Water 2010: Assessing dependence on water for agriculture and social resilience

National Assessment of Community Dependence on Water and Social Resilience

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Foreword

Water issues are now considered among the most important drivers and limitations for natural resource management in Australia. This includes management of biodiversity, primary production and environmental hazards like salinity and drought, through to urban and rural water supplies. A better understanding of water availability is needed across the entire continent, and is relevant to the implementation of key government policies.

In 2004, the Bureau of Rural Sciences (BRS) recognised that it would be beneficial for Australia to have a comprehensive and consistent source of information on the dynamic water balance, that is, on the spatial and temporal relationships between rainfall, evaporation, transpiration, drainage to ground and surface water, and runoff to rivers and storages. Gathering this knowledge became the primary focus of a project known as Water 2010.

Water 2010 is a BRS driven research collaboration designed to address the information needs of the National Water Commission, and to support the Department of Agriculture, Fisheries and Forestry (DAFF) in developing sound water policy. The project is designed to capture information on the water balance at a variety of scales, investigate the consequences for water resources of likely or desired changes in land use, population growth, climate and water policies and practices, and then examine the potential impacts of these scenarios on communities, industries and regions to identify the challenges for industries and regions and suggest opportunities and trade-offs.

There remains considerable uncertainty associated with projected changes in climate, land use and demography, particularly at regional and local scales where most of the impacts will be felt and at which many management decisions are made. Three key aspects to understanding and predicting impacts are: community dependence on water use, profiles of community resilience to change, and the potential for adoption of improved practices to mitigate impacts.

Social resilience to change can be gauged by reference to socio-economic variables or indicators derived from an extensive range of baseline data sources at a variety of temporal and spatial scales. A simplified framework for measuring social resilience assumes that resilient communities are those who sustain social vitality, lessen the level of social distress and enhance social participation. A low level of resilience constrains collective action to manage change, while a high degree of social resilience enables collective action to reshape the course of change.

There has been limited investigation of the capacity of agriculture-dependent communities to respond to long-term changes in the availability of water resources. Water 2010 is revisiting the concept of natural resource dependency using a multidimensional approach that encompasses the ecological, socio-economic and cultural dimensions of resource dependency. This multidimensional approach is based upon an understanding that the use of water for agriculture and food production is closely intertwined with social and ecological processes.

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Assessing dependence on water for agriculture and social resilience
Executive summary

Report background
This report contains the BRS Social Sciences Program’s contribution to the Water 2010 project. The Water 2010 project is an interdisciplinary cross-Bureau project investigating the information needed to further develop sound water reform policy in a changing biophysical and social context in Australia.

Purpose of the report
The purpose of this report is to develop methodological tools for understanding and measuring:

- community dependence on water for agriculture; and
- social resilience to changes in water access at different spatial scales including national and regional levels.

By exploring measures of socio-economic dependence, resilience and capacity to manage change, the report derives an index of community susceptibility to changes in water use and access.

This provides tools for identifying communities most likely to be impacted by changes to water access and use and those least able to adapt and manage change.

A practical approach
The BRS Social Sciences Program approached the task of measuring community dependence on water for agriculture and social resilience to changes in water access by developing composite indices. These indices were overlaid to produce an overall index of ‘susceptibility of agricultural communities to changes in water use and access’. The aim of calculating and mapping these indices is to contribute a better understanding of the complex processes that shape both the dependency on water resources for agriculture and the capacity to manage changes in agricultural communities.

Water for agriculture
The agricultural sector is the largest user of water in Australia and water resource dependency has attracted increasing attention in the field of water resource management. For this reason, there has been increasing interest in understanding how changes in access to, and use of, water resources might impact on agriculture dependent communities. The complimentary concept of social resilience has been increasingly used as a way of understanding how people and communities manage change due to processes of social and economic adjustment, environmental change and natural resource depletion. These concepts are explored and defined in a comprehensive literature review in the body of this report to support the development of composite indices for spatial mapping.

A framework for targeting priority areas and regions
Composite indices are a reliable and practical tool for summarising complex social and economic issues or to measure changes over time. The indices of dependence on water, social resilience and susceptibility developed and applied to agricultural communities in this study provide a first insight to communities most likely to be impacted by changes to water access and use and those least able to adapt and manage any changes. This information can assist in framing policy agendas by providing the potential for targeting priority areas and regions where more detailed work is needed.
National and regional scales and integration of varied data sources

The indices presented use simplified but representative measures at national and regional scales to spatially examine broad differences across regions and communities. A regional case study was also undertaken of the Burnett Mary area as a way of refining these indices through the inclusion of both ABS data and primary BRS data sources and to explore the extent to which these measures could be applied meaningfully at multiple scales. Integrating various information sources and the application at different spatial scales enables the best use of available data and contributes greater potential for understanding the extent of resource dependence and social resilience of agricultural communities.

Community dependence on water for agriculture

Community dependence on water is a composite index combining two indicators; resource reliance and livelihood reliance.

- **Resource reliance** is defined as a direct measure of reliance on water and is based on number of irrigated establishments and the volume of water they apply.

- **Livelihood reliance** acknowledges that impacts of changes in water access and use will extend beyond those who use water for irrigated agriculture. This dimension reflects the number of irrigated farms and the extent of employment in downstream agricultural industries.

These two indicators were developed using ABS data and mapped at different scales by Statistical Local Area (SLA).

The overlaying of these two indicators generated the index of community dependence on water. This was mapped at both national and regional scales. The national application suggests that many areas dependent on water for agriculture and downstream agricultural industries are located in a band west of the great dividing range extending from central Victoria through central New South Wales up into southern Queensland.

Social resilience

Social resilience is a composite index combining three indicators; social vitality, social distress and social inclusion. This index assumes that resilient communities are those that sustain social vitality, lessen the level of social distress and enhance social inclusion.

- **Social vitality** is a measure of the level of skilled labour and change in the working age population.

- **Social distress** is a measure of household income and unemployment in an area.

- **Social inclusion** draws on ABS data including the extent of women’s participation in the skilled occupations and the engagement of young people in educational activities.

Overlaying these three indicators to map levels of social resilience across Australia suggests that less resilient areas tend to span across many remote and populated inland areas. In addition, many less resilient areas tend to intersect with areas that have a high reliance on either irrigated water supplies or on employment in the irrigated agricultural produce sector.

Susceptibility of agricultural communities to change in water access and use

Susceptibility measures the ability of agricultural communities to withstand and shape significant change in water use and access. The index of susceptibility is a combination of the community dependence on water index and the social resilience index. Agricultural communities...
with a high level of susceptibility can be characterised as having low levels of social resilience and high levels of dependency on water for agriculture at the farm level and in terms of employment in downstream industries.

Mapping the index on a national scale showed that high levels of susceptibility to changes in water availability are dispersed throughout several states, particularly, inland NSW, Queensland and in south west Western Australia. This suggests areas highly dependent on irrigated agriculture, areas with high rainfall variability, and communities with low social resilience especially within the indicator of social vitality, have higher levels of susceptibility.

Regional case study (Indices at a regional scale) – the Burnett Mary

A key consideration in this project was to explore how these indices could be applied meaningfully at multiple scales. While there are only limited national data collections that cover variables closely related to notions of community dependence and social resilience, at finer scales there is considerable potential to include a wider range of variables.

Regionally specific attitudinal data of community concern about water availability and water quality collected by the BRS Social Sciences Program in the Burnett Mary region was incorporated into the index of community dependence on water and was used to explore the usefulness of the indicators at a regional scale.

The ability to integrate primary and secondary data sources in this manner provides considerable potential to further refine indicators of community dependence, social resilience and susceptibility of agricultural communities for regional use based on the availability of complementary data that enhances regional relevance.

Interpretation of regional maps

The inclusion of BRS survey data specific to the Burnett Mary region provides a slightly different picture from the national map of community dependence. While the pattern is very similar there appears to be higher dependence on water across SLAs in the west and centre of the Burnett Mary region. The higher level of dependence on water for agriculture is likely to reflect stronger social concern about water availability and water quality in these areas. When incorporating the survey data into the index of susceptibility of agricultural communities to change in water access and use, the relative susceptibility shifts slightly with lower susceptibility in the east and higher susceptibility in west and central west SLAs.

It must be noted that values of dependency and resilience at a regional scale will not hold the same value at other scales of analysis.

This exploratory study develops indices that have the potential to be adapted and further refined

The work outlined in this report has provided a first insight into those agricultural communities most susceptible and therefore more likely to be impacted by changes to water access and use, and those least able to adapt and manage any changes. The indices of dependence and resilience could be further refined and applied in other contexts and regions. The release of the 2006 ABS Population and Housing Census data presents an opportunity for longitudinal comparisons between conditions in 1996, 2001 and 2006. Validating this approach to measuring social, economic and biophysical phenomena would enhance our understanding of the way that agricultural communities respond to and manage change and thus support the development of future water policy and program.
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1 Background

This report presents a summary of tasks completed as part of the Bureau of Rural Sciences (BRS) Social Sciences Program contribution to the Water 2010 project. The Water 2010 project is an interdisciplinary cross-Bureau project aimed at addressing the information needed to further develop sound water reform policy in a changing biophysical and social environment in Australia.

By exploring measures of socio-economic dependency and capacity to manage change, this report focuses on developing methodological tools that can be used at different spatial scales to understand community dependency on water for agriculture and social resilience to changes in access to water.

Specifically the objectives of this report were to:

- Facilitate understanding of the social dynamics of communities whose livelihoods are largely resource-dependent on water for agriculture
- Facilitate understanding of the social capacity to manage and shape processes of structural change in water resource management
- Assess conceptual and methodological approaches used to measure resource dependency and capacity to change
- Identify appropriate measures of community dependency on water for agriculture and social resilience to change in water access
- Calculate indices for spatially qualitative assessments of community dependency on water for agriculture, social resilience to change in water access, and susceptibility of agriculture communities to changes in water use and access at a regional and a national scale.

Structure of the report

Section 1 provides the theoretical framework for the Water 2010 project, particularly through discussing notions of dependence and resilience.

Sections 2 and 3 outline the methodology used for calculating and mapping the indices of community dependence on the use of water for agriculture and social resilience to change in water access. Section 4 outlines suggested areas for future inquiry.

There are three appendices. Appendix 1 provides the specifications for national scale indicators (community dependence on water for agriculture and social resilience to change in water access) and specifications for regional scale indicators (community concern about water availability/quality and community dependence on water for agriculture).

Appendix 2 provides the Indices Maps at a national scale.

Appendix 3 provides the Indices Maps at a regional scale for the Burnett Mary catchment.
2 Dependency on the use of water for agriculture

Since the agriculture sector is the largest user of water in Australia (ABS 2001a), water resource dependency has attracted increasing attention in the field of water resource management. To some extent, this has been driven by the need to better understand how changes in access to and use of water resources (e.g. permanent/temporary water markets, groundwater management, separation of land and water entitlements) would impact upon agriculture-dependent communities.

Water resources (e.g. surface, groundwater) serve a variety of often competing purposes. However, there has been limited attention to water resource dependency with respect to the capacity of agriculture-dependent communities to respond to changes in the use of water for long-term sustainability of the resource.

Drawing upon recent trends in social sciences, there is a compelling need to revisit the concept of natural resource dependency from a multidimensional perspective. Such an approach would encompass the ecological, socio-economic and cultural dimensions of resource dependency.

This multidimensional approach would also facilitate an understanding that the use of water for agriculture and food/fibre production is closely intertwined with the interplay of social (e.g. cultural practices, institutional arrangements, technological change, and legal framework) and ecological processes (e.g. hydrological cycle, soil, climatic factors).

2.1 Characterising resource-dependent communities

The concept of resource dependency has a long tradition in American rural sociology, primarily associated with extractive industries. The first studies looking at the relationship between resource dependency and American rural communities date back to the early 1920s (Machlis and Force 1988). Their primary area of interest was analysing the negative impacts of resource dependency upon community stability.


The traditional view assumes that resource-dependent communities are vulnerable to changes in resource allocation and use, with little capacity to act upon the negative effects of structural change. Within this tradition, emphasis has largely been given to the exploitation of natural resources (e.g. timber, fishing, minerals), without considering that natural resources have social and cultural meaning.

Without ignoring the contribution made by these studies, Flint and Luloff (2005) have recently argued that this approach displays an incomplete understanding of community life. Drawing upon recent forest dependence studies, Flint and Luloff (2005) suggested a need for appreciation of a wide range of values, increased attention to the diversity of social and economic structures and populations, and a better understanding of the environmental factors associated with high quality of life across forest-dependent communities.

Following these recent developments, research in the field of resource-based communities has shifted its attention to explanations about the capacity of resource-based communities to reduce vulnerability to changes in access and use of natural resources while sustaining their human and ecological systems (Bradshaw 2003, Flint and Luloff 2005).

2.2 Characterising agriculture communities dependent on the use of water

A shift in understanding resource-dependent communities as complex and dynamic entities provides inspiring opportunities to contextualise dependency on water resources in a holistic fashion. This holistic approach also takes into account the capacity of agriculture-dependent communities to both sustain and secure water resources.

This shift in understanding means we can examine the two-fold character of water-resource dependency as an instrumental means to sustain both human livelihoods (provision of food, drinking water, sanitation) and biomass growth, and the other as a social construction, where water resources are socially and culturally
defined. Indeed this rationale not only recognises the intrinsic relation between the biophysical and the social components of water resources, but also recognises dependency on water resources for agriculture and food/fibre production as an interactive practice between biophysical and social processes as illustrated in Figure 1.

Although it may be problematical to demonstrate at a practical level how biophysical and social variables interact with each other, their inclusion in the hypothetical model depicted in Figure 1 offers great insights into the complex relationships between natural and human processes. Nevertheless, this model would also address issues related to surface and groundwater connectivity and integration of land and water management practices, of relevance to the Water 2010 Project (refer to outcomes of Water 2010 Project).

The shift in understanding water-resource dependency also allows us to see agriculture-dependent communities as complex webs of human and non-human entities, interacting across space and time. As illustrated in Figure 2, an agriculture-dependent community can be seen as a complex, interactive, and non-hierarchical system where human and non-human entities (e.g. people’s practices, institutional arrangements, technology, shared knowledge, water flows, land management, soil, and micro-organisms) interact, providing meanings and references to collective action, and impacting one upon the other through negotiation and communicative actions.

This dynamic notion provides a new perspective on agricultural community life in that it offers a holistic appreciation of the interrelationships between the biological, physical and human processes embedded in agricultural production (Noe and Arøe 2003). In this account, community life appears to become more reflexive and less constrained by social structures. This perspective is of particular interest to studies examining the local capacity of communities to manage external forces (e.g. volatility of markets, land degradation, and diminishing level of capital investment).
Technology (availability and appropriation)

Ground/surface water interrelationship (withdrawals & diversions)

Water tenure system, rights and entitlements

Institutions (formal and informal)

Type of crops, crop varieties

Climate, soil, morphology, hydrology, topography

Water reuse & water waste management

Land management practices

Values and perceptions of water use/reuse/waste

Figure 1: Dependency on water resources for agriculture and food production as an interactive practice of biophysical and social dimensions
2.3 Water-resource dependency measurement applied to agriculture communities.

Resource dependency has been traditionally operationalised by single economic measures associated with quantification of inputs and outputs. For example, income, gross value of resource production derived from employment in resource production industries, or ratio of employment in resource production industries to total employment. In part, this is owed to the availability of secondary socio-economic data on resource-based industries (agriculture, forestry and logging, fishing and mining) that may facilitate the quantification of flow-in and flow-out impacts.

Despite calls for broader measures of resource-dependency, non-economic measures (e.g. attitudes and values) are seldom scrutinised in resource-dependency studies. Such limitations in carrying out ad-hoc or specific surveys to measure non-economic aspects of resource-dependency seem to be derived from a bias towards studying qualitative aspects of economic action (e.g. farming is an economic activity, but also is exercised and mediated by changing and permeable cultural practices).

Conversely, there is no single definition of a resource-dependent community (Machlis and Force 1988, Adger 2000, Bradshaw 2003) and consensus is seldom found in applied community studies. Paradoxically, operational definitions of resource-based communities have been subject to the unit of spatial analysis for which most secondary socio-economic data were available (e.g. county, town, economic region, collections of counties). Fenton et al. (2003) assert that resource-dependent communities would be better represented as systems of social dependence than group towns based on a shared dependence on specific resources. This approach would allow for quantifying the extent of inter-dependent relationships and potential impacts on resource–based communities owing to changes in tenure and management of resources.

In the context of water resources for agriculture and food production, dependency upon water resources appears to be operationalised in terms of both water usage and source of water usage (surface, groundwater, and renewable/non-renewable). Several measures of water-related dependency have been developed for international comparability by the Food and Agriculture Organisation of the United Nations (FAO) through its AQUASTAT global information system on water and agriculture program. For instance, the water use intensity indicator is defined by the amount of water used in the agricultural sector per hectare of arable and permanent cropland in any given year. This is an indicator measuring the dependency on irrigation for agricultural production.
Interestingly, Falkenmark (1995) distinguishes dependence on green and blue water flows in the hydrological cycle for agriculture. Blue water flow is the water used from surface water and renewable groundwater. By contrast, green water refers to the soil moisture used by plants and returned to the atmosphere as vapour flow (Falkenmark et al. 2001). Blue water has traditionally been conceived as the most valuable resource on which irrigated agriculture communities heavily rely. Conversely, green water on which rain-fed agriculture communities depend, has not been identified as a significant water source (Falkenmark et al. 2001). This presents promising avenues for understanding water-resource dependency on agriculture as intrinsically associated with broader hydrological and social factors, with implications for water management practices (e.g. integration of blue and green water in farming systems, conservation of rainwater).

2.4 Developing measures of water-resource dependency

The aim of this work is to suggest some measures of water-resource dependency for agriculture from a broader perspective. As illustrated in Figure 1 dependency on water-resources can be defined as an interactive process influenced by both biophysical and socio-economic variables.

At a general level, dependency on the use of water might be gauged by indicators of water usage and water source (surface, groundwater, green water). However, the use of water is not solely a biophysical factor sitting outside the realm of social life. For this reason, including measures that account for the social and economic factors affecting the use of water are also important.

Focusing on the variety of factors influencing the use of water for agriculture production as illustrated in Figure 1, water resource dependency might be operationalised by measures that express both biophysical and social components of the use of water for agriculture, and hence water resource dependency. This is depicted in Table 1 which illustrates how hypothetical measures of water resource dependency have been selected, first by clustering factors shown in Figure 1 around a biophysical dimension and a social dimension, and then by selecting indicators reflecting some specific aspects of these two dimensions.
**Table 1: Hypothetical measures of water resource dependency: the use of water as an interactive process of biophysical and social dimensions**

<table>
<thead>
<tr>
<th>Suggested dimensions</th>
<th>Suggested indicators</th>
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| 1. Biophysical dimension which accounts for natural processes associated with the use of water for agricultural and food production. | • Water usage by source (this might indicate the level of water withdrawals by source: groundwater/surface water, green/blue water).  
• Rainfall variability (this might reflect the variability in the reliability of rainfall at different times of the year that would be otherwise overlooked when compared with annual averages).  
• Water quality degradation (this might reflect losses in soil productivity given that the use of water for agricultural and food production can be restricted by the levels of salinity, turbidity, acidity and nutrient loads).  
• Land and water management practices (this might be captured by water use efficiency practices and land management practices aimed at improving water quality. These measures also reflect the ability and willingness of land managers to respond to change in resource conditions).  
• Irrigation efficiency.  
• Water conservation efficiency.                                                                                                           |
| 2. Social dimension which accounts for social processes associated with the use of water for agricultural and food production. | • Employment in agriculture and food production (this might reflect the importance of agricultural production to provide both material and non-material benefits for those both directly and indirectly engaged in this activity).  
• Off-farm income (this might indicate the ability of a community to withstand major shocks that might affect income from agricultural enterprises. For example, a community that has multiple sources of income would be less vulnerable to changes in resource access and condition).  
• Tenure system (this might be important to understand how community rights in relation to water resources can enhance or impede its ability to manage change in resource access and condition).  
• Social value of water usage (this might help to understand the range of values associated with the use of water amongst different users of water, e.g. water-based recreation, aesthetic values, thus helping to understand dependence on water resources as a concept that has broader implications than agricultural production). |
3 Social Resilience

The notion of social resilience has been increasingly used as a conceptual tool to explore how people and communities interact with unpredictable, rapid and profound changes in light of processes of social and economic adjustment and exposure to environmental degradation and resource depletion.

Although the term resilience has been used in slightly different ways in social and ecological theory, there are some commonalities implied in the idea of being resilient. First, the term is intrinsically associated with being able to manage tension, stress, resistance and challenge without being alienated and losing self-control. Secondly, resilience is about processes played out in relational situations, rather than a state of static capacity of individuals to cope with distressing situations stemming from environmentally disadvantaged conditions. Thirdly, the idea of being resilient brings the notion of “freedom within constraints” (Giddens 1987, 1999, Sewell 1992), which is of increasing interest for understanding the relations between human actions and broader social, economic and political structures (e.g. the market, natural resource management regimes, globally economic forces, institutional arrangements, cultural organisations).

3.1 Contextualising and defining social resilience

Defining social resilience is neither straightforward nor unproblematic as the concept was extrapolated from the natural science disciplines and passed onto the social science disciplines with the typical complications of drawing analogies between the natural and social realms.

Resilience was coined in the 1950s in the fields of physics and engineering with direct reference to the ability of materials to recover their original shape after exposure to external impacts. Since the 1970s resilience has been adopted by the field of ecology to understand the ability of ecosystems to retain control on function and structure (Holling 1996, 1973) after being exposed to drastic disturbances affecting their core functions and behaviours. Within ecological theory, ecosystem resilience is commonly understood as the capacity of an ecosystem to cope with change and external impacts (Maberg and Galaz 2005), but it also depends on the evolving institutions that govern people and their use of natural resources (Alcorn and Royo 2000).

By the early 1990s, the concept of social resilience gained attention within the social sciences literature, and in particular within the psycho-social disciplines. The pioneering studies carried out by Werner and Smith (1992) have illustrated clearly how at risk children show resilience by maintaining positive adaptation in spite of family and social hardship. This seminal piece of work has substantially questioned the deterministic perception that human actions and behaviours are determined by structural constrains and socio-environmental conditions.

Despite being widely used as a conceptual tool to explain non-mechanistic human-environmental relations, no single definition has overcome the ambiguities implied in the idea of social resilience. Thus several attempts have been made to define social resilience in a more or less exhaustive fashion. For instance, Rutter (1987) states that resilience has been characterised as a pool of social and intra-psychical processes enabling people to remain positive and constructive in a harsh environment. Similarly, Grotberg (2001) claims that resilience is the capacity of human action in the face of adversity not only to bounce back but also to be transformed. In a similar fashion, Luthar et al. (2000) argue that resilience is a dynamic process by which positive adaptation in conditions of drastic adversities is the ultimate outcome. At a collective level, resilient communities are those that take intentional action to enhance the personal and collective capacity of its citizens and institutions to respond to, and influence the course of social and economic change (CCE 1999). Importantly, Maberg, et al. (2005) contend that social resilience differs fundamentally from ecosystem resilience by considering the capacity of humans to anticipate and plan for the future.

What all these definitions share is the importance of human action for shaping change and exerting some form of control over structural adjustment processes. This approach has also contributed to the understanding of structural constraints and human actions as a process where social, economic and environmental conditions simultaneously constrain and enable people’s actions and practices.

As it stands today in current literature, social resilience is a concept, like social capital, promising to capture the relational and interactive side of human action by helping to understand human beings as an active component of social change.
3.2 Its relevance in water-resource management

Conceiving social resilience as an element enabling social change has opened up new ways of viewing water-dependent ecosystem management. This new view involves a shift from a non-conventional natural resource management paradigm to one that views the impacts of changes in resource allocation and use on social-ecological systems as being linked to different social and cultural values rather than fixed outcomes.

Conventional water resource management has been built upon the ideas of ecosystem stability (e.g. feedback loops, order, homeostasis, balance, linear cycles) to explore how social and ecological systems adapt to changes in water supply and water resource regimes, heavily associated with concerns about functional ecosystems (Adger 2000, Berkes et al. 2003, Levin 1998). Criticisms that many of these concepts have attracted (Botkin 1990, Long and van der Ploeg 1989, Long and van der Ploeg 1994) lie in a narrow understanding of human-water dynamics and water-resource management.

Recent advances in water-resource management literature emphasise that social resilience is an alternative approach to environmental determinism, shifting the focus from controlling the extent of change to one that sustains and enhances the capacity to cope with, adapt to, and shape change (Maberg and Galaz 2005). It is in this sense that the relevance of applying the resilience concept in water-resource management has several appealing implications for sustaining both human and ecological systems within an adaptive management framework.

First, there has been a trend towards co-management of water resources principally associated with distrust in top-down and centralised natural resource management controls. Second, the focus has shifted to a water-resource management approach that strives for sustaining and enhancing the capacity of both human and natural systems to cope with and shape the course of environmental change (Maberg and Galaz 2005). Third and overtly related to the trends depicted above, there has been an increasing recognition to analyse human-water dynamics as multi-scale and multi-layered phenomena (Sneddon et al. 2002). Lastly, there is a growing interest in analysing the social-institutional dimensions of water-dependent ecosystems (e.g. river basin, irrigated farmlands, watersheds) to understand which factors contribute to strengthening the resilience of social-ecological systems (Maberg and Galaz 2005).

3.3 Its characteristics and components

Although a large body of empirical work has burgeoned since late 1990s onwards, little consensus has been reached in what makes an individual or a community resilient. Current literature characterises the capacity for resilience as a cognitive coping predisposition, nourished and fostered by continuous social learning processes rather than an innate condition. In this sense, the resilience approach attempts to understand human action within a specific context and explores the resources available to people to enact change processes. For example, resilience to a change in access to water.

For instance, literature stemming from the European and Canadian movement of healthy communities (IHCF) stresses the role of promoting resilient factors to sustain social, economic and ecological community wellbeing. Under the healthy community framework, social resilience is enhanced or constrained by a series of factors synthesised in Table 2.

Table 2: Factors that enable or inhibit social/community resilience

<table>
<thead>
<tr>
<th>Enabling factors</th>
<th>Inhibitive factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altruism</td>
<td>Paternalism</td>
</tr>
<tr>
<td>Empathy</td>
<td>Fatalism</td>
</tr>
<tr>
<td>Solidarity</td>
<td>Red tape</td>
</tr>
<tr>
<td>Civic engagement &amp; participation</td>
<td>Fraud/Corruption</td>
</tr>
<tr>
<td>Supportive networks</td>
<td>Discrimination/Prejudice</td>
</tr>
<tr>
<td>Equality in access to social services</td>
<td>Violence (physical and symbolic)</td>
</tr>
<tr>
<td>Endurance</td>
<td>Egoism</td>
</tr>
<tr>
<td>Confidence in community leadership</td>
<td>Manipulation</td>
</tr>
</tbody>
</table>
In a succinct fashion, the Center for Community Enterprise based in Canada has characterised the resilience of rural communities, at its broadest level, as comprising a set of four interrelated core components:

- Attitudes and behaviour of people in the community: this component explores these values and perceptions related to leadership, initiative, education and optimism. It is also about evaluating sense of pride and openness to new ideas and alternatives, education, and awareness of economic impact of social issues.
- Attitudes and behaviour of organisations in the community: this component explores the ‘assets’ (organisations) and their capacity to cope in times of social and economic change.
- Awareness and use of resources in the community: this component analyses not only the ‘level’ of resources but also the way in which those resources are viewed and utilised.
- Thinking, participation and action in the community process: this component examines the planning, participation and implementation process in the community and how resilient communities analyse and plan for their future.

![An interactive model of Community Resilience](image)

**Figure 3**: An interactive model of Community Resilience. Center for Community Enterprise, 2000

The inter-relation between these components as illustrated in Figure 3 highlights an interactive approach. In essence, this model focuses more on what communities do as opposed to what communities possess, understanding social resilience as learning-by-doing processes. Although resources (e.g. natural, human, social and infrastructure capital) provide the material and symbolic basis of human actions, the processes by which individuals and communities produce and reproduce social interaction provide both constraints and opportunities to manage change.

### 3.4 Developing measures of social resilience

As highlighted in the previous sections, social resilience is multidimensional, being more about social collective processes and changes over time rather than outcomes, with several socially and environmentally structural factors enhancing or hindering the capabilities of communities to cope with and shape the course of change. Nevertheless, social resilience can be gauged by reference to socio-economic variables or rogue indicators derived from an extensive range of baseline data sources (e.g. censuses, community surveys, administrative records) at both temporal and spatial scales.
As a starting point, the set of 23 characteristics of resilient communities portrayed by CCE in its participative research manual (CCE 1999) can be synthesised in at least three basic dimensions as shown in Table 3. This approach allows for a simplified set of dimensions, sub-dimensions and apparent indicators as a sensible way to understand the capacity of communities not only to cope with changes but also to shape the trajectory of change. This simplified framework for measuring social resilience assumes that resilient communities are those that sustain social vitality, lessen the level of social distress and enhance social participation. While a low level of social resilience would constrain collective action to manage change, a high degree of social resilience would enable collective action to reshape the course of change.

Table 3: Hypothetical dimensions, sub-dimensions and indicators of social resilience

<table>
<thead>
<tr>
<th>Suggested dimensions</th>
<th>Suggested sub-dimensions</th>
<th>Suggested indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Change in social vitality: the processes by which communities over time enhance its natural, human, economic and social capital by social practices that cope with change and reduce uncertainties</td>
<td>• Extent of attachment to one’s place&lt;br&gt;• Extent of inter-generational or cross-generational reliance&lt;br&gt;• Extent of human resource development&lt;br&gt;• Extent of job creation&lt;br&gt;• Extent of non-degradation of agricultural land and water</td>
<td>Population change, in-out migration (this might indicate the ability of a place to remain attractive over time in terms of opportunities, e.g. employment, education and training, housing affordability, entrepreneur climate, lifestyles choices, and so on).&lt;br&gt;Change in the % of working age population (this might indicate the ability of a community to sustain over time its economically dependent population).&lt;br&gt;Change in the proportion of labour force participants with post-school qualification (this might indicate the ability of a community to sustain over time a skilled labour force in order to face the challenges of a knowledge-driven economy).&lt;br&gt;Change in the employment-population ratio (this might indicate the ability of a community to sustain over time job creation).&lt;br&gt;Change in land and water quality (this might indicate the ability of a community to sustain over time environmental well-being).</td>
</tr>
<tr>
<td>2. Change in social distress: the processes by which communities over time ameliorate impacts on basic human needs, such as shelter and means of livelihoods</td>
<td>• Extent of housing distress and affordability&lt;br&gt;• Extent of financial distress</td>
<td>Change in the % of households under housing stress (mortgage and rental repayments) (this might be indicative of the ability of a community to sustain housing affordability in order to prevent apparent community stress and foster capital investment through home ownership).&lt;br&gt;Change in the % of households with at least one adult member unemployed, change in household debts (this might indicate the ability of a community to sustain over time levels of social angst due to financial constraints).</td>
</tr>
<tr>
<td>3. Change in social inclusion: the processes by which communities over time empower citizens</td>
<td>• Extent of engagement of traditionally disadvantaged social groups</td>
<td>Change in the % of women working in non-routine production occupations, change in the % of mature age unemployed persons, change in the % of youth either employed or attending an educational institution, change in the % of single parents employed. These might indicate the ability of a community to sustain over time community participation and equal treatment to socially disadvantaged groups, such as women, mature aged jobless people, youth and unemployed single parents. For example, women have been traditionally over-represented in unskilled occupations, even though women’s level of educational attainment has risen over time; mature aged people have been severely affected by processes of structural adjustment in labour market requirements; health risk behaviours among young people make them more vulnerable to be disengaged from community participation; unemployed single parents are more vulnerable to be trapped in poverty, and less engaged in community participation due to social stigma.</td>
</tr>
</tbody>
</table>
As illustrated in Table 3, three dimensions of social resilience have been identified as expressing, to some extent, community carrying capacity to changes in a broad range of social, economic and environmental conditions. The sub-dimensions aim to capture more detailed and specific features of social resilience to sustain its human capital (e.g. size and composition of its population, level of educational attainment, skills and knowledge), its natural capital (quality of the environment in which a community operates), its economic capital (e.g. job creation, financial resources), and its social capital (e.g. social participation). Furthermore, the suggested indicators aim to express tangible and obvious aspects of social resilience in relation to the outlined dimensions and sub-dimensions.

Finally, it is worth noting that one of the primary purposes of this discussion paper is to advance some measures of social resilience that can be used across several scales of analysis (e.g. river basin, watershed, rain-fed farmlands, and irrigation districts).
4 Developing indices of community dependence on water for agriculture and social resilience

In order to provide a tool that can be used in a water resource policy-planning context, the Social Sciences Program approached the task of measuring community dependence on water for agriculture and social resilience to change in water access by developing composite indices. A key consideration in this approach was to ensure that the measures could be used at a range of spatial scales in a manner that is easily accessible to policy makers.

Composite indexing is a practical approach that serves the purpose of integrating different measures associated with particular phenomena that would otherwise be difficult to measure. Additionally, composite indices have progressively become identified as reliable and practical tools to summarise complex social and economic phenomena, to measure changes over time and frame research policy agendas across a wide range of topics.

This section outlines the methodology used for calculating and mapping the indices of community dependence on the use of water for agriculture and social resilience to change in water access built upon the theoretical framework and the hypothesised models outlined in Sections 2 and 3. More specifically this section outlines the process of variable selection, calculation of indices and mapping at a national scale based on secondary quantitative data. It then provides an alternative methodological approach at a regional scale incorporating primary quantitative data for the Burnett Mary Catchment region. The section finishes with an analysis of the degree of susceptibility of agricultural communities to changes in water access and use.

The indices presented in this report use simplified but representative measures on a national and regional scale to spatially examine broad differences across regions and communities. The aim of calculating and mapping these indices is to contribute to a better understanding of the complex processes that shape both the dependency on water resources for agriculture and the resilience to changes in water access in agriculture-dependent communities. Both indices are intended to provide a general overview of those communities most likely to be impacted by changes in water use and allocation. The analysis derived from the spatial assessment of both indices can then be used to target more detailed examinations of how agriculture-dependent communities, including producers and farming families, respond to and manage change.

The advantage of the indices created by the Social Sciences Program to satisfy Water 2010 objectives is that they are summary measures that can be used as multidimensional tools, combining several indicators of resource dependency and social resilience into different component indices that express some quantifiable aspects of these concepts. The index scores of the components can be easily aggregated to produce overall measures of community resource dependence and social resilience enabling qualitative assessments at various scales of these two interrelated concepts.

Community dependence on water resources is considered to lie in a multidimensional process influenced by both natural and social factors. Assessment of the array of factors underpinning the reliance upon water resources in agriculture-dependent communities will improve understanding of the relationships between the biophysical and the social and economic variables that mould the use of water resources to sustain both human and natural livelihoods.

Social resilience is a similarly complex concept being concerned with processes of transformative collective action towards enhancing and building sustainable livelihoods. In its broadest sense, social resilience conveys an understanding of not only the processes by which people cope with changes but also how people’s actions shape the trajectory of change. Improving the understanding of how agriculture-dependent communities manage and shape the course of change will assist policy makers in the targeting of their programs.

For the Water 2010 task, the community dependence on water resources and social resilience to change in access to water indices were combined to produce an overall index for the ‘susceptibility of agricultural communities to changes in water use and access’. This index highlights communities that have high dependence on water and low levels of social resilience, providing an additional tool for analysis.
4.1 Operational definitions of community dependence on water for agriculture

Because it is widely recognised that both the natural and the human spheres interact in a dialectic manner, community dependency on the use of water for agriculture has been hypothesised as being a function of both biophysical and social processes.

While the biophysical domain accounts for a myriad of natural processes associated with the use of water for agriculture, the social domain account for social processes associated with the use of water for agriculture. Therefore, dependence on the use of water for agriculture can be formulated as follows:

\[ f \text{ dependence on water for agriculture} = (\text{biophysical phenomena, social phenomena}) \]

For the most part, each dimension of this function is either implicitly or explicitly impacted and reshaped by the numerous sub-components that integrate each dimension as expressed below, (for example where \( b_1 \) can be soil moisture, \( b_2 \) are climate conditions, \( b_3 \) are water management practices, etc., and where \( s_1 \) can be the decision to plant certain variety of crops, \( s_2 \) can be the individual or social value associated with producing food and fibres to satisfy human needs, \( s_3 \) are the formal and informal institutions that govern farming practices, etc.).

\[ f \text{ reliance on water} = (b (b_1, b_2, b_3, b_4, b_5, b_6, b_7, ... b_n), s (s_1, s_2, s_3, s_4, s_5, s_6, s_7, ... s_n)) \]

Resource reliance refers to the direct reliance of communities on water resources for agricultural production. Livelihood reliance on the other hand, refers to the broader range of activities that are in some way dependent on water resources for agricultural activity. After clustering these sub-components into a resource reliance component and a livelihood reliance component as the broad dimensions of the conceptual definition, the next step was to select indicators that can measure some outputs associated with the highly intertwined interaction of all these numerous sub-components within each dimension. Table 4 shows the suite of indicators selected after applying the following criteria for indicator inclusion:

1- Indicator measures relative outputs derived from the interrelated nature of the concept
2- Indicator can be easily understood by general audiences
3- Indicator is available at a national and sub-national scale
4- Indicator is readily available from quantitative secondary and reliable sources
5- The likelihood of indicator availability over time to examine changes and trends is relatively high
6- Indicator cannot be highly correlated with any other within the particular dimension.

The degree of farms relying on irrigation and the amount of water used for agricultural production were chosen as associated measures that account for resource reliance. The extent of flow-on employment to on-farm employment and to farm businesses, and the degree of household reliance on on-farm and downstream employment were selected as associated measures of livelihood reliance.
### Table 4: Operational process for calculating the index of community dependence on water for agriculture at a national scale

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Resource reliance</th>
<th>Livelihood reliance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indicators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of irrigated farms</td>
<td>Ratio of employment in agriculture to downstream agri-industries</td>
<td></td>
</tr>
<tr>
<td>Average of volume of water applied to farm establishments (1)</td>
<td>Agricultural and downstream agri-industries households</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ratio of employment in agricultural and downstream agri-industries to agricultural establishments</td>
</tr>
</tbody>
</table>

**Index**

Index of community dependence on the use of water for agriculture

(1) Despite stochastic factors affecting the volume of water applied to agriculture such as rainfall, this indicator appears to be a robust measure of resource reliance in terms of outputs after extended consultation with Water 2010 project experts.

### 4.2 Operational definitions of social resilience

Social resilience is said to be the human capacity to buffer from external shocks and stresses. However, if the capacity to shape the course of change is left out from this somewhat curtailed definition, associated measures of social resilience will not reflect the ability of humans to enhance and extend their ever-changing adaptive strategies. Additionally, social resilience is enhanced or weakened by factors that are somewhat intangible such as the relationships between differing interests within a community, governance and attitudes and values that shape the perception of particular changes. Whether a community can maintain or enhance its general social resilience requires deeper examination of aspects that are unable to be measured quantitatively. This said, these ‘qualitative’ aspects of social resilience are very important and should be investigated further in future research.

Taking into account these limitations, at least three basic dimensions of community resilience can be outlined from the theoretical model progressed in Section 3. Each of these dimensions is believed to represent broad social capacities that accounts for community resilience as depicted in Table 5. The social vitality dimension refers to the capacity of a community to sustain its level of attractiveness as a place for providing opportunities. The social distress dimension accounts for the capacity of a community to lessen the level of stress associated with social and economic insecurity. The social inclusion dimension relates to the capacity of a community to enhance and increase opportunities for self-promotion and self-development. In a similar fashion to the indicators of community dependence on water for agriculture, the selection of indicators within each dimension was conducted by applying the following criteria:

1- Indicator gauges relative outputs and indirect flow-on effects of the social capacities implied in each dimension
2- Indicator can be easily understood by general audiences
3- Indicator is available at a national and sub-national scale
4- Indicator is readily available from quantitative secondary and reliable sources
5- The likelihood of indicator availability over time to examine changes and trends is relatively high.
6- Indicator cannot be highly correlated with any other within the particular dimension.

Table 5: Operational process for calculating the index of social resilience at a national scale

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Social vitality</th>
<th>Social distress</th>
<th>Social inclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicators</td>
<td>Change in working age population</td>
<td>Low-income households</td>
<td>Women in non-routine occupations</td>
</tr>
<tr>
<td></td>
<td>Skilled labour force</td>
<td>Households with unemployed adult members</td>
<td>Youth educational engagement</td>
</tr>
</tbody>
</table>

The extent of change in working age population and the representation of skilled labour force were drawn on to build indicators of social vitality. The extent of low-income households and households with unemployed members were selected to construct indicators of social distress. The extent of women employed in non-routine type of occupations and the degree of youth participation in education were chosen as headline indicators of social inclusion.

4.3 Calculating and mapping composite indices of community dependence on water for agriculture and social resilience

A key consideration in designing any composite index is the relative weight or importance of each component in contributing to the composite score. Closely linked to this issue is the method of transforming the raw scores of individual indicators to reflect the desired weight. These issues are particularly important where the indices combine different types of data (e.g. percentages, ratios, frequency, volume) with very different ranges and distributions.

For this exercise it was decided that each indicator contributing to the various dimensions and each dimension contributing to the indices of community dependence and social resilience should carry equal weight. This approach reflects the largely exploratory nature of this work and the lack of any concrete evidence to suggest certain elements contribute more or less to community dependence or social resilience.

To achieve this result each indicator, dimension and index was transformed to a value between 0 and 1. This method ensured that both the lowest and highest values on any indicator carried the same weight while also maintaining the original shape of the distribution from the raw scores.

The approach used to create the indicators, dimensions, and indices is briefly described below.

Indicators:

1. Each raw indicator score was transformed to a value between 0 and 1 by dividing each SLA score by the largest score for any SLA on that indicator.
2. Where step 1 did not include 0 in the range (i.e. there were no SLAs with a raw score of 0) each SLA value was subtracted from 1.
3. Step 2 resulted in a range of values between 0 and <1. Each of these values was then divided by the highest value for any SLA on that indicator to give a full range of data between 0 and 1.
4. The values from step 3 were then subtracted from 1 to make the lowest SLA score for each indicator 0 and the highest SLA score 1.
Dimensions:
5. The transformed indicator scores associated with each dimension were added together.
6. To account for the fact the some dimensions had more indicators than others, each dimension score then needed to be converted to a score between 0 and 1 by dividing each SLA score by the highest value for any SLA.
7. Steps 3 and 4 above were then repeated for each dimension resulting in scores between 0 and 1 for each dimension.

Indices:
8. The transformed dimension scores associated with each index were added together.
9. For each SLA the index score was then divided by the highest score for any SLA.
10. Steps 3 and 4 above were then repeated to transform each index score to a value between 0 and 1.

Susceptibility of agricultural communities to change in water access and use:
11. The final step involved adding together scores from each of the indices to provide an overall measure of the susceptibility of agricultural communities to change in water access and use as presented in Table 6.

Table 6: Operational process for calculating the index of susceptibility of agricultural communities to change in water access and use at a national scale

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Social dependency</th>
<th>Social resilience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicators</td>
<td>Index of social dependency</td>
<td>Index of social resilience</td>
</tr>
<tr>
<td>Index</td>
<td></td>
<td>Index of susceptibility</td>
</tr>
</tbody>
</table>

4.4 Interpreting the index of community dependence on water for agriculture

The index for measuring community dependence on the use of water for agriculture developed for this project assumes that the most dependent communities are those that have a high reliance on irrigation water for agricultural production and those that depend on agricultural and associated industries to maintain their livelihood. These measures are intended to provide a relative assessment of which communities are most likely to be affected by changes in water use and access.

The index of community dependence is predominately based on the use of ‘blue’ water or irrigation/applied water from surface or subterranean sources. But as highlighted in Section 1, consideration must also be given to ‘green’ water - the product of naturally occurring rainfall which is stored in the ground as soil moisture and transpired back into the water cycle - since it provides the vast majority of water to agriculture across the world (Falkenmark et al. 2001, Savanje 1998). The measure of reliance on livelihoods derived from downstream agricultural activities gives a partial measure of ‘green water’ reliance.

It is beyond the scope of this project to provide a detailed assessment of the specific impacts that might result in a particular community from changes in water use and access. Rather, the index presented in this report provides an indication of those communities most likely to be impacted by changes and can be used to guide more detailed and targeted investigations.

4.4.1 Dimensions of community dependence on water:

1. Resource reliance

The dimension of resource reliance presented in Map 1 (Appendix 2) developed for this project is based around the number of agricultural establishments that irrigate and the average volume of water applied for
agricultural production. This map suggests that the highest dependence on water for agriculture is concentrated in small areas including the far north coast of Western Australia, a band extending from the north border of central Victoria and extending into New South Wales, and a small area on the central Queensland Coast near the Burdekin.

These findings are consistent with previous research indicating the vast majority of water used for agriculture occurs in relatively small areas with intensive irrigation.

2. Livelihood reliance

The dimension of livelihood reliance shown in Map 2 (Appendix 2) acknowledges that the impacts of change in water access and use will extend beyond those who use water for irrigated agriculture. This dimension developed for the water 2010 project is based around the ratio of employment in agriculture to downstream agri-industries, the proportion of all households with at least one member employed in agriculture or downstream agri-industries, and the ratio of people employed in agriculture and downstream agri-industries compared to the number of agricultural establishments (EVAO >$5,000).

The map of livelihood reliance indicates that scattered inland areas of New South Wales, Queensland, Western Australia and Victoria are also highly dependent on water. This map clearly indicates that any changes in water use and access are likely to have important impacts beyond those communities with a high level of irrigated agriculture. These findings reflect the presence and importance of downstream agri-industries across many inland, regional and remote communities.

4.4.2 Index of community dependence on water for agriculture

The overall index of community dependence on water for agriculture combines the measures of resource and livelihood reliance to identify those communities that are both highly dependent on irrigation and broader agriculture and downstream agri-industries. This index suggests that those communities most dependent on water for agriculture are located in a band west of the Great Dividing Range that extends from the northern border of central Victoria through central New South Wales and into southern and parts of central Queensland. The far north coast of Western Australia and a small area on the central coast of Queensland are also identified as regions highly dependent on water for agriculture.

4.5 Interpreting the index of social resilience

The index of social resilience assumes that resilient communities are those who sustain social vitality, lessen the level of social distress and enhance social inclusion. This is intended to provide a relative assessment of the capacity of communities to withstand and respond to change.

4.5.1 Dimensions of social resilience

1. Social vitality

The social vitality dimension is a measurement of the level of skilled labour and change in the working age population. As shown in Map 4 (Appendix 2), areas with low levels of skilled labour and decreases in working age population are considered to have low social vitality.

Low levels of social vitality occur in the inland, regional and remote areas of Australia compared to the populated coastal areas which display higher levels of social vitality. This could be due to a number of factors. The high proportion of low skilled workers in these areas suggests a high reliance on a small number of economic sources such as broad acre farming. These areas have low economic diversity and thus few alternatives when there is a disturbance to these industries. It also suggests there is little opportunity for developing new skills, possibly due to a lack of education and training opportunities in these areas.

A decrease in the working age population suggests low resilience within the community, and is possibly linked to changes in economic and employment opportunities, an ageing population and the movement of retirees and young people away from these areas. This index suggests that many inland regional and remote areas continue to face ‘rural community decline’ which highlights the changing face of rural Australia, as more people leave rural areas, the size of farming enterprises increases, and essential services, provided by both government and the private, sector disappear (Lockie and Bourke 2001).
2. Social distress

The social distress dimension is a measurement of household income and unemployment. Areas with a high proportion of households experiencing low income and unemployment are considered to have high levels of distress.

As shown in Map 5 (Appendix 2), high levels of distress are dispersed across populated coastal regions, inland regional and remote areas of Australia. The coastal and several inland regional areas of NSW appear to have moderate to high distress levels, suggesting the seasonal nature of household income from industries such as fishing and tourism have an impact on average income levels. High distress in more remote areas suggests a lack of economic activity, few employment opportunities and a lack of education and training options.

Areas of low distress appear to be located where there is strong rural economic base. For example, mining enterprises in Western Australia and Queensland, intensive diverse irrigated agriculture regions such as the Murrumbidgee Irrigation Area, Ord River, Barossa Valley and the sugar cane regions of Queensland. Low distress in these areas could also derive from averaging disparate income levels (e.g. indigenous or low income communities with those earning above average incomes in the mining sector, in areas such as Mount Isa, Kimberley Region) (ABS 2001b, Cocklin and Dibden 2005).

3. Social inclusion

The social inclusion dimension is a measurement of the number of women in skilled occupations and youth in full-time/part-time education. Areas with low numbers of women in skilled occupations and young people in full-time/part-time training are considered to have low levels of social inclusion.

As shown in Map 6 (Appendix 2), low levels of social inclusion tend to occur in more remote areas of Australia, especially north and central west Queensland, the Northern Territory and in parts of Western Australia. It is not surprising that these areas are of particular interest in relation to low social inclusion as they tend to host mining activity and other traditionally male dominated professions (e.g. cattle farming). These industries are traditionally heavily skewed towards adult male workforce participation, with fewer women and youth participating in the labour force and education (ABS 2001b).

Low inclusion in these areas may be even further pronounced due to the high proportion of indigenous Australians in these remote areas. These groups tend to have even lower social participation on average than the general population.

In contrast, the significantly higher levels of social inclusion in the south east of Australia, regional centres and peri-urban areas surrounding coastal metropolitan cities may reflect the development of both traditional and ‘new economy’ activities (e.g. horticulture, grapes, fruit, vegetables, tourism) which have extended economic diversity and frequently offer employment and education opportunities.

4.5.2 Index of social resilience

The overall index of social resilience presented in Map 7 (Appendix 2) suggests that remote and populated inland areas have lower levels of social resilience and thus appear less able to adjust to significant events (e.g. climatic, environmental, economic, political and social) that affect their local region. Many less resilient areas tend to intersect with areas with a high reliance on either irrigated water supplies or on employment derived from the irrigated agricultural produce sector. Thus the greatest vulnerability to change and the least ability to cope would be experienced in these inland and remote areas.

4.6 Susceptibility of agricultural communities to changes in water use and access

Susceptibility is a measure of the ability of agricultural communities to withstand and shape significant change. Agricultural communities with a high level of susceptibility, as presented in Map 8 (Appendix 2), might generally be characterised as having lower levels of social resilience but a high level of dependence on water for agriculture at the farm level and in terms of employment in downstream industries. Chances are that such communities would experience more stress if access to the resource is restricted or disrupted.

This discussion is based on overlaying water dependency and social resilience indicators to produce a map which identifies relative capacity of different agricultural communities to manage change, in relation to water access and use. Understanding the dynamics of change in rural Australia is seen as a useful starting point for further research into the strategies of specific communities to manage change in relation to changes in water access.
The index shows susceptibility is dispersed throughout several states, particularly, inland New South Wales, Queensland and in south west Western Australia.

- **New South Wales**: Agricultural communities located on the southern New South Wales border with Victoria are likely to be more susceptible to changes in the availability of water. This may be due to the high dependence on irrigation-based activity in these regions, such as rice, horticulture, viticulture, and fruit production in the Murrumbidgee Irrigation Area, despite high levels of social resilience. This situation suggests that any change in the flow regime of the Murrumbidgee River (e.g. environmental flows, irrigation, flow variability) may impact these areas (MDBC 2006).

  In addition, agricultural communities in the north western region of New South Wales and across the border into South Australia appear to have high susceptibility to changes in water access and use, particularly rainfall variability (Kokic et al. 2005). These communities rely heavily on employment flowing from a range of agricultural industries including wool and beef, and increasingly mining, cotton, grains and fruit (e.g. Menindee Lakes region relying on Lower Darling River wetlands) (DIPNR 2005).

  Several further regions across inland central New South Wales display a high degree of susceptibility to changes in water allocation and use, due to their significant dependence on irrigated water supplies (e.g. Murray-Darling River system and artesian water) combined with a very high livelihood reliance on agriculture.

- **Victoria**: Much of Victoria appears strong on these indices with apparently low susceptibility to adverse impacts from changes in water access and use. Regions in Victoria support a very diverse range of economic activity including dairy, beef, lamb, vegetables, fruit, viticulture and aquaculture. Much of this is due to natural advantages such as temperate climates, good rainfall, rich soils and year round grazing and productivity gains (e.g. farm efficiency, improvements in technology) (DPI 2005). High social resilience (and low susceptibility) in south eastern Australia suggests that a ‘critical mass’ (consisting of a diversity of agricultural and industrial enterprise, population, access to education, services and transport) is important in sustaining communities through change.

- **South Australia**: Several areas in the south east of South Australia display a relatively high susceptibility to changes in water access and use. Areas on the Eyre Peninsula with mid-sized dryland grazing farms (wool and cereals mainly) and the several irrigated horticulture areas to the east of Adelaide (Barr 2004) seem to have high susceptibility mainly due to low social vitality (low skill levels and decline in working age population).

- **Queensland**: The region inland from Toowoomba stretching along the Queensland border shows a high level of susceptibility to change. These regions consisting largely of mixed farming, cropping and small beef enterprise, tend to be low on social vitality and inclusion (low skills/flexibility and access to employment) suggesting there is a lower capacity to earn off-farm income (Barr 2004).

- **Western Australia**: The Kimberley region in Western Australia appears to have a high level of dependence on irrigated water (Ord River Irrigation), but may have strong social resilience to handle any significant changes. Also, dispersed areas in the cropping belt in the south west of the state show high susceptibility to change, suggesting a decline in social vitality (low skills and therefore, flexibility and loss of working age population).

- **Northern Territory**: The area south of Darwin appears to have high susceptibility. This area can be characterised as part of the ‘central rangelands’ with grazing predominant and larger than average farm sizes (Barr 2004). High susceptibility in these areas may derive from medium dependency on irrigated water, but more so on the very low levels of social resilience due to low inclusion (women and youth) and low social vitality (low skills; change in working age population).

- **Tasmania**: Several areas in central Tasmania appear to have a high susceptibility to changes in water access and use. Much of this area could be described as ‘hill country’ dominated by relatively small family farms (meat and wool production) (Barr 2004, DPIW 2004). Susceptibility seems to derive in large part from the social vitality problems related to these areas rather than resource availability, including lower skill levels and a declining working age population.

The national data presented here does not account for local contextual conditions and the daily experiences of landholders in managing changes occurring in relation to land and water resources. By introducing the regional scale analysis which includes attitudinal data (see next section), regional differences in the social dimensions of change can be further explored.
4.7 Other social dimensions: example of indices at a regional scale

One of the key considerations in identifying measures of community dependence and social resilience in this project was the extent that the measure could be applied meaningfully at multiple scales. While there are only limited national data collections that cover variables closely related to notions of community dependence and social resilience, at finer scales there is considerable potential to include a wider range of variables.

This section of the report outlines how the indices of community dependence, social resilience and susceptibility can be applied at a regional scale and how additional regionally specific information can be incorporated into these measures to enhance their regional relevance.

By taking the indicator data for SLAs in a particular region and applying the same 11 steps outlined in section 4.3, it is possible to develop regional indices that identify the most dependent or least resilient areas within a particular group of SLAs. When adopting this approach it is important to remember that the most dependent or least resilient areas within a specific regional analysis will not necessarily hold the same value as those from other analyses at any scale (that is the determination is entirely comparative based on the unit of analysis).

Maps 9, 10 and 11 (Appendix 3) present the indices of community dependence on water for agriculture, social resilience and susceptibility of agricultural communities to changes in water access and use for the Burnett Mary region of Queensland.

In 2004, Byron et al. (2006) conducted a survey of landholders in the Burnett Mary region. Amongst a range of topics this survey explored landholder perceptions about the importance of water availability and quality and the proportion of total household income derived from on-property production. These primary data provide an opportunity to complement the national data sources by adding new dimensions to the measures of community dependence on water for agriculture. Drawing on this data we have added an index of social concern about water availability and water quality as a component of resource reliance, and the proportion of total household income generated from on-property production as a component of livelihood reliance (see Tables A1 and A2 in Appendix 1 and Maps 12 and 13 in Appendix 3).

These new indicators can then be combined with the national indicators to generate refined measures of community dependence and susceptibility (Maps 14 and 15). The integration of primary and secondary data sources provides considerable potential to further refine indicators of community dependence, social resilience and susceptibility of agricultural communities for regional use based on the availability of complementary data.

As outlined in Maps 9 and 14 the inclusion of survey data specific to the Burnett Mary region provides a slightly different picture to the original map of community dependence. While the overall pattern is very similar, Map 14 shows higher dependence across SLAs in the west and extending into the centre part of the region. The higher level of social concern about water availability and quality in these areas is likely to reflect a strong reliance on rain fed agriculture. This finding was also supported by the higher proportion of income coming from on-property sources. When incorporating the survey data into the index of susceptibility of agricultural communities to change in water access and water use Maps 11 and 15 show a similar trend as the relative susceptibility shifts slightly with lower susceptibility in the east and higher susceptibility in the west and central west SLAs.
5 Where to from here?

This report has demonstrated how social theory can be used to help frame and guide the use of widely available national data sets to help unravel the complex relationships between agricultural communities and the resources they depend on to maintain their livelihoods. While community dependence and resilience are highly complicated multidimensional issues, the measures developed as part of the Water 2010 project provide a useful starting point to help advance and further develop our understanding.

An aspect of the work outlined in this report was to provide insight into those communities most likely to be impacted by changes to water access and use and those least able to adapt and manage change. We hope this information will provide a range of opportunities for more targeted investigations that will help inform future policy and program design, and that undertaking more detailed investigations will allow the ‘ground truthing’ of the measures we have developed.

However, care needs to be taken in the conclusions drawn from the indices’ outputs. At the time of the release of this report, the data used for the indices (ABS Census 2001) are six years old and rural communities in Australia have faced considerable challenges in the intervening years in regard to drought. It would be appropriate to apply the indices using more recent data as it becomes available.

We also recommend that further work is undertaken in regard to the measures of resilience. In particular, as yet we have little understanding about the differences in general resilience at the community level which might denote a capacity to manage most types of change and resilience in a specific context (e.g. resilience to reduced access to water). A related area that requires further investigation is to develop measures that might indicate a capacity to manage change in the short term (e.g. health may be included here) versus measures that might indicate community capacity to adapt in the long term (e.g. skills and qualifications might signal human capital useful for adaptation).

The ability to assess resource dependence and social resilience of agricultural communities at both a regional and national level, while also allowing integration of other data sources where available, will greatly assist government to target policy more effectively.
Appendices

Appendix 1 – Indicator specifications
Appendix 2 – Indices maps at a national scale
Appendix 3 – Indices maps at a regional scale – Burnett Mary Catchment
## Appendix 1 – Indicator specifications

### National scale

**Table A1:** Index of community dependence on water for agriculture at a national scale - Indicator definitions

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Indicator name</th>
<th>Indicator definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Resource reliance</strong></td>
<td>1.1 Irrigated farms</td>
<td>Percentage of farm establishments that irrigated</td>
<td>2001 Agricultural Census, ABS</td>
</tr>
<tr>
<td></td>
<td>1.2 Average volume of water applied to farms</td>
<td>Volume of water applied to agriculture production divided by the number of farm establishments</td>
<td>2000-2001 customised data, ABS</td>
</tr>
<tr>
<td><strong>2. Livelihood reliance</strong></td>
<td>2.1 Ratio of employment in agriculture to downstream agri-industries</td>
<td>Ratio of persons employed in ANZSIC Division A Subgroup 01 (Agriculture) to persons employed in Division C Subdivision 21 (Food Beverage and Tobacco)(^1)</td>
<td>2001 Census of Population and Housing, ABS</td>
</tr>
<tr>
<td></td>
<td>2.2 Agricultural and downstream agri-industries households</td>
<td>Households with at least one member employed in ANZSIC Division A Subgroup 01 (Agriculture) and Division C Subdivision 21 (Food Beverage and Tobacco) as % of all households</td>
<td>2001 Census of Population and Housing, ABS</td>
</tr>
<tr>
<td></td>
<td>2.3 Ratio of employment in agricultural and downstream agri-industries to agricultural establishments</td>
<td>Ratio of persons employed in ANZSIC Division A Subgroup 01 (Agriculture) and Division C Subdivision 21 (Food Beverage and Tobacco) to number of farm establishments with an estimated value of agricultural operation (EVAO) greater than $5,000</td>
<td>2001 Census of Population and Housing and 2001 Agricultural Census, ABS</td>
</tr>
</tbody>
</table>

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\(^1\) It includes Class 2173 Seafood Processing. The number of persons employed in this class is negligible in almost all SLAs under the scope of this study, and therefore it does not impact on the overall figure of the Subdivision.
### Table A2: Index of social resilience at a national scale - Indicator definitions

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Indicator name</th>
<th>Indicator definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Social vitality</strong>&lt;br&gt;1.1 Skilled labour force&lt;br&gt;1.2 Change in working age population</td>
<td>Percentage of labour force participants with certificate or above qualifications&lt;br&gt;Change in the number of working age population between 1996 and 2001</td>
<td>2001 Census of Population and Housing, ABS&lt;br&gt;1996 and 2001 Censuses of Population and Housing, ABS</td>
<td></td>
</tr>
<tr>
<td><strong>2. Social stress</strong>&lt;br&gt;2.1 Low-income households&lt;br&gt;2.2 Households with unemployed adult members</td>
<td>Percentage of households earning less than $300 per week&lt;br&gt;Percentage of households with at least one adult member unemployed</td>
<td>2001 Census of Population and Housing, ABS&lt;br&gt;2001 Census of Population and Housing, ABS</td>
<td></td>
</tr>
<tr>
<td><strong>3. Social inclusion</strong>&lt;br&gt;3.1 Women in non-routine occupations&lt;br&gt;3.2 Youth educational engagement</td>
<td>Percentage of females employed in occupations above Advance Clerical and service workers occupations&lt;br&gt;Percentage of persons aged 15-24 years attending an educational institution either full time or part time</td>
<td>2001 Census of Population and Housing, ABS&lt;br&gt;2001 Census of Population and Housing, ABS</td>
<td></td>
</tr>
</tbody>
</table>
### Regional scale – Burnett Mary Catchment

**Table A3:** Index of community concern about water availability and quality at a regional scale - Indicator definitions

<table>
<thead>
<tr>
<th>Indicator name</th>
<th>Indicator definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of access to water</td>
<td>Percent ranked SLA based on level of reported concern by landholders</td>
<td>BRS landholder survey</td>
</tr>
<tr>
<td>Concern about availability of water</td>
<td>Percent ranked SLA based on level of reported concern by landholders</td>
<td>BRS landholder survey</td>
</tr>
<tr>
<td>Concern about decline in water quality</td>
<td>Percent ranked SLA based on level of reported concern by landholders</td>
<td>BRS landholder survey</td>
</tr>
</tbody>
</table>

**Table A4:** Index of community dependence on water for agriculture at a regional scale - Indicator definitions

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Indicator name</th>
<th>Indicator definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Resource reliance</td>
<td>1.1 Irrigated farms</td>
<td>% of farm establishments that irrigated</td>
<td>2001 Agricultural Census, ABS</td>
</tr>
<tr>
<td></td>
<td>1.2 Average volume of water applied to farms</td>
<td>Volume of water applied to agriculture production divided by the number of farm establishments</td>
<td>ABS, customised data</td>
</tr>
<tr>
<td></td>
<td>1.3 Index of community concern about water availability/quality</td>
<td>Percent ranked SLA based on level of reported concern about three water related issues</td>
<td>BRS landholder survey</td>
</tr>
<tr>
<td>2. Livelihood reliance</td>
<td>2.1 Ratio of employment in agriculture to downstream agri-industries</td>
<td>Ratio of persons employed in ANZSIC Division A Subgroup 01 (Agriculture) to persons employed in Division C Subdivision 21 (Food Beverage and Tobacco)</td>
<td>2001 Census of Population and Housing, ABS</td>
</tr>
<tr>
<td></td>
<td>2.2 Agricultural and downstream agri-industries households</td>
<td>Households with at least one member employed in ANZSIC Division A Subgroup 01 (Agriculture) and Division C Subdivision 21 (Food Beverage and Tobacco) as % of all households</td>
<td>2001 Census of Population and Housing, ABS</td>
</tr>
<tr>
<td></td>
<td>2.3 Ratio of employment in agricultural and downstream agri-industries to agricultural establishments</td>
<td>Ratio of persons employed in ANZSIC Division A Subgroup 01 (Agriculture) and Division C Subdivision 21 (Food Beverage and Tobacco) to number of farm establishments with an estimated value of agricultural operation (EVAO) greater than $5,000</td>
<td>2001 Census of Population and Housing and 2001 Agricultural Census, ABS</td>
</tr>
<tr>
<td></td>
<td>2.4. Percentage of total household income from on-property income</td>
<td>Percent rank by SLA of the proportion of reported household income from on-property sources</td>
<td>BRS landholder survey</td>
</tr>
</tbody>
</table>
Appendix 2 – Indices maps at a national scale

Map 1 - Resource reliance

Assessing dependence on water for agriculture and social resilience
Map 2 - Livelihood reliance

Livelihood reliance
- Very low dependence (0 - 0.173)
- Low dependence (0.173 - 0.287)
- Moderate dependence (0.287 - 0.43)
- High dependence (0.43 - 0.635)
- Very high dependence (0.635 - 1)
- No Data

Map 3 – Index of community dependence on water for agriculture

Index of community dependence on water for agriculture
- Very low dependence (0 - 0.14)
- Low dependence (0.14 - 0.228)
- Moderate dependence (0.228 - 0.324)
- High dependence (0.324 - 0.456)
- Very high dependence (0.456 - 1)
- No Data
Map 6 – Social inclusion

- Very high resilience (0 - 0.27)
- High resilience (0.27 - 0.40)
- Moderate resilience (0.40 - 0.51)
- Low resilience (0.51 - 0.68)
- Very low resilience (0.68 - 1)
- No Data

Map 7 – Index of social resilience

- Very high resilience (0 - 0.354)
- High resilience (0.354 - 0.516)
- Moderate resilience (0.516 - 0.634)
- Low resilience (0.634 - 0.748)
- Very low resilience (0.748 - 1)
- No Data

Assessing dependence on water for agriculture and social resilience
Map 8 – Susceptibility of agricultural communities to changes in water access and use

Susceptibility of agricultural communities to change in water access and use
- Very low susceptibility (0.056 - 0.542)
- Low susceptibility (0.542 - 0.737)
- Moderate susceptibility (0.737 - 0.932)
- High susceptibility (0.932 - 1.068)
- Very high susceptibility (1.068 - 1.449)
- No Data

Assessing dependence on water for agriculture and social resilience
Appendix 3 – Indices maps at a regional scale: Burnett Mary Catchment

Map 9 – Index of community dependence, Burnett Mary region

Index of community dependence on water for agriculture
- Regionally very low dependence (0 - 0.10)
- Regionally low dependence (0.10 - 0.19)
- Regionally moderate dependence (0.19 - 0.44)
- Regionally high dependence (0.44 - 0.72)
- Regionally very high dependence (0.72 - 1)
- No Data

Assessing dependence on water for agriculture and social resilience
Map 10 – Index of social resilience, Burnett Mary region

Map 11 – Susceptibility of agricultural communities to changes in water access and use, Burnett Mary region
Map 12 – Social concern about water availability/quality (resource reliance), Burnett Mary region

Social concern about water use and access (survey)
- Regionally very low concern (0 - 0.14)
- Regionally low concern (0.14 - 0.33)
- Regionally moderate concern (0.33 - 0.52)
- Regionally high concern (0.52 - 0.76)
- Regionally very high concern (0.76 - 1)
- No Data

Map 13 – Proportion of income from on-property sources (livelihood reliance), Burnett Mary region

Proportion of household income from on-property (survey)
- Regionally very low proportion (0 - 0.14)
- Regionally low proportion (0.14 - 0.33)
- Regionally moderate proportion (0.33 - 0.52)
- Regionally high proportion (0.52 - 0.81)
- Regionally very high proportion (0.81 - 1)
- No Data
Map 14 – Index of community dependence (survey), Burnett Mary region

Index of community dependence on water for agriculture (survey)
- Regionally very low dependence (0 - 0.07)
- Regionally low dependence (0.07 - 0.21)
- Regionally moderate dependence (0.21 - 0.39)
- Regionally high dependence (0.39 - 0.68)
- Regionally very high dependence (0.68 - 1)
- No Data

Map 15 – Susceptibility of agricultural communities to changes in water access and use (survey), Burnett Mary region

Susceptibility of agricultural communities to changes in water access and use (survey)
- Regionally very low susceptibility (0.04 - 0.29)
- Regionally low susceptibility (0.29 - 0.57)
- Regionally moderate susceptibility (0.57 - 1.01)
- Regionally high susceptibility (1.01 - 1.27)
- Regionally very high susceptibility (1.27 - 1.66)
- No Data

Assessing dependence on water for agriculture and social resilience


