BROADBAND AND THE ENVIRONMENT

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Availability of broadband to rural and remote communities would enable agriculturists to use Landsat, Geo-positioning and Agronomy to better manage the environment. Landsat imaging has developed significantly since the first Landsat satellite launch in 1965. Data now available from these can provide beneficial applications including improved water management, crop assessment, land clearing, soil erosion, salt contamination and pollution. Access by farmers and graziers to information and analyses from commercial organisations via high speed broadband on land conditions and the effects of some agricultural practices provides an opportunity to prevent or minimise environmental damage and support effective use of water resources.

INTRODUCTION

Broadband on its own is not a solution to environmental issues. It is an enabler that allows data, technology and social developments to be integrated in any number of combinations to meet many of the challenges of today including the environment. This paper does not discuss the technical aspects of broadband but is only concerned with its potential application to the environment and the ability to address some of the issues facing the world, in this case focussing on the Australian environment although much is common worldwide.

A key need at this stage, like all quantum leaps in capability, is to promote to the decision makers and the entrepreneurs the vision of what can be achieved from a capability that – for the first time in history – enables individuals around the world to exchange ideas, develop approaches to common problems and to initiate action to address them quickly in a coordinated effort using the power of broadband.

Environmental issues stand out as one of the key challenges to the human race. Whether one believes in global warming or not, communication around the world indicates that climatic changes are affecting the wellbeing of individual populations and having damaging impacts on agricultural output. Broadband cannot fix these, but what it can do is enable rapid identification and initiation of action to ameliorate potential degradation: in some cases created by mankind, in others by natural phenomena.

Some may be reactive applications that can to some degree be handled with current practices, but the strength of broadband comes from the ability obtain potentially available information necessary to identify situations before detrimental situations occur, to initiate action instantly to prevent or at least minimise the environmental impacts, and to control or stop activities that negatively impact the environment.

One paper cannot address all possible applications supportable by broadband Therefore this paper considers just one – that is, integrated approaches using broadband to distribute the information to address the issues facing Australia in the agricultural industry.

BACKGROUND

Agricultural practices and crops across Australia vary depending on the general and expected climatic conditions. However they all need similar resources to support the particular agrarian
endeavour: water, fertiliser and pesticides. Whether they are in livestock, horticulture or cropping, the most common requirement is water. This can come from locally stored supplies in dams and tanks, from irrigation allocation or directly from rainfall. The amount of water required for sustainable farming is dependant on the type of crop or livestock and the location. Typically cotton and rice crops require significant water resources while dry land grain and fruit crops can be supported by lesser rainfall but some level of irrigation. Cattle and sheep require continuous access to water, the amount depending on the herd or flock sizes.

Water impacts all aspects of farming. Water from flood causes destruction of crops, livestock and infrastructure and is generally an uncontrollable act of nature, although there exists a number of approaches to predicting stream flow and where and when flooding is likely to occur. However excess human-induced irrigation, in conjunction with overuse of fertilisers and pesticides, creates its own problems of soil loss from erosion that can include nutrients, pesticides and other contaminants, resulting in water contamination from run off into rivers, dams, and reservoirs.

Water is required for domestic and industrial use. In Australia as in other countries, it is also used in power generation through both hydro electric schemes and coal-fired power generation station cooling. Even proposed nuclear power stations require water both for power generation and safety. Water is also a key element in mining, on which Australia is heavily dependant. Consequently it can be said that without adequate water Australia would be unable to support its population, its industry or its agricultural output at a level necessary to sustain the standard of living presently enjoyed.

The natural environment, including rivers, wetlands and forests, also needs water which enables these to survive and support the wildlife of Australia; and in a situation where climatic and environmental changes are occurring, competition among the players is becoming more intense, and unless there is some reasoned approach there will be major winners and losers.

Water use is currently inefficient, and wasteful. Allocation for irrigation is imbalanced and generally unmatched to the actual requirements of the particular operations. In industry, including the agricultural industry, water use tends to be arbitrary, with little incentive until the recent droughts to manage usage. This also applies to household use and building design where only when water availability has become a key political issue has any action been taken.

This paper does not address crops, livestock or industries that appear patently inappropriate for a dry land like Australia, but considers how the correct levels of water supply to satisfy each of the needs could be better achieved and how high speed broadband in conjunction with the appropriate support technology could assist management of this resource at the core operating levels. That is at the farm gate, the industry door or in the cities and town suppliers.

DISCUSSION

Developments in satellite technology and geo-positioning have enabled significant progress to be made in monitoring weather patterns, to observe environmental climatic events, urban sprawl and the impact of human practices in agriculture, land clearing, forestry and many other human invoked operations. Satellite technology enables high- or low-resolution scanning of land and sea to identify changes in fertility, crop conditions, water and pollution. It has been used to note excessive land clearing in all parts of the world and to identify the degradation of the soil and pollution of waterways resulting from loss of ground cover. To some degree, satellite and wireless
technology has been used to measure water levels and flow such that predictions and dispersion of irrigation water has been made although much of this process continues to be labour intensive.

Unfortunately, to date there has been little effort in coordinating all the information and providing it to users in a systematic and equitable manner. For much of the history of European settlement in Australia, the use of land and water has been the domain and responsibility of the individual users. Allocation of water for irrigation from river systems has traditionally been State managed and controlled, with each State government primarily concerned with the agricultural output and viability within its own State and the revenue from the water allocation levies.

This approach in control and allocation appears to be based on criteria that seem little concerned with the ability of the water sources to meet all the allocations made, in some cases by Federal and in others by State regulatory authorities. Unfortunately to date this allocation tends to be based on parochial requirements and the first served principle of water allocation occurs.

While there are moves by Government to at least place the Murray/Darling basin under some common control, there has been no move to identify actual water requirements dependant on the actual needs by the users and little effort to use water only where and when it is required. Part of this problem is that the users can only base their assessment of water, nutrient and pesticide need on personal observation, past experience and historical practices, even though the capability of providing specific data is available quickly if the infrastructure was in place to deliver it.

Therefore much of the farming practices in Australia continue to be prescriptive rather than using precision farming that could be possible if the information and analytical data was easily available to farmers, graziers, horticulturists and other users of the land and water.

By providing farmers and other users with specific and targeted information about the condition of their particular properties and water availability, each user could determine where irrigation, as well as fertilisation and pest control, is needed and where it is not. Some very large corporately-owned properties do make use of satellite information to determine the general condition of their land and their crops, and treat accordingly. However access to the current technology and information can be expensive, and relies upon accurate translation by specialists. For example, while the acquisition of high-resolution satellite data is in itself of relatively low cost the mass data provided by a single pass and the assessment of that information can be expensive and out of the reach of many users. Also the major problem for many in the rural and remote locations is that access to that information, even if they were prepared to pay for it, is either not available or so late in receipt as to be of little value or to be excessively time-consuming to obtain.

Landsat or broad area scanning is suitable for observing large areas and identifying the general condition of crops and a number of soil properties by agronomists using varying spectrum technologies. High resolution Spot Imaging can provide detailed assessments, and using GPS technology can identify very specific conditions in very specific locations. It is more expensive than Landsat scanning, but the data can include not only where water is and is not needed but also mineral deficiencies and where top dressing may be required to optimise output. It can identify potential areas where salt contamination exists or can occur if excess water has been used or excessive land clearing has taken place.
But reactive solutions are only part of the issue. For land owners both to rapidly respond to the needs of their land, livestock and crop conditions and to take pre-emptive action, they need usable information continuously, quickly and at an acceptable cost. The costs can to some degree be offset by reducing the operating costs of providing water, fertiliser and pesticides where they are not required.

By the same process, by aggregating wide area scanning regulatory authorities can determine the national position with respect to water flows, storage levels and weather predictions and provide that information to land owners and industry as well as make long term decisions on such practices as water allocation based on knowledge, need and availability rather than arbitrary allocation based on revenue return.

TECHNOLOGY AND BROADBAND

Surveying is one of the oldest technologies applied over the centuries for the construction of roads, railways, housing and water catchments, to name but a few of the applications of this technology. The development of satellite technology and the ability to survey both small and large geographical areas has expanded the reach of surveyors from cadastral survey to analyses of much more terrestrial information. These views of the earth not available for much of the last century have enabled man to identify the climate and the state of the land, sea and air on which the survival of mankind depends.

The information gathered by surveys using satellite has to a large extent remained within the closed communities of scientists, meteorologists and technicians to assess and determine whatever outcome their particular interest requires. The result of some analyses is freely available and ac-
ccessible to those who have access to technologies that enable them to receive it. There are also commercial operations that collect and analyse Landsat and Spot Image data and translate it into usable information. A paper presented at the AGU meeting in 2006 identified that in the 34 years of Landsat imaging there have been significant opportunities for social improvements in applications such as water management, and suggests that there is a need to move Landsat technology into more user applications (Davis and Rocchio 2006). However even though available, for many who need the information promptly and in detail, it is not readily accessible in an expeditious manner or in an understandable form or available where the communication infrastructure is such that the large amount of data available cannot be accessed easily.

A further technological development resulting from satellite technology is geo-positioning, where pinpoint accuracy in determining a position on the surface of the earth is now possible without the need for terrestrial grid markers and the measuring equipment required from time immemorial to measure positions. Therefore it is possible to identify a particular terrestrial feature or condition with a degree of accuracy not previously available to surveyors, analysts or farmers without the time-consuming process of visiting all sites.

Agronomy is also a long known and used technology for consideration in this paper, the influence of which can be expanded to many parts of Australia and provided to the agriculturists and their support industries. Traditionally the process has required soil and water samples to be taken in various locations by agronomists visiting specific sites. The ability of satellite scanning to pinpoint soil conditions from an overfly scan means that much of the time-consuming ground level data collection can be reduced.

Spectral imaging has been used primarily in the mining and mineral research arena. A paper in the Lincoln Laboratory Journal shows the typical level of information that can be realised by the use of electro-optical resolution scanning using satellite or aerial survey techniques (Shaw and Burke 2003).

These advances, in conjunction with wireless technology and a well established mobile network, can harness the ability to collect information, provide it quickly to the individuals who have management over the areas that affect the environment, and enable them to take action to use that data wherever and whenever action is required.

Figure 2 Simplified taxonomy of applications for hyperspectral imaging

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The first step therefore is to provide a means of delivery of usable information simply and easily – for without access by the users no enterprise can consider providing the finance or resources to expand the integrated infrastructure necessary unless the output is used and there is a better degree of use and return possible.

The sciences associated with agriculture have made significant advances since the mediaeval days of crop rotation needed to maintain healthy soil and good output. The growth in the world population and the increasing demand for all that the earth can produce has put considerable strain on the earth’s resources resulting in the need for increases in agricultural land, chemical treatment of soil and increases in demand for water. To this end, agriculturists, agronomists, chemists and the farming industry have made major improvements in improving the output from the land.

Today, these scientists and technologists can identify fertiliser treatments required, areas of land degradation, water needs and crop suitability for specific areas of land. Biologists have developed genetic modification of some crops capable of growing in areas not feasible in the past, to a point where dry land cropping or husbandry is now undertaken.

But, to date, this information is predominantly in the hands of those who develop the technologies, and is either not easily or not quickly available to the people who use the land. That is, into the hands of the farmers and agricultural workers who can adapt farming practices to meet the needs of the land or take remedial action to resolve threats to the viability of their primary produce.

THE APPLICATION OF BROADBAND

Internet is available to some non-metropolitan areas but in limited form, generally via a dial up service or by entry-level broadband using DSL but only if the customer is within 4 km of a suitably equipped exchange. In other locations the availability of information may be available via fixed or mobile telephones, using satellite telephones, or more commonly as general radio broadcasts. The ability to obtain rapid and up to date information, other than in an emergency situation, that may either directly or indirectly affect their well being is mostly not accessible.

Green (2006) identified that a key issue to the success of Landsat is:

‘...the effective distribution of its data to a wide variety of users...’

Given the potential information that could be available, the lack of high speed or in some cases any, broadband is seriously hampering the ability of the farming community to obtain this data and for them to implement both financial and environmental practices that the new technologies could make available to them.

Satellite, GPS and satellite analysis of soil and crops has the ability to provide information on specific sites to farmers, farm chemical companies and to agronomists on the condition of land and crops that would enable farmers to more appropriately control their use of water, fertilisers and pesticides. The current broad area, arbitrary application of these products may or may not provide the increased yield, but regardless, is a significant cost to farming. Moreover, the application of excess amounts of chemicals may have undesirable consequences not only in the agricultural arena but also on the environment.
As previously indicated, run off of nitrates and other chemicals can impact on water quality in rivers and ultimately the sea, as has been demonstrated in a number of locations around Australia. Equally the excessive use of pesticides has a direct impact on the food chain of wildlife and humans, resulting in morbidity and in some cases extinction of species.

The use of water for livestock and cropping and the current agricultural practices for provision of water to support farming is based on 19th century knowledge and application. Flood irrigation is one of the most wasteful approaches to the use of water and in general is only marginally acceptable for selected crops such as rice. Evaporation and water run off is a significant issue, resulting in the run off of nutrients into waterways and the contamination of rivers and depletion of fish stocks. In a worst-case scenario, when accompanied by inappropriate and excessive land clearing, it can cause soil erosion.

With applied foresight that could be provided to the industry by broadband, agriculturists would not willingly contribute to wasteful expense or to the deterioration of the capital investments on which they live.

The availability of broadband and technology innovation, and the integration of these, could enable farmers and rural communities to better use the resources for which they are responsible. The only three things that are preventing this from developing into a thriving capability are broadband availability, politics and money.

Current practice is for farmers and graziers to request and receive their estimate of water requirements. For these allocations of water, Governments receive revenue from the users based on the megalitres requested. Historically, how the water is used is of no consequence to the regulators. Therefore, once the water is allocated there is no particular incentive for farmers to not use their allocation. On most farms, water can be stored in dams or tanks typically for livestock farms, or distributed using irrigation ditches and a number of usually manual water management devices. The use of spray irrigation tends also to be manual and used to cover blanket areas of crop.

Because of the limited information and the semi-manual distribution systems, it is simpler and less time consuming for general area watering to be undertaken rather than specific location irrigation. Farmers observe overall crop conditions, and apply their allocation as they perceive it is required; and therefore could be using water where none is really needed. This blanket process also applies to the application of fertilisers and pesticides, at a considerable expense in the farm operating costs. The larger combined farm operations, where size acts as a buffer, do however use all the information available – and in many cases have automatic management of water and chemical additives on the land.

In general however, the many smaller properties are either unable to access the information or because of the size of their operation cannot justify the expense of scanning and control mechanism. One solution is for adjacent properties to combine into a group, but at this stage there is little incentive to do so. Equally, because the information is not readily available via broadband links, current operational practices will prevail.

After the successful development and launching of Landsat satellites in 1972, W. Pecora, at a meeting of a panel of scientists said that one of the most challenging problems for the future would be:

‘...supplying remote sensing data to the users...’
His concern at that time was the collection and provision of simple, easy to understand translation of the data, with an assumption that a means to deliver that information would be needed. Broadband did not exist in 1972 and therefore his expectations for expeditious delivery of environmental information was not an option. However today, 35 years later, the means to deliver that information does exist and needs to be available to those that need it – that is to the practical applicants and users of that information.

**TYPICAL INTERNET INFORMATION AVAILABILITY**

Typical of the information that could be available for those who have access to broadband is that indicated by the Centre for GIS at Monash University (Xiaye et al. 2005). In this paper they indicate that by using Digital Elevation Models (DEM) traditionally used to generate topographical maps in conjunction with Light Detecting and Ranging (LiDAR), it is possible to identify areas of salinity risk.

State Government departments such as the NSW Department of Primary Industry are frequently sources of general information on the impacts of some current agricultural practices such as over-irrigation and the inappropriate use in some locations of particular fertilisers (Schumann 2002). Unfortunately at this stage, this information remains generic, and without access to specific information on particular locations by the agricultural industry, the management of water and chemicals by agriculturists will continue to be based on assumption rather than specifics.

CSIRO Livestock Industries have developed technology using satellite imaging to measure pasture conditions for livestock wellbeing (Coppings 2001). They indicate that at this time only
West Australia has been covered, but the inference is that further development is dependant on the use made by farmers of the information during a trial period: ‘we will also be assessing the use of the information by farmers.’ Consequently access to the information must be a consideration in whether such developments are expanded to the rest of Australia.

Satellite Imaging Corporation (2007) claims to be able to provide imaging and evaluation of vegetation, water and overall soil condition at any location on request which could enable landowners to identify what action they need to take to ensure the viability of their property or what activity they need to curtail to prevent possible degradation of soil, water and the environment.

As a brief overview of what is potentially available, this shows what can be provided to farmers, and other agriculturists, who have access to a reasonable broadband service. But further development is highly dependant on the ability of the providers of the information and the agronomists, scientist and engineers to have access to their intended customer base in timely and understandable forms. Without high speed access via broadband this development is likely to be delayed or to be seen as uncommercial.

At this stage this information remains largely in the domain of research institutions and application by other research organisations, universities and government instrumentalities.

**MONEY, POLITICS AND INNOVATION**

There is a need for some form of Government incentive. Governments in principle control the allocation of water, and should be in a position both to identify water availability nationally and to inform users about what is available. Then by using the information available from Government agencies and scientific institutions it would be possible to provide via the network the information the farms need to manage their business while minimising negative environmental impacts.

One of the issues facing farms and farming enterprises is the cost of accessing the desired information. The cost of broadband, even should it be available, is but one part of the equation. As previously indicated the actual scanning process is relatively inexpensive. Landsat ETM provides an image of approximately 32,400km² at a per-unit cost in the order of $0.009/ha. A single sensor of the Spot image satellite covers 3,600 km² at approximately $0.024/ha. The analysis of the spectrum data, and the translation of what it means and what action needs to be taken, requires collection and storage of a mass of data; and specialists are needed to turn it into simple usable information. Consequently costs can be high, depending on the degree of information required by the user. While Spot imaging is the most suitable for agricultural application, the lower cost Landsat imaging is currently used by those who do have the means to access the information.

Cooperation between by farmers using Landsat would reduce the costs to individual farmers by splitting the overall scanning costs; but the analytical cost would still be high, although cost reduction could be expected if more users were able to access the information.

Unfortunately, while there is no ability for the users of the information to access or pay for the information, the likelihood of some entrepreneurial organisation undertaking to innovate broad area scanning and analysis for distribution to the agricultural industry at lower cost is remote, to the detriment of the environment and the ability of the industry to adapt to the changing and challenging environmental situation.
Because there is at present limited access to the Internet via broadband, efforts to establish a commercial base for the distribution of specific data to particular farm businesses have to date been based on attempting to stimulate agricultural support industries to use the information to better support their customers. Various GIS capable survey organisations have attempted to attract support from such industries as the chemical producers and distributors and irrigation and drainage facilities to little avail. Because of the dispersed distribution of their customers, the agricultural support industries have in the past tended to be either reactive to customer requests or prescriptive, with little incentive to actively market based on perceived customer need. Consequently until farmers and the users of the information can easily access data and request specific location data from the suppliers this approach is destined to be unsuccessful.

Although there are analytical models that enable the translation of scanning and survey information, these are generally used by scientific institutions and the research departments of universities and not available or easily understandable by the people that need the information to support their businesses. The complexity of the information and the need for accurate translation needs two key elements to enable its use:

• appropriate software to convert geospatial information and integrate it with agronomic analysis into easily understandable action requirements;
• a communications medium that can deliver significant data downloads in a reasonable time span.

The second requirement cannot be achieved without broadband and the first is unlikely to progress without some guarantee of commercial viability.

Access to the information is therefore only one part of the equation. The question then becomes: how to provide the information to the users and how to use the information to minimise or eliminate the adverse effects on the environment and at the same time support the agricultural industry.

Politically, decisions need to be made concerning the aggregation of all the data that is potentially available and the delivery via broadband to locations that are seen by the possible providers as of marginal (if any) profitability for communications organisations. There also needs to be an incentive for the farming community to access the information, and in conjunction with industry and government to identify what action can and should be undertaken to change long-held practices that are damaging the environment.

An already clearly defined environmental issue has been identified by satellite scanning and some agriculturists – salt contamination of once arable farmland. This has resulted from a number of activities since European settlement in Australia, land clearing and irrigation being the most obvious culprits. In some cases a solution seems remote. In others, with early identification action can be taken to prevent it spreading or to reverse the process. But this can only be undertaken if the farmers can identify where it is likely that contamination will occur, what they need to change to stop it, and some Government involvement in both enabling information access and defraying some of the costs involved.

Another issue is the problem of water and the current practice of individual State arbitrary water allocation. As previously mentioned, flood irrigation is wasteful, but so are many other irrigation practices. By scanning, it is possible to identify where water is required, rather than
the current process of watering an entire cropping or fruit growing area. Where excess water is applied the only outcome is run-off and loss of nutrients into the water system, where the contamination is detrimental both to the water, to wild life and to the farm livestock. By controlled and point watering the losses of water and nutrients can be minimised. Part of the problem is that some of the water storage practices and the irrigation channels that transport the water are subject to evaporation losses. Once again the level of loss can be measured by remote scanning rather than the current manual methods, and remedial action can then be taken.

But all this costs money and requires commitment by both State and Federal Governments to support major changes in the way they view the agricultural industry as a whole, and its use of the natural resources.

There are currently incentives in metropolitan locations to minimise water and power use. The issue is whether there is sufficient incentive provided by Government in the rural areas to address some of their more complex issues. Broadband provision is one part. Another is how broadband can be effectively used to support the farming community’s best endeavour to solve negative environmental impacts while at the same time increasing agricultural output.

It has long been recognised that the agricultural industry provides a significant contribution to Australia’s GDP and is a key exporter of grain, livestock and other primary and secondary products. As indicated by Professor Button (2005) one of the key attributes of Spectrum scanning is that it is possible to manage both prescriptive and precision farming practices. Equally, by monitoring variations in the spectral response from crops, the condition of the crops can be determined and an accurate assessment made of yield potential or of specific treatment that is required.

The use of these various technologies is a key to improving the environment and to provide assistance and increases in agricultural contribution to the wealth of Australia. It therefore behoves both State and Federal Governments to ensure that these advances in technology are accessible in the areas needed. This requires a specific and determined approach to the provision of high speed broadband to the rural communities. If the access to the information is made available, then enterprise will follow with the cheaper and better information that is necessary.

**CONCLUSION**

The situation is that those who work on the land or have an association with agricultural or natural environment have a direct impact on the environment, and maintenance of a sustainable environment is to their immediate benefit. Without information, they have no easy way to identify or to predict what effect the actions they take have on the environment in which they live, nor to modify ingrained practices that may be creating problems in the short and long term for them, their businesses and the environment in which they live.

It would appear that in the current political metropolitan-focussed situation, rural and remote communities are being denied access to the high speed – or in many cases, any – broadband that would enable them to access technology to manage water, nutrient use and pest management and therefore minimise the impact of farm practices on the environment and nature as a whole.

It seems evident that without the active participation by both State and Federal Governments to support both the development and expansion of high speed broadband into the non-metropol-
itan areas, the potential for action to be taken by these communities to conserve and protect the environment is constrained.

While it would be desirable for private enterprise to initiate the collection and aggregation of the information on environmental issues made available by technology for provision or sale to the agricultural industry, without some commitment by the decision makers in Governments this is unlikely to happen.

Application is the key driver for the growth of broadband. Without recognition of the practical applications of combining technologies in the non-metropolitan areas, and the need for high speed broadband to deliver it to where it is needed, the process of supporting a healthy environment and helping the farming community and small population centres is stultified.

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Cite this article as: Saunders, Roger. 2007. ‘Broadband and the environment’. Telecommunications Journal of Australia 57 (2/3): pp. 27.1 to 27.12. DOI: 10.2104/tja07027.