Communities vulnerable to unpredictable and unreliable water supplies in many parts of the world rely upon irrigation as a means of increasing food and fibre production. However population growth within the developing world and increasing access to global markets for agricultural production, have been a driver for increasing irrigation demand such that water availability commonly constrains production. Pursuit of alternative water sources is often the first response to shortfalls in catchment yield, with prospects for improved efficiencies (production per unit volume of water available), considered only when other options are exhausted. However even where improvements in system or application efficiencies are sought, potential benefits from integrating the management of all the available sources of water are seldom considered. Such benefits include optimising productivity and equity in the management of the total water resource irrespective of its source and promoting sustainability within an economic, environmental and social context. The outcome of adopting a planned approach to conjunctive management is an operational model that approaches the optimal capture, storage, abstraction, system and on farm irrigation delivery of all water sources, and the management of surface and sub-surface drainage, and so contribute to achieving sustainable economic, social and environmental outcomes.

 Conjunctive use of groundwater to supplement surface water supplies is common in many parts of world, however integration is generally incidental, arising from spontaneous actions rather than being an outcome of a robust planning process. Under the “spontaneous” approach, irrigators opportunistically decide whether to source their water needs from groundwater, surface water supplies, or a combination of both, with their decision influenced by factors such as short term resource availability, costs of delivery to the crop, tradability of unused allocation and water quality. Such farm scale conjunctive use has the potential to provide benefits to some individual irrigators in the form of reducing costs and increasing productivity and profitability, but does not optimise the economic, environmental and social benefits for the system as a whole (and hence all users). Such higher level objectives are the benefits sought from central planning of the total water resource as indicated above.

 As surface water and groundwater are in most cases considered by both managers and users as separate resources with policy and management evolving in response to resource development, institutional and governance arrangements have within most states also evolved separately. The effect has been the establishment of ‘boundaries’ within the existing policy, statutory and regulatory framework that apply to the management of surface and groundwater resources. These boundaries are problematic as adoption of a full conjunctive management model is dependent upon a single integrated institutional framework and a robust governance structure that incorporates authority, accountability, transparency, stakeholder participation in planning and regulatory/compliance arrangements.
Re-structuring institutional arrangements so as to build governance within the context of a fully inte-
grated conjunctive management framework requires commitment within the highest levels of government. Such a commitment is essential to instigate the reforms required to bridge legislative and policy gaps that are likely to lie between agency regulated and managed canal based systems, and the legacy of unregu-
lated access to groundwater that dominates in most states around the world.

Upon instigating institutional reforms, governance arrangements are required that are able to apply a sound and robust policy/planning base founded in sustainability principles, with robust implementation/ delivery mechanisms to achieve on-ground outcomes. These include:

- a consistent policy and legislative framework associated with both surface water and groundwater entitlements that:
  - recognises any unique attributes associated with a specific entitlement, but also provide trading mechanisms so as to enable the market to support the highest economic uses of water.
  - provide statutory power to government or a delegated agency to administer and regulate on behalf of the government.
  - Includes accountable and transparency in the decision making processes with mechanisms in place supportive of natural justice such as enabling appeals against decisions to be independently reviewed.
- a compliance management framework.
- mechanisms to instigate voluntary irrigator behavioural change (market instruments, direct incentives, extension).
- recognition and commitment towards the participation of stakeholders in the planning process, and provide advice to institutional agencies on issues associated with implementation.
- cost recovery models that provide a sustainable recurrent financial resource base to sustain institutional capacity for planning and operations over the long term.

There are a range of possible aspects to conjunctive management such as Managed Aquifer Recharge (MAR), natural hydrological connection between surface water and groundwater resources, supply integration, water quality management and drainage management. Key aspects to these opportunities for conjunctive management are as follows:

- MAR enables surplus surface water to be captured (during high flow events) and utilised at times when the dam or streamflow is depleted or when water is required for other purposes.
- Understanding of connectivity is critical within the context of resource assessment and water accounting, most importantly recognising that groundwater pumped from a connected surface water system will induce increased leakage from the stream or canal system reducing the volume of available surface water.
- Supply integration enabling groundwater to provide a supplementary source to a canal based system, that smoothes out the supply/demand balance either across seasonal patterns of water availability, or across decadal variability in climate. Such integration may involve groundwater distribution to the public canal system, although in most irrigation systems, such integration normally occurs on farm, as groundwater abstraction infrastructure is commonly privately owned with the pump located close to the irrigated area.
Conjunctive use and management of groundwater and surface water within existing irrigation commands

- Management of the quality of applied irrigation water such as accessing an alternative supply if the primary source is poor quality, and/or mixing surface and groundwater supplies to achieve and overall acceptable water quality for application to crops.
- Integration of farm drainage either by surface drainage networks returning water to the irrigation canal system, or sub-surface drainage systems that control land and water salinisation and waterlogging, through either groundwater abstraction and re-use or salt disposal.

Planned conjunctive management presents an opportunity for significant benefits to be realised in the management of canal based systems that are supplemented by groundwater resources. Such benefits arise because of the complementary characteristics of surface and groundwater water resources; characteristics that through planned integration of both water sources collectively will contribute improved economic, social and environmental outcomes.

Whilst some sovereign states will continue to pursue new ‘green field’ irrigation developments based upon new dams or further groundwater development, within a generation, the growth in such initiatives, and even maintaining existing levels of development are likely to be challenged by water supply and ecological decline. Accordingly, it is necessary to recognise the constraints posed by our physical environment and consider conjunctive management as a means of achieving more with less.

Whilst poor understanding of the technical aspects of conjunctive management may be an impediment to adoption, it is the absence of integrated institutional and governance arrangements that is likely to be the greater barrier to progress. Institutional structures, policy objectives and regulatory powers must be enabling so as to achieve a holistic approach to water resource and irrigation system management for the collective good. Without such institutional and governance arrangements, the economic, social and environmental potential that lie within state and communities water resources will not be realised.