
GLOBALIZATION AND WATER RESOURCES MANAGEMENT: THE CHANGING VALUE OF WATER

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DOLLARS AND SENSE: WATER ALLOCATION DECISION MAKING IN TROPICAL WESTERN AUSTRALIA.

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ABSTRACT: Tropical irrigated agriculture on the Ord River, Western Australia has struggled to be commercially viable since it commenced in the mid 1960's. Today, water is supplied to (a gross) farmland area of only 15,000 ha compared with the planned 72,000 ha when the Ord Irrigation Project was originally proposed. The completion of the Ord Main Dam in 1972, combined with the small volumes diverted since, dramatically altered the downstream flow regime. Wet season flooding is now greatly reduced. The dry season flows, previously intermittent, are now continuous and substantially higher than occurred naturally. In the 1990's, when the economic outlook for irrigation improved and expansion of the supply area was again considered, new community and environmental values had developed around the modified river regime. Significant in-stream uses including water based tourism, recreational fishing and hydropower generation had developed. The paper describes recent work on the re-assessment of the available water for further irrigation development given the need to protect the new social and environmental values of the river.

KEY TERMS: Irrigation, environmental water requirements, water allocation.

INTRODUCTION

Recent re-evaluation of the water available for the expansion of the Ord River Irrigation Project, Western Australia demonstrates how social attitudes to water and the environment have changed dramatically in a generation. The Ord River Project is located in the north-eastern portion of the Kimberley region of Western Australia. The region covers the Western Australian portion of the Timor Sea Drainage Division of Australia and contains 80% of the State's surface water resource development potential (National Water Audit, 2000). However, finding economic uses for these "undeveloped" water resources has always been the challenge. Enthusiasts for Kimberley development have proposed diverting water to Perth, the State capital 3200 kms to the south-west, and Adelaide the capital of South Australia, a similar distance to the south-east. The Ord River Irrigation Project is the only proposal that has ever proceeded passed the concept stage.

The Ord River Project, originally conceived in the 1940's, was commenced in 1963 with the commissioning of the Kununurra Diversion Dam and 12000 ha of serviced farmland on the fertile black flood plain soils of the Ord River valley. This was the first of four stages, with subsequent stages being the construction of the Ord Main Dam and further expansion of the irrigated farmland up to 72,000 ha. Only the main dam (in 1973) and a further 3000 ha of farmland have subsequently been commissioned.

The Ord River Project was controversial from the beginning. It's early political, economic and engineering history is summarised by Davidson and Graham-Taylor (1982) and Le Page (1986). They record the State Government's enthusiasm for "developing the north" via the project and the Commonwealth Government's reluctance to provide funds because of economic viability concerns. They also reflect the importance of the electoral cycle in finally securing Commonwealth financial support and the struggle of the early irrigators to find economically viable crops during the 1970's and 1980's.

It wasn't until the early 1990's, with improved roads and better protection of produce during transport, that

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horticultural crops became commercially attractive. Cucurbit crops such as melons and pumpkin, grown out of season from traditional areas in southern Australia, were introduced and banana's and mango plantations established. Sugarcane processing was introduced in 1994 and by 2001 at 11 000ha irrigated, the developed area is approaching full utilisation.

Planning the development of the final two stages of the original scheme was re-kindled in the 1990's. However, much has changed since the 1950's. Unlike the original development further expansion of the distribution areas will be subject to full environmental assessment. National water policy reforms, established in 1994 and which have been progressively implemented since, now specifically require environment needs to be considered in allocation decisions. Today, governments are encouraging private industry investment in water infrastructure projects. Under the new national water reform policy, if government's intend to investment in water infrastructure through their Government Trading Enterprises (GTE's), they are expected to achieve a 4% return on assets or explicitly justify lower returns in terms of other benefits or government policy.

Most significantly, the flow regime and associated riverine ecology downstream of the Kununurra Diversion Dam has changed dramatically since the completion of the Main Ord Dam. Wet season flooding is now greatly reduced; a consequence of the design of the dam and spillway (see below). The water diverted has only reached about 15% of that originally expected. Consequently the dry season flows, previously intermittent, are now continuous and substantially higher than occurred naturally. Significant in-stream uses including water based tourism, recreational fishing and hydropower generation have developed.

This paper describes the hydrologic and economic studies carried out to assess a new sustainable diversion limit for the Ord River, consistent with new water and environmental legislation and given interim environmental water provisions that protect the new social and environmental values of the lower Ord River. The development of environmental water provisions are discussed in a companion paper at this conference.

HYDROLOGY AND THE EFFECTS OF REGULATION

The Ord River basin lies between Latitudes 15 and 19 degrees South and drains an area of 55,100 sq kms from the Durack Ranges in the west, the Great Antrim Plateau in the south and east, to Cambridge Gulf and the Timor Sea to the north. The climate is semi arid to arid monsoonal with two distinct seasons: a warm, dry season and a hot, wet season. The wet season occurs between November and April. Rainfall occurs from local thunderstorms or more widespread tropical depressions, often the remnants of cyclones that develop over the Timor Sea. Rainfalls can be intense particularly in the January-February period and over 80% of the streamflow occurs January to March. During the remainder of the year, falls are light and sporadic, and several consecutive months without rain are common. Trayler, King (this volume), Ruprecht, and Rodgers (1999) provide further details of the climate, geology, vegetation and location of the catchment.

The high rainfall intensities, combined with the sparse vegetation and shallow soils results in a quick river response and flash flooding is common. The Ord River, prior to its regulation, recorded a peak flow rate of 30,800 m³/sec in 1956, close to the highest recorded flowrate of any world river of equivalent catchment. During the dry, evaporation is dominant, soils dry rapidly and most river systems dry up by June each year. Ruprecht and Rodgers (1999) provide further hydrologic details.

The Ord Main Dam is located in the Carr Boyd Ranges approximately 150 kms upstream of the mouth of the river in Cambridge Gulf. The dam catchment is 46,100 sq km and has a mean annual inflow of 3980 GL/yr. The dam stores 10,700 GL in Lake Aryle at full supply level, but was designed with a narrow spillway and sufficient flood storage to capture all the inflow from the wettest season on record, (maximum flood storage exceeds 30,000 GL). In such extreme years the spillway can flow for most of the dry season slowly dissipating the flood storage.

The surface area of Lake Argyle at full supply level is 980 sq kms and has a maximum possible area of 2100 sq kms. Net evaporation from the reservoir can be over 1100GL per year or almost 30% of the average inflow.

Water from Lake Argyle, either released from storage or overflowing as spillage, is diverted for irrigation at the Kununurra Diversion Dam 60 kms downstream. The diversion dam is located on the coastal plain and creates Lake Kununurra, a small storage (relative to its inflow) of 100 GL, which floods the river valley almost back to the Main Dam. Irrigation diversions have averaged 295 GL over the last three years. In contrast, the flows released downstream have averaged 2665 GL since 1974. Monthly differences between pre and post dam levels in the river downstream of the diversion dam are shown in Figure 2 of the companion paper [Trayler and King(2001)] Much of the dry season flow comes from release of surplus water to enable tour boat operators to navigate from the Diversion Dam to the base of the Main Dam and to stop cattle straying. These informal releases of around 50 m³/sec contribute over 900 GL if maintained over a seven month period. While not established as a legal obligation the releases have contributed to the changed social expectations and riverine environment following the construction of the dams.

PLANNING THE EXPANSION OF IRRIGATION AND SETTING SUSTAINABLE WATER DIVERSION LIMITS

The Water and Rivers Commission was established in 1996 to manage the water resources of the State. The Commission is responsible for resource investigations, establishing environmental water provisions (EWPs), setting sustainable diversion limits, and licensing water for diversion within these limits. Licences are issued to individuals or organisations that carry out the diversion and have a defined water allocation and purpose. Both private water users and “water service providers” that distribute water to customers, all require licences if they divert water from the natural environment. The Commission is also responsible for overseeing trade in these “rights” to water. New EWPs and diversion limits proposed by the Commission, are subject to environmental assessment by the Environmental Protection Authority.

In the 1990’s the Department of Resources Development, the agency responsible for co-ordinating development projects in Western Australia, sponsored a series of investigative studies and conceptual designs (DRD 1995, 1997a, 1997b) to update earlier development plans. These provided a base for the Governments of Western Australia and the Northern Territory to call for expressions of interest from the private sector to consider financing the expansion of the irrigated areas.

In 1998, a joint venture of Wesfarmers Co., Marubeni Corporation and the Water Corporation, were awarded preferred developer status to investigate the financial and environmental feasibility of a project based on the processing and export of raw sugar produced in the Ord Irrigation District. Known as the M2 Sugar Project it involved growing sugarcane on 32 000 hectares of farmland to the east of currently developed areas (see Figure 1 of the companion paper). The joint venturers are well down the path of State environmental approval (see below), are currently undertaking final financial feasibility and must decide whether to proceed by December 2001 or risk losing their preferred developer status.

In May 1999, the Commission released a draft interim allocation plan for public comment (Water and Rivers Commission, 1999). It proposed an interim sustainable diversion limit of 1235 GL to irrigate 54000 ha within a gross farm area of about 64 000 ha. This was to provide for current irrigation use, the M2 project and development of a further 10000 ha downriver. The environmental provision was based on maintaining the 20 percentile of pre-dam monthly flows along the lower Ord river, and indicated that 265 GL remained unallocated. The plan highlighted that the environment had first priority to this water when allocated and foreshadowed its use as a dry season EWP to mitigate changes in dry season flows when further diversions took place (Trayler and King, this conference). This was expected to occur in 3 to 5 years when adequate data on riverine ecology became available. Nevertheless, the EPA, after considering the public submissions received, recommended the Commission review their draft EWP’s to more explicitly protect the riverine environmental values established since the construction of the Ord Main Dam. The Commission is currently finalising the revised allocation plan before releasing it for further consultation and formal environmental assessment of the M2 Project licence(s).

In November 1999 the M2 Sugar Project joint ventures released their environmental impact assessment report on the project. Termed an Environmental Review and Management Program (or ERMP), it stated the proponents intention to divert 740GL/yr to irrigate their 32,000 ha of cane. This was consistent with the Commission’s May 1999 draft interim allocation plan. Amongst other environmental commitments, the proponents propose to implement efficient irrigation practices and groundwater management controls to minimise environmental impacts of their water use. After reviewing public and agency submissions on the ERMP, the EPA recently gave conditional support for the Project (EPA 2001). They have advised the Minister for the Environment that the project can be managed to achieve the EPA objectives, subject to the proponents original commitments, the completion of some more detailed studies and additional commitments made during the assessment process, including a reduction in the project area from 32,000 ha to 30,500 ha to protect particular vegetation communities.

MODELLING TO ASSIST WATER ALLOCATION DECISIONS

When the EPA advised that the lower river should be managed to protect the modified post dam flow regime, the “sustainable diversion limit”, previously thought to be sufficient to irrigate all the suitable soils of the area, suddenly became a significant potential constraint on further development. Trade-offs between the water needs of the in-stream environment and irrigation development, and between the current irrigators and proposed irrigation developments would be necessary.

If the Commission were to make sound revisions of the May 1999 proposed allocations, the best available knowledge on hydrology, river hydraulics, river ecology and crop water requirements plus the economic effects of each allocation option was needed. Simulation models ranging from complex proprietary software packages, to

custom built spreadsheets were used. A key requirement was the need to link output from the hydrologic modelling to the economic models to assess the impact of different EWPs and water restriction policies on the economic returns from irrigated agriculture.

Hydrologic, Hydraulic and Economic Modelling

The MIKEBASIN hydrologic model was configured to simulate the water balances for the two storages and flow regimes at nodes along the river from Lake Argyle to the Lower Ord River. Water demands were established for the existing and proposed irrigation areas and for power generation. The water supplied to meet each demand was normally 100% but could be reduced when Lake Argyle's storage was low. The amount of reduction could be varied as a function of Lake Argyle's water level for each demand type. This enabled different water restriction policies to be studied for each irrigation area and for the hydro-power demand. The EWPs were included as a separate demand type enabling EWP options for drought periods to be developed in a similar way to the irrigation and hydro demands. Estimates of monthly catchment inflows, reservoir and irrigation district rainfalls between 1905 and 1990 formed the primary hydrologic input. The output included the simulated reservoir levels and achieved diversions for each demand, and river flow rates at the key river node points. While most data were based on a monthly time step, the flood storage and spillway configuration required iterative calculations on a shorter time step to correctly simulate the water balance, lake levels and spillway outflows Rodgers(2001).

The MIKE-ELEVEN hydraulic computation package was used to simulate river levels, velocities and travel times during flood and low flow periods along the lower Ord River. Changes in river height, and "wetted perimeter" at 51 cross-sections, and residence times in key river pools along the 94 km reach were calculated for different allocation and EWPs options. Acceptable changes in these characteristics, relative to post dam flow conditions, were used as indices of likely change in aquatic habitat and formed the key criteria on which the revised interim EWPs were based (see Trayler and King, this conference). They therefore were the key determinants of the interim sustainable diversion limit for irrigation.

To understand the economic effects of different allocation options the Commission commissioned two economic models. The first was a model of the steady state economic benefits of the Ord system as developed under EWP constraints. It included farm gate returns from irrigated agriculture, and benefits from sugar processing. Gross revenue, gross margins, cash returns and net profits were calculated. The model estimates gross value of production of the economic benefits from recreational and commercial fishing, hydro-power generation, water based tourism and potential aquaculture ventures on Lake Argyle (White, 2001 in prep.) The model included a hydrologic component based on an earlier custom built FORTRAN model of the Lake Argyle, Kununurra Diversion Dam system (Ruprecht and Rodgers, 1999). This enabled the returns to irrigated agriculture to change when crop water demands could not be fully met.

The second was an investment analysis model for the development and operation of an irrigated sugarcane growing and refining project. The Commission needed to understand the potential impacts of its allocation decisions on private sector decision making in the M2 Project. The model was formulated to estimate the effects of a range of frequency and severity of water restrictions on the returns on investment in the M2 Project. Outputs from the hydrologic simulations (the probability of restrictions of different severity) were used as input to the investment model. These probabilities modified the unrestricted farm income and thereby reduced the cash flows of the project and the internal rate of return on the investment. Although a world wide search of data on investment and operating costs in large scale sugar processing was made, none was available at a reasonable cost so current stage one costs of production was used recognising that the economies of scale would differ.

PRELIMINARY ECONOMIC RESULTS

Economic Activity Generated from the Current Ord Irrigation Project

Table 1 summarises economic activity able to be generated from Stage 1 of the current Ord Irrigation Project. The irrigated agricultural benefits are estimated to be almost ten times larger than the tourism and recreational benefits generated from the project infrastructure, the reservoirs and the dry season flow regime along the lower Ord River. Tourism is a significant industry in the Kimberley region and Kununurra acts as the eastern gateway to a range of Kimberley tourist and recreational destinations. Separating the tourist and recreational benefits directly attributable to the project was therefore difficult and the figures in Table 1 are indicative only.

While the non-agricultural benefits arising from the lower Ord River were only \$3million per year, they have a high profile in the local community. Visitor surveys indicate 22 per cent of visitors purchase a river cruise

and 26 per cent go fishing. Fifty per cent of local residents report they spent 19.6 days fishing each year of which half is spent in the lower Ord River area, the remainder being spent outside the catchment. The need to preserve this regime to maintain recreation and other values was strongly expressed in submissions on the May 1999 draft plan and was a factor in the EPA's advice to the Commission on the plan.

Table 1 Economic Activity Generated by the Current Ord Irrigation Project

Economic activity – by sector and product or service	Gross Value of Production or costs of activity¹- \$million
Irrigated Agriculture and initial processing-Stage one	134
▪ Horticulture & other crops (7 000 ha) ²	57
▪ Sugar cane growing (9 000 ha @ \$26.25/tonne)	28
▪ Sugar refining ³	49
Water related activities- reservoir and project area based	10
▪ Extended stays to visit the project area and infrastructure ⁴	7.0
▪ Lake tour operations	1.0
▪ Incremental tourism directly associated with lake touring	1.5
▪ Commercial fishing	0.8
Water related activities- lower river based	5
▪ Recreational fishing, local and tourist ⁵	1.7
▪ Fishing charter operations	0.9
▪ Incremental tourism associated with fishing activity	2.0
▪ Food gathering	0.1

1. Values reported use 2000 prices for all commodities but sugar
2. Includes maximum likely area cropped and some provision for double cropping of areas planted to short growing season crops
3. Estimated at a projected Year 2004 price of \$A560/tonne- for comparison with M2 Project assessments)
4. Based on tourists staying 1 extra day in Kununurra to see the project area and dams
5. Based on fisherman spending an average of \$42 per day

Potential Benefits from Expanded Irrigation

Within limits set by the revised sustainable diversion limit (see below), Table 2 indicates the magnitude of additional agricultural production and associated sugar production when the three new distribution areas are fully developed. The farm budgets used local production costs and yield figures where available, and in the case of new crops included price projections of the proposed market on which the products are to be sold. While recognising the limitations of such projections, the analysis confirmed that irrigated agricultural enterprises are now profitable, although cost structures are still high (earnings being generally less than 50% of the gross value of production).

Table 2 -Additional Agricultural Benefits Under Expanded Irrigation

New distribution area	Gross Value of Production \$million	Earnings Before Interest and Tax \$million
Mantina Flats (3600 ha) ¹	104	45
Carlton Plains (4100 ha)	135	78
M2 Project (28 200 ha) -sugarcane growing	89	19
-sugar refining	219	88

1. Net area irrigated in any one year

SEARCHING FOR A SUSTAINABLE DIVERSION LIMIT

Over 100 hydrologic simulations for a range of allocations, restriction policies, and EWP options have been investigated to develop a sustainable diversion limit that protects the post dam values of the lower Ord River, but

also provides sufficient water, at an acceptable reliability to encourage private sector investment in expansion. This has involved input from key stakeholders groups, the community and a scientific panel with expertise in aquatic ecosystems (Trayler and King, this volume). It led to the proposal to set a minimum dry season EWP flow rate of 45 m³/sec between the Dunham River confluence and a point 57.5 km downstream (House Roof Hill). The median 5 month dry season flow rate in this reach has been 50 m³/sec since the dam was completed. Below House Roof Hill the channel becomes “U” shaped and aquatic habitat is less sensitive to changes in minimum flow levels. A minimum dry season EWP of 40 m³/sec is proposed downstream from this point to the tidal limit. Changes in dry season river levels will be minimum and “wetted perimeters” changes will be limited to acceptable levels (Trayler and King, this volume).

The above interim EWP regime enables a total of 1075 GL/yr to be diverted in 95% of years. This was insufficient to meet the expectations of all the current and potential irrigators and additional options were further considered.

Water Restrictions and Their Economic Impacts

Additional water can be made available at a lower reliability of supply. The dry season EWP could be reduced in drought periods if the risk to the aquatic environment can be shown to be minimal. Using economic models (see above) the effect of these approaches are summarised in Table 3. For M2 the effect of reducing the allocation reliability from 95% to 90% is small relative to other factors. Reducing the minimum dry season EWP to 35 m³/sec has a similar small benefit.

Table 3. M2 Project Sensitivity to Allocation Options Relative to Other Project Investment Parameters.

Parameter	Change in Parameter	Change in Internal Rate of Return
Allocation Options		
Reliability of allocation	95% to 90% reliability	0.5% reduction: 15.5 to 15%
Reducing the EWP during drought	45 m ³ /sec to 35 m ³ /sec	0.5% increase: 15.5 to 16%
Other Project Parameters		
Potential 2-3 year sugar price change	A\$560/t to A\$360/t ¹	12% reduction ; 15.5 to 3.5%
Exchange rate volatility	A\$1= US\$0.65 to US\$0.50	4 to 5% reduction-sugar price dependent
Increase charge for water service	\$20/ML to \$25/ML	0.7% reduction: 15.5 to 14.8%

Given that the investment decisions are yet to be made, and the effect of reduced reliability is small relative to other factors, the Commission is proposing that new allocations from Lake Kununurra be offered at 90% reliability and that existing use be licenced at 95% reliability. This enables the sustainable diversion limit to be increased to 1150 GL per year, and provide adequate water for the M2 project at the scale approved by the EPA albeit at 90 per cent reliability.

Opportunity Cost of the Interim EWPs

The interim EWPs restrict development of additional irrigable land upstream of House Roof Hill. This represents about 2 300 hectares of fertile sandy loam levee soils suitable for horticultural crops with a potential annual gross production of \$65million. The reduced reliability of the allocation to the M2 Project represents a potential annual loss of revenue of about \$6 million to the M2 Project.

CONCLUSION

This paper describes the background, public review processes and analyses involved in establishing a sustainable diversion limit of water from the Ord River, Western Australia. Since the main dam was completed in 1972, irrigation diversions have only been 15% of originally expected and new in-stream uses have developed that rely on the modified downstream flow regime. These are now placing new constraints of the diversion limit to a degree never envisaged by those who originally conceived the development. This is as it should be.

Resource managers must adapt to changing society values and develop resource allocation solutions that meet today’s environmental standards. However, where difficult trade-offs are involved resource managers should make the economic and environmental consequences of the alternatives clear. In this example the Water and Rivers Commission has played an important role in finding a sustainable limit that protects the new values and which does not preclude most of the potential benefits of expanded irrigation from being realised.

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