NATIONAL PROGRAM FOR Sustainable Irrigation

Research Bulletin

Irrigation Mosaics in Northern Australia

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Tropical landscape in north Queensland showing a 'mosaic' of land uses ((C) CSIRO Land and Water; Photography by Willem van Aken)

The Northern Australia Irrigation Futures (NAIF) project has undertaken a review of research into irrigation mosaics as an approach to irrigation in northern Australia. Irrigation mosaics involve smaller patches of irrigation distributed across the landscape as an alternative to large contiguous areas of irrigation (see Figure 1).

This research has examined the current understanding of irrigation mosaics drawing lessons from ecology, forestry, meteorology and saline basins. This work aims to aid understanding of the concept of irrigation mosaics and whether it may be an appropriate style of irrigation for northern Australia. This research has also investigated the application of existing and new biophysical modelling and analysis tools to explore potential advantages and disadvantages of irrigation mosaics.

Key messages from the research include:

- There is growing interest in irrigation mosaics as an alternative approach to traditional large-scale contiguous irrigation systems
- Irrigation mosaics may have both negative and positive biophysical effects compared with more traditional approaches to irrigation. The overall effect will depend on site specific features such as the hydrogeology
- Further research is required on the biophysical, ecological, social and economic advantages and disadvantages of irrigation mosaics

Background

Debate about using more of the water in the north for irrigation and other uses is increasing. Making informed decisions about the future of irrigation in the north will require greater understanding of tropical systems and whether irrigation can be designed and managed in a way that is more harmonious with the natural ecosystems.

Most irrigation areas in Australia are characterised by large-scale contiguous irrigation systems. Few consist of small patches separated by larger tracts of unirrigated land. The large irrigation areas are attractive from an engineering point of view as they

offer 'economies of scale'. However, some have also resulted in environmental changes and problems associated with rising water tables, salinisation, groundwater pollution and major changes to natural river flows.

Irrigation mosaics could be an alternative for northern Australia and as such trying to improve understanding of mosaics and what benefits they may deliver over traditional large scale contiguous irrigation systems is of particular interest to northern Australia.

In the north, land ownership is different than in the south with indigenous Australian communities managing large proportions of the land. Mosaic-style irrigation development may present an opportunity to some communities to develop sustainable enterprises. Small-scale mosaic irrigation may also offer opportunities for existing large-scale cattle stations to diversify and integrate sustainable irrigation with other enterprises. However, the longer-term environmental impacts of irrigation mosaics, especially in tropical environments, are still largely unknown.

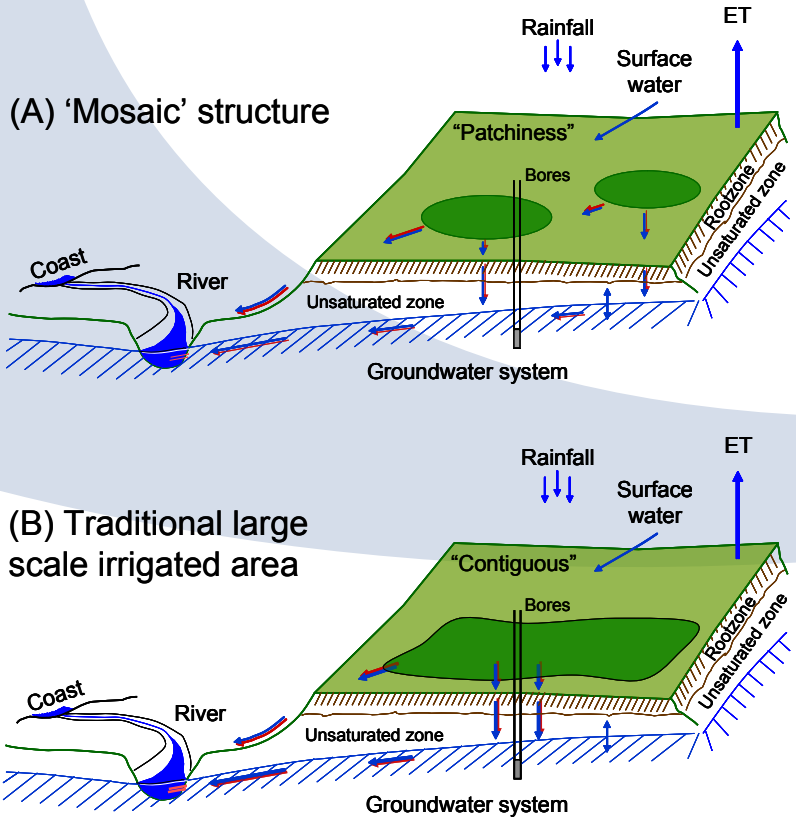

Figure 1 Schematic showing basic features of large contiguous irrigation compared with irrigation mosaics involving smaller patches of irrigation distributed across the landscape.

Key findings

This work examined some of the issues associated with irrigation mosaics with a particular focus on the bio-physical effects compared to large-scale contiguous irrigation systems. This was done in two steps:

1. reviewing the current information on irrigation mosaics by drawing knowledge from other fields (Paydar et al. 2007)
2. examining the effects of irrigation mosaics through biophysical modelling analysis (Cook et al. 2008)

Knowledge Review

Current knowledge on the implications of irrigation mosaics within the context of ecologically sustainable development is very limited. However, other areas of study dealing with spatial patterns in the landscape provide insights which can be used to help improve analysis and understanding of irrigation mosaics. Other areas of study examined include ecology, forestry, meteorology and saline basins. This work highlighted:

1. the importance of the patch size, shape and spatial arrangement,
2. the role of ecotones, and
3. the effect of advection on evapotranspiration

1 Patch Size, Shape and Spatial Arrangement

From a review of ecological research literature we found that patch size, shape and spatial arrangement are important characteristics in landscape analysis and planning. These characteristics affect processes, patterns and organisms in different ways.

Patch size has some implications in terms of system losses in transporting water. For example, there are obvious engineering economies of scale and potentially lower unit costs resulting in cost-effective provision of infrastructure and services in large irrigation schemes. The literature we reviewed also indicated that larger irrigation schemes tend to attract more government support and can be easier to organise than multiple smaller projects. On the other hand, the literature also showed that smaller irrigation areas give greater opportunity to farmers to participate in planning and management of the system. Being smaller they are better adapted to supply local markets, and, individually, they incur smaller risk of adverse environmental and social impacts, such as displacement of settlements or disruption of wildlife habitats.

2 Ecotones

Ecotones are zones of transition between two or more distinct habitats or ecosystems, for example the zone between a field of irrigation and grassland. Ecotones are important characteristics of mosaics and play an important role in energy and material fluxes. Irrigation mosaics could be used to create or enhance ecotones in the landscape for greater biodiversity, modifying microclimate, minimising erosion, and in absorption of surplus nutrients flowing from irrigated lands.

In some cases though, irrigation mosaics can disrupt continuous tracks of land that are used by wildlife. This can be detrimental for biodiversity. This highlights the need to understand site specific features and potential long term impacts prior to implementing particular types of irrigation.

3 Effect of Advection on Evapotranspiration

Advection is the transfer of heat, cold or humidity by the horizontal movement of an air mass across a boundary between two different land surfaces, for example, a hot wind blowing from dry land across wet, irrigated land. Hot, dry air blowing over small isolated patches of irrigation can cause additional evaporation on the small irrigated area compared with large contiguous irrigated areas. This is because evaporation demand is highest at the edge where the hot dry air meets the wetter irrigated part of the landscape, but decreases as the air mass moves further in from the edge and equilibrates more with the wetter irrigated surface. This means that smaller isolated areas of irrigation could result in more evaporation per unit area than larger contiguous areas of irrigation because there is not a large enough area of wet irrigated land for the air to equilibrate.

Preliminary analysis of these issues suggests that water use per unit area in irrigation mosaics could be greater than that in large irrigated areas by as much as 10 percent, maybe more. This may not be desirable in northern tropical Australia, particularly in the dry season when one would want to irrigate.

The key findings from examining the literature on patch characteristics, ecotones and advection have been used to inform our initial development and application of computer models to help build further understanding of the advantages and disadvantages of irrigation mosaics.

Modelling Analysis

The NAIF project developed new analytical and numerical solutions and programs to analyse spatial and temporal issues associated with irrigation mosaics. These new solutions and programs considerably reduce computation time compared to older methods. The analytical solutions can be used to quickly assess possible mosaic arrangements and then more detailed site specific analysis can be carried out using the numerical methods. This combination of methods provides an efficient means of obtaining useful information for designing and assessing irrigation mosaics and other proposals.

From this research it is clear that irrigation mosaics could have both negative and positive environmental impacts:

Positive Impacts	Negative Impacts
• reduced water-table rise	• increased water-table spread
• reduced solute concentration	• increased solute spread
• improved filtering of surplus nutrients	• higher evapotranspiration
• reduced erosion	• increased operational losses
• ability to exploit natural variability	

The actual net positive or negative effect will depend on a range of factors including the actual location within the landscape, size of the individual patches, spacing between patches, and the assimilative capacity of surrounding areas. In this regard the key results from this work include:

- water table rise under an irrigation patch is strongly dependent on the size (radius) of the patch
- in an idealised system water table rise is linear with time until the system starts to come into an approximate steady-state with the surrounding landscape
- calculations of realistic field conditions show that the water table rises more slowly and exhibits more periodicity than it would with steady-state recharge, but that the same inevitable rise in water table height can occur
- the area impacted by solutes increases as the size of the patch increases
- isolated patches may evaporate more water to the atmosphere due to advective effects caused by heat coming from surrounding dry areas
- as more patches are added into the landscape it is likely that the evaporation rate will approach that of a large contiguous irrigated area

Implications

There is growing interest in the potential for irrigation mosaics to deliver improved social and economic opportunities for rural and remote (often indigenous) communities in northern Australia.

This research shows that there are likely to be both advantages and disadvantages of irrigation mosaics compared to more traditional forms of irrigation. Depending on the circumstances, this may result in a net benefit on biophysical grounds; however the longer-term environmental impacts of irrigation mosaics are still largely unknown.

The potential impacts need to be studied carefully, and design criteria (size, shape, density, connectivity and spatial arrangement) need to be established because environmental benefits may be short lived if space and time lags just delay any unwanted consequences of irrigation.

Where to from here

To gain an improved understanding of the potential for irrigation mosaics in northern Australia, and suitable designs, further biophysical research and model development on the following is needed:

- analytical solutions for periodic recharge of groundwater
- solute transport using particle tracing methods
- the effect of advection on evaporation rate as effected by size and number of irrigated patches
- the water and solute balance and irrigation requirements of sites throughout northern Australia

Studies into the ecological, social and economic performance of irrigation mosaics, and the policy and governance frameworks they require, are also needed to improve understanding of their potential advantages and disadvantages. Studies could focus initially on the performance of existing irrigation areas that demonstrate irrigation mosaic characteristics, such as the Daly River.

Understanding the likely performance of irrigation mosaics can help determine the potential future for planning mosaics and help identify how existing irrigation systems could be reconfigured for improved harmonisation with natural systems.

For more Information

Cook, F.J., Xevi, E., Knight, J.H., Paydar, Z. & K.L. Bristow. 2008. Analysis of biophysical processes with regard to advantages and disadvantages of irrigation mosaics. CSIRO Land and Water Science Report No. 14/08, CRC for Irrigation Futures Technical Report No. 07/08.

Paydar, Z., Cook, F.J., Xevei, E. and K.L. Bristow. 2007 Review of the current understanding of irrigation mosaics. CSIRO Land and Water Science Report No. 40/07, CRC for Irrigation Futures Technical Report No. 08/07.

NAIF reports can be found at **www.npsi.gov.au** or visit the NAIF website at **www.clw.csiro.au/naif**

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About the Program

The National Program for Sustainable Irrigation defines and invests in research on the development and adoption of sustainable irrigation practices in Australian agriculture. The aim is to address critical emerging environmental management issues, while generating long-term economic and social benefits that ensure irrigation has a viable future.

The Program has 16 funding partners: Australian Government Department of Environment and Water Resources, Cotton Research & Development Corporation, Gascoyne Water Asset Mutual Co-operative, Gascoyne Water Co-operative, Goulburn-Murray Rural Water Corporation, Grains Research & Development Corporation, Harvey Water, Horticulture Australia Limited, Land & Water Australia, Lower Murray Water, Ord Irrigation Asset Mutual Co-operative, Ord Irrigation Co-operative, South Australian Research and Development Institute, Sugar Research & Development Corporation, Sunwater, and Western Australia Department of Water.

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