IRRIGATORS' EXPECTATIONS OF SUPPLY RELIABILITY AND IRRIGATION INVESTMENT

J Sandall
Centre For Water Policy Research
University of New England
Armidale NSW 2351

and

G Kaine
Rural Development Centre
University of New England
Armidale NSW 2351

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INTRODUCTION

This paper arose from a study in which the economic performance of the Newton Boyd inland diversion scheme was explored, on the assumption that the diverted water would be used for irrigated cotton production. In order to investigate the performance of the scheme, a simulation model was employed. The investigation revealed that the economic benefits from the irrigation scheme varied depending upon the reliability of water supply and the assumed behaviour of irrigators in response to supply reliability.

It is the intention of this paper to illustrate that the management decisions of both water management authorities and individual irrigators can affect the economic and physical performance of an irrigation system. Therefore the management decisions of both these groups should be taken into account in the formation of water resource management policy, otherwise unexpected or unintended results may eventuate, preventing the maximisation of economic benefits.

BACKGROUND

Water management authorities primarily encourage various types and levels of irrigation development through the issuing of entitlement licences. These licences restrict the volume of regulated flow that can be pumped from the regulated water supplies[1]. The conditions attached to these licences and the volume of the licences issued will reflect the management policy of the authority involved. For example, the authority could choose to issue entitlements sufficient to ensure that irrigators can operate with a highly reliable water supply[2]. Alternatively, a policy of expanding the volume of entitlements issued to encourage increases in the area of land under production and the number of irrigators on the system might also be adopted. In the latter option the expansion of production would be traded off against lower reliability levels. Therefore it would be likely that the optimum economic benefit generated by a particular scheme would occur at a reliability level below 100%.

When the long term reliability of water supplies is below 100%, irrigators must form expectations regarding long term reliability in order to resolve decisions

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1 Regulated flows are any flows debited against allocation accounts, these flows are usually released from the headwater storage, although they can be flows entering the system from rivers or streams below the headwater storage (tributary flows).

2 Note that there are three definitions of water supply reliability known to the author. The first refers to the percentage of announced allocation actually delivered to licence holders. The second refers to the number of years in which licence holders receive their full volumetric entitlement. While the third definition, the definition adopted in this paper, is the average percentage of the total volumetric entitlement received by licence holders over a given number of seasons.

about the appropriate area of land to develop and the appropriate level of investment in on-farm storage. Consequently, the way in which irrigators form expectations about long term reliability, as well as reliability itself, will affect the management of the water system and the benefits arising from, say, an inland diversion scheme.

In the remainder of the paper attention will be primarily focussed upon the above issues. In the following section some of the relevant characteristics of the Border Rivers irrigation system, the receiving system of the proposed diversion scheme are noted. This is followed by an outline of the simulation model and the simulation experiments. A description of the Newton Boyd inland diversion scheme itself can be found in Coffey (1983), Chen (1986), Coffey (1988),or Sandall (1991).

THE BORDER RIVERS IRRIGATION SYSTEM

The Border Rivers Basin is located immediately west of the Great Dividing Range and crosses the boundary between New South Wales and Queensland. The irrigation system on the New South Wales side of the Basin is managed independently to that on the Queensland side, and is the irrigation system referred to in this paper.

The water resources of the system are fully committed, with the volume of licensed entitlements issued amounting to 202 000 Ml. This entitlement currently supports 20 000 hectares of irrigated cotton production, approximately one sixth of the area considered suitable for irrigated cotton production in the region (Kaine-Jones et al. 1990).

Cotton irrigators in the Border Rivers are currently operating in an unreliable environment, with regulated water supply averaging about 30 per cent of the licensed entitlement and varying between zero and 55 per cent. Consequently many irrigators have invested in on-farm storages in order to supplement the regulated water supply with unregulated flows[3]. At the present time, irrigators with on-farm storage hold 70 per cent of the total licensed entitlement. The total capacity of on-farm storage on the system is 50 500 Ml.

Irrigators are able to successfully operate on-farm storages on the system due to the availability of substantial unregulated tributary flows. In Figure 1. the estimated monthly inflows into Glenlyon Dam (the largest headwater storage on the system) and the estimated streamflow in the Mole River (an unregulated tributary) are graphed. The figure clearly illustrates the fact that although flows in the Mole River are highly variable, they are significant when compared to the Glenlyon Dam inflows.

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3 Unregulated flows are those flows not debited against allocation accounts, these flows are usually flows entering the system from rivers below the headwater storage, although they may include spills over the headwater storage.

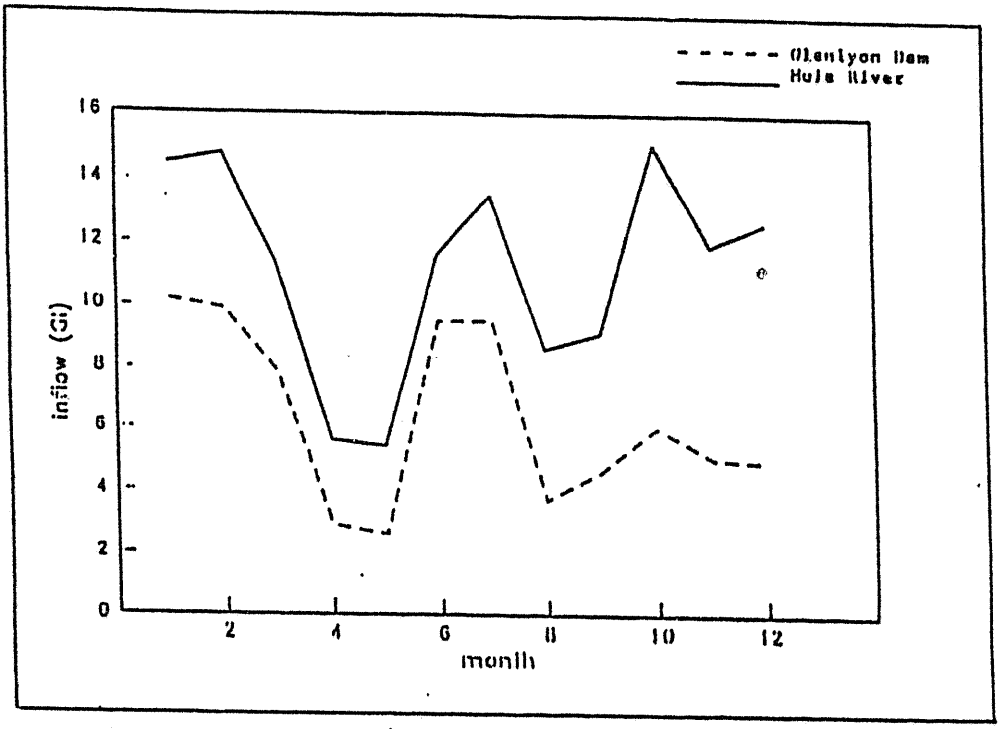

Fig 1. Estimated monthly inflows intc Glenlyon Dam and the Mole River.
Source: Kaine-Jones et al. 1990

THE MODEL

The Dumaresq-Macintyre model (Kaine-Jones et al., 1990) was adapted to simulate the operation of the Border Rivers irrigation system with the implementation of the Newton Boyd scheme. The model is an integrated hydrologic and economic model which has been used previously to assist in the formation of management policy (Kaine-Jones et al., 1990). Only those aspects of the model relevant to this paper are described here, a more detailed description can be found in Rindfleish (1986), Kaine-Jones et al. (1990) and Sandall (1991).

The hydrologic component of the integrated model was originally developed for the Queensland Water Resources Commission (Rindfleish, 1986). The module operates on the basis of a monthly time interval and required information concerning streamflows, licensed entitlement, on-farm storage volumes, demand for irrigation water, and parameters representing management policy (Kaine-Jones et al., 1990). The streamflow data used to simulate flows in the existing river system are based on historic flows. The data representing inflows into the diversion dam in the Clarence Valley were obtained from a hydrological study of the Newton Boyd scheme by Chen (1986).

Given the above information the hydrology module calculates a monthly series of announced allocations, off-allocation declarations, the volumes of available regulated and unregulated supplies, and the volumes of water in on-farm and headwater storages. The module also records the volume of water diverted by irrigators and updates allocation accounts accordingly (Kaine-Jones et al., 1990).

The economic module simulates the management of irrigated cotton enterprises and is based on a set of decision rules (Kaine-Jones et al., 1990). The rules were derived following interviews with irrigators and are appended in Appendix 1. The operation of the integrated model is also appended. The major assumptions associated with the use of the model for this study are discussed in the context of the simulation experiments.

DEVELOPMENT OF THE SIMULATION EXPERIMENTS

Three sets of experiments were developed to demonstrate the impact of irrigators' management decisions on the performance ot the Newton Boyd scheme. The main parameters of these scenarios are outlined in Table 1. The choice available to management authorities through the issuing of irrigation licences was explored by varying the level of entitlement across the scenarios to produce long run reliability levels ranging from 100 per cent down to the extreme case of 15 per cent average allocation.

Within each set of scenarios two types of irrigation enterprises were considered. One type of irrigation enterprise consists of enterprises with a licence entitlement and possessing on-farm storage, while the other type consists of enterprises with a licence entitlement only. Both types of enterprise are currently operating on the Border Rivers irrigation system.

The first set of scenarios are referred to as the BASE scenarios and are numbered one to six. In these scenarios irrigators were assumed to resolve their land development decision on the basis that they assume water supply will be perfectly reliable. That is, in these scenarios irrigators take account only of their nominal entitlement volume when deciding the appropriate area of land to develop for irrigation. As a consequence the area of land developed in each of these scenarios was increased as the entitlement volume increased. This is depicted graphically in Figure 2a. Each scenario can be distinguished by the particular reliability level associated with it (defined as the average percentage of entitlement supplied over the simulation period). The purpose of the BASE scenarios then, was to provide a benchmark against which the sets of scenarios which incorporated a different hypothesis concerning the ways in which irrigators' formulate expectations about supply reliability, could be compared.

Table 1: Table of Scenarios

Run	Long run reliability level %	Licensed Entitlement (ML)	On-farm storage (ML)	Area developed (ha)
BASE SCENARIOS				
1	100	750 000	50 500	106 733
2	75	1 125 000	50 500	156 733
3	60	1 371 875	50 500	189 650
4	50	1 595 500	50 500	219 467
5	30	2 649 500	50 500	360 000
6	15	5 199 500	50 500	700 000
ENTITLEMENT SCENARIOS				
7	100	750 000	50 500	106 733
8	75	1 125 000	50 500	156 733
9	60	1 371 875	50 500	189 650
10	50	1 735 863	50 500	201 150
11	30	2 869 000	50 500	198 000
12	15	6 027 888	50 500	195 000
STORAGE SCENARIOS				
13	100	750 000	175 000	106 733
14	75	1 125 000	262 500	156 733
15	60	1 371 875	960 313	189 650
16	50	1 735 863	405 035	201 150
17	30	2 869 000	669 433	198 000
18	15	6 027 888	1 371 647	195 000

In the second set of ENTITLEMENT scenarios (numbered seven to twelve) irrigators were assumed to adjust their land development decision in line with a different formulation regarding expectations about supply reliability. Two major problems were faced when formulating these scenarios. First, developing a plausible representation of the way in which irrigators form expectations about reliability, and second, how to incorporate the impact of these expectations into irrigators' decisions concerning land development.

To begin with, it was assumed that irrigators' expectations about the long run reliability matched the actual reliability. In order to achieve this situation, the model was iteratively run until actual reliability closely approximated an assumed expected reliability.

A number of options were considered in an attempt to resolve the problem as to how irrigators' expectations impact upon their decision concerning the area of land to develop for irrigation. One option considered was to determine the developed area according to the average allocation. However, because irrigators will receive a supply greater than the average allocation a significant amount of time, such a rule was considered unrealistic. Eventually a rule was selected which was thought to take into account both the advantages associated with developing an area which would enable irrigators to plant a large area when high allocations are announced, while paying due regard to the development costs involved.

Preliminary analysis revealed that for reliability levels below 60 per cent, the maximum allocation observed was usually about 1.67 times the value of the average allocation over a simulation run. At reliability levels of 60 per cent and above, the maximum allocation observed was 100 per cent. Given this result, it was thought that a plausible rule might be that irrigators would develop an area consistent with their expectations concerning a maximum allocation. Consequently, the developed area rule used in the Dumaresq Irrigation Project (Kaine-Jones et al. 1990) was modified such that irrigators were assumed to develop an area consistent with a maximum expected allocation which was given by 1.67 times the average allocation. This rule can be represented by the following formula:

$$AD = ([1.67.EA.LV] + OS)/7.5$$

Where AD represents the area developed (ha), and OS is equal to the capacity of on-farm storage (Ml). The term in square brackets [1.67.EA.LV] is the product of the volume of entitlement, LV, and the expectation of a maximum allocation of 1.67 times the mean allocation, EA. The bracketed term, then, represents the irrigator's expectation of maximum announced allocation.

Figure 2b illustrates how the above rule affects the land developed in these scenarios. Contrary to the first set of BASE scenarios, the area developed by irrigators represented in these scenarios does not increase indefinitely with increasing levels of volumetric entitlement, but declines in response to declining reliability levels below 50 per cent.

In the ENTITLEMENT scenarios the level of on-farm storage on the system and the developed area associated with this level of storage were held constant at the corresponding capacity and area currently existing in the Border Rivers. By holding the storage capacity constant, the effects of the expectations rule could be

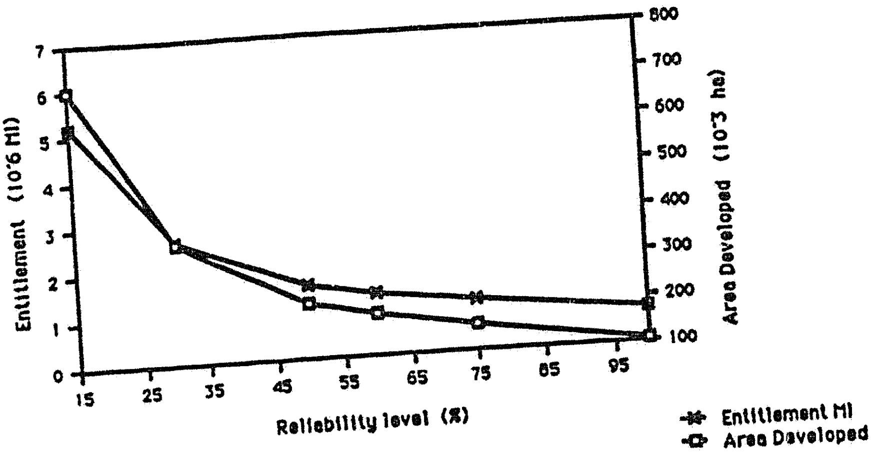

Figure 2a : Area Developed for BASE runs.

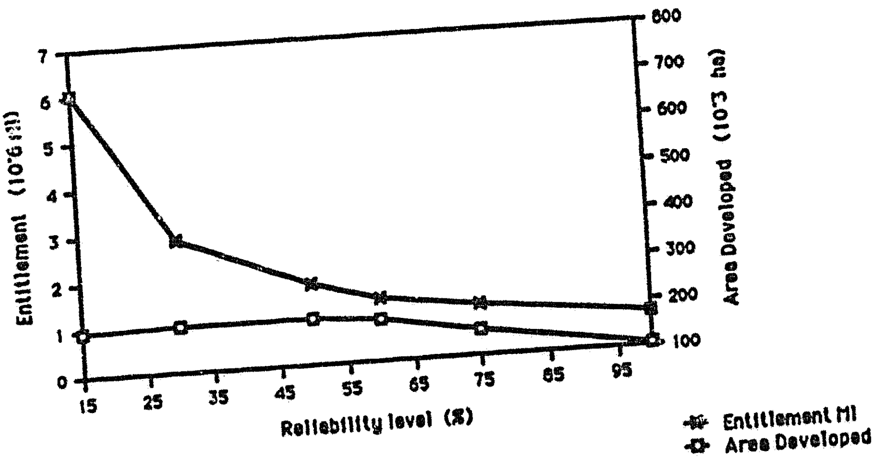

Figure 2b : Area Developed for Runs Incorporating Expectations Rule.

explored in isolation. Also, by setting the storage capacity and the developed area to those associated with enterprises with on-farm storages currently operating on the system, the implications of further irrigation development for these irrigators could be explored.

Although it was recognised that expectations about supply reliability would play a role in the decision to invest in on-farm storage, as well as the land development decision, this was not directly addressed in this study. This was not attempted because such a consideration would have involved developing quite complex rules concerning the reliability of unregulated flows as well as regulated supplies, and it was not possible to do this within the constraints of the study. Therefore the development decision concerning investment in on-farm storage was addressed by conducting simulation experiments with various levels of storage in the model. These experiments are referred to as the STORAGE scenarios, numbered 13 to 18 in Table 1.

There is a matching STORAGE run for each ENTITLEMENT run. The entitlement and the area developed for each STORAGE run are the same as for the matching ENTITLEMENT run. The difference is that the capacity of on-farm storage was progressively increased in the STORAGE runs as reliability levels were reduced. The level of storage construction in the STORAGE scenarios was determined on the basis of the storage capacity currently existing in the Border Rivers. That is, it was assumed that for each STORAGE run seventy per cent of irrigators (by entitlement volume) were assumed to possess on farm storage. On the same basis, the capacity of their storage was set at one-third the volume of their entitlement. Although somewhat arbitrary, this approach seemed reasonable given the time and resource constraints.

For all three sets of scenarios it was assumed that all new entitlements were issued to new enterprises on the system. This enabled the predicted impacts of increased levels of development on existing enterprises to be examined. In addition, it was assumed that the size (in volumetric units) of new entitlements issued to new enterprises would be consistent with the size of those currently held by irrigators on the Border Rivers system.

<u>Evaluation Criteria</u>

Each scenario was evaluated at both the regional and individual farm level. The measures used to compare scenarios at the regional level were average regional gross income from cotton production and the variability in gross income, along with the corresponding measures for net income.

At the individual farm level five measures were adopted as economic indicators. First, average gross margin per hectare and the variability in the gross margin were used as initial indicators of the profitability and riskiness of irrigation enterprises. In addition, the probability of a negative income was used.

The final two measures for comparing scenarios at the individual farm level were the average net income per developed hectare and the variability in new income. These two measures were used to indicate the impact of changes in the relative reliability of allocation and off-allocation supply upon the profitability and riskiness of enterprises with and without storage.

RESULTS

The ENTITLEMENT and BASE scenarios

The most significant result of the ENTITLEMENT scenarios when compared to the BASE runs was that the economic performance of the scheme at reliability levels below 60 per cent was better for the ENTITLEMENT scenarios than for the BASE scenarios. The model predicted that the average area planted for the runs which incorporated the expectations rules was higher and less variable than that for the corresponding BASE runs. As a consequence the average regional income was also higher and less variable in the ENTITLEMENT runs. These results are illustrated by Figures 3a and 3b.

As a consequence of the different manner in which expectations were formulated and incorporated into the irrigators' decisions concerning land development, the level of entitlement at which gross regional income was maximised was predicted to decline by 34.5 per cent in the ENTITLEMENT scenarios when compared to the BASE runs. In the BASE runs a maximum gross regional income of $134 million was achieved at an entitlement volume of 2.6 million Ml and a developed area of 360 000 hectares (and at a reliability level of 30 per cent). While in the ENTITLEMENT runs a maximum value for gross regional income of $136 million was predicted for an entitlement volume of 1.7 million Ml and a developed area of only 201 150 hectares (and a reliability level of 50 per cent).

Since the expectations rule does not impact on the land development decision until reliability levels fall below 60 per cent, the results for both the BASE and ENTITLEMENT scenarios are the same for reliability levels of 60 per cent and above. Therefore, for both sets of scenarios, net income was maximised at an entitlement volume of 750 000 Ml, a developed area of 106 733 hectares, and a reliability level of 100 per cent.

At reliability levels below 60 per cent, regional net income was predicted to be higher and less variable in the ENTITLEMENT runs when compared to the corresponding BASE runs (Figures 4a and 4b). In fact, at a reliability level of only 15 per cent, the regional net income from cotton production in the ENTITLEMENT runs was predicted to be only 14 per cent lower than the predicted maximum of $ 80 million. While in the BASE runs the regional net income to cotton production at the same reliability level was predicted to be negative This result was to be expected given that the area developed in the BASE runs was assumed to increase with increasing levels of entitlement, despite the decline in reliability levels. This reflects the decreasing ability of irrigators to service their developed area as water reliability declines and becomes more variable.

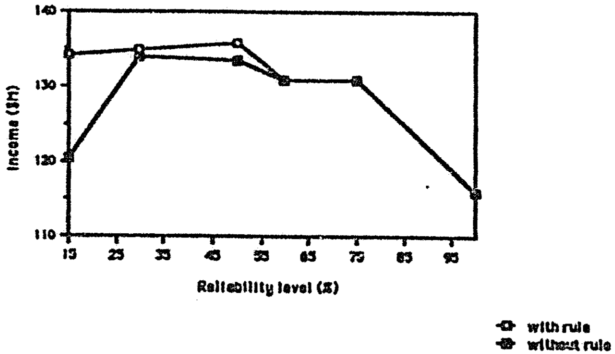

Figure 3a : Regional Gross Income With and Without Expectations Rule

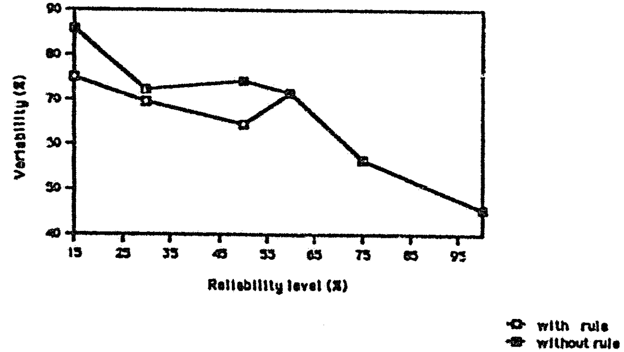

Figure 3b : Variability in Regional Gross Income With and Without Expectations Rule

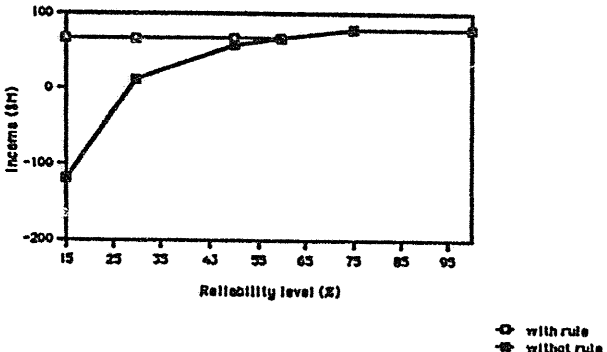

Figure 4a : Regional Net Income With and Without Expectations Rule

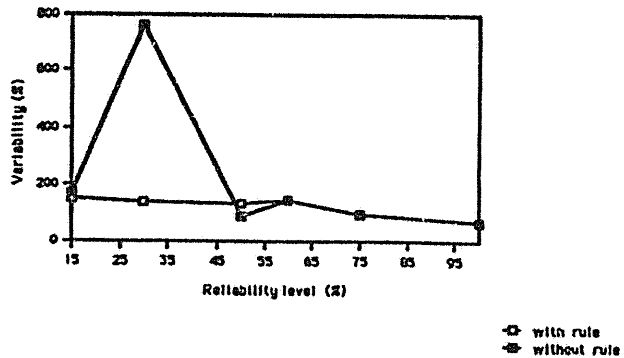

Figure 4b . Variability in Regional Net Income With and Without Expectations Rule

An interesting result with respect to the ENTITLEMENT runs was observed when the performance of the new enterprises and existing storage enterprises was compared. Figures 5a and 5b, illustrate that at reliability levels above 50 per cent existing enterprises with on-farm storage were predicted to experience higher net income per hectare than the enterprises with entitlement only. However at reliability levels below 50 per cent enterprises with storage were predicted to receive lower net income per hectare than enterprises with entitlement only.

This occurred because at high reliability levels the scale of irrigation development would be sufficiently low in relation to water supply to enable irrigators with storage to supplement reasonably reliable regulated supplies with unregulated tributary flows. However, as the entitlement volume and the developed area associated with new enterprises on the system was increased (and therefore the demand on regulated supplies was increased), the degree to which unregulated flows could be used to supplement regulated supplies declined.

This situation was compounded by the fact that the developed area associated with the existing storage enterprises was held constant regardless of water supply reliability, while the developed area associated with new enterprises was adjusted down in line with irrigators' expectations concerning maximum allocations. Consequently, as water reliability declined, the financial performance of existing enterprises tended to worsen more rapidly than did that of the new entitlement enterprises.

Given that the storage enterprises were intended in the ENTITLEMENT runs, to represent the existing irrigators with on-farm storage on the Border Rivers system, the above finding suggests that there is the potential for the high levels of irrigation development resulting from the diversion scheme to adversely affect irrigators currently operating in the Border Rivers system.

The STORAGE scenarios

As previously mentioned the main objective of the STORAGE scenarios was to investigate the impact of investment in on-farm storage on the performance of the irrigation scheme. The most interesting result of these scenarios was their relative performance when compared to the ENTITLEMENT scenarios.

In the STORAGE scenarios, average gross regional income was maximised at $134 million when the level of storage on the system was set at approximately 700 000 Ml (and reliability was 30 per cent). This value was less than the maximum achieved in the ENTITLEMENT runs which was previously noted as $ 136 million (at a reliability level of 50 per cent with total on-farm storage set at 50 500 Ml).

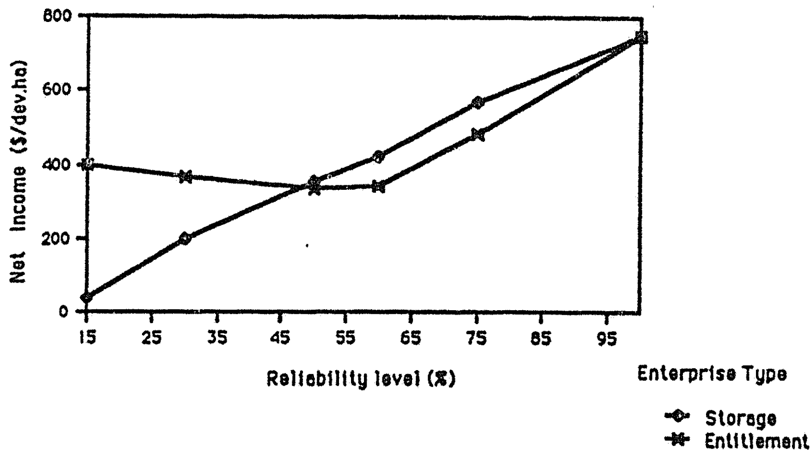

Figure 5a : Average Net Income per hectare - ENTITLEMENT Runs

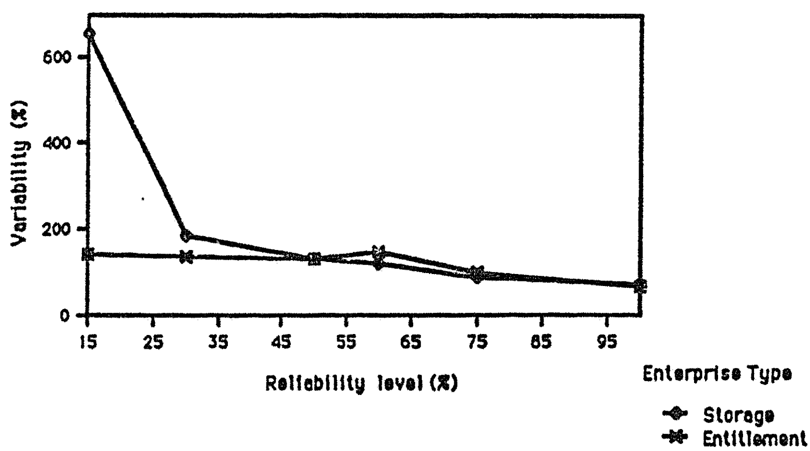

Figure 5b : Variability in Net Income per hectare - ENTITLEMENT Runs

Although the maximum regional gross income predicted for the STORAGE runs was less than the maximum for the ENTITLEMENT runs, the economic performance of some of the scenarios was improved with the addition of storage. Figures 6a and 6b, and 7a and 7b, illustrate that the addition of the specified storage capacities at 75 per cent and above resulted in an improvement in the economic performance of the system when compared to the matching ENTITLEMENT runs. However, at reliability levels below 75 per cent apparently counter intuitive results were obtained. That is, the model predicted that irrigators would be made worse off by investing in storage, even though the area developed was not increased as a result of increasing the capacity of on-farm storage.

The reasons for this decline were found to lie in the predicted overall decline in the reliability of the system due to investment in on-farm storage, a decline in the frequency and volume of off-allocation flows with decreasing reliability, and as a result of the scale of irrigation development relative to the volume of tributary flows entering the system below the headwater storages.

As a consequence, the investment in on-farm storage appeared to be not only of little value to the individual enterprise when water supply was unreliable, but in fact was predicted to lower the profitability and increase the riskiness of irrigated cotton enterprises.

CONCLUSIONS

This paper has demonstrated to some degree the way in which long term supply reliability, irrigators' expectations about supply reliability and investment in on-farm storage can affect the performance of an irrigation system. The results raise a number of policy issues of direct relevance to the management of the Newton Boyd scheme in particular, and irrigation schemes in general. Those of particular relevance to the Newton Boyd scheme are the first to be discussed.

The implications of particular significance to the diversion scheme involve the value of storages and the management of off-allocation flows. Depending on the scale of development there may be little or no value in irrigators investing in on-farm storages. In fact, in some circumstances if irrigators were to invest in on-farm storage, the aggregate impact of doing so would be to reduce the economic benefits arising from the diversion, in total and for individual irrigators. This may be a serious issue for those responsible for the management of the scheme, should it be developed, as it has become standard practice for irrigators to invest in on-farm storage on the Border Rivers system in order to supplement unreliable regulated water supplies.

The second issue of relevance to the diversion scheme relates to the management of off-allocation flows and follows on from the first. Presently, irrigators in the Border Rivers have unrestricted access to off-allocation flows. The results of the analysis indicate that the frequency of off-allocation flows is seriously reduced by the scale of development likely to accompany the Newton Boyd scheme. Recognising that access to off-allocation flows influences investment in on-farm storage, this implies that management authorities may have to develop policies concerning access to off-allocation flows as development occurs.

Those issues of general relevance to irrigation schemes relate to long run reliability levels, irrigators expectations of reliability and the impact of these expectations on irrigators' investment decisions. Consequently the relevant management authority must be sensitive to the impact of these expectations on the development decisions of irrigators if the economic benefits of the scheme are to be maximised.

The results imply that irrigators should perhaps be supplied with information concerning the intended long term supply reliability and access to unregulated flows at the commencement of a scheme to enable them to properly resolve land development and storage decisions. Otherwise, early entrants may well incur losses as the system develops and reliability levels decline. As a consequence, issues may then arise concerning the compensation of irrigators for losses incurred as a result of substantive changes in management policy, or as a result of additional development on an existing irrigation system.

In conclusion, if the issues discussed in this paper are not considered in the formation of management policy, then a sub-optimal outcome is likely. In the paper a range of complex issues were addressed. Not the least of these issues is the way in which irrigators formulate expectations about water supply reliability. The incorporation of these expectations into development decisions has been shown in this paper to influence the economic returns from social investments in irrigation schemes.

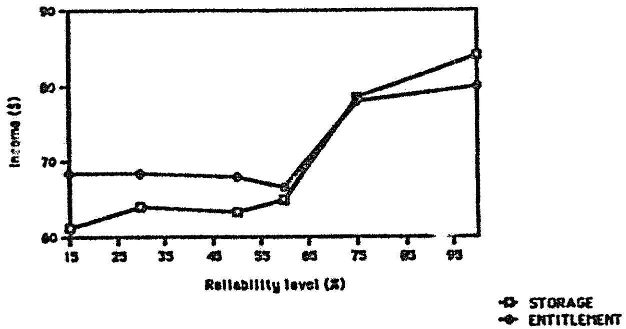

Figure 6a : Average Regional Net Income.

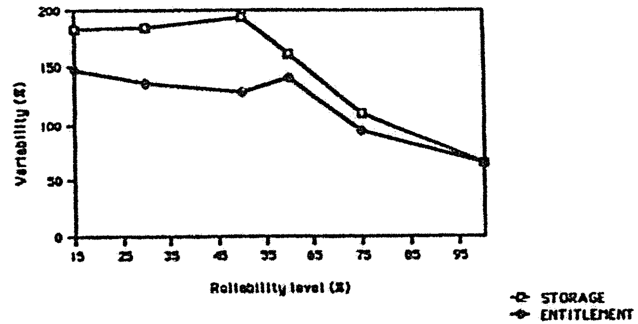

Figure 6b . Variability in Regional Net Income.

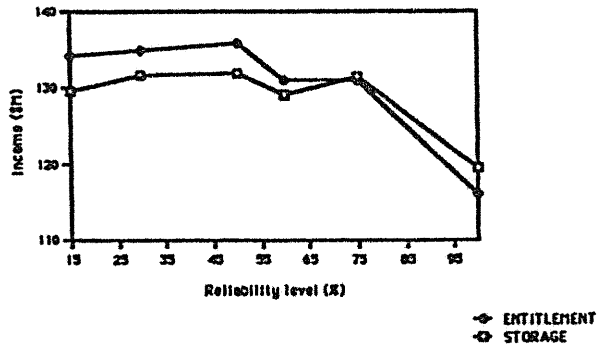

Figure 7a : Average Regional Gross Income.

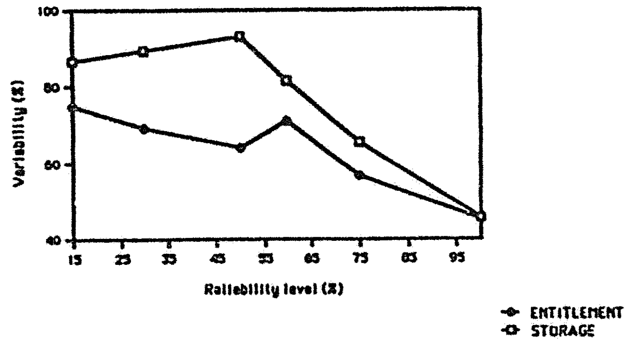

Figure 7b . Variability in Regional Gross Income.

Appendix 1

The Border Rivers Economic Module

The first decision rule describes the area planted to cotton, given farmers' expectations about water supplies. This rule is represented by the following equation:

$$A = (EA.LV + S) / (R - HF)$$

where

A	=	area planted (ha)
EA	=	expected final allocation (a value between 0 and 1)
LV	=	licensed entitlement (ML)
R	=	estimated seasonal crop requirement (ML/ha)
HF	=	estimated crop requirement for an irrigation (ML/ha)
S	=	volume of water in on-farm storage (ML)

The crop requirement parameter was set at 7.5 ML/ha, and sensitivity analysis by the model's developers revealed that the predictions of the model were not sensitive to reasonable changes in this parameter (Kaine-Jones et al., 1990).

For the purposes of this study two types of cotton irrigators were considered. Irrigators dependent on entitlement only, and irrigators with both an entitlement and on-farm storage. For irrigators with entitlement only, the storage volume (S) and estimated crop requirement for an irrigation (HF) were set to zero. Irrigators with storage on the other hand expect to obtain one irrigation per season from off allocation flows which are pumped into their on-farm storages. Given that the estimated crop requirement for a single irrigation is 1.1 ML/ha, the HF parameter was set at this value.

The second decision rule was developed to describe irrigators expectations about final allocations. Irrigators were assumed to use a three year moving average procedure in forming expectations about final allocations. This rule is written algebraically as:

$$EA = 0.33 \sum_{i} (F_{-i} / I_{-i}) \quad i = 1,3$$

The rule can be conceived as a learning rule, where the expected final allocation (EA) is an average of the ratio of final (F) to initial (I) allocations, over a three year period.

The final rule considered here represents production cutbacks carried out by irrigators when shortfalls in water supply occur late in the season. That is:

$$AI = A (SW/DW)$$

where

AI	=	area to be retained fully irrigated (ha)

A = area planted (ha)
SW = the water supply available for irrigation (ML), and
DW = the demand for irrigation water (ML)

This cutback rule rarely comes into operation because the headwater storage management system is designed to deliver the announced allocation 95 per cent of the time. Consequently, shortfalls late in the season are unusual and normally small (Kaine-Jones et al., 1990).

Appendix 2

The Integrated Hydrologic and Economic Model

The hydrology and economic modules were integrated in a study of the Dumaresq Irrigation Project. The following draws largely on the report of that study (Kaine-Jones et al., 1990) and a representation of the model adapted from the report is presented in Figure 3.3.

The diagram illustrates the operation of the integrated model beginning with the input of streamflow data and system management parameters into the hydrology module. The model processes this information to produce initial allocations at the beginning of the cotton season. The planting rule previously outlined than uses information on initial allocations and on-farm storage volumes to determine the area of cotton planted.

The Enterprise Management sub-module (a component of the economic module) then calculates the available water supply. At this stage the module also determines whether or not off-allocation is declared and updates allocation accounts. Given the supply of available water, the Enterprise Management sub-module uses the production cutback rule to determine whether cutbacks are required.

At the end of the season irrigation supplies, demand, areas, planted, and price data are used as inputs into the Financial Operations sub-module which calculates Gross Margins, Net returns and regional income from cotton.

Finally, the financial information from the economic module and the appropriate hydrological parameters are passed to the Risk Assessment sub-module which provides information on supply reliability, income variability, and the probabilities of achieving certain income levels, allocations and areas planted over the simulation period.

The capacity of the model to describe reality in the Border Rivers was verified by Kaine-Jones et al.(1990). When the development parameters were set at levels currently existing in the Border Rivers (ie. entitlement level,area developed, capacity of on-farm storage) the model's predictions about the area planted and supply reliability were reasonably accurate.

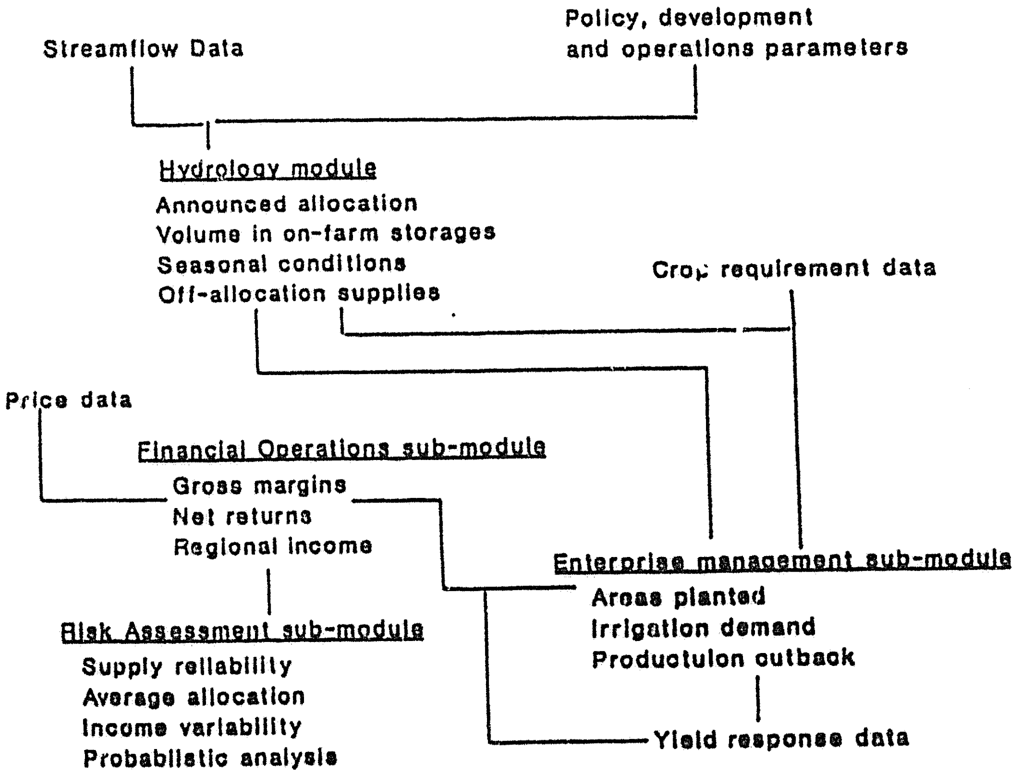

Fig 1. The integrated Border Rivers Model.
Adapted from Kaine-Jones et al. 1990.

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