Summary actions</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary (caravans, back-packers, seasonal labour)</td>
<td>Temporary residents in savannas are users of regional natural resources and free riders on regional infrastructure. They are a source of stress for social capital in the short term but may in the longer term contribute to human and social capital. They make a variable but modest contribution to regional financial capital.</td>
<td>What do they do in addition to being a member of the community?</td>
<td>Economic status, origin,</td>
</tr>
<tr>
<td>Regional Aboriginal communities</td>
<td>Indigenous communities are subsistence users of natural resources and have a custodial relationship with those resources. They contribute significantly to human capital in most savanna regions and make important contributions to social capital within their communities. They have unique needs in terms of physical infrastructure.</td>
<td>Land ownership / custodianship, Kinship / community</td>
<td></td>
</tr>
<tr>
<td>Welfare and super dependents</td>
<td>This sector brings significant financial resources to savanna regions. They are more likely to expend those resources within the region than other sectors. They contribute significant numbers to savanna regions in terms of population but also are a source of stress for services providers and social capital.</td>
<td>What do they do in addition to being a member of the community?</td>
<td></td>
</tr>
<tr>
<td>Employees</td>
<td>Employees are key consumers within regions and are key positive contributors to regional social and human capital.</td>
<td>What do they do in addition to being a member of the community?</td>
<td></td>
</tr>
</tbody>
</table>
6.1.3 Definition of indicators of the state of capitals

While more attention was paid to agents and actors than indicators, a preliminary list of the types of indicators of capital that might be appropriate for use in the context of an agent-based simulation was explored, as summarised in Table 6.2.

Table 6.2 Potential indicators of the state of regional capitals for use in agent-based simulation

<table>
<thead>
<tr>
<th>Indicators of natural capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary productivity of land resources</td>
</tr>
<tr>
<td>Aesthetics of land resources</td>
</tr>
<tr>
<td>Quality of water resources/riverine areas</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indicators of human capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skills/experience to take up opportunities (enterprises)</td>
</tr>
<tr>
<td>Health/mental well-being</td>
</tr>
<tr>
<td>Numbers (labour availability)</td>
</tr>
<tr>
<td>Employment rate</td>
</tr>
<tr>
<td>Net migration rate (in +ve)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indicators of financial capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real household income</td>
</tr>
<tr>
<td>Equality of real household income</td>
</tr>
<tr>
<td>Local capital for investment</td>
</tr>
<tr>
<td>External capital for investment</td>
</tr>
<tr>
<td>Business diversity</td>
</tr>
<tr>
<td>Variability in regional income</td>
</tr>
<tr>
<td>Net regional debt</td>
</tr>
<tr>
<td>% regional income leaving region/multipliers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indicators of physical capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roads—extent, % all weather, weeks open/year</td>
</tr>
<tr>
<td>Telecommunications—availability, quality (reliability, baud rate)</td>
</tr>
<tr>
<td>Access to hospitals, schools</td>
</tr>
<tr>
<td>Dwellings, housing</td>
</tr>
<tr>
<td>Reliability and cost of energy and water</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indicators of social and institutional capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance of language</td>
</tr>
<tr>
<td>Extended family and connectiveness</td>
</tr>
<tr>
<td>Social dysfunction (crime rate)</td>
</tr>
<tr>
<td>Community participation rates, reciprocity</td>
</tr>
<tr>
<td>Tenure and its flexibility</td>
</tr>
<tr>
<td>Access/input to policy</td>
</tr>
<tr>
<td>Capacity of local govs/communities/NGOs (ICPA, Land Councils, AgForce, Landcare)—% participation</td>
</tr>
<tr>
<td>Connectedness of internal actor groups/ease of knowledge flow</td>
</tr>
<tr>
<td>Strength of external/upward influence</td>
</tr>
<tr>
<td>Weight of external control/imposition</td>
</tr>
<tr>
<td>Social dysfunction (inc. +ve)</td>
</tr>
<tr>
<td>Flexibility of tenure/access structure</td>
</tr>
<tr>
<td>Confidence in knowledge about status of other capitals (quality of monitoring)</td>
</tr>
<tr>
<td>Development of matrices</td>
</tr>
</tbody>
</table>

Matrices of the impact of actions of agents on indicators of capitals and visa versa, the direct relationships between agents (alliances, antagonism) and the interactions between capitals were constructed and the relationships that make up these matrices explored. A trial assessment of the relationships was undertaken as (i) a statement of change as indices, (ii) formal but qualitative statements of relationships and (iii) quantitative
statements of functional relationships. All were so incomplete that they are not presented here, but the exercise provided some insights taken up in the next section.

6.1.4 Assessment of approach

Assessment of justification for approach

The approach proposed here can be justified on the basis of two assertions: (i) savanna and other remote regions in Australia are sufficiently different structurally and functionally from other regions to require a different approach to modelling dynamics; and (ii) that savanna regions are sufficiently simple to make the type of highly disaggregated agent-based simulation viable and insightful.

Key questions in understanding regional dynamics in savannas

The justification for a modelling effort focused particularly at remote regions has been presented elsewhere in this document and won’t be repeated here except in so far as it directly relates to the contributions that an agent-based simulation might make.

The characteristics of remote regions that have been discussed include the variability of circumstance and aspiration of different sectors. In terms of circumstances, there is a clear need to ensure that key indicators are measured/modelled for different key communities, for example indigenous versus non-indigenous given the generally disadvantageous circumstances of the former even when operating within the same world view. In terms of aspiration it is important to allow for the fact that indigenous and non-indigenous sectors may be operating under different worldviews at times. Indeed, aspirations may vary significantly across sectors with, for example, objective functions varying from financial goals (e.g. for commercial companies) through lifestyle with satisfying financial goals through to cultural goals with satisfying financial goals.

Arguably the main drivers of change in the north are shifting from production (closely related to commodity values) to amenity values (more related to tourism, indigenous, conservation, etc. values) resulting in a growing priority to understand non-market and fugitive income. This is reflected at a community or regional scale in the existence of both productivist and non-productivist paradigms for resource use. Furthermore, the mix of paradigms, aspirations and circumstances varies dramatically across regions as a result of the varying composition of regional communities.

By contrast to more heavily populated and developed regions of Australia with generally more stable economies and populations, savanna regions are highly sensitive to changes in the system (e.g. the development or departure of a mine from a region). This raises significant methodological challenges in applying analytical techniques aimed at marginal changes (such as input-output models).

The types of issues summarised here suggest that regional dynamics in savannas are likely to lead to a broader range of likely outcomes than in larger urban centres, suggesting that more detailed process-oriented models may be required to gain insight into the differences between regions and the trajectories of regions.

Tractability of agent-based simulation approach

Agent-based simulation provides a potentially powerful tool to assess regional dynamics in that it “…permits the coupling of environmental models to the social systems that are embedded in them such that the roles of social interaction and adaptive, disaggregated (micro-level) human decision-making in environmental management can be modelled. It also permits the study of the interactions between different scales of decision-maker, as well as the investigation of the emergence of adaptive collective responses to changing environments…” (Hare et al. 2001). However, the complexity of most regional economies means that aggregation from human-level decision-making is exceedingly challenging. The comparative simplicity of savanna regions in terms of number of sectors and individuals may make these approaches on a whole-of-region basis tractable in a way that is not viable in other areas of Australia.

Assessment of potential insights from approach

The goal for further development of this approach is, at least, to produce a framework that explores which agents are critical to regional development under differing circumstances and why, and which can help inform innovative approaches to how regions might be profiled, recognising the changing priorities in northern Australia. A robust and empirically defensible characterisation of agents of change, their aspirations and their individual and collective behaviours would, in its own right, be a substantial contribution to regional planning and management.
Options for understanding regional dynamics in northern Australia

Provided the approach presented could be developed to be at least semi-quantitative (i.e. a mixture of qualitative and quantitative modelling) it is likely that it could be used to provide insights on the differing trajectories of various regions that come about as a consequence of their local community structures and external interests.

Subject to the fundamental issues of the stability or predictability of responses to circumstances by agents at a regional scale and the practical issues associated with information requirements, it may be practical to develop a generic structure for an agent-based simulation in savanna regions that can be populated with data for specific regions and provide sufficiently robust insights into regional trajectories.

Assessment of practical feasibility of approach

The trial conceptual model developed here has highlighted the substantial challenges in deriving robust, insightful and defensible definitions of community sectors, their key attributes and behaviours. There is no question that moving to a useful model that can be implemented would require significant theoretical and empirical work to achieve an adequate information base.

The work undertaken has not assessed the technical feasibility of implementing an integrated agent-based simulation on the scale proposed here.

6.1.5 Questions to underpin further development

In this section a series of questions that we believe are fundamental to further development are posed and explored under three categories: questions relating to conceptual tractability and intent; questions relating to information; and questions relating to implementation.

Questions on conceptual tractability and intent

The ideas explored here raise questions about whether it is possible even in theory to define sectors of communities and their response to circumstance with sufficient certainty to provide insights into regional dynamics. Clearly the answer to this question depends partly on the scale/granularity of the categorisations and behaviours modelled. Distinguishing family-owned grazing enterprises from those run by publicly listed companies and modelling the impacts on a region dominated by one or the other may be relatively straightforward. Modelling community dynamics with the many groups categorised above may not be tractable because the distinctions between sectors may be indefensible and the response to circumstance may be so dependent on context that in a complex mix, responses are essentially unknowable.

These considerations require further attention in conjunction with consideration of intent. So, for example, developing models of regional dynamics that seek to explain or explore the differences between the dynamics of regions might be considerably more tractable than seeking to develop models of regions that are intended to predict development trajectories.

Questions of information

Subject to the theoretical constraints and clarifications of intent outlined above, any further development of the ideas explored depends on the availability of key data and the financial, practical and ethical feasibility of collecting otherwise unavailable data.

- How could the agents of change be empirically distinguished?

In the workshop we used key action and type of organisation as the discriminators for the conceptual groups of actors of regional community. In the sustainable livelihood literature actors are identified by livelihood activities (Scoones 1998; Chambers & Conway 1992; Davies 1996). Complementary to action (livelihood activities), differences of world views on nature, society and or development of the actors on the region can refine the broad conceptual grouping of actors. The use of world views for actors grouping in multi-agent based modelling has precedence (Gunderson & Holling 2002; Janssen & Carpenter 1999; Carpenter, et al. 1999) and the development paradigms (productivist/post-productivist, intensification/extensification) identified during the workshop can assist this process. However, when dealing with agents in specific regions, we will eventually need empirical methods to identify groups of actors. One possible approach used for actor segmentation in tourism that could be explored is a multi-method that combines geographic (urban, rural and remote), demographic (density, ethnicity, age, gender) and psychographic variables (values, attitudes, lifestyles, interests, activities, personalities, habits, preferences, purpose, and objectives) (Hornman 2000).

- How do we characterise and justify the key actions of each of these agents?
To be useful, the key actions of agents need to be based on primary data collection and need to be quantifiable or, if qualitatively, at least to be expressed formally. This is likely to be challenging and expensive but an inherently useful exercise.

- **How can we determine the current and future existence/importance of key actors in each of the savanna regions?**

Again substantial data collection is likely. However, this might not need to be primary data collection but might be mediated through local government, regional bodies etc.

- **How can we capture the relationships between communities / agents and resource clusters?**

Different sectors of the community have different access to spatially distributed resources. Depending on the nature of the models developed, the assumptions of homogeneous distribution of resources across regions may not be justifiable and work may be needed to map community-resource linkages and to allow for these patterns in running models.

- **What challenges are posed by the difficulties in defining regional boundaries?**

The thinking presented here has assumed that a region is relatively clearly defined i.e. that agents hold common views on regional boundaries and operate with those boundaries and that data sits within regional boundaries. This may or may not be a reasonable working assumption.

**Questions of implementation**

As this work was an exploratory exercise, the work reported here has not addressed questions of implementation. These questions would include, *inter alia*:

- How do the ideas expressed here compare with what has proved possible in previous implementations in other domains?
- Are integrated agent-based simulations of regions tractable and worthwhile or can qualitative conceptual frameworks be usefully used to structure smaller (in scope) quantitative models?
- How does the cost of various approaches to implementation compare with the insights that might be gained?
7. An integrated approach to regional dynamics systems analysis
Yiheyis Maru

The purpose of this section is to explore to what extent formal development of the framework outlined in Section 3.4.2 would be feasible and of value to the TS–CRC’s research program. The approach taken is to seek to build on the elements discussed in that section at a level useful to a sensitivity analysis, and as a physical demonstration of the concepts to clients in a consultative program. It is easy to see how such an approach would become unwieldy—too complex to be readily assimilated, parameterised, analysed or validated. The challenge is to ask whether one can keep a representation sufficiently simple to be tractable yet still give some insights into the implications of the interplays between different capitals. The latter goal, rather than any goal of perfectly representing all the dynamics of a region, was deemed sufficiently constrained to be worth allocating a modicum of effort.

7.1 Overview of the approach

Conceptually, we sought a small number of measures of the state of each of the capitals previously discussed – the five capitals of the sustainable livelihoods literature plus institutional capital – then explored the minimum numbers of factors that might precipitate gains and losses in each of these measures, paying particular attention to interactions between the capitals. This raised the questions of what levels of the capitals were desirable, and who would define what measures were the most important? The consequent steps in analysis were:

i. For each capital category, identify three to five measures (stocks not flows) that would be likely to be important to a savanna regional community, paying attention to the issues raised in Section 3.

ii. For each measure, write a list of the types of flows that could increase or decrease the stock of that measure; attempting to limit to those flows which are critical in savanna regions, recognizing that some factors occur everywhere but are nonetheless important.

iii. For each flow, write a list of the critical factors which affect that flow, again with an eye to the issues of importance in savanna regions. Do not include a factor that one cannot at least hypothesise a relationship for.

iv. Create a VENSIM (or equivalent) diagram for each measure then seek the linkages between diagrams.

v. In principle, relationships can now be added to each linkage and a model created in which changes in inputs caused changes to the capitals and flows.

Sixteen VENSIM systems diagrams were developed as a first attempt. The content of these diagrams is summarised in Table 7.1.

In undertaking this exercise, we lacked the experience to do step (ii) and (iii) critically enough with respect to savanna peculiarities, step (iii) has probably not been adhered to strictly enough in terms of potential relationships, and step (v) has not yet been attempted (variables with similar names but a number on the end are probably the same item once thought through properly).

In terms of running any such model a third question arises, which is to tightly define what inputs one is interested in varying; this relates to the question of the timeframe over which one is seeking to consider responses—in general we presume this is looking out 10–20 years, rather than the very short-term dynamics. Hence it is important to think about the ‘slow variables’ which underlie the main responses, and not be too focused on ‘fast’ indicators which contain a great deal of noise.

The exercise was useful in generating a number of insights about the different capitals and questions about the process, which only an explicit attempt would precipitate. We would conclude that it is in fact worth continuing down this path a little further, since it does provide the only way to seeing how very different aspects of regional functions stack up against each other, as well as being an impetus to synthesise across domain boundaries rather than from within them. We discuss these insights further in the rest of this section.
### Table 7.1 A list of stock-flow diagram components relevant to each capital accumulation extracted from VENSIM influenced diagrams

<table>
<thead>
<tr>
<th>Asset/stocks</th>
<th>In flow/ outflow</th>
<th>Driver/control/ influence</th>
<th>Impact/ effect</th>
<th>Remark/ indicators</th>
<th>Data (requirements /availability /source)</th>
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<tbody>
<tr>
<td><strong>1. Financial Capital</strong></td>
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<td>Local Investment</td>
<td>Invests</td>
<td>Attractiveness</td>
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<td>Economic return</td>
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<td>Political return</td>
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<td>Divests</td>
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<td>Competitive advantage</td>
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<td>Bankruptcy</td>
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<td>Centralization</td>
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<td>Local Saving</td>
<td>Income</td>
<td>Interest earned</td>
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<td>Net remittance</td>
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<td>Expense</td>
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<td>Mean Family Real</td>
<td>Gross income</td>
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<td>Income</td>
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<td><strong>2. Human Capital</strong></td>
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<td>Employable Skills</td>
<td>Learn</td>
<td>Learning time</td>
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<td>Learning opportunity</td>
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<td>Net skilled migration</td>
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<td>Employ</td>
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<td>Disuse</td>
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<tr>
<td>Personal Health</td>
<td>Fitness</td>
<td>Safety, prevention and</td>
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<td></td>
<td>Health Maintenance</td>
<td>curative measures</td>
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<td>Injury</td>
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<td>Disease</td>
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</tbody>
</table>

Table 7.1  A list of stock-flow diagram components relevant to each capital accumulation extracted from VENSIM influenced diagrams

<table>
<thead>
<tr>
<th>Asset/stocks</th>
<th>In flow/ outflow</th>
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<th>Data (requirements /availability /source)</th>
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<tbody>
<tr>
<td>3. Social Capital</td>
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<td>Trust</td>
<td>Interdependence</td>
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<td>Discount rate</td>
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<td></td>
<td>Social interaction</td>
<td>Opportunity, cost</td>
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<td>Proximity, closure</td>
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<td></td>
<td>Effectiveness of interaction</td>
<td>Reciprocity Reputation Accountability</td>
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<td></td>
<td>Practice</td>
<td>Proximity, internal morality, psychological and material benefit</td>
<td>No people practicing</td>
<td>Benefits accrued</td>
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<tr>
<td></td>
<td>Promote</td>
<td>cooperative, tolerant or supportive</td>
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<td></td>
<td>Actively maintain</td>
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<td>environment</td>
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<td>Unique culture</td>
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<tr>
<td>(Attractive-ness and compatibility with emerging perspectives)</td>
<td>Practice</td>
<td>proximity, internal morality, psychological and material benefit</td>
<td>Crime rate</td>
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<tr>
<td></td>
<td>Promote</td>
<td>Inequality in basic capability, unemployment, Family dysfunction, isolation, stress</td>
<td>Inequality index</td>
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<td></td>
<td>Actively maintain</td>
<td>Crime control measures</td>
<td>Crime rate</td>
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<td></td>
<td>environment</td>
<td>Remoteness and climatic condition</td>
<td>Remoteness index</td>
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<td>Proportion of “dysfunctional” family</td>
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<td>Suicide rate</td>
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<td>Proportion of Resource spent on short term and long term solution</td>
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<td>Livability</td>
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<td>Outback Lifestyle</td>
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<td>Cost of living</td>
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<td>Access to services</td>
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<td>Crime</td>
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<td>Civil Social</td>
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<td>Organisation</td>
<td>Active and voluntary</td>
<td>Benefits and cost of organisation</td>
<td>Network or / and association density</td>
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<td></td>
<td>membership</td>
<td>Residence proximity, time</td>
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<td>Leadership</td>
<td>Interdependence and tolerance among members</td>
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<td>Heterogeneity</td>
<td>Promotion or substitution efforts</td>
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<td>Dysfunction</td>
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</table>
### Options for understanding regional dynamics in northern Australia

#### Table 7.1  A list of stock-flow diagram components relevant to each capital accumulation extracted from VENSIM influenced diagrams

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<thead>
<tr>
<th>Asset/stocks</th>
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<th>Data (requirements /availability /source)</th>
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<tbody>
<tr>
<td><strong>3. Social Capital</strong></td>
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<tr>
<td>Basic Capability and Equity</td>
<td>Access to primary health, basic education, valued employment, and participation in public life</td>
<td>Historically rooted inequality</td>
<td>Cultural disruption</td>
<td>Poverty spiral traps</td>
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<td>Remoteness</td>
<td>Outward socializing costs</td>
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<td>Self esteem</td>
<td>Long term counter measures</td>
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<td>Socio-economic gradient</td>
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<td>Health inequality</td>
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<td>Income distribution</td>
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<td>Dependence ratios</td>
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<td><strong>4. Institutional capital</strong></td>
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<tr>
<td>Institutional Capability</td>
<td>Flexible, rigid, transparency, accountability</td>
<td>Learning (Resisting)</td>
<td></td>
<td>Inbuilt mechanism for participatory institutional making and changing Captured</td>
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<tr>
<td>Organisational Capacity</td>
<td>anticipatory, Resisting and maladaptive, Effective and Mutual trust, Corruption and Distrust, Leadership and reorganisation skills</td>
<td>Learning</td>
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<td>Robustness</td>
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</table>
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<td><strong>5. Physical capital</strong></td>
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<td>Communication network</td>
<td>Invest /Divest</td>
<td>Attractiveness (economic, political and moral )</td>
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<td>Demand cost of provision</td>
<td>Technology</td>
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<td>Benefit from supply</td>
<td>population number and density</td>
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<td>Distance from service centres</td>
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<tr>
<td>Transport Network</td>
<td>Invest/Divest</td>
<td>Distance from attractor, attractiveness</td>
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<td>Need, Demand Cost of provision Benefits from supply</td>
<td>Safety</td>
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<td>Population mobility</td>
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<td>Technology</td>
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<td><strong>Natural Capital</strong></td>
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<td>Primary productivity</td>
<td>Soil fertility</td>
<td>Mean rainfall</td>
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<td></td>
<td>Nutrient depletion</td>
<td>Climatic variability</td>
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<td>Stocking rate</td>
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<td>Production costs</td>
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<td>Opportunity costs</td>
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<td>Aesthetic Value</td>
<td>Conservation</td>
<td>Promotion</td>
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<td></td>
<td>Promotion</td>
<td>History</td>
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<td></td>
<td>Access</td>
<td>Competitive advantage (e.g. safety destinations)</td>
<td></td>
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<tr>
<td></td>
<td>Uniqueness</td>
<td>Alternative uses</td>
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<td></td>
<td>Intervention Pollution</td>
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</tbody>
</table>
Table 7.1 A list of stock-flow diagram components relevant to each capital accumulation extracted from VENSIM influenced diagrams

<table>
<thead>
<tr>
<th>Asset/stocks</th>
<th>In flow/ outflow</th>
<th>Driver/control/ influence</th>
<th>Impact/ effect</th>
<th>Remark/ indicators</th>
<th>Data (requirements /availability /source)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spiritual value</td>
<td>Access</td>
<td>Rights</td>
<td></td>
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<tr>
<td></td>
<td>Encroachment</td>
<td>Alternative uses</td>
<td></td>
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<td></td>
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<tr>
<td>Mineral</td>
<td>Prospecting</td>
<td>Market</td>
<td>Effects on other capitals such as in (de) vestment</td>
<td>Its regional contribution in terms employment and its multiplier effects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extracting</td>
<td>Technology</td>
<td>infrastructure capital, human capital or divestment such as pollution on natural capital</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7.2 Assessment of integrated systems analysis approach

The first set of questions that arise when delving more closely into integrated systems analysis using the six-captitals framework, relates to how one determines what constitutes a better or worse outcome. This in turn relates to the type of world view brought to bear on the problem, as discussed in Section 3.

Human health has already provided a useful analogy for ecosystem health in the savannas, and is all the more relevant to the current complementary effort that considers the socio-economic well-being of the regions. The analogy raises important issues about the current general state of tropical savannas, given their characteristic high variability in environmental, social and political drivers. Human health is maintained by a high degree of active, strong internal control over the impacts of external disturbance. Primary production has simplified tropical savanna landscapes and reduced their potential and connectivity. With reduced internal control and the current passive strategy of dealing with external variability, external variability controls the destiny of the system (Holling & Gunderson 2002). If this is true, is it a sign of a general pathology of tropical savannas? Is the current strategy appropriate and healthy or do we need to strive towards active, strong internal control? Does human health provide a good metaphor worth emulating or are there better alternatives?

In short, if one accepts the use of the six capital-framework to ensure comprehensiveness, is there some balance of capital accumulations that is somehow better than others? Or are there some measures of internal network complexity in the flows and their controls that are more important?

The adaptive cycle (Holling & Gunderson 2002), as an heuristic theory of change, tracks changes in a capital and their meaning to the health of the system under study. According to the theory, accumulation is attended by slowly growing rigidity that signals impending collapse. A push for capital accumulation beyond a certain threshold may actually lead to a costly catastrophe. Thus capital accumulation per se is not directly correlated to the health of the system. Reduced productive potential (capital) per se also might not indicate ‘ill-health’ unless it is to a level where it cannot support reorganisation (perhaps in extreme cases of desertification?). This raises a set of questions. Is there a range in the continuum of capital accumulation that is ‘best’ for the health and vigour of the region or is it possible to continue to accumulate potential without falling in to the trap of rigidity? Is this desirable in any case under the extremely variable nature of tropical savannas? If so, is it possible to creatively manipulate the adaptive cycle and achieve sustained accumulation and flexibility in tandem? Are there any precedents?

As hinted in the theory and related works, further insights that may help resolve these questions may lie in investigating properties of the capital beyond the level and changes in accumulation. These properties are distribution, resilience, and effects (benefits, costs and externalities in other scales in space, time, and social organisation) of each capital. One conclusion that we can draw is that, as indicators of health of savanna regions, the relevance and meaning of modelling and simulation may differ for each capital measure. We now consider issues relevant to each capital.

7.2.1 Natural capital

We tried to represent natural capital with primary productivity, mineral and aesthetic values. Issues that arose included:

- The rangelands seem to be in a state of post-productivist transition (Holmes 2002) and Abel (1999) suggests that it is an opportune time for effective change because “rigidity is causing structural cracks” in institutions. In addition to the maps of revalued potential of the regions by Holmes (2002), it seems necessary to identify the phase of the adaptive cycle that a region occupies (including the natural system on which the region is based). This is because there could be significant differences between the regions that could provide insights into regional health (unless some changes are because of slow variables that work at a scale of the entire rangelands).

- The natural system, on which natural capital is based, is one of the greatest sources of variability in savannas. The sources of this variability include structuring agents (variables) such as fire and flood that decrease and scatter potential for renewal. Simulating the interactions of these structuring agents and the natural capital could be an area of further study, although considerable effort has already been invested in such activities by the TS–CRC.

- The post-productivist revaluation of land is a relatively new frontier of potential accumulation. How do these new frontiers interact with potential for productivist uses? Modelling may need to consider these interactions, for instance revaluation and the polluting effects of mining and primary productivity.
7.2.2 Social capital
Social capital was represented as civic social organisation, equity, liveability, trust and unique culture. Issues that arose included:

- The distinction between social and institutional capital is useful, for the latter is expected to have a significant role not only in reducing social dilemma but also in dealing with characteristically high environmental uncertainty. The distinction is reflected in the type of social interaction (as horizontal, informal associations and networks versus hierarchical, formal associations and organisations) and major form of externality-generating and maintaining mechanisms (trust and norms of reciprocity versus rules and formal sanctions) in social and institutional capital respectively.

Closure and internal morality are two relevant concepts in social capital formation.

- Closure implies that individuals are interdependent in some way: culture, shared resources, common hardship and proximity of habitation etc. Closure facilitates the norms of reciprocity. Relevant questions are: how is closure and social capital formation possible across cultures, and among people who share a resource base but with different interests, socio-economic status and where they live. It is also interesting to examine the role of shared difficulties of living in remote areas in providing common purpose to social capital formation.

- Internal morality is the degree of freedom members have to leave informal civil organisations for reasons other than the intent of free riding. Generally there is low incentive to invest in social capital because of the inherent difficulty of capturing the benefits. This is because of the public nature of benefits and the lengthy time involved in their generation. However, those who organise it can capture social capital formation. When this happens it is possible that individuals in the network or association can be forced to pursue norms that are not in their interest.

- What is the minimum requirement for an individual to contribute to the formation of social capital; and the minimum social capital necessary for a local community to counter decline?

7.2.3 Institutional capital
Institutional capital was represented as capability and capacity. Issues that arose included:

- Institutions can reduce uncertainty by increasing the predictability of people’s behaviour (and hence reducing variability). How do institutions affect the strategy of dealing with the extreme variability (particularly natural) which is characteristic of the tropical savannas?

- Institutions are meant to facilitate exchange of relations but often end up mediating power relations, due to capture by some interest groups. This can have a pervasive harmful effect on the health of a region and beyond, because of the often enduring nature of institutions (persistence, see Dovers 2002). Moreover, capture seems to stifle the flexibility of institutions, creating a hidden danger to the health of a region. This makes control and access to institutional design and change important areas of investigations.

- Polycentric governance systems with improved subsidiarity, stewardship and cooperation are often promoted as strategies to counter the centring tendency of market and government institutions. The degree to which subsidiarity and the capacity for local governance to act as a mechanism to counter this agglomerative role must be explored, possibly partly using modelling.

7.2.4 Financial capital
Financial capital was represented as mean family real income, local savings, and local capital investment. Issues that arose included:

Indicators of the health of financial capital as a sub-system of a region include:

- Measuring local saving that captures the phenomena of fugitive income, remittance and local liabilities.
- The calculation of family real income (average and a measure of variance).
- Local attractiveness for investment as an indicator of competitive vigor.

7.2.5 Human capital
Human capital was represented by numbers of people with employable skills and personal health. Issues that arose included:

- Mobility and the net flow of human capital.
• Revaluing (value adding) and using local knowledge and skills as a de-centering force.
• Disparity in human capital and its reverberating effect in the other capitals.
• What are the slow and latent variables underlying the dramatic difference in personal health between indigenous and non-indigenous groups of residents?

7.2.6 Physical capital
Physical capital was represented as communications and transport networks. Issues that arose included:
• What accumulation and distribution effects does communication technology (physical capital) trigger in the other capitals?
• What role does physical capital play in core-territory tension?
• Although it is obvious that physical capital can reduce remoteness, under what conditions does it also contribute to the reduction of social distance (socio-economic gradient)?

7.3 Towards a set of indicators for socio-economic ‘health’
The major purposes of pursuing this area of research further would be to (i) generate insights at a ‘helicopter’s eye’ view of the interactions between capitals and flows of major types in a regional community, and (ii) from this to support the definition of a well structured and justified set of regional health indicators which would together provide a useful picture to the local community. This preliminary work suggests three lines of study that could be usefully taken up and which would individually provide some beneficial insights regardless of the success of other work. If they were all successful, a fourth synthetic line might eventually provide useful moves towards the grail of a synthetic scenario model, but this should not be seen as the measure of success in this area.

i. Seek measures of health through consultative process analogous to the TS–CRC’s work on ecosystem health accepting the diversity of views, looking for overlapping and divergent measures to produce a minimum necessary suite of measures to enable these groups to successfully talk to one another. Overlap with the actors’ approach since that would help define a necessary and sufficient set of actor groups (albeit recognising the iterative nature of the process).

ii. Additional thought could be put into what constitutes a balanced set of outcomes for regions of differing qualities, at least initially based on the six-capitals framework. What characteristics would enable the region to do better or worse under the various different world viewpoints discussed earlier? For example, under an ‘adaptive resilience at all costs’ viewpoint, some sort of balance in capitals is probably appropriate; in an economic development viewpoint, the efficient conversion of other capitals to financial and physical capital might be emphasised, but with some measure of human capital needed to service this conversion; from a non-market value, post-productivist viewpoint, the accumulation of social (and human) capital in balance with sustaining natural capital might be paramount. This thinking could build on the value systems elucidated in the previous line of study.

iii. Iteratively with the foregoing process, continue developing the VENSIM-type model to encompass the variables identified, with the goal of formalising a rigorous list of stocks, flows and drivers, and determining which are well or poorly known. This may lead to insights into which relationships are likely to be important in longer-term dynamics but which require focused study. An additional focus on which variables are ‘slow’ and therefore likely to provide most predictive power (if they are measurable) will help ensure that attention is paid to the real drivers of system behaviour, rather than the variable experience of the outcomes that people notice on a day-to-day basis. Thus model development is primarily a device for systematically investigating (and in some degree analysing sensitivity) knowledge gaps, and prioritising monitoring activities that would provide the most useful information for stakeholders. This is particularly important where it is necessary to invest in new data collection.

If, and only if, the model is looking robust, then one might proceed to try to populate it with parameters and explore the dynamic responses more numerically. The key challenge here would be to either keep it strictly as a research model or find a way of leading observers through the model development process so they gain the same insights as the model developers, and thus become confident in using the model—though strictly in domain to which it pertains.

Item (i) would seem to be an important task which should be undertaken at any rate, which will at least help inform regional profiling efforts for diverse stakeholders even if the dynamic relationships are not well understood.
Options for understanding regional dynamics in northern Australia
8. Synthesis and proposed research program

Mark Stafford Smith and Daniel Walker

The Regional Dynamics Scoping Study reported here was carried out for the Tropical Savannas CRC in 2002–03. The project encompassed a substantial literature survey, a workshop of experts with knowledge of the north, several different exploratory model developments, and a collation of basic profiling data for savannas. Here we distil some of the lessons from all of these activities, recognising that their logic emerges from the details to be found by reading the whole report. We then propose elements of a potential research program for the TS–CRC’s consideration.

This document summarises the full project report. It is also available as a stand-alone resource that can be used as an agenda or background paper for subsequent decision-making. To this end, it draws on the report to (i) briefly recapitulate the reasons why one might want to consider regions as systems and study their dynamics, and (ii) re-state what features might need particular focus in such a study of savanna (or indeed any ‘outback’) regions; it then (iii) outlines some key research areas that could contribute to this study, and discusses how these might be taken forward.

8.1 Summary: Regional dynamics and the savannas of northern Australia

Why is it valuable to consider regions as dynamic systems? Examples abound of investments in one sector which have ignored the flow-on effects to another sector, resulting in less net economic benefits than expected. Planners are more sensitised to such issues today—as seen for example in the debate about the Adelaide to Darwin railway and its indirect effects on trucking companies and local employment, or the Coronation Hill mine debate with its net social and environmental impacts—but the tools for analysing these interlinked factors as a system are still limited. When the indirect effects are to be assessed in non-financial domains—such as the environment, human health, social or cultural impacts—it is even harder to make defensible cases, yet society is increasingly demanding such assessments.

Part of the problem is that human systems do not stand still: they change as people, their institutions and environments react to changing circumstances. In this sense the systems are dynamic over time. Feedback loops and downstream effects are the rule rather than the exception. A major area of research and practical endeavour today is therefore in studying regions as dynamic systems in order to contribute to regional decision-making. In many cases just an increased awareness of the systemic effects of investment is sufficient to improve the debate about particular decisions. New tools and approaches, however, enable planners and communities to include more quantitative scenario analyses in their decision making.

The trend towards paying more attention to the regional scale is worldwide, driven particularly by the increasing devolution of responsibilities to regions everywhere. So, given the much greater research capacity in more heavily-populated regions, why study savanna regions in this regard? Why not just wait for the results from other regions? The problem is that there are features of savanna regions which are not shared by the more studied areas of the world and Australia — low population density obviously, but also high environmental variability, remoteness from markets and centres of power, significant indigenous issues, and so on. Hence studies emphasising these features will not emerge from other regions. At the same time, given limited resources, the TS–CRC should focus specifically on studies that address problems that will not be dealt with elsewhere, which means that these studies must be based on a clear understanding of the special features of savanna regions.

Even given all this, why should the TS–CRC invest in such research, rather than expecting some other organisation in the tropics to take this on? This research is by its very nature synthetic across disciplines, institutions and sectors. Other agencies should take on some of the issues raised below, but individual agencies will inevitably tend not to take a systemic view, at least at first. The TS–CRC is a crucial facilitator of this integration.

Given this rationale for research into regional dynamics, what are the implications of the special features of savannas in terms of regional function, and what needs to be known about those implications?

8.1.1 Key drivers of savannas that set them apart from other rural regions of Australia

A regional dynamics approach highlights some key drivers which are most important in savanna regions and yet which are poorly understood because they are not strongly shared with regions elsewhere in Australia. As
argued by Stafford Smith (Section 3), debate about future directions in the savannas is increasingly polarised between productivist and post-productivist value systems (Holmes 2002), effectively setting supporters of economic development against supporters of non-market values. The integrated trade-off challenge that emerges is to balance the impacts of economic development on non-market values (i.e. to take an integrated bottom-line view) while recognising that non-market values will not be sustained in any case if there is no economic future in these regions. The sustainable livelihoods paradigm of five capitals (financial, physical, environmental, social and human, possibly also institutional) is one of several didactic devices for ensuring that values are considered in an integrated way in trade-off thinking.

The project also highlights some critical structural issues which underlie the interplay of these viewpoints and which influence the outcomes of private or public investments:

- There are **intrinsic biophysical and socio-economic structural constraints** on what options are open to different regions. These need to be understood to allow regional communities to be realistic about what they can control or change and what they must design systems to live with. Particular highlights include environmental variability, externally driven markets, low and mobile populations, the significant indigenous component of the population, as well as rapidly changing communications technologies and connections to the rest of the world.

- There are also **extrinsic economic forces at work which limit options** or demand special design consideration, like changing international market prices, energy costs, labour costs, globalisation, and tendencies towards agglomeration driven by critical mass and economies of scale. While these forces are common to all regions, they play out differently in remote areas in terms of their influence on relative prices and production costs on the distribution of economic activity (with potential problems of ‘fugitive capital’), and in investment strategies intended to affect these relationships. Although agglomeration is driven by economics and markets, it also plays out in policy and in social institutions.

- By contrast, there are also political trends **towards de-centralisation and local empowerment**, with the potential for some conflict between demands for cost-effectiveness (agglomeration) and socially desirable outcomes (devolution) if the drivers of each are not understood. Understanding this conflict will steer regions away from some sterile lobbying and enable them to focus on capturing opportunities (where real competitive advantages exist).

Any useful integrated framework for understanding regional dynamics therefore needs to be able to encompass these issues in one or more linked conceptual models, and ensure that these linkages are founded on an understanding of how the underlying drivers play out in the social, economic and biophysical environments in which northern communities live.

### 8.1.2 What general approach could encompass the issues?

In a dynamic view of where a region might be headed it is necessary, but not sufficient, to incorporate an integrated bottom-line accounting of impacts. The problem is that different actors in the regional community (and outside it) respond differently as a result of their belief systems, so that a dynamic view (which has feedbacks over time) must take some account of this. This then raises one of the most difficult problems in studying integrated human/environment systems, related to the ‘middle order number’ problem of classical physics (and Heisenberg’s Uncertainty Principle)—outcomes in small populations are driven by effects which can be neither generalised statistically, nor sufficiently simple as to be modelled individualistically.

To be more specific, most economic models use ‘simplifying’ assumptions like rationality, perfect competition, full employment, and ‘general equilibrium’ to make predictions. Although some of these assumptions adequately approximate the observed reality in ‘western’, urbanised economies, many fail in isolated, rural economies with large indigenous populations and a focus on non-market values. Parallel examples can be found in political theory or concepts of efficient resource development and service delivery based on assumptions of large, statistical populations. At the same time, an extreme anthropological view in which every individual is a case study that is unique and cannot be replicated does not hold out any hope for predictability. Given the increasing responsibility being placed on regional groups to envision their own futures, this condemns them to a continuing inability to assimilate an understanding of regional dynamics which could contribute to their deliberations, and leaves them subject to continued dominance by the most effective lobby groups and dis-empowering policy processes.

Caricatured, an anthropologist’s view on change is opposed to that of the conventional economist, contrasting the uniquely evolving views of individual actors with a simplistic, statistical, rational economic decision maker. The individualistic actor defies generalisation and prediction, while the monolithic *Homo economicus* obscures
differentiated action. Any realistic approach to regional dynamics must come to compromises between these views. This points towards cutting-edge research, appropriate to the TS–CRC’s strategic role; but also more soberly to the need to break the problem down into some achievable elements which can provide useful contributions while the whole is being developed.

The project’s workshop argued for a well-structured integration between some level of new understanding of individual actors which is tailored to savanna conditions, and the application of some tried and tested analytical techniques. A logical set of issues that emerged from this discussion were, in summary:

i. One core element of an integrated model must be **population dynamics** in lightly populated regions, at least tracking indigenous and non-indigenous populations separately, and understanding drivers of inter-and intra regional movements.

ii. A framework is needed to ensure that **multiple values** are considered, for example using the five capitals of the sustainable rural livelihoods approach plus institutional processes as a didactic device, encompassing the diversity of non-market values regarded as important in savanna regions.

iii. The **diversity of actors** must be considered, as at least actor groups related to a ‘necessary but sufficient’ set of syndromes of significantly different impacts and responses; these need particularly to encompass those groups driven by financial incentives compared to those driven by other, non-market, values.

iv. The ways in which **different actors affect the different capitals**, and in which changes in those capitals feed back on the actors, must be determined at an appropriate level of detail.

v. **The effects of agglomerating influences** of globalisation in financial, social and institutional terms must be understood, as well as the interactions between these influences and various policy-related options particularly related to regionalisation and self-determination in remote regions.

vi. A useful set of **key socio-economic health indicators** for savanna regions is needed, on the understanding of which appropriate **dynamic regional models** may be built, to assist with informing investment decisions.

Explorations into several of these areas during this scoping project (see Sections 4, 5, 6 and 7) led us to propose an integrated research framework, which will not answer all questions but seeks to target those critical elements of the understanding needed to deal with issues that are unlikely to be dealt with by researchers working outside the remoter regions of Australia.

The framework encompasses:

i. establishing some basic datasets and community-based priorities,

ii. focusing research on key areas of enabling knowledge, the need for which emerges from the discussion summarised above, and,

iii. developing a suite of tools with greater predictive or explanatory power for planning effective investment in remote regions.

Although this discussion focuses on savanna regions, a considerable part of it applies to any of the remoter outback regions of Australia and their service towns; the differentiation is primarily between these regions and the settled agricultural and peri-urban rural regions of Australia (cf. Stafford Smith 2000). While there are some features specific to savannas (especially in the environmental domain), the result is that these conclusions may often also be relevant to the Desert Knowledge CRC; co-investment in some areas might be sought, as noted below.
8.2 Options for a research program

The following general research areas emerged from this scoping study. The remainder of this document therefore provides the basis upon which these proposals are made. The proposed research areas are presented here so that this section and the preceding Executive Summary can be distributed and read independently from the body of the report.

We present them as seven main areas in three groups, with some specific project definition in each (see Figure 8.1 below). Each research area could independently provide benefits to decision makers. While there would be synergies between some research areas, it will not be feasible to implement all areas at once (or perhaps even within the life of the TS–CRC), so it is fundamentally a stakeholder and research management decision as to which areas should be implemented first or at all. However, the present study does suggest that in several cases, once the decision has been taken to carry out a particular research area, one would logically wish to implement many of its sub-projects.

![Figure 8.1 Savanna regions as systems with seven main research areas organised in three groups. Research areas are discussed in detail in the following subsections.](image-url)
8.2.1 Savanna regions as systems: basic conceptual models

This is an underpinning research area, which the scoping study has already initiated but lacked the resources to progress with full consultation. It will simultaneously provide an understanding of the issues that drive different sections of the community, a defined scope for the remainder of the work proposed here, and some initial clarity on what a sensible categorisation of actor groups may be.

**Goal:** To develop a commonly agreed, conceptual model of the systemic linkages between indicators of integrated savanna health derived from community consultation.

**Task 1A:** Community consultation (using a previous natural resource management model of engagement, Whitehead et al. 2000) of indicators of integrated savanna health as perceived by different stakeholder groups (NB: without an attempt to homogenise these, beyond recognising genuine overlap/duplication).

**Task 1B:** Develop a conceptual systems framework for all of these, which incorporates the drivers and outcomes of change in all indicators, and highlights three key sets of factors: (i) fast variables impinging on day-to-day experience; (ii) slow variables which are crucial precursors to change in the indicators of concern to stakeholders; (iii) contextual variables (very slow variables) which determine how slow variables act out.

**Comment:** Some iteration between Tasks A and B may be required to prioritise and fine-tune the variables of concern, and also to achieve the ancillary outcome of developing the northern community’s capacity to think about their regions systemically. The recognition of value in this may depend on some implementation of Research Area 2. Note that the purpose is *not* to force all actors to accept one set of indicators but rather to develop a set which (i) satisfies and informs key purposes of and debates among different actors and (ii) is informed and enriched by a systemic understanding of the relationships between relevant fast and slow variables (developing the understanding of which may well highlight further basic research questions about causation).

8.2.2 Savanna regions as systems: systemic profiles of regional socio-economic health

Historically indicator lists tend to be plucked from participants’ pet paradigms; this research area seeks to build on a formal systemic framework to provide more meaningful indicators of regional function which are embedded in a process of understanding how they interact with one another. While long-term primary data collection for monitoring should not be the role of TS–CRC, there is a significant research endeavour in setting up a system, linking it as much as possible to existing data collection, and providing rigorous justification for some possible changes in collection priorities among collecting agencies.

**Goal:** In the appropriate partnerships, establish a sustainable data collection/collation, interpretation and dissemination system for regional profiles focused on issues critical to savanna health.

**Task 2A:** Develop an explicit set of critical indicators from the outcomes of Research Area 1, taking care to balance short and long term concerns (‘fast and slow’ variables), with an intelligent categorising into (i) items that are already collected, (ii) items that can be confidently indicated by some other existing measure, (iii) items that could be indicated by another existing measure but require research to confirm an appropriate causative or reliable correlative link, and (iv) items that require new data collection. The rationale for (iv) needs strong explanation (which may have to be balanced by a recommendation to cease collecting some other items).

**Task 2B:** Undertake research to justify the causative/correlative value of promising measures (Point iii and perhaps part of Point iv in Task 2A). [Note this is an ill-defined task due to the uncertainty of its extent at this stage; the purpose is to assure this type of important research a home, but in fact many results may emerge from Research Areas 3 and 4, Enabling knowledge.]

**Task 2C:** Establish a demonstration data collation, interpretation and dissemination system as partnership among those agencies most likely to continue sustaining it. Interpretation may be simple (particularly initially), or may involve some interaction with the products of Research Area 6. Dissemination processes are essential, but some of these are already in place through these agencies.

**Comment:** There is a role for the TS–CRC to initiate and illustrate this process, but for the system to be sustainable it must be embedded in existing agencies; hence the TS–CRC’s role should be principally facilitatory. An appropriate partnership is an essential development here. Clearly the intent is to build more systemically on the existing substantial efforts in this general area, adding value to these, and not treading on
turf. In this regard there is also a potential for co-investment with the National Land and Water Resources Audit and particularly its Australian Collaborative Rangelands Information System developments.

8.2.3 Enabling knowledge: economics
The key features of savanna (and other remote) regions highlight the hypothesised importance of capital flight, agglomeration and the significance of non-market values as economics-related issues which require close attention in these regions. Also important, is the middle order number problem indicating that one may often (but not always) need to apply approaches that are different to those which would be appropriate in more densely populated regions.

Goal: To develop an understanding of how to apply economic methodologies legitimately in savanna regions, and to quantify some baseline economic statistics of relevance to understanding the economics of remote regions.

Task 3A: Identify appropriate methodologies (given limited datasets) and apply them to case studies in a variety of regions with different characteristics to determine what economic multipliers result from different activities.

Task 3B: Apply existing non-market valuation techniques to a variety of landscape uses to generate some order-of-magnitude understanding of the relative value of these to society; a specific project would be to make a pilot comprehensive assessment of the value of different land uses to society, including indigenous traditional land uses, which would help validate public investments in sustaining land uses through Landcare, investments in indigenous land use, and other ‘stewardship salaries’.

Task 3C: Develop simple economic models of regions that could be used to inform decisions about which regional industries and business systems could be promoted in order to obtain different outcomes. The first step in this task is to explore a wide range of existing economic models to determine whether or not their assumptions fail in savanna regions.

Comment: While some development of new methodology (e.g. for non-market values) is occurring widely and would not be a competitive research endeavour in the savannas, building capacity in the application of such methods may be important for TS–CRC. The exploratory application of the methods in order to better quantify the significance of these factors is certainly urgently needed, although it may be possible to promote some of this work in existing agency activities. In this regard, Task 3A might be an expected task of economic development agencies in the north anyway. Task 3B certainly takes issues beyond the current skill base, and could in any case benefit from pilot studies which establish how to do this in remote regions. Task 3C is a novel dynamics modelling exercise, albeit relatively narrowly in the economics domain, which the TS–CRC would need to be responsible for (and which requires data from the previous tasks) in partnership with agencies to help direct investment approaches.

8.2.4 Enabling knowledge: community dynamics
There are both statistical and anthropological aspects to how people make decisions about where to be and what to do there – the behaviour of individuals plays a major but neither statistical nor easily predictable role in the outcomes, and there can be sudden changes in the balance of different actors in communities that lose a mine or gain an influx of tourists. There is a resulting need to understand actors’ decisions in more detail, while still seeking generalities and predictability. Small populations and their marked mobility at several time scales also pose special problems for projecting demography, and consequently for planning where infrastructure will be needed in a few years. This is not demography for its own sake, but rather in the context of understanding what makes regions and communities more or less attractive to people, what drives their capacity to adapt to extreme conditions, and the impacts of their resulting decisions on resource use and economic opportunity. The focus is on people as individuals and loose-knit groups or human communities.

Goal: To understand the drivers and implications of decisions about location and livelihood activities for different groups of actors in savanna regions.

Task 4A: Understand what categories of actor groups are usefully discriminated in different regions, through an analysis of their influence on and responses to the different capitals of the sustainable livelihood paradigm. This task is aimed at informing the appropriate level of resolution for regional models that deal with interacting interests.

Task 4B: Study how different groups of actors interact and how the decisions reached supposedly by regional communities are driven by different groups. How do these processes alter over time in small
communities subject to ‘state and transition’ changes in community dynamics (compared with
equilibrial-type dynamics in larger populations)? Apply interactive tools for exploring how different
actors make decisions, such as experimental economics tools, in savanna cases to understand what
drives actor decisions.

Task 4C: Study the drivers of the attractiveness of remote regions: analyse net immigration and
turnover at the regional scale in the demography of small populations, paying attention to the
differences between groups (particularly indigenous/non-indigenous) within these regional
communities. This task is typically at a Statistical Local Area scale, thus providing a savanna-wide
understanding with regional resolution, on a decadal timescale.

Task 4D: Understand the drivers of the mobility of local populations within regions, particularly
between urban centres and remote settlements (whether indigenous or non-indigenous). This task
would aim to understand what makes individual communities and remoter towns attractive to live in
on a one to 10-year time scale, with the goal of informing decisions about where and how to deliver
services.

Comment: Task 4A could be initiated as an outcome of Task 1A, and may lead to follow-up work not yet fully
understood. Tasks 4B and 5A move toward an explicitly Australian outback sociology that understands how to
live with the social drivers arising from the settlement patterns of Australia with its coastal population centres.
The outcomes are important for social planning, the provision of family services, education and health, which
in turn underpin the attractiveness of regions. The TS–CRC has a role in promoting this type of research in
conjunction with university partners since no one else is likely to take it up until the initial returns become
clear. Tasks 4C and 4D incidentally require an understanding of the limitations to regional census data
accuracy, particularly on remote communities, and their implications for demographic modelling. There appear
to be significant problems with census data on locally mobile populations (e.g. indigenous communities); this is
a concern for ABS, the Australian Grants Commission and various state Treasuries.

8.2.5 Enabling knowledge: institutions, rules and policies

Agglomeration affects social decision making processes. The fundamental issue is to understand how small
remote groups of people interface equitably and comfortably with larger population centres, both within remote
regions with urban service centres, and between rural regions and state or national institutions.

Goal: To understand the factors creating conflict and tension when remote communities interact with larger
population centres, and guide decisions aimed at reducing these tensions.

Task 5A: Develop an understanding of how basic social dynamics among players are affected by the
scale and connectivity of different communities, and consequently to what degree policy and social
agglomeration is an inevitable outcome of social dynamics in remote areas (cf. economic
agglomeration). For what scales and patterns of communities can these effects be countered by minor
subsidy as opposed to requiring fundamental rearrangement of interaction rules? To what extent are
these problems of any remote community and to what extent are they exacerbated by cross-cultural
concerns?

Task 5B: Build a better understanding of how the design and implementation of institutions and
governance structures affects regional dynamics by creating potentially different outcomes from
apparently similar starting points. This is particularly important in terms of how remoter population
centres link with centralised governance systems such as urban centres or state governments, and
should inform the resilience of different systems, their capacity to adapt, and the flow on effects on
attractiveness for habitation and investment. This probably requires a series of workshops to bring
relevant theoreticians and practitioners together to define common questions, and then a series of case
studies targeting parallel design and outcome questions.

Comments: Task 5A is quite basic research which has never been applied in a remote community context; as
with Task 4A, some initial investment is needed to prove its potential. Task 5B is focused on the impacts of
institutions on regional dynamics; this should be distinguished from a large body of work that is needed on
institutional design and governance effectiveness which is outside the ambit of this regional dynamics area but
is fundamental to regional natural resource management as well as the provision of services, and is one core
concern for the DK–CRC.

8.2.6 Regional models: regional futures models

There is an overriding contextual need to understand where different regions of the savannas are headed in
general terms, so that more detailed investigation and investments can be tailored to suit each region’s future
options. Thus there is a need for some models with savanna-wide scope and regional resolution, which help to inform regional communities of their options, and the likely implications of different broad-brush investment strategies. We see two general time scales here, one related to long-term visions and the other to medium term strategies; the focus is particularly on inter-regional opportunities and investment. Both first require a careful assessment of the strengths and weaknesses of existing approaches.

**Goal:** To inform the integrated bottom-line trade-offs involved in major investment decisions and smaller systemic investment patterns at a between-region scale, and to enable regional communities to put their region in context (though not to predict the future!).

**Task 6A:** *Regional stocks and flows model* [timeframe 10–50 years]: this is aimed at ‘what if’ questions over the long term, allowing governments to examine the major resource and economic implications of changing population patterns, and regional communities to see what the outcomes of different future scenarios would be for their region. Such a model could build on existing regional futures modelling for Australia, but focusing down to a regional scale and altering many of the existing components to address the different drivers and implicit relationships in savanna regions.

**Task 6B:** *Regional business and non-financial livelihoods model* [timeframe 1–10 years]: this would build on the outcomes of Task 3C to understand trade-off implications in terms of population, employment, environmental pressures, etc. between regions with different characteristics across the savannas. It would enable public and private investment to be channelled toward activities most likely to enhance the retention of human, social and economic capital in remoter regions, recognising that there may be substantial differences between regions in the appropriate approaches.

**Comments:** Models like this have been tried in other forms before and this effort must be (i) founded on the foregoing understanding and particularly the items emerging from Task 1B, and (ii) carried out as a partnership with relevant planning authorities (with other stakeholders as contributors to priority setting) to ensure a direct pathway into use. However, it is clear that models simply lifted from other regions will not meet many of the purposes required in the north because of the factors discussed in this report.

### 8.2.7 Regional models: local dynamics models

This research area relates to integrated models which have a regional scope but with a resolution related to within-region dynamics; the principle focus is to help inform investment decisions within a region. There are a very large number of possible projects at this scale and the detailed goals of individual projects will depend on the decision-making priorities of target regions. Such projects should call on relevant parts of the research area on enabling knowledge to develop a systems model targeted to the purpose in hand (there is no single comprehensive regional model and this should explicitly *not* be a goal, although there may be useful ‘nuts and bolts’ components that can be used in multiple arenas). Notwithstanding the diversity of possible projects and the need to be led by stakeholder priorities in this regard, the logic expressed in this study suggests that three types of projects should be particularly promoted, as noted below.

**Goal:** To develop integrated regional dynamics models which address targeted regional decision-making concerns in ways which inform the specific trade-offs between different elements of the five capitals and consequently enhance the value of specific investments in savanna regions.

**Task 7A:** *Urban service centre/community hinterland spatial demography and services models*: these models integrate the understanding of demographic drivers with the ways in which small and large communities interface on savanna landscape resources. Mount Isa and the Gulf, Katherine and the Victoria River Distict and surrounds, and Alice Springs and central Australia are all examples of urban centres in remote hinterlands. Each region is faced with the problem of knowing whether they need to plan for population migrating into towns over the coming decades, or should develop service agreements with community government/rural shires to deliver local government services outside town and thereby reduce some services needs on the urban areas. This type of model would draw on the understanding of inter and intra regional community attractiveness as a driver for projected changes, and investigate how different patterns of investments in services might drive and be driven by spatial demographic changes. It would be explicitly sensitive to different modes of function between indigenous and non-indigenous sectors of the population where appropriate.

**Task 7B:** *Integrated bottom-line models of regional trade-offs in savanna intensification*: these models formally investigate the trade-offs between economic development and non-market values in practical examples of proposed developments. The Daly Waters region, the Ord, areas of the lower Fitzroy River, the Burdekin, as well as new suggestions such as cotton on the black-soil plains of northern Queensland are all examples of proposed or actual intensification of land use with attendant
non-market implications. This type of model would draw on the economic enabling knowledge and couple it with communities’ different value sets to provide more and balanced evidence in decision-making debates about these types of developments.

**Task 7C:** *Integrated quantitative analysis of the role of communications technologies* in altering the relationship between remote regions and urban centres: these models would synthesise the implications of ICT in remote areas to help direct the most appropriate investments in this technology and training. It is widely presumed that ICT is a core investment for assisting remote regions, but there is little quantitative evidence for whether the investment should be aimed at connecting remote communities to each other or to urban centres or to markets, nor of the many other systemic impacts of any given ICT investment. These types of models would link an understanding of the social and economic relationships between small communities and urban centres with the aspirations of actors for healthy regions.

*Comments:* Any one of these models would be a substantial undertaking and, to have any value in decision-making, would need to be undertaken with a wide range of relevant stakeholders. However, it is also worth noting that simple approaches to specific problems like these might usefully be undertaken early on (perhaps with less stakeholder involvement) to gain experience which helps to direct the enabling knowledge projects more precisely. This would result in an iterative process through this entire research framework.
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10. Appendix A: Project workshop, Toowong, November 2002

This appendix briefly summarises the participants and process of the main ‘think-tank’ workshop of the project. A separate detailed workshop report was produced for internal use, which captured all the material from white boards and butcher’s paper during the workshop. The interpreted essence of the discussions is reported in the main body of this report. The following background was provided to the participants (and expanded on a little in the introductory material to the workshop, which also contained a survey of data currently available to stimulate discussion, and some summary of the review material expanded substantially in this report, to provide a basis for choosing a framework for the discussions).

10.1 Background and scope of project

This Tropical Savannas CRC project is aimed at the CRC’s objective of contributing to policy and management options for regions, particularly in relation to enabling regional communities to better envision where they are going by providing scenarios of possible regional futures. The project is a short-term (three-month) scoping study to develop an initial conceptual model framework, identify existing and required datasets that could contribute to this (particularly social and economic data), and to develop a process for analysing what key research is needed to improve the ability of the CRC to deliver quantitative planning scenarios. Past scoping studies have not provided an articulation of priorities in a dynamic context. This study will initiate what will begin as crude models but focused on the most critical and integrated variables of importance for regional dynamics in sparsely populated regions.

The modus operandi of the project is literature review and data collation, then a think-tank workshop of a few people experienced in savannas at a regional scale to build an initial systems analysis of the critical issues and relationships needed for a framework. This will be focused towards the features that set savanna regions apart from other parts of Australia where similar efforts might be taking place – eg. low density population, long distances to markets, significant indigenous interests, generally low landscape productivity (with pockets that are ‘rich’), seasonal climate, limited physical infrastructure, (usually) distant policy making processes, etc.

Clients: the immediate client for this study is the TS–CRC itself, which is seeking a clear and concrete articulation of the foundations for a research agenda, but the ultimate clients for this area of work are the regional communities of the tropical savannas. By regional communities we mean the diverse set of interests that might get together to plan the future of a given region, including sectoral (pastoral, tourism, mining, small business), governance (local government, state/NT government agencies, indigenous community government) and community-based (NGOs, health and education service deliverers) groups. Although a wholly integrated process of regional planning is not likely in any region in the near future, the project is predicated on expanding the awareness of all these players of how planning in relation to their sector affects others.

Client goals and model purpose: Ultimate client goals are presumed to be those of net regional human welfare, including economic, cultural and social aspects, over about a 20-year time frame. However, the CRC as a whole has some focus on issues that ultimately affect or are mediated through the natural resource base, and we are intending to be somewhat biased towards these as a fundamental component to be considered. The systems analysis is aimed towards a quantitative modelling framework for developing future scenarios for savanna regions with different characteristics, but at a scale of a ‘helicopter view’ which can incorporate all elements of the integrated bottom line, or factors that drive sustainable livelihoods.

What we’re not doing: We recognise explicitly that there are aspects behind this question which are not amenable to quantitative modelling, even in principle, and are more appropriately in the domain of social science and cognitive psychology, etc. This project is specifically aimed at the potentially quantifiable relationships, while being aware of their limitations and knowing that other projects are pursuing other aspects.

This short scoping study will also unabashedly not include extensive consultation with all the possible interest groups (at the broad level of project goals this consultation has occurred extensively in setting up the scoping project in the first place), but does explicitly aim to include people in the workshop who can bring a reasonable understanding of the diversity of views to the table. One outcome of this small initial investment should be a recommended process for taking the outcomes out into a broader community consultation and design process, so that eventual research priorities are well informed by those stakeholders.

Meeting the goal: the study will actively seek to consider a framework through a variety of different lenses, to ensure that a holistic approach is taken. Initially the intention is to use the five different forms of capital
discussed in the sustainable livelihoods literature as a mechanism to elicit thoughts on this, but we do not necessarily wish to be proscribed by this particular framework.

We don’t want to get hung up on the definition of region at the stage of conceptualising relationships and models; but we must visit the issue critically when it comes to data that could help develop models (IBRAs, catchments, LG boundaries, SLAs, electorates, communications, catchments, etc.). The fact that some of these regionalisations relate to different processes may be an important issue in itself.

Some issues will only be debatable in a comparative sense, and we will need some reference points in terms of the ‘average’ savannas and national states. We aim to emerge with three classes of insights: issues where quantification or modelling of some form can already give useful insights, issues amenable to quantification but where more research is needed to do so; and issues which require investment in other approaches and should not be tackled this way.

**Project outputs,** by early 2003, will be:
- Formalised, if preliminary, integrated modelling framework
- Conceptual (at least) sensitivity analysis and identification of critical research needs (draft plan for potential research priorities emerging and approaches to dealing with them)
- Collation of some relevant datasets not previously assembled with a savannas focus.

Unless they wanted to, participants were not asked to do more than attend and contribute ideas at the workshop.

### 10.2 Workshop design

The workshop took place in Brisbane (Toowong), and broadly took half a day getting all participants to the same general perspective, half a day looking at formal approaches to a model framework, and half a day working out what lessons this framework provides for research.

#### 10.2.1 Workshop agenda

**Before workshop:** participants were requested to identify two to three indicators that they thought were relevant for a regional community concerned with measuring net regional welfare in each of the environmental, economic, physical infrastructure, human and social capital domains.

**Thurs 14th November**
- 09.30–13.00: Introduction
  - Discuss scope of project, domain boundaries and concept of a region; also note the special features of savannas warranting a different focus to elsewhere
  - Group session identifying a suite of potential indicators focused at this (time/space) scale and scope, followed by a brief exercise based around the systemic links among the collated proposed indicators
- 13.45–17.30: Discuss indicators and processes in this systemic context from the perspectives of different sectors, and agree an approach to developing relationships among them; discussion led to two groups forming to deal (1) with extending a conventional economic approach to regional analysis, and (2) to wrestle with the problem that different actors in a region value and respond to change in very different ways; report back at the end of the afternoon.

**Fri 15th November**
- 08.30–1230: Reflect on previous day and synthesise modelling approaches
  - Returned to groups to further develop the approaches, with Group 1 now focusing on extending the economic framework to encompass non-market values, and Group 2 further developing the indicators of interest to and the actions available to different actors. Plenary report back.
  - In plenary, we then discussed a number of issues related to research priorities, including data limitations.

The workshop closed at lunch (the project team continued synthesising and writing up during the afternoon).

## Participants

<table>
<thead>
<tr>
<th>Project team (CSIRO):</th>
<th>Present throughout:</th>
<th>Available Thurs only:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark Stafford Smith</td>
<td>John Holmes (UQ)</td>
<td>Martin Bell (am only) (UQ)</td>
</tr>
<tr>
<td>Dan Walker</td>
<td>Roy Powell (Private)</td>
<td>Gerard Byrne (all day) (QDPI)</td>
</tr>
<tr>
<td>Romy Greiner</td>
<td>Ben Smith (CAEPR, ANU)</td>
<td></td>
</tr>
<tr>
<td>Natalie Stoeckl</td>
<td>Ryan McAllister (UQ/CSIRO)</td>
<td></td>
</tr>
<tr>
<td>Yiheyis Maru</td>
<td>Andrew Ash (CSIRO)</td>
<td></td>
</tr>
<tr>
<td>Joe Breen</td>
<td>Franz Poldy (CSIRO)</td>
<td></td>
</tr>
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</table>
11. Appendix B: ABS statistical boundaries

Source: Greiner et al (2001)

In Australia, most socio-economic data is collected by the Australian Bureau of Statistics (ABS). ABS data are predominantly available for **Statistical Divisions (SDs)**, **Statistical Subdivisions (SSDs)** and **Statistical Local Areas (SLAs)**. For some data, the spatial resolution can be increased to the smallest statistical areas of **Collection Districts (CDs)**. Figure 11.1 illustrates how the various scales or reference areas relate to each other.

<table>
<thead>
<tr>
<th>State/Territory (e.g. Queensland)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical Division (SD) (e.g. ‘Northern’)</td>
</tr>
<tr>
<td>Legal Local Government Area (LGA)</td>
</tr>
<tr>
<td>Statistical Subdivision (SSD) (e.g. ‘Northern SD Balance’)</td>
</tr>
<tr>
<td>(e.g. Dalrymple Shire)</td>
</tr>
<tr>
<td>Statistical Local Area (SLA) (e.g., ‘Dalrymple’)</td>
</tr>
<tr>
<td>Postal Area (POA)</td>
</tr>
<tr>
<td>Census Collection District (CD)</td>
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</tbody>
</table>

**Figure 11.1 Hierarchy of ABS reference areas (Source: ABS, 1996)**

Collection districts (CDs) are the smallest units for which ABS releases census-based statistical information and form the basic building block for statistics and the aggregation of statistics to larger areas. In urban areas, there are about 225 dwellings in each CD but in rural areas the number of dwellings declines as population densities decrease. CDs are defined and current only for each census, therefore posing difficulties for comparisons between census years at that level. For the 1996 Census of Population and Housing, there were approximately 33,000 CDs throughout Australia (ABS online).

Statistical Local Areas consist of one or more CDs. They can be based on Local Government Areas (LGAs), or parts thereof, or any unincorporated area. Statistical Subdivisions consist of one or more SLAs and are used as an intermediate level, general purpose and regional-type geographic unit.

Statistical Divisions comprise one or more SSDs. They do not cross state or territory boundaries and are the largest statistical area building blocks. They are used as large, general-purpose regional type geographic areas. They represent relatively homogeneous regions characterised by identifiable social and economic links between the inhabitants and between the economic units within the region, under the unifying influence of one or more major towns or cities.
12. Appendix C: Details of SEIFA Indices

Source: Greiner et al (2001)

12.1 Variables used in SEIFA indices

*Index of Relative Socio-Economic Disadvantage*

**Weight between 0.2 and 0.3**
- Persons aged 15 and over with no qualifications (%)
- Families with income less than $15,600 (%)
- Families with offspring having parental income less than $15,600 (%)
- Females (in labour force) unemployed (%)
- Males (in labour force) unemployed (%)
- Employed Females classified as ‘Labourer & Related Workers’ (%)
- Employed Males classified as ‘Labourer & Related Workers’ (%)  
- Employed Males classified as ‘Intermediate Production and Transport Workers’ (%)  
- Persons aged 15 and over who left school at or under 15 years of age (%)  
- One parent families with dependent offspring only (%)  
- Households renting (government authority) (%)

**Weight between 0.1 and 0.2**
- Persons aged 15 and over separated or divorced (%)
- Dwellings with no motorcars at dwelling (%)
- Employed Females classified as ‘Intermediate Production & Transport Workers’ (%)  
- Employed Females classified as ‘Elementary Clerical, Sales & Service Workers’ (%)  
- Employed Males classified as ‘Tradespersons’ (%)  
- Persons aged 15 and over who did not go to school (%)  
- Aboriginals or Torres Strait Islanders (%)  
- Occupied private dwellings with two or more families (%)  
- Lacking fluency in English (%)  

*Urban Index of Socio-Economic Relative Advantage*

**Weight between 0.3 and 0.5**
- Families with income greater than $77,999 (%)  
- Employed Males classified as ‘Managers or Administrators’ (%)  
- Employed Persons classified as ‘Professionals’ (%)  
- Persons aged 15 and over with degree or higher (%)  

**Weight between 0.2 and 0.3**
- Employed Females classified as ‘Managers or Administrators’ (%)  
- Employed Males classified as ‘Associate Professionals’ (%)  
- Dwellings with 4 or more bedrooms (%)  
- Persons aged 15 and over at CAE or university (%)  

**Weight between 0.1 and 0.2**
- Employed Females classified as ‘Advanced Clerical & Social Workers’ (%)
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- Employed Males classified as ‘Advanced Clerical & Social Workers’ (%)
- Employed Females classified as ‘Associate Professionals’ (%)
- Dwellings with 3 or more cars (%)
- Households owning dwellings (%)
- Average number of bedrooms per person
- Households owning or purchasing dwellings (%)

**Rural Index of Socio-Economic Relative Advantage**

**Weight between 0.3 and 0.4**
- Employed Males classified as ‘Professionals’ (%)
- Employed Males classified as ‘Associate Professionals’ (%)
- Persons aged 15 and over with degree or higher (%)

**Weight between 0.2 and 0.3**
- Households purchasing dwelling (%)
- Employed Females classified as ‘Professionals’ (%)
- Employed Females classified as ‘Advanced Clerical & Social Workers’ (%)
- Employed Females classified as ‘Associate Professionals’ (%)
- Employed Males classified as ‘Intermediate Clerical, Sales and Service Workers’ (%)
- Persons aged 15 and over with trade or ‘other’ qualification (%)
- Persons aged 15 and over at CAE or university (%)
- Families with income greater than $77,999 (%)

**Weight between 0.1 and 0.2**
- Persons aged 15 and over at TAFE (%)
- Employed Males classified as ‘Advanced Clerical & Social Workers’ (%)

**Index of Economic Resources**

**Weight between 0.2 and 0.4**
- Households owning or purchasing dwelling (%)
- Dwellings with 4 or more bedrooms (%)
- Families with family structure other than two parent or single parent with dependent offspring or consisting of a couple only, and income greater than $77,999 (%)
- Families consisting of a two-parent family with dependent offspring, and income greater than $77,999 (%)
- Families consisting of a couple only, and with income greater than $62,399 (%)
- Families consisting of a single parent with dependent offspring, with income greater than $31,199 (%)
- Mortgage greater than $1,300 per month (%)
- Rent greater than $249 per week (%)

**Weight between 0 and 0.2**
- Households purchasing dwelling (%)
- Households owning dwelling (%)
- Dwellings with 3 or more motor cars (%)
- Average number bedrooms per person

**Weight between –0.2 and 0**
- Households in improvised dwellings (%)

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• Households renting (government authority) (%)
• Households renting (non-government authority) (%)
• Dwellings with 1 or no bedrooms (%)
• Rent less than $74 per week (%)
• Families consisting of a single parent with dependent offspring, with income less than $15,600 (%)

**Weight between –0.3 and –0.2**
• Families consisting of a couple only, and with income less than $15,600 (%)
• Families with family structure other than two parent or single parent with dependent offspring or consisting of a couple only, and income less than $26,000 (%)
• Families consisting of a two-parent family with dependent offspring, and income less than $26,000 (%)
• Dwellings with no motorcars (%)

**Index of Education and Occupation**

**Weight between 0.2 and 0.4**
• Employed Males classified as ‘Professionals’ (%)
• Employed Females classified as ‘Professionals’ (%)
• Persons aged 15 and over at CAE or university (%)

**Weight between 0 and 0.2**
• Employed Males classified as ‘Associate Professionals’ (%)
• Employed Females classified as ‘Advanced Clerical & Social Workers’ (%)
• Employed Males classified as ‘Advanced Clerical & Social Workers’ (%)
• Employed Males classified as Intermediate Clerical, Sales & Service Workers’ (%)

**Weight between –0.2 and 0**
• Employed Females classified as ‘Tradespersons’ (%)
• Employed Males classified as ‘Tradespersons’ (%)
• Employed Females classified as ‘Elementary Clerical, Sales & Service Workers’ (%)
• Employed Females classified as ‘Intermediate Production & Transport Workers’ (%)

**Weight between –0.4 and –0.2**
• Employed Males classified as ‘Intermediate Production & Transport Workers’ (%)
• Employed Females classified as ‘Labourer & Related Workers’ (%)
• Employed Males classified as ‘Labourer & Related Workers’ (%)
• Males (in labour force) unemployed (%)
• Females (in labour force) unemployed (%)
• Persons aged 15 and over who left school at or under 15 years of age (%)
• Persons aged 15 and over with no qualifications (%)

### 12.2 Methodological issues with SEIFA

To allow for easy recognition of high and low scores, the raw index scores the SEIFA are standardised. Each index has a mean of 1000 and a standard deviation of 100 across all collection districts in Australia. In practice, this means that around 95% of index scores are between 800 and 1200. This standardisation allows for easy geographical comparisons and relative assessment of a particular community in relation to a chosen reference point. At the same time the method poses a problem for longitudinal comparison in that the absolute SEIFA values are not comparable between census years. Longitudinal comparisons are restricted to the relative score of an index in relation to determined percentiles.
The indices, like all summary measures, have some limitations. These limitations are explained in ABS – Information Paper – 1996 Census of Population and Housing, Socio-Economic Indices for Areas. Catalogue 2039.0.

- Firstly, the indices contain only limited aspects of wealth. While income and expenditure are represented, aspects such as inherited wealth, savings, indebtedness, and property values are not included. These aspects were not included, as details on them were not collected by the Census. This affects the Index of Economic Resources more seriously than the other indices.

- Secondly, family structure (number of income earners, number of parents, number of dependents, etc.) is not strongly represented in the indices though it does appear to some extent in the Index of Economic Resources. As a consequence, the indices will perform relatively poorly at distinguishing between different family types directly.

- Thirdly, access to infrastructure such as schools, community services, shops and transport are not represented by the indices. These variables are considered to be integral to the concept of advantage or disadvantage. For example, rapidly growing outer suburban areas may suffer from a locational disadvantage situation rather than a socio-economic disadvantage.

The SEIFA are available for a wide range of geographic areas from small areas, such as collection district (an area made up of approximately 200 households), postal areas, local government areas and statistical local areas, to large areas, such as statistical subdivisions.

It is important to remember that comparison can only be made within an index, i.e. between areas described by a single index, not between different indices. Therefore, we can compare the region according to ‘Urban Advantage’ between the urban areas, but it is meaningless to compare these values directly with those of ‘Rural Advantage’.

It is equally important to bear in mind comparisons of indices between census years is not possible by comparing the absolute index values. Rather such longitudinal comparisons are restricted to comparisons between given percentiles. For example, a SLA may have improved from being in the bottom 10 percent for ‘Education and Occupation’ in the last census to being in the 25-50 percentile for the current census.