

# ICT as a Catalyst for Innovation Diffusion

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**Abstract.** The availability of water is a global issue which is predicted to become more pronounced in the future. As a large and relatively dry continent Australia is presented with a series of challenges within the agriculture sector. As a result, the adoption of appropriate, efficient and effective irrigation systems is an important element for future sustainability. In various Australian growing regions different modes and types of irrigation are utilized. However, in many cases the preferred system has been selected based on tradition and local norms rather than on the basis of effective water management. Consequently, there is a socio-psychological element in the adoption of new or alternative systems. This study reports on a project that identifies how the introduction of technology within a variety of irrigation systems types has improved water efficiency, reduced wastage and improved product adoption. In particular the study discusses how technology has improved the use of flood and micro irrigation systems as well as more recent developments in satellite assisted irrigation. The findings of the study suggest that the enhancement of existing irrigation systems through the addition of information communications technology can overcome some traditional barriers by adding specific features that are attractive to growers.

**Keywords:** Irrigation, extension workers, innovation diffusion, water management

## 1 Introduction

Australia is a large land mass with a current population of just over 22 million people. However, the agricultural sector is frequently challenged by drought and a general lack of available water, which has led to the need to irrigate vast holdings of land using a variety of methods. These include Flood, Centre Pivot, Sprinkler and Surface and Sub-surface Drip irrigation systems. The selection of the most appropriate system has been found to depend, to some extent, on crop type, however, barriers to the uptake of the most efficient and effective systems have also

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been found to be based on traditions and local norms. In some cases this has meant that wasteful irrigation methods have prevailed such as flood irrigation where evaporation accounts for up to 30 per cent of wasted water.

At the same time, Australia has a well-developed agricultural sector, with farmers deemed to be extremely innovative in the methods they have used to overcome the harsh local growing environment (Sheehy, 2012). The Australian agricultural sector is also among the least subsidised in the world which has hastened the introduction of innovations in line with the world's best practice, particularly in the production of commodities. This has resulted in a surplus of food year on year (Keogh, 2012). However, the adoption of efficient irrigation systems such as drip irrigation has been relatively poor despite many benefits such as less water used or wasted, uniform targeted water delivery and higher crop yields.

Among the issues related to the availability of water in the future is an expected increase in global food needs based on population growth which is expected to reach over nine billion by 2050 (Food and Agriculture Organization). Australia is a major food exporter and has aspirations to be a significant player in the supply of food to the Asian region in the future (Mascitelli and O'Mahony, 2014). Indeed, Australia has been tipped to become the future 'food bowl of Asia', a phrase that recognises the importance of the food and wine industries as a major driver of future foreign exchange income (Maher, 2014). In Australia there are opportunities for further growth in food production through the opening up of new land to farming, however, this would require significant improvements in agricultural practices as well as in land and water management.

The aims of this study were first to gain a deeper understanding of the influence of publicly available information on the adoption of the most efficient and effective irrigation systems. The second aim was to examine how technology has been used to improve the efficiency and effectiveness of some traditional systems by reducing water wastage. The final aim was to establish how contemporary information and communications technology could enhance the adoption of more efficient and effective irrigation systems.

## **2 Methodology**

The first phase of the study involved a desk top review of both academic and practitioner literature, together with government reports and websites that offer advice on the choice of irrigation systems. In this review a number of barriers to adoption of agricultural products and practices were identified.

The second phase involved site visits to explore how the technology enhanced irrigation systems were operating in various farming regions as well as a series of qualitative interviews with government agricultural advisers. These advisers, who are also known as extension workers, are technically trained, holistic thinkers who are able to deal with complex technical situations. Their role involves farmer education relating to the application of scientific research to agricultural practice. The final phase was to examine how information and communications technology

was helping to overcome some of the barriers to innovation in the use of the more efficient and effective irrigation methods.

### **3 Findings**

The content analysis conducted in the first phase of the study found that tradition has a strong impact on the irrigation system types that are presented to those accessing information and there are distinctions between states, regions and soil types. The emphasis on what is generally practiced in various regions has meant that some psychological barriers would need to be overcome in order to convert farmers to different systems that might be more efficient and/or effective for their crop and soil type. For drip irrigation for example, issues highlighted within this review included the cost and complexity of system installation and a lack of information about the return on investment and a series of other advantages of these systems.

The review also highlighted a number of factors that impede the adoption of sustainable practices in farming. Among these are barriers relating to available information, which includes general information, such as information about the product, product benefits, economic benefits and technical information. In summary, it was found that there are four key influencers and trusted sources of information about irrigation for farmers. These are other farmers, agronomists, field days and the Department of Primary Industries (Bates et al., 2008).

In the second stage of the study, it was discovered that the Victorian Government has provided incentives for farmers to prepare 'whole farm plans' for their properties, so farmers have a better understanding of the way water is used and retained within their farms. Extension workers assist farmers to develop, enact and update these plans. The Victorian State government and the Australian Federal Government have also invested heavily in water distribution infrastructure for flood irrigation and technology which supports a reduction in the footprint of irrigation. Whilst the benefits of connecting to the new infrastructure have been clearly demonstrated, joining the new system is voluntary.

The government investment has been, for the most part, investment in open channel water distribution systems. That is the traditional method used to deliver water to flood irrigation systems. The investment involved funding the repair and improvement of the distribution channels, which, of itself, would not have provided farmers and growers with greater utility. However, the deployment of modern ICT systems together with the careful application of solar generated electricity has significantly enhanced the utility of the government investments for farmers and growers. This is because, with modern, well designed systems of gates and valves, sufficient power can be generated by modest solar generating systems to establish autonomous systems that are not dependent on mains power. In one region of Northern Victoria, this has resulted in the deployment of flume gates that integrate sensors and flow meters which, when combined with a supervisory control and data acquisition (SCADA) systems, enable accurate flow measurement, flow control, power supply and radio telecommunications to be integrated into a single device that can be controlled from the water authority computer. The farmers and growers can program their irrigation from their desktop or tablet via the water authority ICT systems.

These farmers are predominantly growing pasture crops. The technological advancements that have been installed have provided a significant advantage to flood irrigation over more modern irrigation methods. This sort of automation is

not, however, restricted to open channel flood irrigation systems that are controlled by the water authority and their sophisticated ICT systems. Any of the fixed irrigation systems, such as drip irrigation and subsurface drip irrigation that involve pumps and valves can, with appropriate sensors and interfaces, be automated through the use of modern ICT systems. For example, young, tech savvy farmers who are interested in improved lifestyles as well as being environmentally conscious are keen to adopt the latest technology which can provide them with real-time information relating to water availability as well as moisture content of the soil on their farms.

Whilst the government provides incentives and support to improve irrigation practices, there still remain those who are risk averse and reluctant to automate their irrigation systems. This may be addressed by the development of soil moisture measurement devices and wetting front detectors that can make measurements that can be transmitted using modern ICT devices. The incorporation of these developments can provide confidence to the farmers and growers by field testing the systems and observing their performance before progressing to rely on the systems to perform reliably. Once that confidence is achieved, farmers and growers will be more likely to use ICT controlled systems to manage their irrigation systems.

Confidence is obviously a major issue in the adoption of new approaches and methods to farming practice. In California, researchers have developed satellite imaging systems that have been coupled with terrestrial sensors and on farm crop data to provide an integrated system that provides decision support to farmers and growers in their quest to provide irrigation water in the correct quantity in the correct location and at the correct time. Developments in all areas of information and communications technologies as well as many other technologies have clearly been essential to enable this development to be achieved.

In Australia, a project is currently underway to continue a development program that will build on the crop measurement capability (Abuzar, et al., 2015). The Victorian State Department of Environment and Primary Industries (DEPI) has funded this project to integrate the satellite data, weather data from the Australian Bureau of Meteorology and ground level data from lysimeters, soil moisture meters and rain gauges (Whitfield, et al., ).

The integration of these measurements through sophisticated ICT systems has the potential to enable a full picture of the crop water requirements. This information system can then be linked to efficient irrigation systems that can deliver the irrigation water in the correct quantity, at the correct time to the correct location. The system is designed to provide information to the Eastern Seaboard of Australia with the ability to deliver at the level of an individual paddock. Once this system is fully developed, a phase of confidence building will be required that assures growers that the system delivers enhanced production and reduced running costs on a reliable basis. The building of such confidence will, of course, place a heavy burden on the reliability of the ICT information supply chain that drives action in the paddock.

## 4 Conclusion

Previous studies have shown that the social infrastructure of the Australian agricultural environment has an impact on new product adoption and that a farming subculture generally develops within regions which influence farming styles. These developed norms can be difficult to change despite evidence of improvements provided by new products. As a result, the key issues that need to be overcome when introducing new products in the farming context include both economic issues (profitability) and peer acceptance.

While, change agents have been found to be particularly important in addressing the culture and traditions of farming, there is some evidence to suggest that the novelty and ingenuity of innovations in ICT can help to overcome cultural norms while improving the efficiency and effectiveness of irrigation systems especially when these improvements have a positive impact on individuals' lifestyles.

Important networks influencing change include federal and state level agencies and the scientific community who support various land care programs, as well as local agencies, interpersonal networks, industry and community groups and farmers/growers. Membership and participation in formal and informal groups has also been shown to have an influence on individuals. Within these groups farming styles, which have been described as a cultural repertoire, take hold and are communicated between farmers and this directly influences agriculture practice. Addressing these groups may lead to positive changes in the adoption of irrigation products.

This has highlighted the need to engage other stakeholders to test these assumptions and to modify the research approach to gain the most comprehensive information possible. The ultimate payoff will be to open up new swathes of arable land for the production of food crops and dairy and livestock production. The capability of the Australian continent to produce much more food is not limited by the available land, nor the available water, but by the distribution of the available water and its management and use. The development of reliable information supply chains based on the integration of reliable ICT systems that can contribute to the management of the available water resources and irrigation systems will be a major contribution to the fulfilment of the potential of Australia as a major food producer for the rest of the world.

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