The Australian National Agricultural Monitoring System – A National Climate Risk Management Application

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Abstract

Climate variability exposes agricultural producers to considerable risks because the outcomes of their decisions cannot always be confidently predicted. Historically, agrometeorological information has been used by managers of production systems to make farming systems somewhat resilient to variable climates. However, this information is often not available to producers in a form that they can readily access and use in their production systems. This paper describes the National Agricultural Monitoring System (NAMS), an Australian tool being developed to bring together historical and current: information on historical climate variability; contextual factors such as land use and soil type; the impact of climatic variation on a variety of agricultural production systems at a regional level; and economic information on agricultural production system performance. The impetus to develop this tool came from a need to provide support to the Australian government's drought mitigation programs. However, the added potential of this tool to provide real-time climatic and production information to producers was recognised early by a decision to make the information freely available via a Web site. It is envisioned that producers will be able to use the information provided by NAMS to assist in their management decisions, by being better able to judge and assess the risks to production systems posed by climate variability. The development of NAMS has involved extensive collaboration with major stakeholder groups, which has helped ensure that the tool has strong support from its key users and is a valuable tool for individuals outside of its target audience.

Introduction

Agricultural production systems are diverse and include cropping systems, pastoral systems, and mixed farm enterprises. While the systems are diverse, a commonality between them is the need to manage financial, environmental, and social risk. Typically, the management focus is both on a short- and long-term basis: production and profitability are in the simplest sense the short-term management focus; however, management decisions are made within the context of resource conservation, economic, political, and lifestyle influences (Blacket, 1996; Hammer, 2000). An additional major risk factor that affects the biophysical, socio-economic, and political systems is climate variability (Hammer, 2000). Climate variability exposes decisionmakers to considerable risk because outcomes of decisions cannot be confidently predicted, such as: crop rotation decisions, marketing strategies; infrastructure investment; and policy decisions that affect ecosystem management.

Historically, agrometeorological information has been utilised by managers of production systems to make farming systems somewhat resilient to variable climates (Meinke and Stone, 2005; Steffen et al., 2006). For example in many regions of the world, fallows have been adopted for capture and storage of soil water for the following season's crop to insure against the possibility of low, in-crop rainfall (Lyon, et al., 2004; Meinke and Stone, 2005); summer cropping is generally not practiced in regions with unreliable summer rainfall such as southern Australia, the Pacific Northwest of the United States, and Mediterranean regions; and conservation tillage practices have been developed partly by the need for water retention in dry areas (Lyon et al., 2004). However, these systems are not necessarily optimally adapted for climate variability, for example, farming systems developed during a run of wet seasons may not be as resilient during a run of dry seasons (Meinke and Hammer, 1995). In addition, the changes in extremes expected to result from climate change, and already observed in some regions of Australia, are unlikely to be adapted for in current production systems.

Although it is well understood that a thorough knowledge of historical climate variability is an invaluable tool in helping producers manage associated production risks, this information is often not available to producers in a form that they can readily access and use in their production systems. This problem has been recognised by information providers and there are numerous current examples of climatic information being made available, particularly through the internet (e.g., http://www.bom.gov.au/; http://www.metservice.co.nz). However, the scope of this information is often limited by the mandate or interests of the group providing the information. For example, the Australian Bureau of Meteorology (BOM) provides a vast array of climatic information and data but does not provide an agricultural context to this information. Similarly, an agricultural research group may provide information about a specific tool that uses historical climatic information but does not place the tool, or the climatic information used in the tool, in a broader historical context.

Background

Impacts of Climate

Australian agriculture operates in a highly unreliable climate (Laughlin and Clark, 2000; Stone and de Hoedt, 2000), which is characterised by frequent floods and intense, widespread droughts. These climatic extremes affect all types of agricultural production and represent a challenge that farmers must manage in order to remain viable. There is a well-established relationship between El Niño events and drought in Australia, although not all drought events are El Niño related. El Niño events generally occur every 2-7 years (Cane, 2000; Meinke and Stone, 2005). El Niño events typically, but not always, result in severely reduced rainfall in winter and spring, particularly across eastern Australia; where the majority of high-value cropping and livestock husbandry is practiced. Despite the challenges of farming in Australia, agricultural activities cover about 60 percent of the continent, much of it in the dry, semi-arid rangeland regions.

Managing the Risk of Drought

Before 1992, the Australian government did not have an explicit drought policy; assistance to affected producers was provided through a natural disaster relief program. In 1992 a national drought policy was established. This policy shifted the emphasis away from drought being classified as a natural disaster and towards that of a normal component of the operating environment. Drought, and more broadly, climate variability, was seen as an inherent business risk that producers needed to manage as they would any other potential risk. This shift in thinking was intended to create a setting in which drought was considered a normal part of the Australian farming environment; the core principle to encourage producers to adopt self-reliant approaches for managing climatic variability and to prepare for drought. While acknowledging the principles of self-reliance, the National Drought Policy (1992) also recognised that there would be circumstances that were beyond the ability of farmers to manage alone. In these so called "exceptional circumstances," governments could provide assistance to support otherwise viable farm enterprises through periods of "severe downturns" in income.

Drought Assistance

Since the 1992 National Drought policy was enacted, it has been reviewed and its principles reinforced several times; however, the Exceptional Circumstances (EC) component has changed in relation to its criteria and implementation. The current criteria for EC events are: the event must be rare and severe and of a scale to affect a significant proportion of farm businesses in the region; the event must result in a severe impact on farm production and income that lasts for at least 12 months as a result of the event, and that the downturn in income is not a result of other issues such as competition from international markets; and that the event must not be predictable or part of a process of structural adjustment. Rare events are considered to be those that occur on average once every 20 – 25 years; and the event is severe if it lasts for a period greater than 12 months. The framework for assessment of EC revolves around the assessment of: meteorological conditions; agronomic and stock conditions; water supplies; and environmental impacts. Although most commonly enacted as a result of a rare and severe drought, EC events may include a combination of events such as drought and frost. Key to the process of decisionmaking is the involvement of an independent advisory council comprising agribusiness professionals.

Once a region has received an EC declaration, farmers within it are eligible to apply for a range of assistance measures. However, before assessing these assistance measures, farmers still need to demonstrate that they operate a long-term viable enterprise and must also pass income and assets tests. Farmers in EC-declared areas may apply for income support, equivalent to the unemployment benefit, and business support, in the form of interest rate subsidies on operating costs from the federal government. EC assistance lasts for up to 2 years, but regions can be assessed for extension of support before their 2-year period expires if adverse conditions continue. Other concessions and support are available from the state and territory governments in certain circumstances; however, they are not considered here due to their varying nature from jurisdiction to jurisdiction.

The 2002 – 2003 Drought

Australia has recently experienced one of its most severe droughts on record. The most severe part of this drought, in terms of geographic extent and rainfall deficit, occurred between March 2002 and January 2003, and covered most of the agriculturally productive regions in the country. Indeed, the most important agricultural regions generally experienced conditions at least equivalent to a 1 in 20-25 year event, with a number of regions recording their lowest rainfall on record. Not only did the 2002-2003 drought significantly reduce farm production during the event but ongoing effects continue to be felt in many regions. For example, the irrigation industries rely on major reservoirs and many of these, as of 2006, had still not returned to pre-drought levels. The major reservoirs in the Murray Darling Basin, Australia's most important irrigation region, fell to 17 percent of capacity in 2003, and 3 years later are still below levels recorded before the drought. As a result of this shortfall in stored water, irrigators are continuing to experience restricted volumes.

The recent drought led to over 90 applications for EC funding, and just under 50 percent of Australian agricultural land received some level of support. In addition, due to the persistence of the drought, additional measures were developed to provide ongoing support for regions that had clearly not recovered from the impacts of the drought after their initial 2 years of support ended.

A major national drought workshop was held to discuss the efficiency of the current measures in dealing with drought, and to map out new and improved ways to deliver drought assistance. One of the issues raised was that the current system of applying for support was complex and time consuming and often led to support being provided well after the worst impacts of the drought had been experienced. Partly as a result of this feedback, the Australian, State, and Territory Agricultural Ministers, through the Primary Industries Ministerial Council (PIMC), gave consideration to the development of a national agricultural production monitoring system to assist in the development of EC applications and to facilitate decisionmaking for government intervention. It was envisaged that such a system would provide an agreed set of data for use by both the applicants and assessors, and for this data to be readily available via the Web.

The National Agricultural Monitoring System

The rationale behind developing the NAMS was to automate the creation of an EC report via the Web. The automation was intended to streamline the application and assessment processes for EC, and reduce the time and cost associated with the process. It was envisaged that NAMS would also provide up-to-date climatic and production information that could help target regions that may be coming into drought; and also provide climatic and production information that could be utilised by producers to better prepare for, and manage, drought.

To simplify and streamline the existing EC application process, the NAMS Web site was designed to produce reports that provide a complete set of contextual, climatic, production, and economic analyses. From this base, it was intended that state and territorial governments add their own interpretive text and additional supporting information to the provided analyses. One of the potential strengths of this approach is that the analyses will be standardised between all applications, yet the applicant will still be able to provide additional contextual and interpretive information.

NAMS was tailored to produce EC reports for regions, but was also designed to produce state and national agricultural and climatic reports. These reports will be updated monthly and are intended to provide a snapshot of current conditions, primarily to highlight regions where conditions are deteriorating due to adverse climatic conditions. This early alert system could be used to target support to regions before the primary impact of the drought is experienced, thus reducing the social, environmental, and economic impacts.

Although NAMS was initially conceived to assist the Australian government in the delivery of drought policy, it was envisaged that the majority of users would be the general public. NAMS will be a public Web site where people can run any of the available analyses for their region of interest. This open access will make NAMS a valuable resource not only for agricultural producers but also for a wide range of land mangers, including such groups as local governments, water catchment authorities, and local land-care groups.

In the past many stakeholders viewed the analyses undertaken in the EC assessment process as something of a "black box" and as a result did not always accept the rationale or methods used in the process. Loss of trust between stakeholders can impede the flow of information, increase inefficiencies, and possibly lead to more uncertainty in final decisions (Laughlin and Clark, 2000). To circumvent this problem, NAMS, with the participation of state and territorial agencies, provides free access to data that are used both in the EC application and assessment processes. Data and analyses included in the NAMS were chosen by a scientific advisory committee, established with members from major stakeholder groups, including state and territorial governments and key Australian research agencies. The intention of having such a comprehensive advisory group was to maintain transparency in the system and to ensure that trust was maintained with the stakeholders.

As previously stated, in order to receive EC funding, an EC application must show that a region has experienced a severe downturn in production and income as a result of a climatic event that would only be expected to occur once every 20 to 25 years. In order to establish if a region has experienced such an event the analyses used must put the "event" into a historical perspective. This underlying principle guided the choice of analyses included in NAMS. The description below is limited to a sub-set of the analyses contained within the EC report. Further details of the analyses used in NAMS are available from the Web site at www.nams.gov.au.

Regional Context

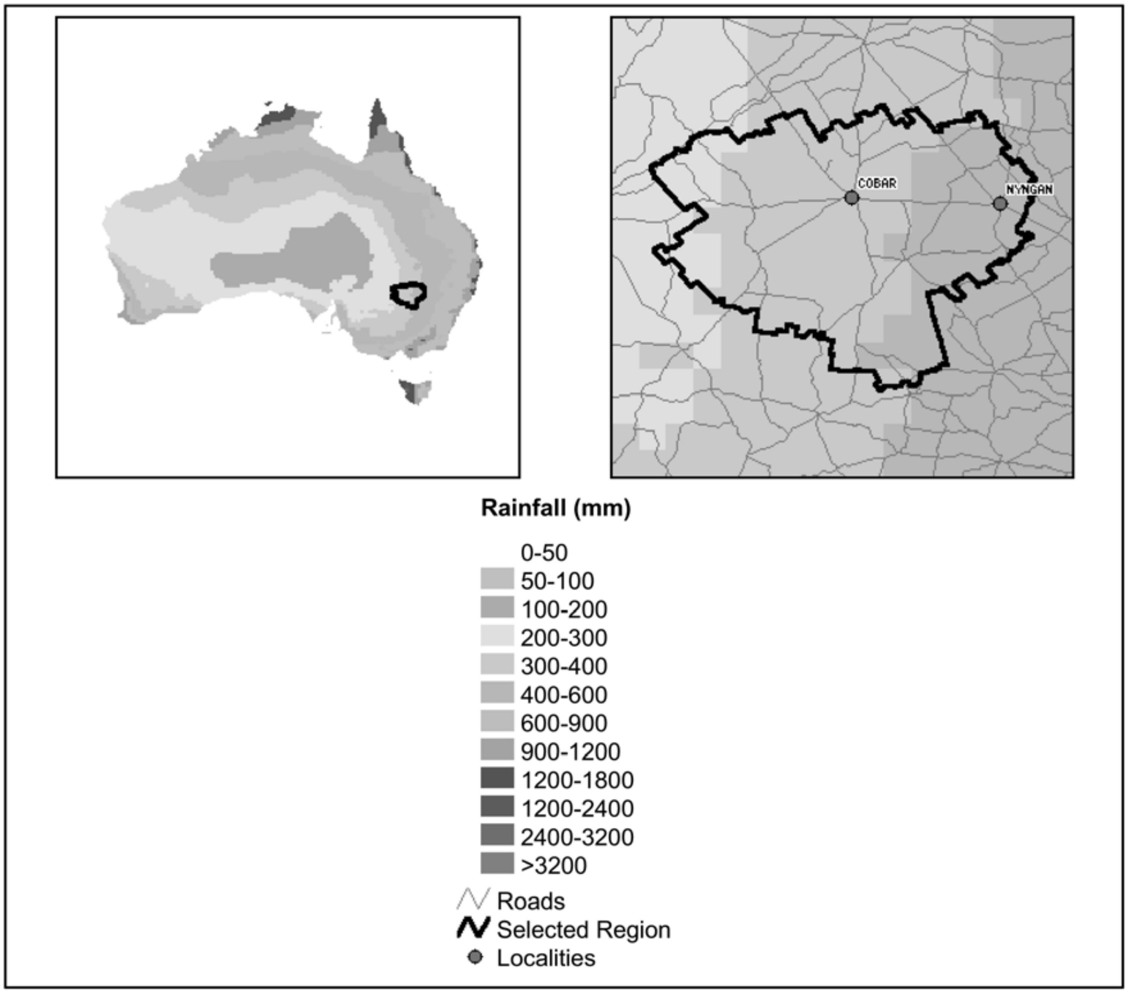
This section of the EC report is designed to provide a detailed overview of the regions biophysical and climatic characteristics. Maps are provided showing relevant layers such as land use, soil type, and water holding capacity. These maps are accompanied by tables containing information on the major farm industries and the number of farm enterprises within a region. Detailed climatic information is also provided for the EC region showing average rainfall and temperature, rainfall reliability, and the growing seasons. Figure 1 shows an example of how average rainfall is displayed for an application region. This figure shows spatially how rainfall varies across the application region and it also puts the region into the broader context by displaying it against the whole of Australia.

Climate

Average rainfall

Average annual rainfall

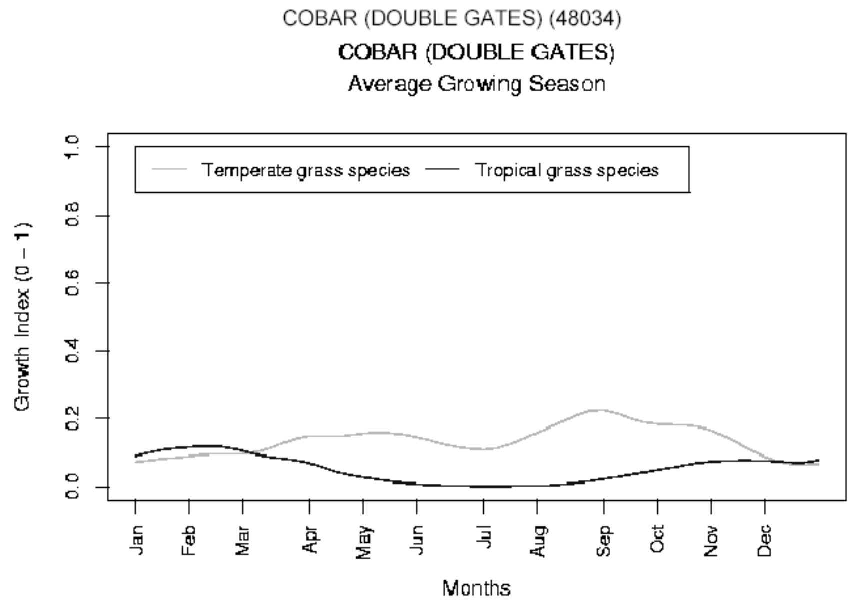
The following figure shows a summary of average annual rainfall for Australia and for the EC report region.



Average annual rainfall for Australia and for the region. The report region is outlined in black. (Source: Bureau of Meteorology).

Figure 1. Average annual rainfall output generated from the NAMS as part of the EC report.

When trying to assess the impact of a climatic event on production it is important to understand the relevant growing seasons for each region. Figure 2 was created using a simple growth model called GROWEST (Fitzpatrick and Nix, 1970) to characterise the growing season for a site. This simple model uses light, temperature, and moisture input data. The figure can be used to help define the normal growing season of the pastures within the region, i.e., for cool season (C3) or warm season (C4) pastures. In this figure zero suggests no growth potential and one suggests optimal weather conditions for growth. This model also includes some soil characteristics, although it is largely weather driven.



Potential growing seasons of warm-season (C4 megatherm) and cool-season (C3 mesotherm) pasture species. (Source: Bureau of Rural Sciences).

Figure 2. Potential growing season output generated from the NAMS as part of the EC report.

Meteorological Event Analysis

The "Event Analysis" section is designed to place the drought event within a historical context. To do this, NAMS uses a range of point-based and spatial analyses based on data provided by the Australian Bureau of Meteorology. To achieve this, percentiles are used throughout the rainfall analysis section and for other variables also. Percentiles are merely a way of ranking data, be it temperature, growth or rainfall, on a 0-100 scale. By conversion 0 is the lowest, 50 the middle, and 100 the highest in any particular series.

Analyses are provided not only for a specified "event period" but also for a range of agronomically relevant periods — a strategy designed to examine "effective rainfall." The importance of assessing "effective rainfall" rather than aggregate rainfall can be highlighted by the observation that reasonable production can be achieved in a drought year if the rain falls at the right times for production. For example, there have been instances where a 5th percentile event was apparent at an 18-month time scale while the important agronomic production season (e.g., spring) within this 18-month period was at the 60th percentile.

The spatial analyses used in NAMS show the extent of rainfall during a range of periods. These include user-defined periods, growing seasons, and calendar seasons within the specified period. Spatial rainfall analyses are based on historical monthly rainfall data provided in approximately 25 x 25 kilometer (km) grid format. Due to the relatively coarse spatial resolution, the use of this tool is limited in areas of low-station density and around tall and narrow mountain ranges. In some areas the grids are also slightly less reliable during summer months due to the patchier and heavier rainfall.

Point-based rainfall analyses are used to develop a better understanding of "effective rainfall;" and how the rain actually fell over the recent past. When developing a report for a region one or several rainfall stations can be selected for detailed analyses. In Australia, climate data are recorded daily at more than 7,000 sites spread across the country. However, for most of these sites a complete data set that contains continuous measurements from 1900 to present is not available. This may be due to maintenance work, instrument failure or for a range of reasons related to the observation network historically being supported largely by volunteers. For the rainfall station analyses within NAMS there is a default that only allows stations with at least 30 years of measured data to be used.

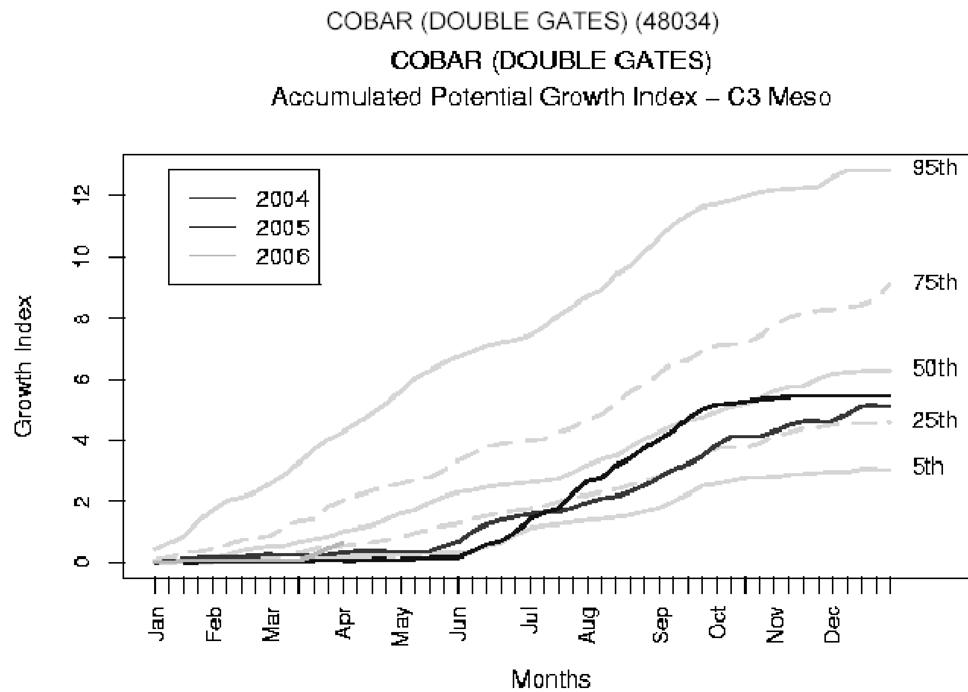
The point-based analyses used in NAMS include a 12-month moving average of rainfall using data from 1900, and bar graphs of monthly and weekly rainfall extending back 5 years. The moving average helps place the current event into a historical perspective by allowing a quick visual assessment of how severe the worst 12-month period of current drought was compared to all other 12-month rainfall periods. The bar graphs of actual rainfall provide a picture of when the rain actually fell, which combined with knowledge of the agronomic system, can provide insights into rainfall effectiveness.

Impact on Production Systems

A region may experience a climatic drought without necessarily experiencing an impact on agricultural production. For example, well below-average seasonal rainfall may have occurred but the timing of the rainfall could have been conducive to pasture growth. Alternately, particular industries may be able to compensate for the lack of rainfall by purchasing fodder or using irrigation water. Therefore, a region needs to establish that it has not only experienced a meteorological drought but that it has also experienced a severe downturn in production as a result of the drought and not some other factor such as product prices or poor management. As in the previous section, the "Impact on Production Systems" section of the EC report places the impact of the current event into an historical perspective. Analyses in this section focus mostly on modelled production outputs and typically use at least 100 years of data for comparisons. The production-based analyses currently used include: pasture growth, both temporal and spatial; cropping models for the main summer and winter crops; and, Normalised Difference Vegetation Index (NDVI), which is a satellite-derived measure of relative "greenness." The value of models is that they allow the end user to see the impacts of the various factors — individually or collectively — on growth. These models are especially useful for assessing rainfall effectiveness. A range of actual data is also used to show historical production levels for a region for crops and livestock.

Plant growth models can also be used to help assess the impact of climate variability on pasture and crop production. AussieGRASS (Carter et al., 2000) and GROWEST are two models commonly used for pasture growth assessments in Australia. AussieGRASS is a detailed growth model that includes the effects of climate, soil, and agronomic practices on growth whereas GROWEST is a simple point-based model of growth potential. Normalised Difference Vegetation Index (NDVI) is based on data collected from satellites, and shows the level of photosynthetic activity (or greenness) within plants, and, as a result, can be used to infer rainfall effectiveness. A limitation of the NDVI model is that data are only available from 1991, and thus does not provide a good historical comparison.

Spatial and temporal comparisons are provided for each of the techniques listed above. For example, Figure 3 shows accumulated weekly potential pasture growth for the C3 plant type over the last 3 years using the GROWEST model. In this figure the horizontal axis is time and the vertical axis is the index of potential growth. Grey lines represent the 3 years of modelled data. The median is represented by the thick black line; and the percentile ranges (30th to 70th and 5th to 95th) are also represented by the grey-shaded areas. There are two components to interpretation: 1) the accumulated value of growth potential to any point in the year; and, 2) the instantaneous growth potential. An alternate way to look at potential pasture growth is to use a spatial growth model such as the AussieGRASS model.



Accumulated potential pasture growth derived from the GROWEST model. The figure compares the accumulated potential plant growth for cool-season (C3 mesotherm) plant types. The grey lines show the percentiles for simulated pasture growth index generated from historical climate data from 1900. (Source: Bureau of Rural Sciences).

Figure 3. Accumulated potential pasture growth for C3 mesotherms generated from the NAMS as part of the EC report.

Economic Information

Economic information is provided to gain a fuller understanding of the impacts of a drought. Economic information is important because rainfall and production figures alone can mask on-farm impacts of a climatic event. For example, livestock production may not necessarily decline during a drought because producers purchased additional fodder to keep stock in prime condition. As result, production might remain stable but profits declined.

NAMS captures this information using a number of economic indicators. The indicators used are: farm financial performance; farm revenue; farm cash costs; and farm debt. The data for these analyses is compiled using an ongoing farm survey program run by the Australian Bureau of Agricultural and Resource Economics. Farm cash income is the primary measure and is used to track farm profits over the last 15 years. Farm cash income is a measure of cash flow while farm business profit is a more accurate measure of economic performance. Farm business profit includes all cash receipts and costs (i.e., farm cash income) plus non-cash items like changes in trading stocks, depreciation and an imputed family labor cost. Analysis of economic data helps answer questions about farm viability and short-to-medium term prospects. More importantly, provision of economic data allows the link between the climatic event and the farm profits to be established.

Conclusions

The NAMS evolved out of a need to streamline the Australian government's drought assistance program but is developing into a broader tool. NAMS has been designed to deliver a number of set products, including EC reports, but also has the capacity to deliver a wide range of climatic- and production-based analyses for any selected region within Australia. Analyses are done both at points and spatially. The analyses selected for use in NAMS were chosen by a scientific steering group, which includes representatives of the major stakeholders. The development of NAMS has involved extensive collaboration with major stakeholder groups, including representatives from the Australian and state and territorial governments, producer groups, and scientific research organisations. The extensive consultation process has helped ensure that the tool has strong support from its key users and that it is a valuable and relevant tool for individuals outside of its target audience.

NAMS also opens up the possibility of providing proactive support to producers before the full impact of a major drought is experienced. This type of assistance could help avert significant environmental damage by helping producers prepare for, and manage, the inevitable impact of droughts. The information provided by NAMS could also help producers better manage climate variability as a business risk. Droughts are a recurring theme throughout Australian agriculture and managing droughts better will improve the long-term sustainability of farming enterprises. It is ultimately hoped that the NAMS tool will be widely used by agricultural producers to help manage climate variability by providing relevant and up-to-date information on historical, current, and emerging climatic and agricultural conditions.

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References

Blacket, D. 1996. From Teaching to Learning: Social Systems Research into Mixed Farming. Publication Q096010. Queensland, Queensland Department of Primary Industries.

Cane, M. 2000. Understanding and Predicting the World's Climate System. *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems*. (G. Hammer, N. Nicholls and C. Mitchell, ed.). Kluwer Academic Publishers, Dordrecht, Netherlands. 29-50 pp.

Carter, J. O., W. B. Hall, K. D. Brook, M. G.M., K. A. Day, and C. J. Paull. 2000. Aussie Grass: Australian Grassland and Rangeland Assessment by Spatial Simulation. *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems.* (G. L. Hammer, N. Nicholls and C. Mitchell, ed.). Kluwer Academic Publishers, Dordrecht, The Netherlands. 329-349 pp.

Fitzpatrick, E.A. and H.A. Nix. 1970. The Climatic Factor in Australian Grassland Ecology. *Australian Grasslands*. (R. Milton Moore, ed.). ANU Press, Canberra, Australia. 3-26 pp.

Hammer, G. 2000. A General Systems Approach to Applying Seasonal Climate Forecasts. *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems*. (G. L. Hammer, N. Nicholls and C. Mitchell, ed.). Kluwer Academic Publishers, Dordrecht, Netherlands. 51-65 pp.

Laughlin, G. and A. J. Clark. 2000. Drought Science and Drought Policy in Australia: A Risk Management Perspective. Canberra, Australia. BRS.

Lyon, D., S. Bruce, T. Vyn, and G. Peterson. 2004. Achievements and Future Challenges in Conservation Tillage. *New Directions for a Diverse Planet* in Proceedings for the 4th International Crop Science Congress, Brisbane, Australia, ed. Published on CD-ROM. Web site: www.cropscience.org.au.

Meinke, H. and G. Hammer. 1995. Climatic Risk to Peanut Production: A Simulation Study for Northern Australia. *Australian Journal of Experimental Agriculture.* 35: 777-780 pp.

Meinke, H. and R.C. Stone. 2005. Seasonal and Inter-annual Climate Forecasting: the New Tool for Increasing Preparedness to Climate Variability and Change in Agricultural Planning and Operations. *Climatic Change.* 70: 221-253 pp.

Steffen, W., J. Sims, and J. Walcott. 2006. Farming Profitably in a Changing Climate: A risk Management Approach, Bureau of Rural Sciences in association with Natural Resource Management Division, Department of Agriculture Fisheries and Forestry, and Australian Greenhouse Office**:** 30.

Stone, R.C. and G.C. de Hoedt. 2000. The Development and Delivery of Current Seasonal Climate Forecasting Capabilities in Australia. *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems*. (G.L. Hammer, N. Nicholls, and C. Mitchell, ed.). Kluwer Academic Publishers, Dordrecht, Netherlands. 67-75 pp.