

Modelling the Complex System of Service Provision:

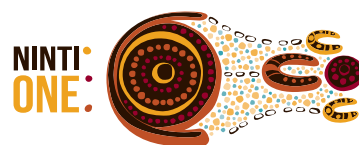
The Housing/Health Interface

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Modelling the Complex System of Service Provision: The Housing/Health Interface

Stephen McFallan, Owen Stanley and Steve Fisher



Contents

Executive summary	1
1. Introduction	2
1.1 The Desert Services that Work project	3
2. Context	5
2.1 Population and remoteness	5
2.2 Settlement types	6
2.3 Service delivery challenges	9
3. Services	13
3.1 Policy environment	13
3.2 Settlement governance structures	17
3.3 Service models	18
3.4 Service funding	24
3.5 Principles of effective service delivery	26
3.6 Performance and evaluation	27
4. Modelling	30
4.1 Complex system	30
4.2 System model	33
4.3 Case study	35
4.4 Model components	38
4.5 Software development	42
5. Research questions	53
6. Recommendations	54
References	55
Appendices	57
Appendix 1: Service delivery, funding and measure of performance	57
Appendix 2: Health practices table	60
Appendix 3: Health hardware table	61
Appendix 4: System level conceptualisation of role and interdependency	60
Appendix 5: Data and sources table	61

Figures

Figure 1: Research sites for the Desert Services that Work project	4
Figure 2: Service delivery process	20
Figure 3: Service process	27
Figure 4: KPI outputs	28
Figure 5: Aboriginal and Torres Strait Islander Health Performance Framework Measures	29
Figure 6: Agent-based model example	32
Figure 7: Conceptual ABM of the lifecycle of a single service system	34
Figure 8: Conceptual ABM of multiple service systems	35
Figure 9: Conceptual system map	36
Figure 10: Areas of potential failure in a typical remote settlement infrastructure system	38
Figure 11: Application user-defined parameters	48
Figure 12: Application setup	48
Figure 13: Running the simulation	49

Figure 14: Single iteration runs	49
Figure 15: Applet simulation speed management	50
Figure 16: Screen shot from development application	51

Tables

Table 1: Estimated resident population, Indigenous 2006 Census	5
Table 2: 2006 Census, Indigenous population – ASGC classifications	6
Table 3: Recent federal funding and programs	25
Table 4: Housing system agents and their behaviour	43

Equations

Equation 1	33
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List of shortened forms

ABM	agent-based models/modelling
APY	Anangu Pitjantjatjara Yankunytjatjara
ARIA	Australian Remote Indigenous Accommodation
ASGC	Australian Standard Geographical Classification
BCA	Building Codes Australia
CA	cellular automata
CAT	Centre for Appropriate Technology
COAG	Council of Australian Governments
CHINS	Community Housing and Infrastructure Needs Survey
DEEWR	Australian Government Department of Education, Employment and Workplace Relations
DKCRC	Desert Knowledge Cooperative Research Centre
DOGIT	Deed of Grant in Trust
FaHCSIA	Australian Government Department of Families, Housing, Community Services and Indigenous Affairs
GST	goods and services tax
HPF	Health Performance Framework
IAD	Institute for Aboriginal Development
IHANT	Indigenous Housing Authority of the Northern Territory
IHO	Indigenous Housing Organisation
KPI	key performance indicator
LGA	local government area
NGO	non-government organisation
NT	Northern Territory

PBI	public benevolent institutions
SIHIP	Strategic Indigenous Housing and Infrastructure Program
SPP	Specific Purpose Payment
USO	Universal Service Obligation
WA	Western Australia

Executive summary

This report provides results from a component of research completed under the Desert Knowledge CRC Core Project 5, 'Desert Services that Work: Demand-responsive services to desert settlements'. The research examined service provision as a complex system and had a focus on the housing/health interface.

Despite the volume of debate and commentary on services to remote settlements undertaken over the last 25 years, the modelling of service systems remains a largely neglected area. This report details an approach which attempts to capture the complexity of the system and also to provide a platform to allow users to interactively adjust system parameters and review potential outcomes of the actions. The model used an agent-based modelling (ABM) approach, which is a complex system modelling technique. Through this approach we can create an environment to explore and perhaps understand the system better. The model created could allow for alternative strategies to be tested, with potential deficiencies to be identified in a dynamic simulation environment. It provides a platform that can provide insights to the service delivery process, allow bottlenecks to be identified, and examine the trade-offs that may be made to achieve desired outcomes. It could also test potential outcomes from a range of technical and governance solution options.

This model has been under development for only six months and is in the early stages of completion. A model of this type would normally take considerably more time to be developed to a point where the complexity of the issue is fully captured and coded to enable simulations to respond to the wide range of relevant research questions. While the model currently provides an idea of its potential, further model development would result in an applet that could assist people working on both the supply and demand sides of the maintenance service delivery process understand the service system more fully, ultimately leading to improvements in service delivery.

This report provides a discussion of the software-based model that has been developed as part of this project. It also provides, for insight to aid modelling the system, information about a range of services and delivery methods available to remote desert settlements. This study provides an analysis of the policy environment and governance structures, some analysis of the funding for specific programs, and an assessment of the performance and evaluation process, again as input data for the modelling. It also provides a description of some services, service delivery models and a typology of service delivery models.

Section 1 provides an introduction to the research and how this work connects with the Desert Services that Work Project. Section 2 sets the context for the modelling, including population, settlement types and service delivery. Section 3 focuses on the service system, looking at the policy and fiscal and physical environments. Section 4 details the model development process, highlighting limitations and constraints, and provides direction for the use and future development of the model and application.

1. Introduction

People working in the administration of Aboriginal Affairs, all over Australia, are telling a similar story: they're overwhelmed by the complexity of the system they're practising in, and policy-makers aren't listening to their story. At a time of unprecedented change in the policy environment, there is growing urgency to understand what is happening in the service system, to build capacity to manage the system, and to find technological and governance solutions to improve the system (Moran et al. 2009).

One of the main challenges faced is that the system is fragmented and, to date, there has been no attempt to model the full range of services available to settlements. Using complex system modelling techniques we can create an environment where we can explore and interact with a system, allowing us to better understand it, and we can also provide a platform enabling us to test potential outcomes from a selection of service provision options, both technical and governance options, through simulation.

This research report documents the development of an agent-based model (ABM) created using the NetLogo® software environment. The report captures information on a range of services available to remote desert settlements and classifies the delivery methods into a typology. The report also provides a review of issues relating to the policy environment, governance structures, service models and service principles in order to understand the process involved and as a basis for development of the model. The review includes generalised information on service provision, performance and indicators and also specific details on a selection of services reviewed for model development.

Services included for review by this project were guided by input from a range of sources, including the project team and the steering committee, and ultimately resulted in a focus on essential services and the maintenance of these systems. Maintenance of these systems can have a direct impact on the health of the end users, and systematic maintenance strategies may lead to improved health outcomes. The systems reviewed in this project include:

- housing
- water
- waste water
- energy
- communication
- transportation and associated infrastructure.

Other services considered and flagged with place markers in the model, but ultimately not included in this study (mainly due to resource constraints), were:

- community services: family, community and social support
- health: hospitals, clinics
- education, training and employment
- community development
- justice: policing, child protection.

1.1 The Desert Services that Work project

The Desert Knowledge Cooperative Research Centre's (DKCRC) 'Desert Services that Work' project provided a platform for researchers to work with communities and community members as well as service providers to develop an understanding of some of the complexity and challenges of services delivery, and to capture the important ingredients of successful service delivery to the settlements under study. The project looked at a range of service delivery process activities and decision points, including an examination of those who make decisions about services, and how services are used.

To guide this project, a series of research questions were considered. They were:

1. What are the characteristics of the interplay between demand and supply of services, according to the perceptions of consumers and service providers engaged at the local interface?
2. What are the conditions that permit successful practice to develop between consumers and service providers?
3. At what scales of governance should different service delivery functions be assigned to optimise both demand-based and supply-based criteria?
4. What are the priorities of consumers for service type and delivery style within a specified budget framework, and what is their capacity to participate and willingness to contribute to services?
5. What are the critical issues and strategies to improve the service system, including the strengths and weaknesses of different technology and governance options?

Further to this, the Steering Group specifically recommended that the project:

- adopt a more sophisticated engagement with supply chain in government, including intergovernmental dynamics between the Australian and state/territory governments
- limit the scope to two categories of services: housing and governance
- respond to the local government reform and the Australian Government's Northern Territory Emergency Response (the 'intervention'), as this unfolded across the research sites
- seek out research sites where groups have own-source income, through mining royalties or private commercial enterprises
- adopt a strategic communications approach in order to maximise uptake of research results by government
- satisfactorily complete research questions one to four (above) before embarking on research question five.
- incorporate secondary data sources from government, especially those evaluating and critiquing its own practice.

Based on this framework and guidance, a series of projects was commissioned to respond to these questions across eight research locations in Queensland, Western Australia, South Australia and the Northern Territory. These are summarised in the map below.

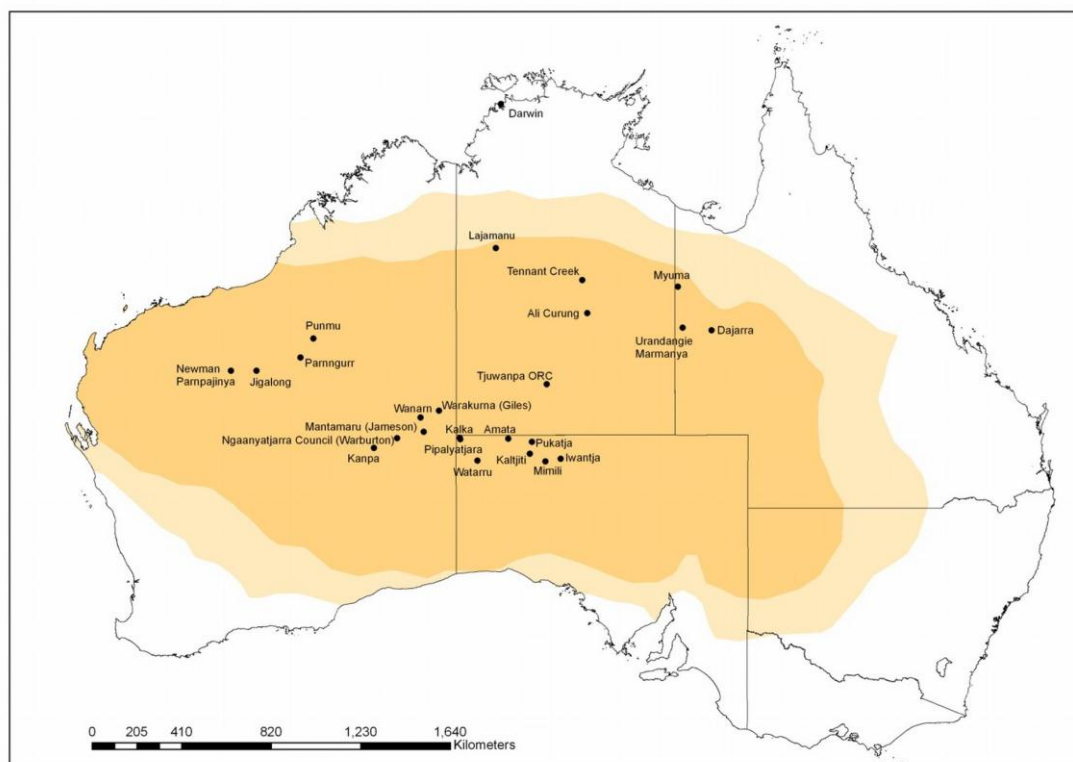


Figure 1: Research sites for the Desert Services that Work project

This service provision component of research provided input for response to research question five, largely investigating the supply side, and relied on access to outputs from other parts of the broader project for information on the demand-side characteristics of interplay and conditions of successful practice. Scale and priorities could potentially be investigated through a final model.

2. Context

The project scope, as was the case for all DKCRC projects, had a focus on remote desert settlements. Relevant statistics providing context for this work are detailed below.

2.1 Population and remoteness

The Aboriginal and Torres Strait Islander population represents approximately 2.5% of the total Australian population, though it is higher in some states and territories. In particular, the percentages are 31.6% in the Northern Territory, 3.8% in Western Australia and 3.6% in Queensland. Relevant population data are presented in Table 1 below.

Table 1: Estimated resident population, Indigenous 2006 Census

	Indigenous total number	Non-Indigenous total number	Total number	%
New South Wales	148,178	6,669,004	6,817,182	2.2%
Victoria	30,839	5,097,471	5,128,310	0.6%
Queensland	146,429	3,945,117	4,091,546	3.6%
South Australia	26,044	1,542,160	1,568,204	1.7%
Western Australia	77,928	1,981,117	2,059,045	3.8%
Tasmania	16,900	473,022	489,922	3.4%
Northern Territory	66,582	144,092	210,674	31.6%
Australian Capital Territory	4,043	330,182	334,225	1.2%
Australia	517,174	20,184,314	20,701,488	2.5%

Source: ABS 2007a

The remoteness structure Australian Standard Geographical Classification (ASGC) is used to classify locations relative to their access to services. Table 2 below lists the five ASGC categories and provides a measure of the Aboriginal and Torres Strait Islander population percentages in these regions. With the exception of the Northern Territory, Western Australia and Queensland, most Aboriginal and Torres Strait Islander people live in cities and inner regional Australia. The percentages in Northern Territory and Western Australia are significantly higher in remote and very remote regions, as can be seen in the oval in Table 2, below, and is the focus of the services project.

Table 2: 2006 Census, Indigenous population – ASGC classifications

	Major Cities of Australia	Inner Regional Australia	Outer Regional Australia	Remote Australia	Very Remote Australia
State/Territory	%	%	%	%	%
New South Wales	42	33	19	4	1
Victoria	48	36	16	-	-
Queensland	26	20	32	8	14
South Australia	48	10	23	5	14
Western Australia	34	9	15	15	26
Northern Territory (b)	-	-	19	18	63
Australian Capital Territory	100	-	-	-	-
Tasmania (a)	-	52	44	2	1
Australia (c)	31	22	23	8	16

Notes

(a) Hobart is classified as Inner Regional Australia

(b) Darwin is classified as Outer Regional Australia

(c) Excludes Other Territories

Source: ABS 2007a

2.2 Settlement types

The review conducted as part of this research made use of two recent publications that define settlement types as well as some analysis of Community Housing and Infrastructure Needs Survey (CHINS) data. This information may be useful to classify the settlements for analysis using the model developed in this study as it is reasonable to expect that different models of service delivery are more appropriate in certain circumstances than in others, and it is possible that specific service models will achieve better outcomes than others, depending on a range of factors including the degree of remoteness and the population. The hope was that a suitable typology could be identified, allowing a variety of 'community types' to be selected and analysed through the model.

According to the 1999 CHINS survey (ABS 1999), there are 1291 discrete settlements across Australia. These settlements account for about one-third of the Aboriginal and Torres Strait Islander population, with 70% of this one-third living in about 12% of the settlements. The majority of the settlements have a population of less than 50 people. One of the challenges of living in these settlements is access: often the time to travel to the nearest service town is

between one and four hours, and even then access is dependent on seasonal issues such as flooding. This causes a reliance on air services, posing significant challenges to service provision.

Based on the CHINS survey, there are 81 discrete urban settlements for which the provision of settlement services may be shared by an Aboriginal or Torres Strait Islander community organisation and the local authority. Outstations are generally decentralised with the residents retaining close associations with a discrete settlement, and there are often frequent movements of people between town and the outstations. The outstations present unique problems with servicing, especially with respect to access and water supply. Outstation occupancy levels fluctuate with seasonal access and the availability of transport and other resources.

The largest proportion of Aboriginal and Torres Strait Islander people live in housing dispersed through capital cities and major regional centres. There are 39 urban centres in Australia that fit the definition of a Dispersed Settlement in Urban Centre (Memmott & Moran 2001). Similarly, a high proportion of Aboriginal and Torres Strait Islander people live in smaller rural towns within mainstream local government authorities.

As mentioned above, the review made use of two research reports. The first was by Newman et al. (2008) for the DKCRC and the second was by Memmott and Moran (2001), as summarised in Long et al. (2007).

The Newman et al. (2008) report set out to classify settlements by typology based on population, economic function, and a compilation of social and economic indicators. They noted that these types did not reflect the settlements' diverse cultural values or livelihoods, nor did it support an understanding of these places from a sustainability perspective. They discussed their concerns for the weakness of the approach. However, for this project this categorisation may provide an appropriate starting point. The typology was classified as:

1. Settlements with a population of 18 000–47 999
 - a) Tourism/population boom advantaged city
 - b) Income advantaged mining city
 - c) Old economy/employment disadvantaged city
2. Settlements with a population of 5000–17 999
 - a) Mining advantaged town
 - b) Old economy disadvantaged town
3. Settlements with a population of 1000–4999
 - a) Regionally, these towns are based around an industry cluster that includes health and community services; government; education; cultural and recreational services
 - b) Regionally, these towns are based around an industry cluster that includes retail and wholesale trade; agriculture; construction; manufacturing; accommodation; finance; communication; utilities
 - c) Regionally, these towns are based around an industry cluster of mining and education
4. Settlements with a population under 1000
 - 200–999

- a) Rural town
- b) Discrete outlying Indigenous settlement, population

50–199

- c) Small rural town
- d) Discrete town settlement
- e) Discrete outlying Indigenous settlement

Less than 50

- f) Discrete town settlement
- g) Outstation/homelands settlement
- h) Pastoral homestead
- i) Transient people

The Memmott and Moran (2001) typology resulted in similar classifications but was directed specifically at Aboriginal settlements, which in general fall mostly in category four under the Newman et al. (2008) model. Aboriginal settlements may be considered as divisible into two broad types: discrete bounded settlements; and dispersed urban housing across towns and cities.

There are three types of discrete bounded settlements:

- discrete settlements geographically separate from other centres
- discrete urban settlements and town camps within or on the outskirts of an urban or rural centre
- outlying discrete settlements dependant on a larger centre for infrastructure or services; e.g. outstations, homelands, and pastoral settlements.

There are two broad types of Aboriginal dispersed settlement in urban townships:

- dispersed Aboriginal housing and communal facilities in a capital city or major regional centre
- dispersed Aboriginal housing and communal facilities in rural centres including those with a majority Aboriginal population.

Memmott and Moran (2001) also point out that there is a sixth settlement type not included, identified as ‘the camps’.

Other settlement typology or classifications were documented in a recent report by Maru et al. (2006) in which the authors attempted to map socio-economic regions in outback Australia. According to Maru et al., the premise of socio-economic districts has merit, especially when the purpose is to deliver services which are often funding constrained. The report found that Statistical Local Areas (SLAs) or administrative boundaries provided a poor basis for understanding the socio-economic characteristics of a region. It also found that the state and territory boundaries disguised the significance of cross-jurisdictional similarities and relationships. The document provided analysis and map classifications of urban centres and localities based on a range of indicators, including industry sectors. It also explored the changes over time, although the report cautioned that poor data was an issue for this region.

Based on the review, it was decided to use the Memmott and Moran (2001) typology as a basis for the modelling, but to make the coding sufficiently flexible to allow for modifications to the Memmott and Moran typology where deemed appropriate.

2.3 Service delivery challenges

It was important to consider some of the challenges and issues around service delivery to be allowed for in the modelling. To that end a review of a recent survey of 1187 Aboriginal and Torres Strait Islander communities (ABS 2007b) was completed. The review highlighted the following problems with infrastructure and service delivery in these areas:

2.3.1 Housing

- A total of 17 177 permanent dwellings were reported as being located in 1187 discrete Aboriginal and Torres Strait Islander communities, of which 15 655 (91%) permanent dwellings were managed by Indigenous Housing Organisations (IHOs). The remaining were state government-owned, owned by other organisations or privately owned permanent dwellings.
- A total of 69% of IHO-managed permanent dwellings were reported as needing minor or no repair, 23% in need of major repair and 7% in need of replacement.
- A total of 70% of permanent dwellings in need of major repairs or replacement reported an average weekly rent of less than \$50. A total of 2922 (13%) of permanent dwellings reported \$0 rent.
- A total of 6973 IHO-managed permanent dwellings reported an average maintenance expenditure of \$2000 or more. Of these, 1779 permanent dwellings remained in need of major repairs and 434 permanent dwellings were in need of replacement.

2.3.2 Power

- There were 274 communities connected to state grid as the main source of electricity. The most common main source of electricity was community generators, reported in 32% of communities, followed by state grid (23%), solar and solar hybrid (18%), and domestic generators (15%).
- No organised electricity supply was reported in 32 (3%) discrete Aboriginal and Torres Strait Islander communities in 2006.
- A total of 275 communities, either self-administered or with a population of 50 or more people, reported interruptions to the electricity supply, mainly due to storms and equipment breakdown.

2.3.3 Communications

- Six hundred and thirty communities (53%) reported public access to a telephone within the community; 454 discrete Aboriginal and Torres Strait Islander communities did not have access to public telephones.
- One hundred and thirty-six discrete Aboriginal and Torres Strait Islander communities (11%) had public access to the Internet; 230 communities, either self-administered or with a population of 50 or more, did not have public access to the Internet.
- One hundred and eighty communities reported use of community-based satellite for purposes of broadcasting, telephone and Internet services.

2.3.4 Sewerage

- Septic tanks with leach drain were the most common type of sewerage system in discrete Aboriginal and Torres Strait Islander communities, with half the communities reporting this type of system.
- A total of 25 discrete Aboriginal and Torres Strait Islander communities reported having no organised sewerage system. The total population affected by the lack of sewerage facilities was 1969 people.
- In the 12 months prior to the survey, 142 communities reported overflows and leakages from their sewerage system. Blocked drains and equipment failure accounted for the largest proportion of overflows and leakages, in 95 and 62 communities respectively. The total population in communities affected by sewerage overflows and leakages was 30 140 people.

2.3.5 Water

- Two hundred and nine discrete Aboriginal and Torres Strait Islander communities reported being connected to a town water supply.
- Bore water was the main source of drinking water, being used by 58% of communities; 18% of communities obtained their drinking water from adjacent town water systems. The number of communities with no organised water supply was nine.
- Twenty-seven communities relied on carted water as the main supply of water.
- Of all discrete Aboriginal and Torres Strait Islander communities not connected to a town water supply (self-administered or reporting a population of 50 or more), 48 communities reported that the community's drinking water had failed testing. These communities had a combined population of 12 059 people.
- One hundred and forty-one discrete Aboriginal and Torres Strait Islander communities, representing a combined total of 46 114 people, reported that drinking water was treated. Chlorination accounted for the highest proportion of water treatments, with 112 communities reporting this type of treatment.
- Sixty-eight Aboriginal and Torres Strait Islander communities, either self-administered or reporting a population of 50 or more and not connected to a town water supply, reported that they did not use any water treatments in the drinking water.

2.3.6 Access

- The usual means of travel to the nearest town that provided major services was by road, with 894 (88%) communities, representing 63 529 people, reporting main mode of transport as road.
- One hundred and thirty-nine communities had their road access cut at least once in the 12 months prior to the survey. In 42 communities, road access had been cut at least five times, affecting a total population of 12 074 people.
- One hundred and twenty-two communities reported that the community was inaccessible by road.
- A total of 147 communities, either self-administered or reporting a population of 50 or more, indicated that an airstrip was located within the community. Around a quarter of these (38) did not have all-year-round access.

The poor health status of Aboriginal people has been widely publicised, and it is now well established that environmental conditions play a major contributing role to this alarming

problem (Memmott & Moran 2001). There are also problems with the delivery of health and education services to discrete settlements, many of which are located in remote settings (ABS 2007b).

2.3.7 Education

- A total of 245 discrete Aboriginal and Torres Strait Islander communities (21%) reported a primary school located within the community; 49 communities (4%) reported having a secondary school up to year 10; and 40 communities (3%) reporting having a secondary school to year 12. The number of discrete Aboriginal and Torres Strait Islander communities that had a secondary school up to year 12 increased to 40 communities.
- A total of 741 (62%) discrete Aboriginal and Torres Strait Islander communities were located 25 kilometres or more from the nearest secondary school up to year 10.
- A total of 374 (38%) discrete Aboriginal and Torres Strait Islander communities were located 100 kilometres or more from the nearest secondary school up to year 10.

2.3.8 Health

- Ten of the 1187 discrete Aboriginal and Torres Strait Islander communities reported that they had a hospital located within the community.
- One hundred and seven communities reported an Aboriginal Primary Health Care Centre located within the community, of which 76 were located in very remote communities, 21 in non-remote communities and 10 in remote communities.
- One hundred and four Aboriginal and Torres Strait Islander communities reported that an 'Other (state funded) community health centre' was located in the community. Of these, 89 were located in very remote communities, nine in non-remote communities and six in remote communities.
- A total of 302 (25%) discrete Aboriginal and Torres Strait Islander communities reported having a male Aboriginal and Torres Strait Islander health worker visit or work in the community.
- Very remote discrete Aboriginal and Torres Strait Islander communities accounted for 236 (78%) of the communities reporting male Aboriginal and Torres Strait Islander health workers visiting or working in the community, followed by remote and non-remote with 39 (13%) and 27 (9%) respectively.
- The number of discrete Aboriginal and Torres Strait Islander communities that reported having a female Aboriginal and Torres Strait Islander health worker visit or work in the community decreased down to 332. Very remote discrete Aboriginal and Torres Strait Islander communities accounted for 283 (85%) of communities reporting female Aboriginal and Torres Strait Islander health workers visiting or working in the community, followed by non-remote and remote with 28 (8%) and 21 (6%) respectively.
- Registered nurses worked or visited a total of 368 (31%) discrete Aboriginal and Torres Strait Islander communities. Very remote discrete Aboriginal and Torres Strait Islander communities accounted for 328 (89%) of communities reporting registered nurses visiting or working in the community, followed by non-remote and remote with 23 (6%) and 17 (5%) respectively.
- A total of 293 (25%) discrete Aboriginal and Torres Strait Islander communities reported doctors visiting or working within the community. Of these communities, 239 (82%) were located in very remote localities.

- A total of 192 discrete Aboriginal and Torres Strait Islander communities reported doctors visiting or working within the community. Most reported a doctor visiting or working in the community on a weekly or fortnightly basis.

According to the 2008 *Aboriginal and Torres Strait Islander Health Performance Framework* report (AIHW 2008), determinants of health include improvements in the living conditions such as access to functional housing. Issues for which there is concern included drinking water quality, electricity interruptions, sewerage system failures and overcrowding in housing. The report also flags that improvements in health can be gained through improved health behaviours, including nutrition. Improvements in storage and preparation facilities would support the knowledge development.

In addition to these factors the survey found that access to health care for physiological, social and emotional wellbeing remains a challenge for many remote communities. Further management of health issues is compounded by the lack of accessibility. These challenges highlight the importance of prevention of health problems when treatment options are so limited. These statistics are used for developing rules for the prototype model.

3. Services

In this section a review of issues relating to the service system, the policy environment, governance structures, and service principles was completed, with the aim of supporting the development of a model.

3.1 Policy environment

This subsection examines the policy environment. It begins with a holistic view of policy and relative legislative powers of authorities, and then focuses on current policy impacting on the areas of interest in this project – specifically Queensland state housing policy and a review of the Building Codes Australia (BCA) requirements.

3.1.1 Legislative powers of government in relation to services

The Commonwealth constitution (*Commonwealth of Australia Constitution Act 1900*) allocates responsibilities to levels of government in relation to services and people. Some of the factors arising from the Constitution are listed below.

- Responsibility for Aboriginal and Torres Strait Islander people rested with the states until the 1967 referendum, when a change to s51 (xxvi) of the Constitution allowed the Commonwealth to pass special laws in relation to Aboriginal and Torres Strait Islander people.
- Laws relating to health, housing, education, safety, etc. are the province of the state and territory governments.
- Local government organisations gain their powers from the state and territory governments.
- The Australian Government can deal with people directly through measures such as tax policy, subsidies, health funding and income support programs (e.g. pensions, unemployment benefits).

The Commonwealth can exercise control over some issues in the states and territories through its power over international relations (s51). These powers include controls over exports and imports, and it can enter into international agreements that are binding on the states and territories. These powers have been used to give the Commonwealth control over mining developments (of exportable products) and the protection of environments.

3.1.2 The Commonwealth's non-legislative powers

Although the Commonwealth has limited powers to pass laws directly affecting Aboriginal and Torres Strait Islander people, it does have considerable power to influence the behaviour of state and territory governments. It has this through agreements and through its control over state and territory government finances.

Agreements between the Commonwealth and the states and territories

The Council of Australian Governments (COAG) was established in 1992 and is an organisation composed of representatives of all of the state and territory governments. The role of COAG is to initiate, develop and monitor the implementation of policy reforms that are of national significance and which require cooperative action by the state, territory and Commonwealth

governments. Examples of such agreements and coordinated action on Aboriginal and Torres Strait Islander issues are:

- *The National Indigenous Reform Agreement*, which is aimed at ‘closing the gap’ between Indigenous and non-Indigenous Australians as measured against seven action areas, or building blocks: early childhood conditions; schooling; health; economic participation; healthy homes; and safe communities; and governance and leadership.
- *The COAG Whole of Government Initiative*, which is aimed at improving the delivery of government services to Aboriginal and Torres Strait Islander people. It attempts to achieve this by applying the principles of shared responsibility between the government and the relevant community.

Other examples of coordinated policy not under COAG, but relevant to this study, are the uniform companies legislation and the development of BCA.

- *Building a Better Future Indigenous Housing to 2010*

In addition to agreements with states and territories together, the Commonwealth has agreements with particular states or territories for specific purposes. An example that is relevant here is the Strategic Indigenous Housing and Infrastructure Program (SIHIP), which is a jointly funded program of the Commonwealth and Northern Territory governments. This is intended to result in the investment of \$672 million over five years in Indigenous communities across the NT. The SIHIP is being delivered through a program alliance contracting methodology. Three alliances have been engaged to date to deliver packages of work ranging from \$30 million to \$50 million. The alliances are required to use local suppliers to deliver the program. It appears that this program is progressing slowly (Robinson and Berkovic, 2009).

Commonwealth’s control over state and territory finances

Since federation, the Commonwealth has extended its control over government finances. The biggest change occurred during World War II when the Commonwealth became the sole level of government to impose income tax (the states gave up their income-taxing powers) and instituted a system to return tax revenue to the states. More recently, the Commonwealth has introduced a goods and services tax (GST) that replaced a wide range of sales and other taxes previously charged by the states and territories.

The Commonwealth Grants Commission is crucial in this process. It makes recommendations to the Australian Government on how to allocate untied funds, now mainly GST revenues, to the states and territories. It applies the principal of ‘horizontal fiscal equalisation’, which means that a state or territory should receive enough Commonwealth revenue so that it can provide the same level and quantity of government services to its residents that are provided in other states and territories without needing to impose higher taxes. This method allocates more per capita revenue to states and territories with higher ‘disability factors’. These factors include the proportion of the population that is Aboriginal and Torres Strait Islander, the proportion of the population that is located in remote areas and the proportion with low incomes. Thus a state or territory with a high proportion of Aboriginal and Torres Strait Islander people living in remote locations will receive a higher per capita allocation because of each of these factors than would otherwise be the case. Whether these extra funds are sufficient for the states and territories to offset the extra costs of providing Aboriginal and Torres Strait Islander people with government

services is not easy to determine. However, recent reports suggest that the NT Government spends less than it should in this way (Hall, 2009). It should be noted that states and territories are not legally obliged to spend the extra money received in the areas of disability.

In addition to untied grants, the Commonwealth allocates Specific Purpose Payments (SPPs) to the states and territories for particular purposes and imposes conditions on their use. Some of these SPPs are allocated for the purpose of improving housing and health in an attempt to improve Aboriginal and Torres Strait Islander socio-economic conditions.

3.1.3 Types of policy and programs

At the broadest level, Aboriginal and Torres Strait Islander people are affected by two types of policy and programs. These are those directed towards:

- all Australians
- Aboriginal and Torres Strait Islander people alone. These are sometimes called 'special programs'.

Many of these special programs do not represent an additional benefit over that which is available to non-Aboriginal people. Sometimes these programs are equivalent to, or almost equivalent to, mainstream programs but have provisions that are believed to be more suited to the circumstances of Aboriginal and Torres Strait Islander people. And sometimes they are created by one level of government to be almost the same as a program as that offered by another level of government.

An example of this is the Abstudy program. This is a Commonwealth program designed for Aboriginal and Torres Strait Islander students that has benefits that are similar to those available to Aboriginal and non-Aboriginal people under state and territory programs. Another example is the free health clinics and hospitals in communities. They provide services that are similar to the public hospital treatment provided under Medicare, available for the mainstream population. There is evidence that many Aboriginal and Torres Strait Islander people prefer their 'own' programs because they believe that the special program better understands their needs (Fleming & Southwell, 2005) and because they enjoy the sense of ownership of it.

3.1.4 Aboriginal and Torres Strait Islander housing

The modelling that has taken place in this study is mainly concerned with the health effects of housing. For this reason the following discussion is concerned with Aboriginal and Torres Strait Islander housing and its supporting infrastructure, such as water supply, sewerage and power systems. Together, these facilities will be called 'housing infrastructure' or a 'facility'. It should also be noted that the following discussion is derived mainly from information from housing in Queensland Indigenous communities.

The supply of housing infrastructure to Aboriginal and Torres Strait Islander communities in Queensland is affected by the policies and procedures of the three levels of government: Commonwealth, state and local. Government policies and programs affect housing in Aboriginal and Torres Strait Islander communities, in a number of ways.

Provision of housing and infrastructure

Social or welfare housing: A government may pay for and undertake the construction, or provide funds to a community housing association, so that houses are provided to people who are considered too poor to undertake the task themselves. Such houses may remain the property for the government or may be owned by a community housing association or by a form of local government. Most of the funds for social (welfare) housing come from the state government, though the Australian Government can be considered to be the original source of the funds (since most state revenue comes from the Commonwealth). In addition, the Commonwealth may provide additional funds directly for this purpose.

Housing for government employees: A government agency often provides housing in a community for its employees, such as police and schoolteachers, or visiting public officials. Most of this housing is provided by the state government for its employees.

Building practices

- Building standards

The state government has the power to set standards for all construction in a community (such as compulsory building codes). While there are differences between states and territories, the cross-jurisdictional Building Codes Australia provides the basic standard.

- Conditions imposed on builders

In relation to Indigenous housing infrastructure, in particular, the relevant government funding authority, usually the state government, may specify who may undertake the construction and under what conditions it can be done. For example, the government may encourage contractors to employ Aboriginal and Torres Strait Islander workers, as in QBuild's case, or it may impose the requirement that the builder must employ a given number of apprentices.

- Other considerations

Some government policies concerned with health and safety have an impact on housing provision and design. For example, attitudes concerning cyclone safety may lead to restrictions on design beyond that required by building codes. For example, in one community, the original tropical styles of houses are no longer being built because of a fear, by some, that the houses are insufficiently cyclone proof.

3.1.5 Codes for building structures

While the constitutional responsibility for housing rests with the states and territories, there are agreements between the states/territories and the Commonwealth that have resulted in the Commonwealth having an important say on the nature of housing and related infrastructure. One of the most important of these agreements is that which resulted in the establishment of the Australian Building Codes Board in 1994 (ABCB 1994) and, with it, Building Codes Australia (BCA). This has the status of building regulations in all states and territories. The BCA attempts to set minimum standards relevant to health, structural and fire safety, amenity, and environmental sustainability (ABCB n.d.) in relation to buildings. In addition to the BCA, the

Queensland Government has its Building Codes Queensland and the Queensland Development Code, which provide more detailed prescription on such matters as siting and amenity, health issues, fire safety, plumbing and water use, and sustainability (Qld Govt n.d.). Other states and territories have similar codes. In some matters, the state and territory governments have allowed local governments to exercise the state and territory responsibilities, though state governments have priority over all local government decisions.

3.2 Settlement governance structures

Given the policy environment and the relative powers of the authorities, a review of the governance structures within settlements provides an insight into the interpretation and execution of policy.

Discrete settlements often differ from other Aboriginal settlement types in that many have local government status, either formally enacted through state or territory legislation (as in Queensland and the Northern Territory) or informally through the receipt of operational funding for local government-type functions (as in South Australia and Western Australia). These settlements receive different kinds of support from government agencies and are politically faced with ensuring the provision of basic services, such as government administration, education, health clinics, housing, local roads and drainage, communication and postal services, waste disposal, and the supply of water and electricity. The extent to which governments provide direct services or financial support for these services varies from place to place and was the subject of a regular housing and infrastructure needs analysis.

It is, however, important to stress that not all discrete settlements have local government status. Indeed the conferring of local government status by state governments often blurs the definition of 'communities' or discrete settlements. For example, it is widely held in Queensland that there are 34 Deed of Grant in Trust communities (DOGIT), but in fact there are 34 discrete settlements with local government status, and up to 10 more discrete settlements without local government status. A similar situation exists in South Australia.

Implementing local government by-laws and other decision-making in these discrete settlements is often undertaken by Indigenous councils. In most cases this arrangement facilitates a freedom of Aboriginal and Torres Strait Islander cultural expression. Lifestyle practices in such discrete settlements are thus often culturally distinct and may involve a range of customary kinship and religious practices as well as traditional domiciliary behaviours. For example, the ABS reported on the visitation of relatives and extended kin for cultural or ceremonial reasons, which highlights not only the tendency for marked mobility amongst Aboriginal people but also the customary obligations to share accommodation and sustenance with kin. Thus:

Community infrastructure often needs to cater for visitors, in addition to the community's usual population. Many discrete communities reported population increases due to visitors staying in the community for two weeks or more. Of communities with a reported population of 50 or more, 79% reported population increases of this kind in the 12 months prior to the survey, with 25% of these communities reporting increases of a size similar to, or greater than, their usual population. The most common reasons reported for these visitors were cultural or ceremonial

reasons (72% of communities experiencing visitors) and visiting during holiday periods (41%) (ABS 1999).

Large discrete Aboriginal settlements usually have a history of imposed institutions, and were established either as missions or government settlements. In many cases several language groups were relocated to the one settlement. Whilst there is always something of a 'community-of-interest' which exists at any discrete settlement level, it should not be assumed that Aboriginal settlements are coherent socially organised communities. Large discrete Aboriginal settlements are characterised by a dynamic social structure consisting of multiple and overlapping groupings including households, families, extended families, clans and language groups. If we think of 'community' as a group in a regular social network with close affiliations and a common identity then we may find several different 'communities' within the one Aboriginal settlement. Likewise, several settlements may be utilised by one such community. In many settlements, the group who are considered traditional owners of the land on which the settlement is located may have most say on any activity involving the use of that land, such as the location of housing, other infrastructure and business activities.

Urban settlements, however, have limited powers of self-governance and are required by statute to conform to the planning schemes, by-laws and other legislation enforced by the shire or town council.

In an analysis of 1996 census data, Memmott and Moran (2001) demonstrated that there are only 35 towns in Australia where the Aboriginal and Torres Strait Islander population is in the range of 30–70% of the total. These towns represent only 2% of the total number of Urban Centres and Localities recorded in the census. It is evident that the vast majority of the Aboriginal and Torres Strait Islander population of Australia lives in two extreme situations: either in the overwhelming majority (as found in discrete Aboriginal and Torres Strait Islander settlements); or in the overwhelmed minority (as in a larger non-Aboriginal and Torres Strait Islander centre). The 35 towns in between these two extremes had a majority Aboriginal and Torres Strait Islander population, which suggests that they could be considered as discrete Aboriginal and Torres Strait Islander settlements.

The presence of the Aboriginal and Torres Strait Islander population in these settlements would be clearly evident and felt to the extent of challenging non-Aboriginal social-spatial characteristics of the town living environment. Referring to such rural towns in Queensland, Memmott (1991) comments that Aboriginal and Torres Strait Islander people have maintained a social distance and a distinct social character, either through the forces of discrimination, or because of their substantial numbers in relation to the non-Aboriginal population. He suggests that effective processes of assimilation have only occurred in the larger regional and urban centres where the non-Aboriginal and Torres Strait Islander population is in the overwhelming majority.

3.3 Service models

The focus of this study is on service delivery models for remote desert settlements. The research is largely orientated to the supply side of services complementary to other studies completed within the jurisdictions for Desert Services that Work. This project focused on a range of

government services delivering to (and /or available to) settlements. Attempts were made to identify specific sources of data and capture some of this for modelling purposes.

The project took a top-down macro view of institutions and funding for Aboriginal service delivery and analysis outputs; however, modelling of supply and demand was necessarily carried out at a bottom-up micro level. Input data was drawn from publicly available documents and/or through support from the service provision agencies, while the behavioural and environmental modelling relied on data collected by jurisdictional studies detailing settlement infrastructure, condition, and service provision, as well as behavioural responses. Effort was directed towards a review of existing policy for delivery of services. However, this is a highly dynamic space and maintaining a state of currency proved difficult.

The project explored a range of specific service delivery models and developed a typology of service delivery models which served as a basis for the modelling component and to support future development. From the preliminary activities a conceptual system model of the service provision was developed.

The approach to service delivery taken in remote communities is determined by:

1. the scope and nature of the service
2. the funding arrangements for the service
3. the technical or specialist capacity required to provide the service
4. historical precedent
5. the influence of service users
6. the cost of service provision
7. government policy directions and priorities
8. management and governance arrangements.

A service model is an arrangement by which a service provider enables users to gain access to a service or set of services. Service models either evolve over time through the interplay of the factors above or they are determined by the way in which a service is designed and established by providers. As a result, a large number of service models exist across remote Australia. Taken as a whole, they present a complex and sometimes fragmented set of arrangements.

Figure 2, below, provides a topological abstract of service delivery. In this figure, the yellow arrow depicts the service provision and the red is the funding stream. The blue triangles are the service providers.

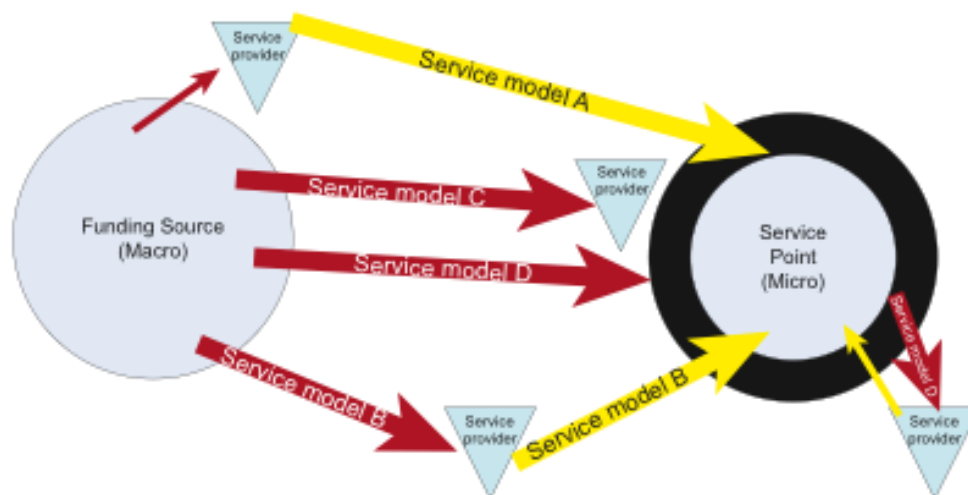


Figure 2: Service delivery process

Many process models are likely to exist. For the purpose of abstracting, the following four are discussed.

1. **Service model A** depicts a model where the service provider is remote from the service point. This could be analogous to a system in place for provision of telecommunication infrastructure where decisions, funding and delivery may often be made at a national level.
2. In **service model B** the service provider is depicted as remote to the service point and the funding source. An example of this model might be in the provision of training where funding policy and budgets are made and a range of service providers (often remote to the communities) deliver the service.
3. In **service model C** the service provider is close to or internal to the service point and distant to the funding source. For example, a number of infrastructure maintenance activities are delivered using a similar model.
4. In **service model D** the funding is directly provided to the service point and a service provided is contracted directly. For example, a number of housing maintenance activities are delivered using a similar model.

The distance could be administrative distance, geographical, cultural or facilitative, while the arrow breadth serves to indicate the volumes of money potentially flowing via the different service models – suggesting that some methods may result in monies not reaching the intended goals due to costs of service, or possibly having a compounding effect. These processes and abstract models can be adopted under a number of service delivery typologies, some of which are discussed below.

3.3.1 Service model typology

This typology categorises services according to the mode by which the service is delivered.

National private sector providers

Applies to services that are most efficiently delivered through national networks, such as telephone and broadband. The service model that applies in this case is one of centrally defined and managed services to national standards determined through an act of parliament. In the case of telephones, provision is defined by the Universal Service Obligation (USO), which requires access to a telephone in population centres of a certain size, regardless of remoteness.

Staff are town-based and they travel to remote settlements to conduct maintenance, repairs and other technical work. Adaptations for local use may be limited in scope but are feasible and can have a positive impact on the access and value of the service to users. The Community Phone Project implemented by the Centre for Appropriate Technology (CAT) in partnership with Telstra is a case in point, where provision of a protective shield for the telephone and inclusion of a single button for access to phonecard service has improved the technology for use in some remote settings.

Resource centres

Resource centres are Aboriginal-governed organisations with the status of incorporated associations or wholly owned private companies. They maintain a technical competence and capacity across a range of essential services that are provided to defined clusters of communities, most often outstation groups, but can also include larger communities such as those on the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands. Examples are PY Services and Pilbara Meta Maya. These services include maintenance for housing, bores, diesel generator, wind or solar electricity supply, fencing, firebreaks, airstrips, access and internal roads, community facilities (such as bough shelters) and so on. New capital works are generally sub-contracted to private contracting companies.

Characteristics of this service model are opportunities for local employment, especially through cooperation and overlap with work-for-dole and training programs, and potential for long-term relationships between service providers and users. Governance arrangements can enable local residents to be directly involved as board or management committee members.

Transaction centres

This mode of access to services relies on broadband Internet access and a suitable building housing equipment, technical support and customer service. This model is more common in tropical Queensland and the Kimberley than desert regions, with Ringer Soak in Western Australia and several Cape York communities offering good examples. More recently the pilot PYKu program in South Australia offers an example of a remote desert service for the population of six major communities in the APY Lands (Tedmanson et al. 2011).

Modes of governance for remote transaction centres vary. In Western Australia, governance is through direct government provision in WA. By contrast, PYKu is governed and managed through PY Media, an Aboriginal corporation. Features of remote transaction centres as a service model are that:

- they are restricted to services that can be delivered via the Internet, which are often regulatory (such as motor vehicle licences and some Centrelink services)

- the experience of service users is largely determined by the quality of the equipment and the responsiveness of staff
- the potential for local employment is good given the need for customer service staff in each centre.

Local private contractors

Private contractors become involved in remote services as a result of a specialist technical requirement. Examples are contractors in building and construction, electricity and water supply, and satellite installation and maintenance for communication services.

Much like any arrangement with a contractor, the scope of works defines the activities undertaken. Contractors and their staff are almost always town-based and travel from there to service smaller communities. Exceptions include locally based private contractors, which range from small family enterprises in plumbing and electrical work to larger private entities that may be Aboriginal-controlled, such as Myuma Pty Ltd (Memmott 2010). As such, openings for local employment vary.

The degree of interaction between service users and providers is influenced by the kind of service (for example, house repairs require greater local interaction than maintenance of a community firebreak or airstrip) and the level of interest and willingness that local residents and contractor staff have in talking about the service.

Programs specific to Aboriginal and Torres Strait Islander people

For services that are specifically aimed towards Aboriginal and Torres Strait Islander people, government programs are sometimes defined in a way that includes consultation and governance arrangements specifically designed to meet the needs of Aboriginal and Torres Strait Islander service users. Examples include Bushlight (energy services for small communities), Fixing Houses for Better Health, the Strategic Indigenous Housing Investment Program (SIHIP), and a myriad of culture-related, law and justice, natural resource management, small enterprise, and housing-related programs.

As a service model, Aboriginal and Torres Strait Islander-specific programs offer opportunities for engagement between service providers and users, especially in cases where critical knowledge and expertise comes from Aboriginal and Torres Strait Islander people and the services are therefore reliant on their leadership. Where programs are established in order to work with local communities, then staff are likely to include people with skills in community development or cross-cultural facilitation, as well as Aboriginal and Torres Strait Islander people with a commitment to working with local residents.

Specialist Aboriginal and Torres Strait Islander corporations

Although similar to Aboriginal and Torres Strait Islander-specific programs in their focus on meeting the needs of Aboriginal and Torres Strait Islander people, specialist Aboriginal and Torres Strait Islander corporations are distinguished by being independent and incorporated under state or territory legislation and not restricted to a particular fixed timeframe or budget determined by government. They often have a geographic or thematic specialism and expertise

to match. Examples are Tangentyere Council (which provides services to town camps in and around Alice Springs), the land councils and the education provider the Institute for Aboriginal Development (IAD).

Governed through boards made up of Aboriginal and Torres Strait Islander people and with a higher representation of Aboriginal and Torres Strait Islander people on the staff than comparable non-Aboriginal and Torres Strait Islander corporations, these organisations offer services that are determined by their constitutions and funded through a combination of self-generated income, government funds and contracted work. As with Aboriginal and Torres Strait Islander-specific programs, the level of engagement between the service provider and user is likely to be higher than non-Aboriginal and Torres Strait Islander providers. However, it may also be the case that cultural and language factors inhibit communication in some settings.

Local government agencies and community councils

As a level of local government, community councils are a means of providing access to services that is governed and managed in the community. These services may include a range of minor works, repairs and maintenance to housing and infrastructure, youth and childcare services, natural resource management, and other services for which local skills are available.

Local employment opportunities are likely to be higher in community council-managed services and responsiveness to local needs and demand better than that from services provided externally, although this may not be the case where local governance and decision-making is inefficient or skills and capacity inconsistent. The local democratic process also offers potential for local residents to influence service effectiveness through elections to council seats.

Non-government and public benevolent institutions (NGOs and PBIs)

Organisations established to provide particular services sometimes find a niche role in desert Australia as part of their broader remit nationally or internationally. These often include health and caring services such as those provided by Mission Australia, the Salvation Army or the Fred Hollows Foundation. Or they may be emergency services specific to remote Australia, such as the Royal Flying Doctor Service.

In many cases, NGOs and PBIs sub-contract services in the way as private contractors. This takes place for aged care facilities, for example, or particular mental health services. From the perspective of the service user, opportunities may exist to influence services through the anticipated openness of staff to feedback from local people or through membership of local boards and other governance arrangements.

Commonwealth government agencies

Most Commonwealth government services are regulatory services accessed through direct telephone or office contact, Internet or through remote transaction centres of the kind described earlier in this paper. The most common example is the benefits provided by Centrelink. As these are standardised and nationally determined services, the scope for negotiation and flexibility in delivery is limited. Users gain access to their entitlements rather than seeking or expecting a more demand-responsive service.

The flexibility in the service for users can come through the mode of access, which may be easier for people living remotely if they can use a transaction centre or a telephone service that enables them to talk to someone who recognises their particular needs.

Significant change is felt by service users in desert Australia where major policy shifts occur federally and are then 'rolled out' through the states and the Northern Territory. The introduction of Shared Responsibility Agreements and Regional Partnership Agreements, along with the Northern Territory Emergency Response, are the best-known recent examples. Subsequent reviews and evaluations of progress have enabled submissions to be made by local people and organisations.

State and territory government agencies and statutory authorities

Through their own agencies, state and territory governments provide a high proportion of local services in desert Australia. Access to services takes place through government staff working in health and education (for example, at schools, hospitals and clinics), sport and recreation, housing, energy, water and a range of other services. The Power and Water Corporation is an example in the Northern Territory, along with the Aboriginal Lands Protection Authority, but there exists a multitude of services grouped within the relevant government department across all states.

Changes to policy priorities are felt most keenly by the users of state and territory government services. Reorganisations, new policy directions and government reforms have a big impact on the ground. The ability of service users to do any more than adjust to those changes has historically been limited, although well-informed interpretation and adaptation of policy at the local level is one way in which remote communities have sought to gain greatest benefit from alterations to policy and resourcing of desert services.

3.4 Service funding

A review of some of the recent Australian Government budgeted programs was carried out in order to understand the complexity and order of funding available for service delivery as set out in the table below.

Table 3: Recent federal funding and programs

Department	Aboriginal and Torres Strait Islander program	Funding (\$m) in 2008–09
Department of Education, Employment and Workplace Relations (DEEWR)	Boarding colleges Expand literacy and numeracy School enrolment NT crèches NT enhancing education NT welfare reform NT school nutrition	18.1 8.1 11.6 2.3 19.1 66.4 7.4
Department of Families, Housing, Community Services and Indigenous Affairs (FaHCSIA)	Closing the Gap for Indigenous Australians Early learning and development Mothers' Accommodation Closing the Gap in NT Government personnel: Accommodation in remote communities Community engagement Early childhood Family support Government business managers Income management Governance and coordination Playgroups Promoting law and order Youth alcohol diversion Other measures Closing the evidence gap	3.1 2.0 0.3 3.8 0.4 9.8 30.8 60.1 32.4 0.7 11.6 9.5 1.1
Department of Health and Ageing	Closing the Gap in Indigenous Health NT Follow-up care Child and maternal Child heart fever Drug and alcohol Bringing them home counsellors	13.6 9.9 1.6 4.0 4.4
Department of Human Services	NT Centrelink NT income management	4.2 3.6
Department of Infrastructure, Transport, Regional Development and Local Government	-	-

Source: Macklin 2008

The Australian Government has a range of specific programs relevant to Aboriginal and Torres Strait Islander health and housing, in addition to those funds coming to the states and territories through the grants commission.

Specific to housing was a range of planned programs, including implementation of the Australian Remote Indigenous Accommodation (ARIA) program, with a budget of \$293.6 million over four years aimed at reducing overcrowding in remote Aboriginal and Torres Strait Islander communities. This was over and above the current level of Aboriginal and Torres Strait Islander housing funding of around \$380 million a year.

Other programs include Health@Home Plus, which has a further \$37.4 million to provide home visits by health professionals and support teams for children aged 0–8 in outer regional and remote areas. On top of this is a \$13.8 million commitment aimed at development of Aboriginal parenting skills.

3.5 Principles of effective service delivery

During its first year of research, Desert Services that Work captured a range of elements that, if adopted, would likely lead to more effective service delivery. These factors can influence the successful delivery of services. Throughout the project a number of principles for effective service delivery for remote desert communities were distilled from the analysis of case studies into a set of principles (Moran et al. 2009).

Quality and adequacy of supply

Service providers set out to deliver a high quality service that meets the needs of users at a standard that is appropriate for the local context and that the supply is adequate for local needs.

Supply of service is adaptable to local conditions affecting demand

This principle calls for an informed understanding of the aspirations of local people and responsiveness to local conditions. Service standards need not replicate urban standards, where the outcome may ultimately lead to unsustainable costs of living for remote area residents. Local circumstances call for a more adaptable and flexible approach.

Clear decision points

There needs to be a relevant and recognisable and accountable supply chain with identifiable decision points.

Involvement of trusted outsiders and insiders

There needs to be a two-way communication tool to bridge the gap between service providers and Aboriginal people.

Quality of interpersonal relationships across a service network

Time is needed to build rapport and understanding between people. Service outcomes are enhanced where services providers anticipate local concerns, manage misunderstandings and communicate clearly

Form of engagement between service providers and users is determined by function

Effective engagement is determined by the scope and nature of services and can take many forms.

Stability in the policy environment

The presence of mature local organisations, and a low turnover of staff in key positions, has enabled transitions from one policy to another to be managed effectively.

Service match to local needs and capacity

A long-term vision for a settlement and the region within which it is located enables the supply chain of services to be better designed and orientated to goals to which residents themselves make a commitment.

3.6 Performance and evaluation

'You can't manage if you don't measure' is a statement often remarked and it is true – provided that the correct parameters are being measured and the right data collected. An important part of the service delivery cycle is performance measurement. The Australian Government has processes in place to guide on measuring and evaluating performance. A review of the Government Service Provision compendium (SCRGSP, 2008) indicates that the process of service provision begins with a program or policy that sets out the objectives, the services process to be invoked, and the outcomes to be achieved. These outcomes are influenced by a range of externalities. This model is depicted in Figure 3 below.

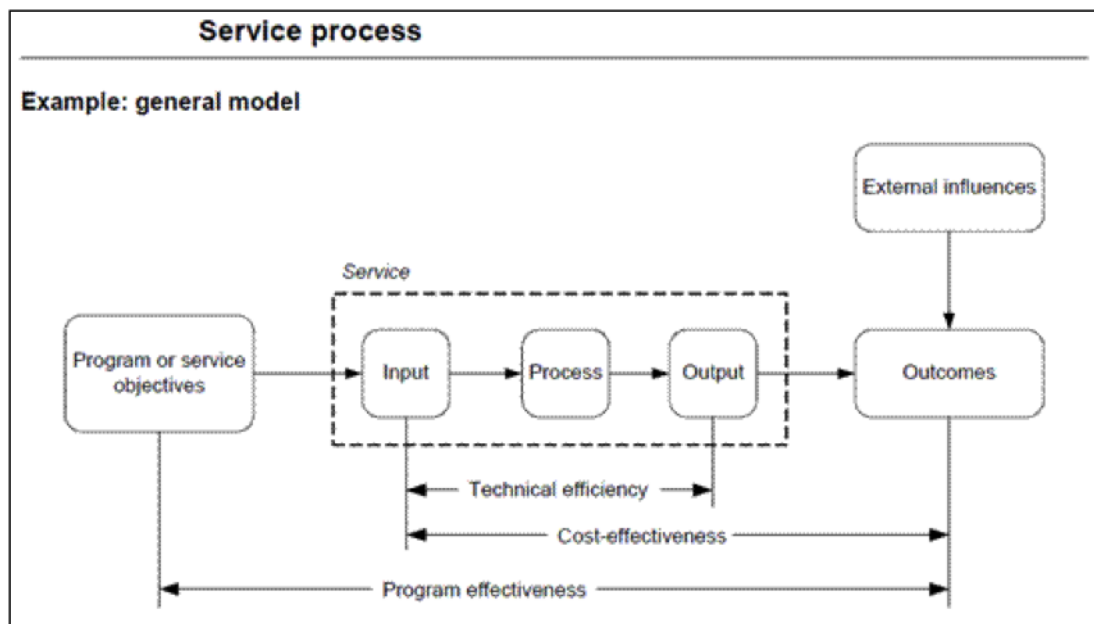


Figure 3: Service process

In essence, this model is the basis for the performance indicators in a complex model to be developed. Based on the model, there are three measures that should be captured: program effectiveness, cost effectiveness and delivery efficiency. Indicators of these vary depending on the program objectives and delivery model employed. They should be selected to reflect existing reporting and data flows where possible. The following table outlines a range of data currently captured for various reporting requirements (SCRGSP 2008, p. 15). As can be seen, there are very few measures around efficiency and effectiveness documented, nor is there any discussion on service standards. This could be a limitation to this approach to assess the efficiency and effectiveness of new models for service delivery.

Table 2.1 Reporting of at least one data item on Indigenous Australians, 2008 Report

Service area/indicator framework	Descriptive	Outcomes	Outputs		
			Equity	Effectiveness	Efficiency
Early childhood, education and training					
Education preface	✓	x	x	x	x
Children's services	x	x	✓	x	x
School education	✓	✓	✓	✓	x
VET	x	✓	✓	✓	x
Justice					
Justice preface	x	x	x	x	x
Police services	✓	✓	✓	✓	x
Court administration	x	x	x	x	x
Corrective services	✓	x	x	✓	x
Emergency management					
Fire events	x	x	x	x	x
Ambulance events	x	x	x	x	x
Road rescue events	x	x	x	x	x
Health					
Health preface	✓	✓	x	x	x
Public hospitals	✓	x	x	x	x
Maternity services	x	✓	x	x	x
Primary and community health	✓	✓	✓	x	x
Breast cancer	x	x	✓	x	x
Mental health	✓	✓	x	x	x
Community services ^a					
Community services preface	✓	x	x	x	x
Aged care services	✓	x	✓	x	x
Services for people with a disability	✓	✓	✓	✓	x
Child protection	✓	x	x	✓	x
Out of home care	✓	x	x	✓	x
SAAP	x	✓	✓	✓	x
Housing					
Public housing	✓	✓	x	x	x
State owned and managed Indigenous housing	✓	✓	✓	✓	✓
Community housing	✓	x	x	x	x
Indigenous community housing	✓	✓	x	✓	✓
Commonwealth Rent Assistance	x	✓	✓	x	x

^a Descriptive data on Indigenous Australians are also available for juvenile justice services of the 2008 Report (chapter 15), however indicators by Indigenous status are not available while an indicator framework is under development. SAAP = Supported Accommodation Assistance Program. ✓ = At least one data item is reported. X = No data are reported.

Source: 2008 Report, table 2.4, p. 2.20.

Figure 4: KPI outputs

Source: SCRGSP 2008

In terms of health outcomes, the Aboriginal and Torres Strait Islander Health Performance Framework Report 2008 reported against the Aboriginal and Torres Strait Islander Health Performance Framework (HPF). The HPF was developed to monitor the progress of the health

system and broader determinants of health and is comprised of three tiers of performance: health status and health outcomes; determinants of health status; and health systems performance.

Health Status and Outcomes (Tier 1)		
Health Conditions 1.01 Low birthweight infants 1.02 Top reasons for hospitalisation 1.03 Hospitalisation for injury and poisoning 1.04 Hospitalisation for pneumonia 1.05 Circulatory disease 1.06 Acute rheumatic fever & rheumatic heart disease 1.07 High blood pressure 1.08 Diabetes 1.09 End stage renal disease 1.10 Decayed, missing, filled teeth 1.11 HIV/AIDS, hepatitis C and sexually transmissible infections 1.12 Children's hearing loss	Human Function 1.13 Disability 1.14 Community functioning Life Expectancy & Wellbeing 1.15 Life expectancy at birth 1.16 Perceived health status 1.17 Median age at death 1.18 Social and emotional wellbeing	Deaths 1.19 Infant mortality rate 1.20 Perinatal mortality 1.21 Sudden infant death syndrome 1.22 All causes age standardised deaths rates 1.23 Leading causes of mortality 1.24 Maternal mortality 1.25 Avoidable and preventable deaths
Determinants of Health (Tier 2)		
Environmental Factors 2.01 Access to functional housing with Utilities 2.02 Overcrowding in housing 2.03 Environmental tobacco smoke Socioeconomic Factors 2.04 Educational participation and attainment of Aboriginal and Torres Strait Islander adults 2.05 Years 10 and 12 retention and attainment 2.06 Year 3, 5 and 7 literacy and numeracy 2.07 Employment status including COEP participation 2.08 Income 2.09 Housing tenure type 2.10 Index of disparity	Community Capacity <i>Demography</i> 2.11 Dependency ratio 2.12 Single-parent families by age group <i>Safety and Crime</i> 2.13 Community safety 2.14 Contact with the criminal justice system 2.15 Child protection <i>Other</i> 2.16 Transport 2.17 Indigenous people with access to their traditional lands	Health Behaviours <i>Tobacco, alcohol and other drug use</i> 2.18 Tobacco use 2.19 Tobacco smoking during pregnancy 2.20 Risky and high risk alcohol consumption 2.21 Drug and other substance use including inhalants <i>Physical activity</i> 2.22 Level of physical activity <i>Nutrition</i> 2.23 Dietary behaviours 2.24 Breastfeeding practices <i>Other health behaviours</i> 2.25 Unsafe sexual practices Person-related Factors 2.24 Prevalence of overweight and obesity
Health System Performance (Tier 3)		
Effective/Appropriate/Efficient 3.01 Antenatal care 3.02 Immunisation (child and adult) 3.03 Early detection and early treatment (including cancer screening) 3.04 Chronic disease management 3.05 Differential access to key hospital procedures 3.06 Ambulatory care sensitive hospital admissions 3.07 Health promotion Responsive 3.08 Discharge against medical advice 3.09 Access to mental health services 3.10 Aboriginal and Torres Strait Islander Australians in the health workforce 3.11 Competent governance	Accessible 3.12 Access to services by types of service compared to need 3.13 Access to prescription medicines 3.14 Access to after hours primary health care Continuous 3.15 Regular GP or health service 3.16 Care planning for client with chronic diseases	Capable 3.17 Accreditation 3.18 Aboriginal and Torres Strait Islander people in Tertiary Education for health related disciplines Sustainable 3.19 Expenditure on Aboriginal and Torres Strait Islander health compared to need 3.20 Recruitment and retention of clinical and management staff (including GPs)

Figure 5: Aboriginal and Torres Strait Islander Health Performance Framework Measures

Note: The **Safe** domain is measured within the National Health Performance Committee framework.

These performance indicators can form the basis for development of outputs for the model.

4. Modelling

The aim of this component of the research is to use the data to represent the system in sufficient detail to enable a user to interactively explore the system and generate outputs that allow understandings to emerge. Using complex system modelling techniques we can provide such an environment that allows exploration and interaction, and also provide a platform to test potential outcomes from a range of service provision options, both technical and governance, through simulation. The strengths of this approach is in the flexibility offered in this environment. Potential weaknesses are in the data availability and the need to remain current to drive the models and the modelling itself, which can range from a simple (logical) representation through to a complicated spatially and temporally correlated behavioural model with many levels of interactions.

The system chosen for examination in this research was the housing system in remote communities of approximately 200+ persons. Of interest was the impact on occupants' health within remote communities from housing and associated infrastructure. This system was selected with the aim of testing the potential of improved housing and health outcomes from varied serviced delivery models in the housing and essential services sector. The community size of 200+ was chosen for modelling simplicity; however, it can be adapted to other population sizes given sufficient detail of changed dynamics due to population changes.

The objective of the modelling is to provide a platform to aid understanding the system and project possible changes given modified practices. The focus here is on a small part of the system and so care has been taken not to understate the system, or in fact to introduce too many real world parameters and overly fit a model. This approach is useful for scenario and policy development but is reliant on fine resolution statistical data.

4.1 Complex system

As discussed, the system can be represented using a complex system software platform for model development. A modular approach was implemented during the development, thereby allowing extensions in future development or versions that might include different community sizes, and other parameters (such as education and training) to be added in future versions.

According to CSIRO Centre for Complex Systems Science (CSIRO 2005), a complex system is a system that shows emergence behaviour that is more than a sum of the parts of the system alone. It is self-organisation and its behaviour is not obvious, given the interconnected parts. In essence, the outcomes of a complex system cannot be predicted easily and are sometimes unknowable based on an analysis of any of the system's parts. Complex systems often exhibit a range of unexpected behaviours and are often sensitive to starting conditions. Complex systems fall into three basic types: chaotic, adaptive or non-linear. The services systems model may be classified into any or all of these classes.

A feature of a complex system is that the system may often be open, with boundaries that are difficult to determine and often arbitrarily assigned. Complex systems may have a memory; that is, they change over time and a future state may be dependent on a present state. These systems

can be nested and are by nature dynamic, with many interactions that are often non-linear and generally contain feedback loops. Approaches to modelling complex systems include the use of:

- networks
- cellular automata
- agent-based models
- game theory
- evolutionary models
- neural networks
- chaotic dynamics, fractal patterns
- non-linear dynamics; e.g. percolation theory.

This system has evolved over time with many small, and some large, condition changes over time. There are a large number of actors and interactions within the system, and outcomes are often difficult to understand directly.

4.1.1 Agent-based modelling

An agent-based model (ABM) is a bottom-up modelling approach that represents a system through the development of the agents, their 'characteristics and preferences' and the 'rules' under which the system operates. This approach is a flexible approach, which can use data at any level for agents or behaviours, and is often used to support other approaches for addressing complex systems.

It is used to simulate the actions of dynamically interacting rule-based agents to help understand the effects on a given system. The approach relies on behavioural rules of a range of agents acting in their own interest at different scales with varying decision-making rules and potentially learning rules. ABM is a means of analysing systems by representing the individual elements or 'agents' from which they are comprised, and simulating their actions and interactions. Attributes and behaviours of the individual agents are defined and modelled together in a way that scales up their interactions, providing insights into the system behaviour itself. An example of an ABM is depicted below in Figure 6.



Figure 6: Agent-based model example

Source: Daniell et al. 2006, p. 125

ABM reveals emergence from the lower (micro) level of systems to higher (macro) level outcomes and enables researchers to move past traditional modelling limitations by allowing:

- representation of heterogeneous agents
 - limited knowledge and access to information
 - agent learning and adaptation
 - explicit interactions and communication
 - representation of feedbacks and non-linearities of complex adaptive systems.
- (CSIRO 2007)

ABM is also ideal for interdisciplinary modelling, and often shows the emergence of surprising and complex behaviour at the broader system level. The benefits of ABM over other techniques are that it is flexible and provides a natural description of the system but importantly it captures emergent phenomena (Bonabeau 2002).

There are a number of platforms available to carry out the modelling, including Swarm®, which was one of the first general purpose ABM systems and is used by programmers with C or C++ experience. iThink® also provides a useful modelling domain for systems problems. The platform has been used widely for public policy, supply chain and consumer satisfaction simulations, all of which to some extent reflect the problem outlined here.

The environment chosen to develop the software here was NetLogo®, a high level program for creating ABMs that is widely used by researchers and educators alike. Netlogo® is a cross-platform multi-agent programmable modelling environment. In Netlogo® agents (ABMs) are

termed 'turtles' which have the capacity to move around the 'world'. The world consists of a grid of 'patches', which have specific characteristics. A third element is a link that connects one patch to another; these have a specific role and can be directed or undirected. The last element is an 'observer', which is a reporting mechanism.

4.2 System model

In order to capture the actors in the system it was necessary to develop an abstract model of the system and then to conceptualise the roles of the agents and any interactions within the system(s).

4.2.1 Abstract mathematical model

The aim of the model is to provide the maximum service quality (measured by effectiveness) for the minimum cost (measured by efficiency). An abstract model of the system is captured in Equation 1 below.

$$\begin{array}{c} \longleftrightarrow \\ f[Policy] \bullet f[ServiceDelivery] \bullet f[enduser] \Rightarrow Service(effectiveness, efficiency) \\ \Rightarrow \max |serviceeffectiveness, serviceefficiency| \end{array}$$

Equation 1

This equation describes the system as a function of policy (P) with a functional relation of the service delivery (D) combined with a function of the end user environment (U), which results in a service outcome. The service output is measured by efficiency and effectiveness and our aim is to maximise both. Note that the sets P, D and U are not exclusive and may intersect and, moreover, may include any of the functions in the equation. For example, P is the set of all parameters and variables relating to the Policy function, but P may contain parameters or variables in common with D or U. Further, the components of P might also be the functions Service and EndUse; that is, service effectiveness and efficiency and service end use are inputs to the formulation policy.

A change in any of the input parameters can lead to a different outcome, but not always. In Figure 6 below the three ovals depict the context boundaries or constraints for the components which impact on their ability to influence the service outcomes; in some instances there is significant overlap while at other times the interaction between the contexts is minimal. The arrows reflect a more direct relationship between the policy and end user environments.

4.2.2 Conceptual model

The process begins with a conceptual model. Here, questions, agents and behaviours are identified and the model grounded. In this version of the model the 'end' is an individual, though this is not necessarily the case for variations of this model. Users may be nested in terms of their behaviour, as may be the case in a household situation, or largely independent, as may be the

case when using water or power or other utilities. This model can be duplicated as required and combined to simulate multiple service systems acting on an individual actor.

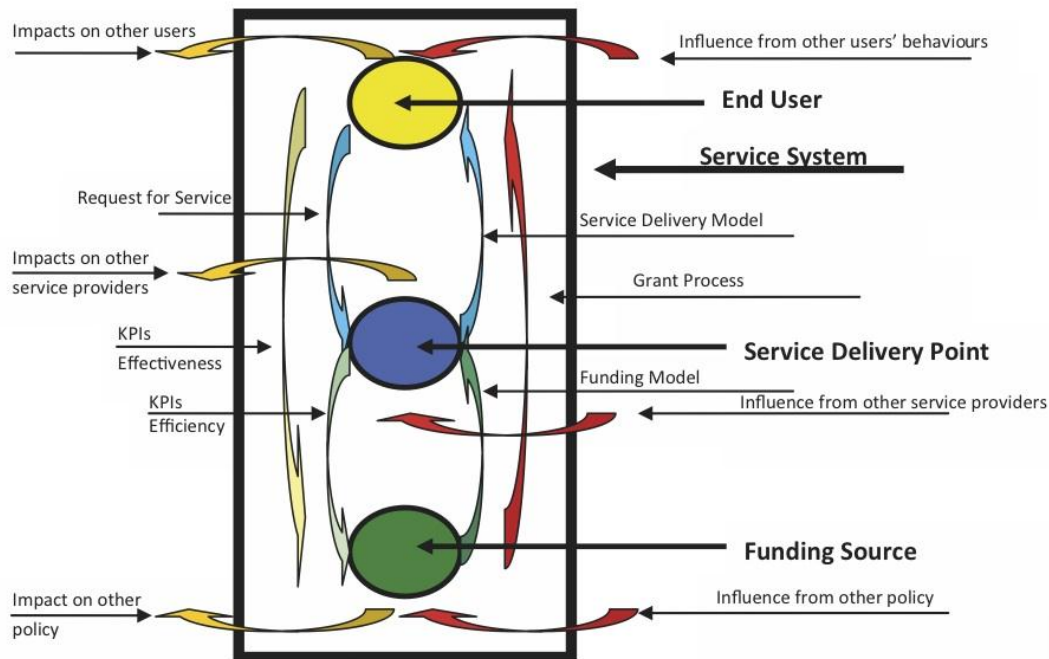


Figure 7: Conceptual ABM of the lifecycle of a single service system

In the above model the three functional inputs of the abstract, depicted here as the central circles, are connected through a series of 'events'. These events may be requests for service or the delivery service. The boundary is the service system, and there are a range of inputs and outputs across the boundary.

Specific policy is contained within the system boundary; however, the policies developed may impact on other sectors as other policies will impact on the system of interest. The funding source node (as determined through the various policies) is connected to the service delivery node through a funding model and the feedback loop is represented as a range of key performance indicators (KPIs).

The end user and the service delivery point are connected through an expression of demand and service delivery through a specific model. This does not imply that there is no role in the service delivery for the end user. Again, across the boundaries are influences and impacts from outside the system. For simplicity in this model these are minimal and managed.

There is also a connection from the end user and policy represented here as effectiveness KPIs and grant process.

Considerations beyond the abstract include a context layer which adds yet another layer of complexity to the system. The funding component is linked to a political context while the end user is immersed in a context where parameters of influence include access, education, environment and cultural influences, and others which all impact on the end user's ability to

request/receive and consume the service. It would seem the component with the greatest opportunity to influence the service outcome is the service agent where there is potential for overlap in the contexts with both other actors. Some of the contextual issues facing the service agent include remoteness, settlement size and access. These may be able to be captured in the model through introduction of a settlement type, as discussed earlier.

A generalisation of this model could see the end user as the focus (presented here as the single node at top) and services providers (which may be multi-functional) delivering a range of services. This is depicted in the below model.

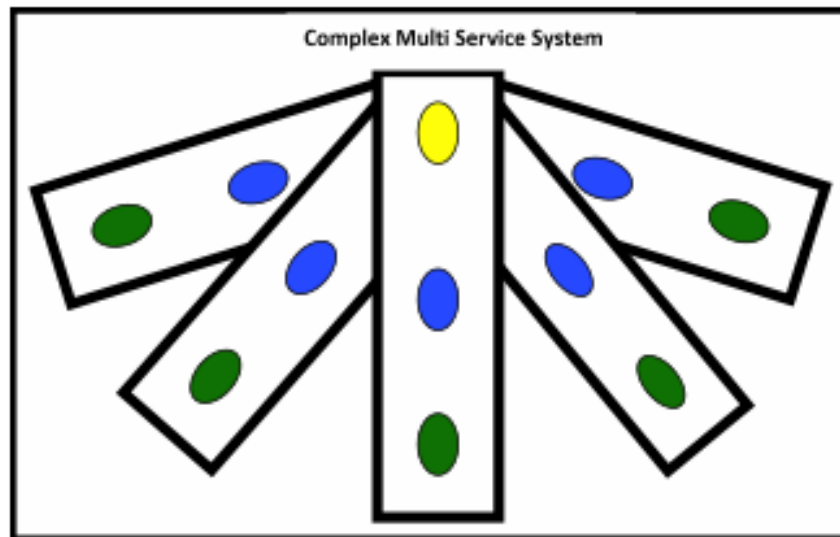


Figure 8: Conceptual ABM of multiple service systems

4.3 Case study

The model seeks to simulate this focused system. To develop and test the approach a case study of the delivery of housing services and associated power and water services was considered. Major drivers for this choice were the potential for access to data and familiarity of the system for the researchers, and complimentary research carried out by other researchers that would allow meaningful sensitivity analysis. The existing research being conducted by the Desert Services that Work project in a western Queensland location by Jenine Godwin, and also by Tim O'Rourke (O'Rourke 2011) presented a useful site, since it involved two jurisdictions delivering these services, and offered contrasting input/output relationships.

As stated earlier, the focus for this study is the system as it impacts on occupants' health, or more specifically, the management of housing maintenance system as the outcomes impact on the occupants' health. The mind map below (Figure 9) represents the wider system from which the main components of interest were identified inside the blue dotted circle.

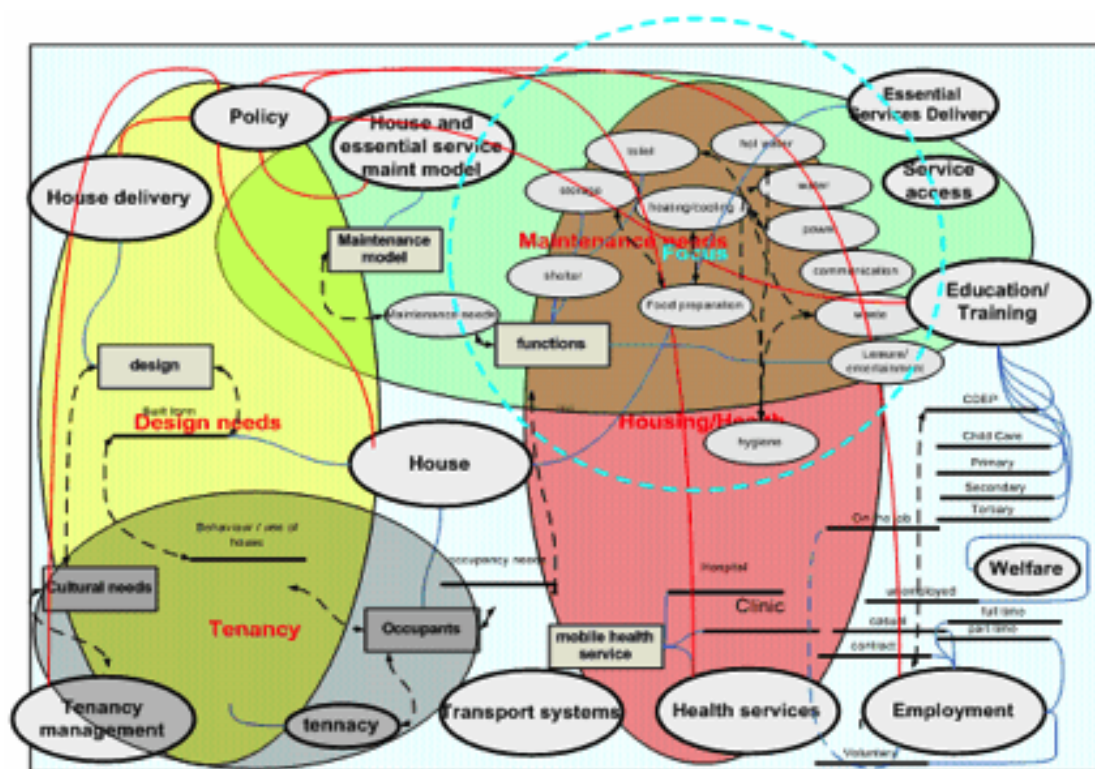


Figure 9: Conceptual system map

The focus section captures the home and housing components most associated with health and hygiene outcomes, including the necessary supporting infrastructure. Other aspects, such as design and occupancy management, were left outside of the focus area despite the opportunity for improved outcomes as the model attempts to represent the on-the-ground status at the time. The potential for adding improved design/tenancy management to test outcomes may be considered in future versions.

Considerable data is required to develop a representative model. For example, data for components of the model, including elements within a home and infrastructure support, must be collected, as will details for the components maintenance. Further data detailing health impacts from poor performing components – or indeed the impacts where components fail due to secondary causes (such as lack of power supply, water supply or access), or perhaps even due to lack of training in the use of the component – will be required for the model to be able to simulate the outcomes successfully. This data would provide the basis of the model but will also require data from occupants/users where uses of household components and or health living practices are not well understood.

The main aim of this model is to provide a platform to test whether changes in the housing services delivery model can impact on occupants' health and attempt to understand co-benefits, limitations or bottlenecks in the system. The model was developed specifically with a range of policy questions in mind:

- What is the effect of the number of houses in the system on the health of the residents?
- What is the impact of increased maintenance budget?

- What would be the likely effect of improved living skills?
- What is the net impact on visitors to the system?
- Are other service delivery models likely to result in better outcomes?

4.3.1 Constraints

The system under consideration is highly complex and challenging to model in its entirety; hence, a number of constraints were implemented in this development version to enable a simplified representation of the system, and as an attempt to achieve a workable model. The major constraint was lack of time to develop a complete system understanding. This necessitated the development of the conceptual system map (Figure 8) to ensure major elements and connections were recognised.

Modelling constraints implemented due to lack of data or access to data included the use of discrete distributions to describe events to effect an 'arrival' of an event in the simulation rather than continuous distributions or preferably sourced data. Examples of this include the value of housing stock, breakdown frequency and repair costs for some housing, and infrastructure components and maintenance identification, scheduling, executing and costing.

4.3.2 Limitations

Clearly, the constraints result in considerable limitations to the model; however, the most significant limitation of the model is in the coding for behavioural aspects. This refers to situations where individuals are to respond to stimulus. In this type of model only a range of response options can be included. Much more data would be required to develop the full set of responses; thus, a limited set were created in this development version. The reality is that the true response may be though an irrational response by someone outside the system and may not be known by most in the system – let alone included as a response option. The inclusion of a likelihood distribution of a given response will be approximately correct for a specific point in time and individual or for a simulated study of a group of individuals; however, it is very likely to be incorrect for all of the individuals. Given that the process of building the model is based on a disaggregation of the system it is likely that components of the system which impact on its complexity have not been included or not given sufficient consideration during this development stage. These system components may well be identified in a model review or future development process.

4.3.3 Data Sources

Some of the data used in this model were captured from existing reports, including the work of Pholeros from the 'Healthhabitat' site (Health Habitat n.d.), which has been the source for the health related infrastructure section that follows. However, data for areas such as relationships and behaviours was difficult to capture and therefore was developed based on a number of discussions with researchers currently in close contact with communities.¹ These data will serve to aid development; however, more formal and accepted methods for data collection are needed for a full development version.

¹ In particular I would like to acknowledge the support and efforts of Jenine Godwin for her insights and input.

4.4 Model components

The purpose of this section is to describe the connections between infrastructure and health in remote settlements. Representation of these connections in some detail will be important in a final product. For this version we included a simplification of the interactions. Health Habitat (n.d.) details aspects of the housing and infrastructure that can impact adversely on the health of the residents. The elements listed below are believed to contribute to the ability of a home to contribute to healthy living practices. These elements are:

1. washing people
2. washing clothes
3. removing waste
4. improving nutrition
5. reducing crowding
6. separating people from animals, vermin or insects
7. reducing dust
8. controlling temperature
9. reducing trauma.

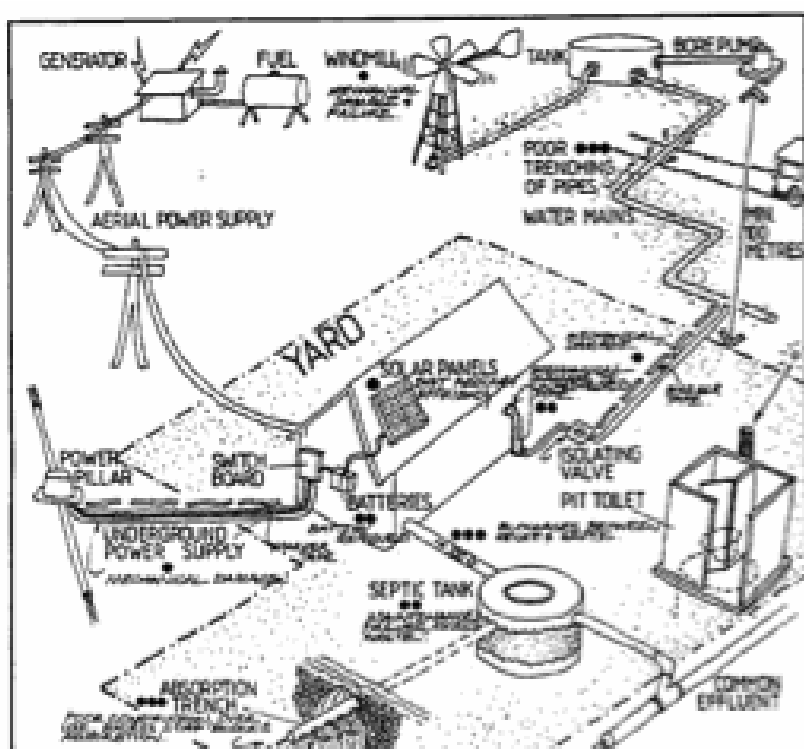


Figure 10: Areas of potential failure in a typical remote settlement infrastructure system

Source: Memmott & Moran 2001

Figure 10 provides an analysis of potential damage and failure to the infrastructure system in a remote discrete Aboriginal and Torres Strait Islander desert settlement, which in turn would have an adverse impact on environmental health. An awareness of these vulnerabilities could lead to the development of strategies to minimise impacts. However, there are other factors that can influence improvements. The figure highlights both the independence of the components

and how they interconnect to provide a functioning house. Using this approach we were able to break down the system in the model to its modular components. The benefit here is that introduction of new technologies in any of the component systems (such as improved sewerage system) can be easily introduced into the model. Equally, the connection to health impacts can be written in sub-routine form allowing for modular development and improvement of the model over time as our knowledge and data improves.

The following section is mostly extracted from Pholeros's work (Health Habitat n.d.) and explores the health-related infrastructure in some detail. Other data has been captured from *The Bush Book* (NTG 2007). Details on the impacts on health and the factors leading to the health outcomes will provide the variables to develop the model. Initial parameters will be estimated. Precise parameters reflecting the relative impacts will need to be sought from health and housing statistics.

4.4.1 Housing

The effect that the state of housing can have on occupants' health includes the incidence of infectious diseases, such as gastroenteritis and asthma. The impacts on chronic disease and mental health, however, are less well understood. Health impacts can be due to:

- social factors – socio-economic status, kinship responsibilities, education in relation to disease, education on maintenance and cleanliness
- physical factors – design, function, crowding, and remoteness (isolation).

In the course of this research, we have heard anecdotes that residents modify a home to maintain a lifestyle rather than modify the lifestyle to meet the demands of a poorly designed home. And where access to services is not readily available, residents will make alternate arrangement for service delivery. This type of non-documented information is critical to model. Eliciting data that captured these type of parameters would be a significant challenge, particularly where there is an expectation of significant differences in both the motivations and capabilities.

Factors contributing to the health outcomes include crowding, temperature control and design for safety features. Crowding of houses contributes to the rapid and easy spread of respiratory diseases, skin infections, enteric diseases and a range of diarrhoeal diseases in all age groups. Groups such as children (especially if they are sick), older people, and those with chronic illnesses are particularly vulnerable to extreme or sudden changes in temperature. Many physical injuries result from preventable accidents: burns, cuts, scalds, electric shocks and poisoning. Some of these may be life threatening.

High maintenance needs are most often caused by the combined effects of:

- wear and tear caused due to overcrowding
- shortage of housing
- the age of the houses
- inappropriate design and poor construction of many existing houses
- lack of ongoing maintenance
- vandalism (especially when houses are empty).

Maintenance is often a problem in due to:

- a shortage of funding for maintenance
- a lack of systems for regular housing inspection and the reporting of faults
- a lack of local skills and materials to undertake repair and maintenance.

4.4.2 Water

Daily washing reduces the risk of skin disease and diarrhoea and so it is important to educate adults because children and adolescents model their behaviour on that of their elders. It is especially important that children under five are washed in order to reduce the prevalence of the four most common childhood illnesses: diarrhoea and respiratory diseases; pneumonia; skin infection; and trachoma.

Washing clothes reduces exposure to faeces, secretions, scabies and mites, and will reduce the prevalence of skin infections and diarrhoeal disease. The availability of adequate safe water is critical to improved health. Health problems related to water can include:

- Infectious diseases, such as gastroenteritis. These can be prevented through basic hygiene: bathing, washing, cleaning.
- Respiratory disease and eye infections. These can increase when dust is not suppressed or grass is not grown to cover dust in outdoor areas.
- Dehydration and or substitution with high sugar fluids
- Nutrition, which can be improved via crop cultivation.
- Natural or anthropological contamination of water at source, outlet or along the system.

4.4.3 Power

Power provides access to reliable cooking, cooling, heating and lighting, as well as hot water and appliance use. On remote settlements, power is required to run water pumps and other domestic, industrial and commercial facilities.

Benefits of power availability include improved hygiene outcomes and the ability to effectively store food, control temperature, and wash bodies, clothing and bedding. The ability to improve food quality can lead to improved diet, thereby reducing the potential for obesity, diabetes, cardiovascular disease and renal disease. The nutritional problems of Aboriginal people contribute to:

- low birth-weight
- failure to thrive
- obesity, diabetes, hypertension and cardiovascular disease later in adult life
- increased likelihood of picking up communicable disease in early childhood.

Alternative power sources, such as open fires (petroleum or otherwise fuelled), can contribute to respiratory problems; further, risk of fire and can have an impact on people's financial resources, thereby limiting funding for other health-related costs. The costs of using 'active' heating and cooling systems to make poorly designed houses more comfortable are very high and need to be considered in the model.

4.4.4 Sewerage and rubbish disposal

Waste water in the living environment can lead to illness via the transmission of disease-causing bacteria. Reliable rubbish disposal is a similarly important health factor. Improved waste removal systems may help to prevent or reduce the prevalence of:

- waterborne diseases
- diseases carried by insects
- parasites
- acute and chronic diarrhoeal disease
- skin infections.

A range of sewerage systems are in use, the most common being the septic tank in combination with a leach drain nearby. Some issues arising in relation to this system are the:

- adverse impacts on the system through crowding, poor design and location near groundwater supply
- pit toilet design, which should preclude risks from flooding, vermin and flies
- pan systems, which require daily handling and present risks to handlers. This could lead to contamination of drinking supplies if the contents are not correctly disposed of.

Risks associated with a poorly operating sewerage system include infectious and parasitic diseases. Health risks include:

- a higher risk of infectious disease transmission
- injury from objects
- food poisoning through use of contaminated containers.

4.4.5 Communication, transport and roads

Good communication and transportation facilities improve access to health services as they lead to shorter delays in treatment. They can also act as a preventative measure through nutritional improvement and access to education. They enable:

- communication with health and emergency services
- transport to health services
- transport of fresh food, water and other provisions
- access to and for maintenance.

The benefits of sealed roads include the minimisation of eye irritations and pathogen distribution, better household cleanliness, and reduced accidents.

4.4.6 Health facilities and personnel

Some issues in relation to health facilities and personnel are:

- access to primary health care – distance to facilities and availability of professionals are determinants (including the ability to effectively communicate)
- proximity of facilities can assist with local planning and interventions
- coordination of clinical care
- prevention and early intervention.

4.4.7 Education

Improved education can increase knowledge of healthy living and improve employment opportunities. Educational levels of mothers in particular can be a determinant for health of children.

One of the most neglected aspects of environmental health is the area of settlement planning; that is, how communities are 'set out'. As Moran (1999) states:

Environmental health programs have justifiably focussed on direct human contact with disease, such as transmission routes relating to housing, water supply, and sanitation. They have largely neglected the social, cultural and environmental health dimensions to Aboriginal settlement.

4.4.8 Responsibility for environmental health

There are a range of agencies that have a role in the delivery and maintenance of health outcomes, highlighting the complexity of the system. Agencies that have a role in environmental health in the Northern Territory include:

- Territory Health Services through its Environmental Health Program
- environmental health workers
- the community government council and its employees, such as essential services officers (ESOs)
- the Power and Water Authority
- the Department of Housing
- the Department of Lands, Planning and Environment
- the Indigenous Housing Authority of the Northern Territory (IHANT)
- private consultants and contractors such as electricians, plumbers and builders
- other non-government service providers such as landcare agencies.

4.5 Software development

As discussed earlier, the system can be classified as a complex system, and one of the analysis methods available to help understand these types of systems is ABM. A model has been developed to test the suitability of the method in terms of output/graphical user interface, simulation capability and data requirements. The approach has shown itself as potentially useful; however, there are concerns about how data-hungry the technique will be and how well it may work in a simplified form. That is, it will likely require substantial effort beyond this development stage to create a version which could replicate the system to respond to a full range of policy questions. This development may require substantial effort but would likely result in a very useful, highly interactive policy-testing platform. In the context of this model, an agent is something that evolves or acts. Agents perform roles or functions and have behaviours, responses and dependents/dependencies.

Table 4 below captures examples of housing system agents, their role, behaviours and dependencies.

Table 4: Housing system agents and their behaviour

Agents: individual agents to be generated in and by the model	Role/Function: the main functions of the agents	Behaviours/Responses: types of behaviours to be modelled in the simulation	Dependencies/Dependents: the environmental, physical and human factors that impact on the agents
Roof	Shelter	Deteriorates over time	Weather
Door	Security/privacy	Hardware failure	Use
Windows	Security/ventilation/light	Broken	Use
Water supply	Water provision	Pipe or system failure	Water infrastructure
Tap	Access to water	Leaking,	Use
			Water quality
Shower	Cleaning	Leaking,	Use
			Water quality
			Waste water system
Hot water	Hot water	Failure	Use – water quality – power supply – weather (solar)
Gas	Power to stoves	Lack of service	Gas supplies limitations
Stove	Cooking		Power availability
Electricity	Power	Lack of supply –	Community generator failure -
Light	Lighting	Bulb failure	Use
Heating/cooling	Maintain temperature	Failure	Power - water quality (air conditioners) – use – weather
Switches (power)	Power provision	Failure	Use
Waste water system	Maintaining healthy environment		
Toilet	Waste		Waste water system
Communications infrastructure – phone, mobile, TV and computers	Power/phone lines mobile connections	Line down, power failure hardware failure	Use, power supply, weather, signal strength, surges
Personal appliances (refrigerators, washing machines TV Computers...		Early failures due to	Water quality – wash machine Surges – all appliances Impact on personal income as high replacement costs

The components listed represent only a small proportion of the ‘actors’ in the system. However, they illustrate the process and highlight the complexity of the system for a remote community where the Aboriginal population generally make up a large proportion of the population and the houses are largely rented and publicly owned. There may be other actors, privately owned or owned by other government service providers such as education or justice, where properties are managed separately. These properties require a different treatment in the model, including

different deterioration, budget, funding and maintenance models. Tables in Appendix A provide some information of the range of actors considered and potential data sources; this table provides a basis for further data collection and model development

In this work, we recognise that cultural influences on housing services are significant. The priority and value that people living in the house place on small repairs and maintenance, the extent to which they secure the house when they are absent, the obligations that people have to other members of their family and the numbers and length of stay of visitors are all factors that affect the components of a house system. It is beyond the scope of the research for a comprehensive analysis of these influences to be included.

To ensure appropriate detail is captured a range of considerations, listed below, would need to be thought through prior to model development.

4.5.1 Spatial considerations

Ideally the model will have a mechanism to select the ‘community type’ from a given range. These could vary in terms of the remoteness and population size, and of course this would impact on the range of service delivery options. Initial development will focus on the 200+ population communities, which are remote but generally accessible.

4.5.2 Temporal scale

The planned timeline for the simulation was chosen to be three years, as this is typical of a budget planning cycle. However the application will be able to run until all agents are either exhausted or equilibrium is attained. This information goes to the step function in the simulation and helps understand the resolution of the data required to support the model.

4.5.3 Hierarchy

In the model framework there is a hierarchy for both the supply and demand sides. For the supply side a hierarchy constraint for the model would be the funding agent link (or indeed multiple funding sources) to the service delivery agent. There may also be multiple levels – that is, funding source to funding source – who may include additional funds (or retain and/or redistribute funds) to service agent to service agent to user. There would also need to be a hierarchy to the demand side in which an individual is nested below a ‘family’ group, which is itself nested in a community, which is nested in a region, though this can be dynamic allowing movement from (or to) a region.

4.5.4 Interrelationships

As is the case for the hierarchy, there are also interrelations for both the supply and demand side of the service provision. For the supply side there are correlations between the funding and delivery of specific services that can impact greatly on the funding and delivery needs of other services. There are also potentially non-linear relationships in the scale of supply where buying power may improve the cost of delivery. These relationships will need to be captured when exploring the complex system for a final model. Further, the demand side has interrelationships that will need some understanding for the model to be successful, including the service access and consumption dynamics for shared resources such as energy and water.

4.5.5 Stationary versus mobility

Both supply and demand will have elements of the process where the agent will be stationary and some processes where the agents will be mobile. To capture this, agents could be developed with both characteristics and utilised as required. In the case of health services, for example, it may be that to access specialised (or even routine) services there may be a need to travel to a regional centre where a user may be competing for services with a much larger population. A queuing model may be required to progress the user through the system.

4.5.6 Priority

Decisions about funding allocations, budgeting and the use of limited resources in settlements are a significant challenge. A decision tree can be used to prioritise needs and service delivery where applicable. An in-depth understanding of the decision processes and constraints will be required to develop this module.

4.5.7 Funding agent

The funding agent(s) will be required to be as flexible as possible as the sources and processes will vary significantly. Funding may be public or private, and funding may often be pooled allowing decisions to be made locally on expending funds. This will add a non-trivial degree of difficulty to the coding; however, it is an important process and must be given the thought required to develop a successful funding module.

4.5.8 Solution options

A range of potential service delivery options may be considered; thus, the solutions options space is an area where the model will require the most flexibility. Solutions may take the form of governance and regulations or may be technical and not compulsory. It is possible that for the non-mandatory options a series of uptake models will be required to drive the implementation of solution options for assessment. The rate of uptake can be driven by a basic diffusion model.

4.5.9 Model agents and initialisation

Development of the model begins with setting up the actors and variables and then providing the distributions from which they can initiate, as well as parameters to guide their responses to the simulated conditions. In the current model the variables included to date are:

- time control – daily, weekly and annually
- events – triggers for visitor arrival
- population characteristics of Aboriginal and non-Aboriginal residents
- health and illness
- visitors variables – visitor characteristics and house placement, as well as indicators to set visit time
- property data, including value maintenance needs and costs
- house size – family placement and housing attributes
- community data, including roads portfolio make-up and distribution, schools, store, landing strip and community health variables
- infrastructure items such as water, power and waste systems, each of which have a range of control variables
- service provider data, including availability and capacity
- other variables, such as funding sources and policy development agents.

The model essentially creates a community, including infrastructure, then populates the community with a population that is made up of randomly assigned families assigned to a 'home' property. Each individual has a profile, which includes age, sex, educational level, income, health status and variables nominally labelled 'life-skills'.

The process is to set up the simulation, establishing initial parameters for each agent in the model. These initial parameters are either defined by the user or generated through a random number generator in the applet and based on a distribution assigned to the variable. These distributions require further investigation and development during the final development phase once interactions and impacts are better understood. Ideally, the distributions can be (and probably should be) sampled from historical data.

In this model, houses can be tenanted or not and can be characterised as 'crowded'. (Note that community housing uses different initial conditions to government employee housing.) The inclusion of this was based on analysis of available data; however, this will require further research prior to final development.

Infrastructure items can be in use or not and have a capacity and a condition which is correlated with the general house condition at the time of set up. They also have a 'fill' level in the case of water or waste systems. Health infrastructure internal to a house has an initial condition which is also correlated to the house condition. After initialising, a flag is set to indicate the need for maintenance, which is displayed as a red sad face on the interface when the element requires attention. A green happy face indicates no maintenance required, while yellow face indicates a 'repair if there' flag.

The location of houses, roads and other community infrastructure or structures is a random allocation but could be more deterministic, as can allocation of the properties to families. Ideally this would be based on a tenancy policy module currently not included. The model has a population growth algorithm which is relatively basic and could be improved on if deemed necessary.

The model has a sub-routine to 'create' diseases with pre-set 'infectious' parameters. This is completely random in the model at present and serves as a bookmark to flag the need for closer investigation during final development. Similarly, the arrival of the Royal Flying Doctor Service and other health service personal or resources requires consideration. Exposure and susceptibility modules need to be created to better capture the likelihood of health impacts on the population.

With the model under discussion, people move about the community in simulated 'trips to work' or to visit other modes. This could be better directed through better data on the movements of individuals in and around the communities, as could the visit module and the migrate module. The income module is not well considered and could be further developed if needed. The model discussed assigns income on the basis of a multiplier of the basic minimum pay slide on the input screen based on job status and or Centrelink eligibility.

Community maintenance funding is based on an amount per property and a one-off amount to assist with administration costs. The module includes a check to ensure funds are available to carry out maintenance prior to completing any work.

Each housing element, health infrastructure and community infrastructure element has a failure or breakdown module, which should be improved in a final model.

A range of maintenance service delivery models have been considered for the application, which could allow the user to test the differences in outcomes that may arise for the differing methods. Below is a list of abstract housing maintenance models that were considered for the modelling component of this study:

1. Responsive only – where service is in response to a reported failure only.
 - a) Contractor.
 - b) Agencies' own tradesman.
2. Responsive and opportunistic within house – where the tradesman responds to a reported failure but takes the opportunity to survey the property for other maintenance needs within the expert domain.
 - a) Contractor.
 - b) Agencies' own tradesman.
3. Responsive and opportunistic neighbour's house – where the tradesman responds to a reported failure but takes the opportunity to survey the property and nearest neighbour's house for other maintenance needs within the expert domain
 - a) Contractor.
 - b) Agencies' own tradesman.
4. Responsive (30%) and planned (70%) – where maintenance is carried out based on a proportion of budget allocation following a planned regime derived from historic breakdown records. Funding is often set aside for emergency responsive maintenance.

Other parameters still to be considered are climate/weather parameters.

4.5.10 Running the simulation

The model is in the *.nlogo application format, which is embedded in an html file (the html format is the preferred environment for running the application). Running the applet requires the user to set the user-defined parameters using the blue/green slide or switch controls in the applet and then click the SETUP button. When setting up the applet, care is needed when considering initial conditions for scenarios to ensure that the starting conditions make sense.

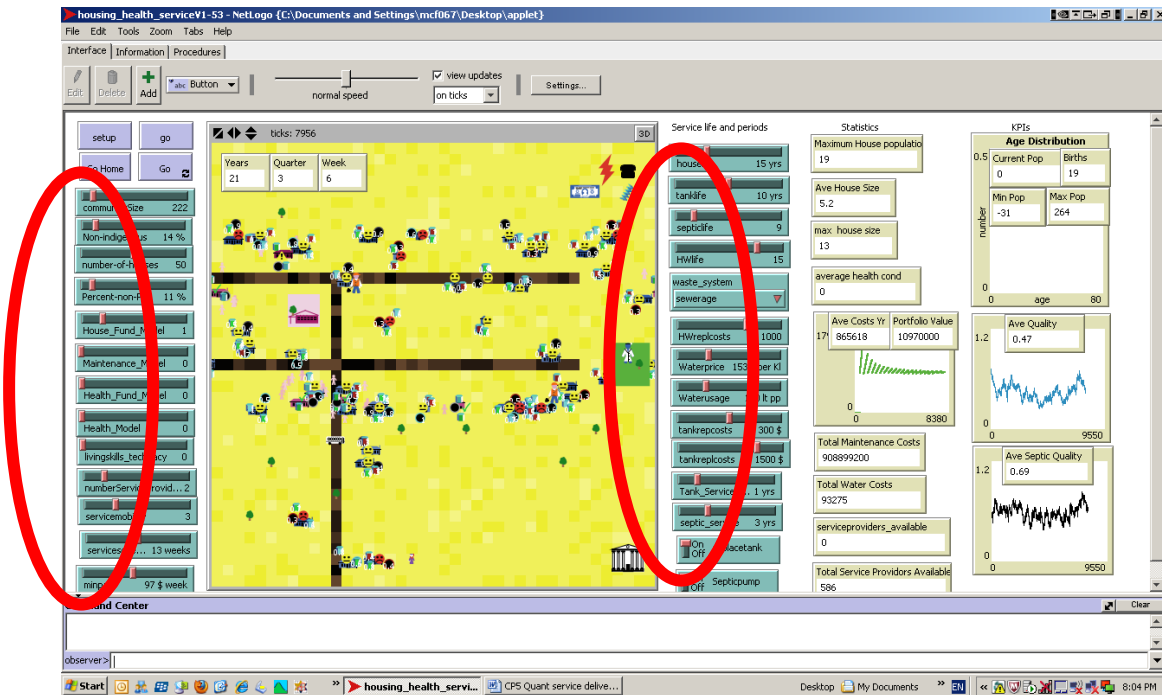


Figure 11: Application user-defined parameters

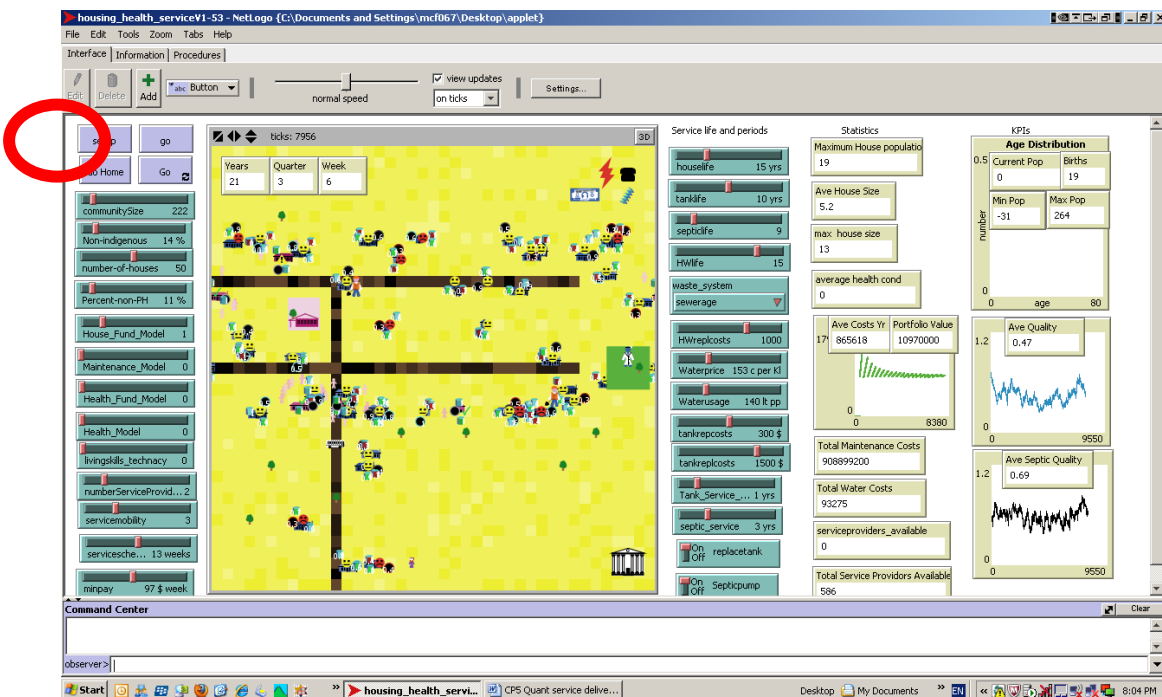


Figure 12: Application setup

Once the environment is setup the user clicks the **GO** button to run the simulation; re-clicking the button stops the simulation.

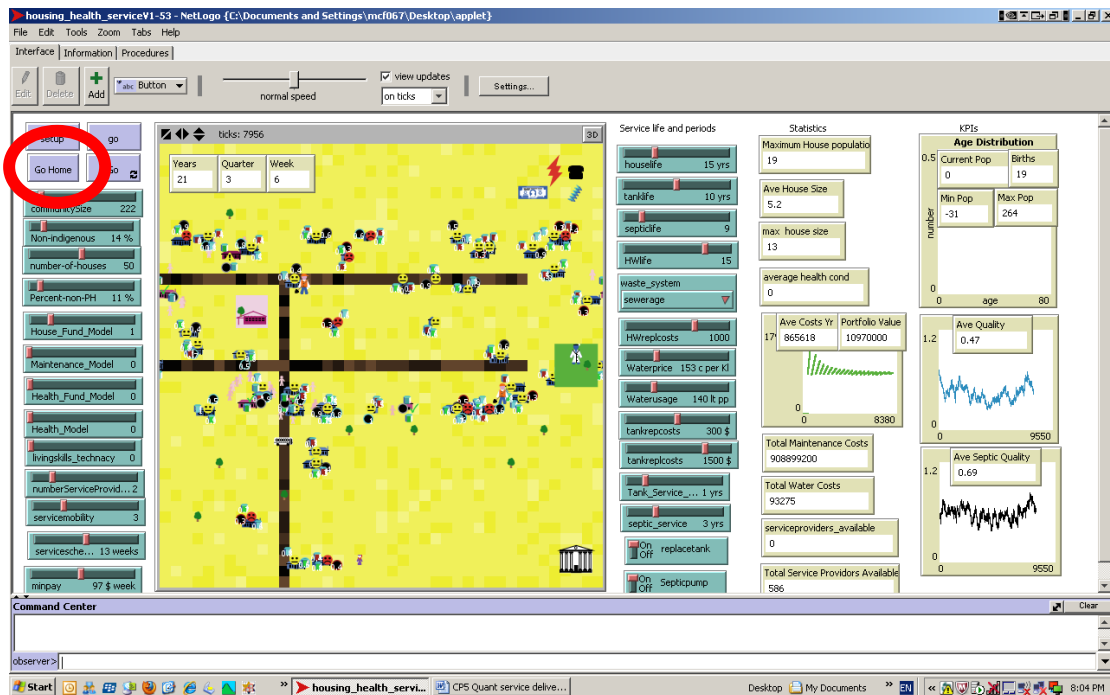


Figure 13: Running the simulation

Other options are to click GO, which runs one iteration of the simulation, or click GO HOME, which sends all agents home.

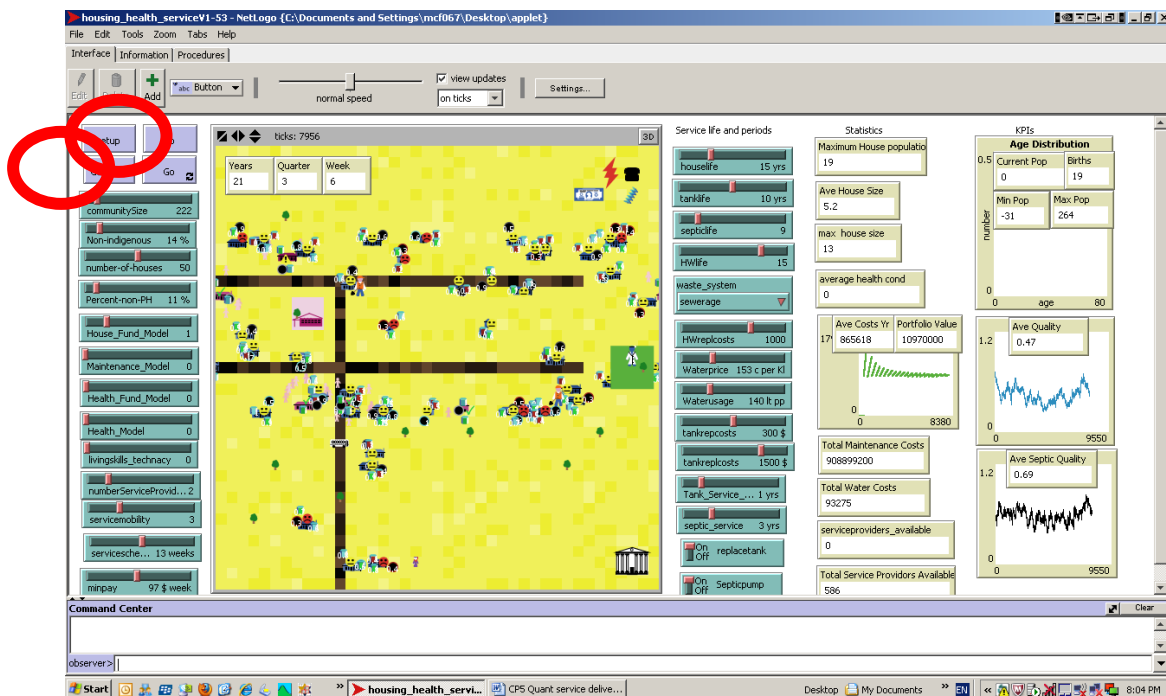


Figure 14: Single iteration runs

The applet simulation speed can be adjusted if required by sliding the speed control button, as highlighted below.

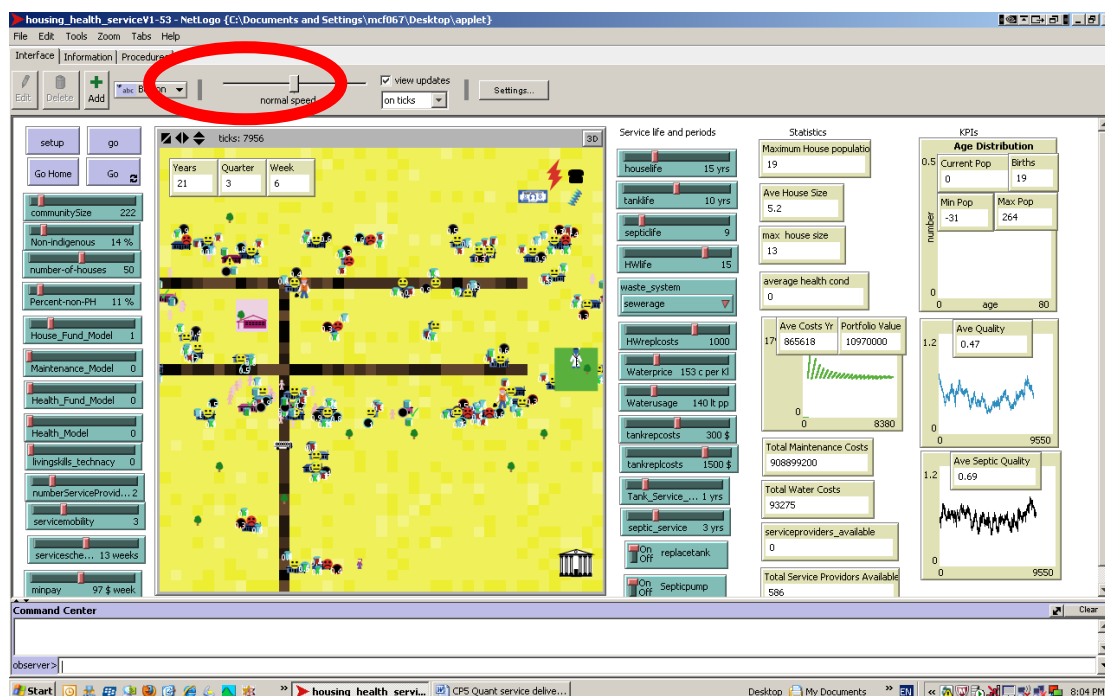


Figure 15: Applet simulation speed management

4.5.11 Model outputs and outcomes

Of significance to the model is the ability to measure success; currently, a range of KPIs are used to measure the success for the service delivery. An important step will be to consider the value of the KPIs under current or alternative service models. Output information boxes provide the user with feedback throughout the simulation, as shown below.

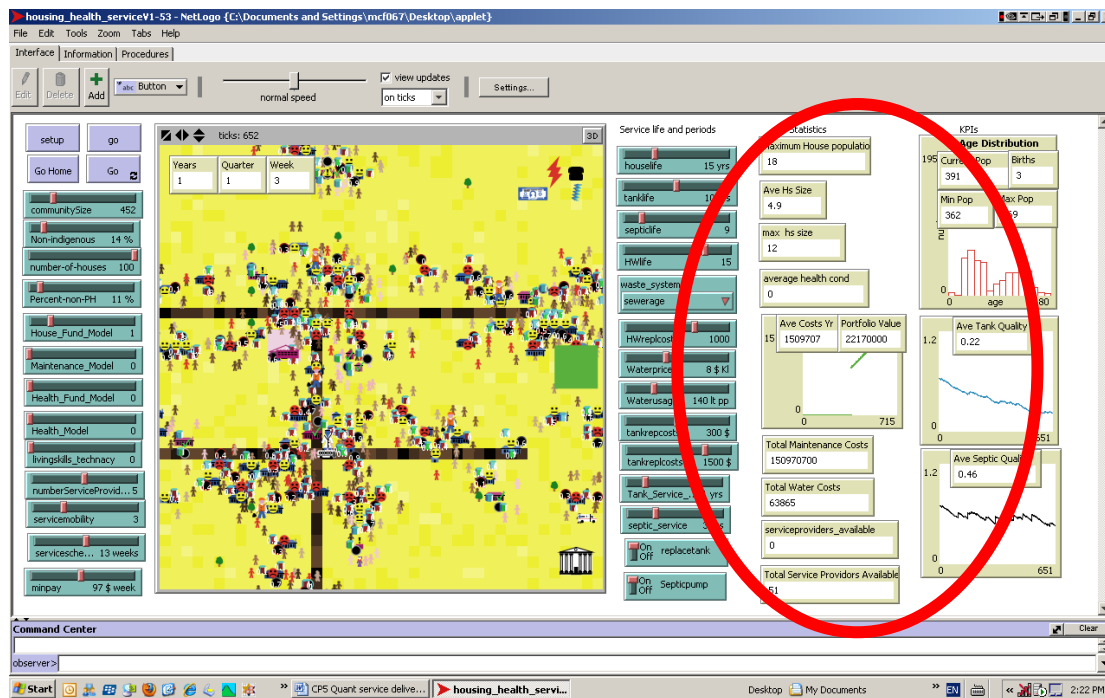


Figure 16: Screen shot from development application

The output in the above example shows the applet is able to output both a range of graphical and statistical results to inform the user, which is updated with each iteration. Statistics on a range of variables of interest can be generated and displayed, which may support policy development and/or delivery efficiencies. In this development model the statistics displayed are not important; rather, the purpose is to show a range of data and display types such as:

- aggregate values
- unit costs, minimums, maximums and averages (mean, mode and medians)
- counts of outcomes/incidences
- time-related statistics
- a range of charts.

Output can be tailored to match reporting statistics required by agencies of management.

4.5.12 Future model development needs

While considerable effort has gone into developing this model there is still much to do before the tool is useful for testing policy options. A full review of the model and coding of the processes, agents and behaviours is required prior to any verification and validation effort. Ultimately, the

model must be verified by checking that the model behaves as expected under a range of input parameters, including extreme values and large numbers of simulated runs to test the model's stability.

This model will require effort in data collection and distribution development, behaviours and responses to the stimuli to be documented, processes and procedures to be captured and relationships to be understood and documented. The coding has been prepared in a modular framework allowing each 'stand alone' component of the system to be modelled, with the output from the module to be used as an input for the 'child' modules or other linked modules.

It is not unusual for a complex model to generate unexpected results, which may appear counter-intuitive, but this may well be an accurate representation of the system. In this instance, given the reliance on observed and expected input parameters rather than data-driven parameters based on behaviors, a challenge is to interpret or not misinterpret the output from alternative strategies. At this point it is expected that ad hoc and unexplainable outputs could be generated due to issues from interaction effects, heterogeneity and inter-dependencies not foreseen.

The version of the model discussed here has not undergone any verification, validation or calibration, which would be necessary as part of the next stage of its development. Once the model is functioning 'as expected', the structure and parameters could be calibrated for external validation. This is often a trade off between inclusion of 'real world' elements and model simplicity. A clear focus on the purpose can guide the choice of inclusion. Again, many simulations will be required to test assumptions, as well as sensitivity analysis to test model robustness followed by analysis of variation from the outputs before the model could be used confidently for the designed purpose.

5. Research questions

This study makes an important contribution to answering each of the research questions by providing an understanding the supply side of service delivery to settlements. Aside from the analysis provided earlier in the report, it does so by providing a platform for analysis of the policy environment and governance structures, some analysis of the funding for specific programs and an assessment of the performance and evaluation process. It also provides a description of a range services and service delivery models and a typology of service delivery models for analysis.

Additionally, the model that has been developed could provide detailed analysis of the service delivery process, allowing bottlenecks to be identified and an examination of trade offs to be undertaken. The model also allows for alternate service delivery strategies to be tested, with potential deficiencies to be identified in a dynamic simulation environment.

6. Recommendations

The focus of this study is a complex and little understood area despite the volume of research carried out. One of the areas where more effort could be directed is the systems approach to aid understanding of this interaction and its effects. One of the objectives of this study was to capture the complexity and make it available in a form in which researchers, services providers and users could interact and modify inputs to the system to better understand the possible effects on outputs and outcomes.

At the time of publication the model had been in development for six months and so was in the early stages of its creation. A model of this type would expect to take considerably more time to be developed to a point where the complexity is fully understood and fully coded to enable simulations to respond to a wide range of relevant research questions. Further model development would result in an applet that could assist both the supply and demand sides, and other interested parties could understand the system, leading to improvements in service delivery.

One of the major needs to further develop this model is the collection of relevant data in a consistent way across jurisdictions and departments, and also an investment in research that could capture expected behaviours of the actors given a range of environmental and economic conditions.

References

- [ABCB] Australian Building Codes Board. nd. Australian Building Codes Board. www.abcb.gov.au
- [ABCB] Australian Building Codes Board. 1994. *The Australian Building Code*. Australian Building Codes Board, Sydney, NSW.
- ABS. 2007a. *Population Distribution, Aboriginal and Torres Strait Islander Australians, 2006*. Cat. no. 4705.0. Australian Bureau of Statistics, Canberra.
- ABS. 2007b. *Housing and Infrastructure in Aboriginal and Torres Strait Islander Communities, 2006*. Cat. No. 4710.0. Australian Bureau of Statistics, Canberra
- ABS. 1999. *Housing and Infrastructure in Aboriginal and Torres Strait Islander Communities, 1999*, Cat. no. 4710.0, Australian Bureau of Statistics, Canberra.
- AIHW (Australian Institute of Health and Welfare). 2008. *Aboriginal and Torres Strait Islander Health Performance Framework, 2008 report: Detailed analyses*. Cat. no. IHW 22. AIHW, Canberra.
- Bonabeau. E. 2002. 'Agent-based modeling: Methods and techniques for simulating human systems', *Proceedings of the National Academy of Sciences*, May 14, 2002, vol. 99 no. 3, pp. 7280–7287.
- CSIRO. 2005. Complex or just complicated: what is a complex system? Fact sheet available from: <http://www.csiro.au/resources/About-Complex-Systems.html>
- CSIRO. 2007. Agent-based modelling. <http://www.csiro.au/science/CABM.html>
- Daniell KA, Kingsborough AB, Malovka DJ, Sommerville HC, Foley BA and Maier HR. 2006. Sustainability assessment of housing developments: A new methodology. In *Complex science for a complex world: Exploring human ecosystems with agents*, edited by DF Batten and P Perez. ANU EPress, Canberra. http://epress.anu.edu.au/cs_citation.html
- [FaHCSIA] Australian Government Department of Families, Housing, Community Services and Indigenous Affairs. 2008. National Indigenous Housing Guide. <http://www.fahcsia.gov.au/sa/indigenous/progserv/housing/Documents/default.htm>
- Fleming, R and Southwell, B. 2005. 'An investigation of some factors in the education of Indigenous Australians.' *Australian Association for Research in Education Conference*. Parramatta, 27 November – 1 December 2005. <http://www.aare.edu.au/05pap/fle05489.pdf>
- Hall. L. 2009. '\$2bn diverted from aid for Aborigines and welfare.' *Weekend Australian* 28/29 November, <http://www.theaustralian.com.au/news/nation/bn-diverted-from-aid-for-aborigines-and-welfare/story-e6frg6nf-1225804773394>.
- Health Performance Framework Australian Health Ministers' Advisory Council. 2008. *Aboriginal and Torres Strait Islander Health Performance Framework Report 2008*. AHMAC, Canberra.
- Long S, Memmott P and Seelig T. 2007. *Final Report No. 102: An Audit and Review of Australian Indigenous Housing Research*. Australian Housing and Urban Research Institute, Queensland.

- Macklin J. 2008. 'Closing the Gap between Indigenous and Non-Indigenous Australians.' Budget statement, the Hon. Jenny Macklin, Minister for Families, Housing, Community Services and Indigenous Affairs. 13 May 2008.
- Maru Y, Chewings V, Jones M and Breen J 2006, Mapping Socio-regions in Outback Australia, Report of a study for the Desert Knowledge Cooperative Research Centre, Desert Knowledge Cooperative Research Centre, Alice Springs.
- Memmott P. 1991. *Humpy, House and Tin Shed – Aboriginal Settlement History on the Darling River*. Ian Buchan Fell Research Centre, Department of Architecture, University of Sydney.
- Memmott P. 2010. *Demand-responsive services and culturally sustainable enterprise in remote Aboriginal settings: A Case Study of the Myuma Group*. DKCRC Research Report 63. Desert Knowledge CRC, Alice Springs.
- Memmott P and Moran M. 2001. 'Indigenous Settlements in Australia.' In *Australia: State of the Environment Second Technical Paper Series*. Australian Government Department of the Environment and Heritage, Canberra.
- Moran. M. 1999. *Improved Settlement Planning and Environmental Health in Remote Aboriginal Communities*. Report cat. no. 99/6. Centre for Appropriate Technology, Alice Springs.
- Moran M, Anda M, Elvin R, Kennedy A, Long S, McFallan S, McGrath N, Memmott P, Mulgan R, Stanley O, Sullivan P, Tedmanson D, Wright A and Young M. 2009. *Desert Services That Work: Year One Research Report*. Working Paper 30. Desert Knowledge Cooperative Research Centre, Alice Springs.
- Newman P, Marinova D, Armstrong R, Raven M, Marley J, McGrath N, Spring F. 2008. *Desert Settlement Typology: Preliminary Literature*. Research Report 35. Desert Knowledge Cooperative Research Centre, Alice Springs.
- [NTG] Northern Territory Government. *The Bush Book*.
http://www.health.nt.gov.au/Health_Promotion/Tools_for_Good_Practice/index.aspx
- O'Rourke T. 2011. *Delivering drinking water to Dajarra, north-west Queensland*. DKCRC Research Report 64. Ninti One Limited, Alice Springs.
- Health Habitat. n.d. *Environmental Health and Design*. <http://www.healthhabitat.com/>
- Queensland Government. n.d. Department of Local Government and Planning.
<http://www.dlgp.qld.gov.au/>
- Robinson N and Berkovic N. 2009. 'Minister may quit over NT housing.' *Australian*, 24 July 2009, p.1,
<http://theaustralian.newspaperdirect.com/epaper/viewer.aspx>.
- SCRGSP (Steering Committee for the Review of Government Service Provision). 2008. *Report on Government Services 2008*. Indigenous Compendium, Productivity Commission, Canberra.
- Tedmanson D, Muirhead M and Fisher S. 2011. 'Anangu serving Anangu - Plenty Ninti!' *The PY Ku Network on the APY Lands*. DKCRC Research Report 68. Ninti One Limited, Alice Springs.

Appendices

Appendix 1: Service delivery, funding and measure of performance

Primary Funding		\$ million	Primary delivery		Goal	KPI	
Agency	Govt Level		Agency	Govt Level		Effectiveness	Efficiency
Attorney-General's Department	Federal	0.8	DLGH	Territory	NT interpreter service		
		2.0	NAAJA & CAALAS	NFP Agency	NT legal assistance		
		17.7	Various Shire Councils	Local	NT night patrol services for 73 communities across the NT		
Australian Crime Commission	Federal	4.2			NT extension of Indigenous Violence & Child Abuse Task Force		
Department of Education, Employment and Workplace Relations	Federal	18.8			Indigenous boarding colleges		
		8.1			Expansion of intensive literacy & numeracy programs & individual learning plans		
		11.6			Getting remote Aboriginal children to enrol in school		
		2.3			NT crèches		
		19.1			NT enhancing education		
		66.4			NT further welfare & employment reform		
		7.4			NT school nutrition		
Department of the Environment, Water, Heritage and the Arts	Federal	2.0			Expansion of arts & crafts industry support program		
Department of Families, Housing, Community Services	Federal	3.1			Early development & learning services – parenting support		
		2.0			Mothers' accommodation		

Primary Funding		\$ million	Primary delivery		Goal	KPI	
Agency	Govt Level		Agency	Govt Level		Effectiveness	Efficiency
and Indigenous Affairs		1.1			Closing the evidence gap		
		0.3			NT accommodation for govt personnel in remote communities		
		3.8			NT community engagement		
		0.4			NT continuation of early childhood program		
		9.8			NT family support package		
		30.8			NT govt business managers		
		60.1			NT income management		
		32.4			NT leadership & coordination		
		0.7			NT playgroups		
		11.6			NT promoting law & order		
		9.5			NT youth alcohol diversion		
Department of Health and Ageing	Federal	4.4			Bringing them home counsellors & link-up services		
		9.9			Child & maternal health services		
		1.6			Reducing rheumatic fever for Indigenous children		
		4.0			Drug & alcohol services		
		13.6			NT follow up care		
Centrelink	Federal	4.2			NT Centrelink role		
Department of Human Services	Federal	3.6			NT income management		
Aust Public Service Commission	Federal	2.6			Aust Public Service – Indigenous employment strategy - continuation		
Office of	Federal	0.2			NT Commonwealth Ombudsman support		

Primary Funding		\$ million	Primary delivery		Goal	KPI	
Agency	Govt Level		Agency	Govt Level		Effectiveness	Efficiency
Commonwealth Ombudsman							
Department of Resources, Energy and Tourism	Federal	1.8			Extension of Business Ready Program for Indigenous Tourism		

Appendix 2: Health practices table

9 Healthy practices	Infrastructure	Primary responsibility	Health hardware	Health benefit
Washing people	Water	Water authority		
	Housing			
			Water supply	
			First flush diverters	Organic and inorganic removal
			Water tanks	Fresh water for drinking and cooling
			Pipes and taps functioning	Access to water
Washing clothes	Water and power	Power authority Water Authority		
Removing waste	Waste system	Local government area (LGA)		
	Drainage system	Housing Authority		
Improving nutrition	Power education water	Power Authority Education Department		
reducing crowding,	Appropriate housing	Housing authority	Houses must accommodate fluctuating populations	
Separating people from animals, vermin or insects,		LGA Housing authority	Hot water systems habitat for vermin	
Reducing dust	Water	LGA		
Controlling temperature		Housing authority		
Reducing trauma	Electrical system		Electrical safety switch	
			Electrical earth connection	
			Undersize cabling	
			Incorrectly wired power points – average 18 per home	
			Faulty lights and or switches On average 12 per house	

Source: FaHCSIA 2008

Appendix 3: Health hardware table

Hardware	Requirement	Issue	Prevalence	Solution	Maintenance	exposure	Health impact	Likelihood	Health service
Bathing and cleaning									
Hot water	50lt/person/day	Costs of heating	43% provide requirement	Element size <2400watt					
		Water quality impacts on system	Electric hot water 50% 18% not hot enough 47% too hot Solar hot water 40% 34% not hot enough 20% too hot Gas hot water 6%	Choice of system and water filters	Check temp >45°				
		System damage		Appropriate siting (near shower) and installation					
		Pressure relief valves operating (and not discharging to roof area)	74% functional		Test valves				
Taps	Bench mounted without plastic handles with suitable washers	Non-return valves on external taps to prevent contamination	Functional taps 75% - use table as random generator for failure		Check and replace valves, handles and washers				
Wet area design	Accessible Ventilated – not		Independent shower toilet and						

Hardware	Requirement	Issue	Prevalence	Solution	Maintenance	exposure	Health impact	Likelihood	Health service
	draughty Well lit – (preference natural to save costs) Adequate size Hook provision		laundry 74% Functional hooks and rails 34% Ventilation 87%						
Shower and bath		Water quality Water proofing	Functioning shower 62% Drain 65% Seals 75% Graded waste 66%		Appropriate shower rose dependent on water quality				
Laundry to wash children	Large (70lt) and bench height		98%						
Isolation valve	For maintenance		52% found and 37% functional						
Washing clothes									
						Bacteria irritants	Diarrhoeal and skin or respiratory infections		
Laundry	Appropriate size Shelving Taps and Outlet for washing machine and power access		97% with laundry 75% with wash machine		Check washers and drains check for leaks Check power				

Hardware	Requirement	Issue	Prevalence	Solution	Maintenance	exposure	Health impact	Likelihood	Health service
Drying facilities	Secure and Accessible clothesline				Check line				
Removing waste									
Flushing toilet	At least one toilet		86% toilets operate		the stop valve is operating pan does not move toilet flushes and refills				
Dry toilet	Can be used in addition to flush toilet for crowded house	Risks for high rainfall areas	2%		Move pit as required (5-10yrs)				
House drains	Floor drains 100mm in wet areas	75% ok			Test operation and overflows				
Septic tanks	Appropriate capacity for number of occupants	3% no waste water system 42% septic 28% septic CED 14% septic trenches			Secure lid Check for leaking System independence				
Waste water treatment		1%							
Improving Nutrition									
Quality drinking water	Access to potable water Rainwater tanks not subjected to damage		20% functional tank 33 % downpipes functional		Water quality tests Tank still functioning Filters operating				

Hardware	Requirement	Issue	Prevalence	Solution	Maintenance	exposure	Health impact	Likelihood	Health service
	Free from contamination Filter prior to tap Gravity, hand pump or pressure pump installed Non-return valve								
Food storage	Cupboards present and water resistant Doors attached Power accessible fridge space		No cupboards 11% Adequate cupboards 47% No fridges 22% Fridge temp OK 47%						
Preparing food	Benches waterproof Sink in place Adequate lighting		Suitable bench 66%						
Cooking	Standardised stove		72% electric 19% gas? Working oven 70% Outside cooking areas 41%						
Kitchen design	Natural lighting and ventilation Shading from sun Non-slip flooring								

Hardware	Requirement	Issue	Prevalence	Solution	Maintenance	exposure	Health impact	Likelihood	Health service
Crowding									
Performance of hardware	Good quality hard wearing Sufficient hot water Appropriate size wastewater system Sufficient cooking facility Sufficient sleeping space		100m2 home 41% 100-200 52% >200 6% People per house <5 49% (house 118m2) >4<11 44% (house 126m2) >10 7% (house 125m2)						
Developing home									
Temperature control									
Climate and comfort									
Passive design									
Active cooling									
Active heating									
Trauma									
infrastructure									
Water		biological contaminants and pathogens cause viral, diarrhoeal or gastric illnesses chemical contaminants such mineral			regularly take water samples as per NHMRC Australian Drinking Water guidelines				

Hardware	Requirement	Issue	Prevalence	Solution	Maintenance	exposure	Health impact	Likelihood	Health service
		salts, heavy metals, are dangerous to people's health. And health hardware							
Power									
Wastewater									
Rubbish									
Planning									
Landscaping									
Communications									

Appendix 4: System level conceptualisation of role and interdependency

Agents	Role	Behaviours	Dependencies
Funding/income			
Housing, refer policy details table	Provide financial resources	Funding based on policy rules	Policy outcomes New housing provision Housing maintenance – planned and unplanned Housing upgrades
Housing income		Rent – income subsidises housing funding	Personal income
Health	Funding for this agent will be based on a per capita average as no detail accessed	Interest is on change in the total health costs while maintaining a minimal housing service budget using varying service delivery models	Considerations include costs for hospital / hospital access, transportation to medical services (evacuations), mobile health services, clinics
Personal income	Capacity to access nutrition, health services, rent, transport, ... purchase appliances	Employment Centrelink CDEP/training Rental support	Employers Centrelink services Training programs Government assistance Go to rent, food... Levy
Household income	Remittances		
Community income	Royalties Ability of a community to self fund	Community and business development /cooperatives – employment/education	Health outcomes via education
Local government funding	Essential services provision	Funding from state authorities Rates Levy	

Appendix 5: Data and sources table

The table below begins to capture a range of data identified as required and potential sources and referred sources for the data.

Data and source	Referred source
Population and distribution (ABS);	Pop 180; ABS Mt Isa data Family groups
Relationships (housing/health thesis – social and technical determinants)	
Behaviours (mobility – Long, Memmott)	
Housing– products, condition and statistics(Qld Dept of Health, ABS, IHN05);	
Housing systems (CAT, Long thesis);	Long report power and water
Health systems and statistics (Qld Govt, ABS, ..);	
Communities (Newman, Maru, Pleshet, ...)	
Health data	Djarra Clinic Housing and environmental health - 4704.0 abs (2003) NAHS program – funding for ? housing for health outcomes?
People – types, characteristics	Long report power and water
Behaviours (mobility)	Memmott and Long paper
Natural 'disasters' impacts	Flooding, ...
Climate/weather data	Rain temp...
Can we describe a range of 'typical' individuals?	
How they interact with each other	
How they interact with the environment	Can be a seasonal shift in use of house where wood stoves exist cooking can be outdoors/ too hot in summer; social Can be generational differences in use of house based on the availability of air conditioning/TV Older are more likely to pursue outdoor activities and cool areas Younger may lend towards technology (Xbox, cable, net, aircon, ...) therefore indoors.
Daily activities	
Other predictable habits	
Weekly, monthly, annual activities	
Seasonal differences	School breaks and holidays (leaving for camping and other destinations)
Employment distribution data	ABS - Voluntary work statistics? CDEP stats? Djarra?

DKCRC Partners

