Chapter 1

INTRODUCTION AND OUTLINE OF STUDY

1.1 Introduction

Australia is a relatively dry continent. Its rainfall is sparce , fickle and unreliable. On most cultivated lands, rainfall is the major source of water for agricultural activities. Watson, et al (1983, p.1) commented that "low and variable rainfall and scarce supply of good quality of water have always been limiting factors to development of its agricultural sector". The availability of water, therefore, plays a major role in determining the pattern, location and profitability of agricultural production in Australia and has been given a prominent place in the country's rural-regional growth and development. The importance of water has often been addressed by drawing attention to the comparative scarcity, by world standards, of available water resources and to the fact that rural-regional growth and development could eventually be curtailed, because of the paucity of this essential natural resource (Dunk, et al, 1967). This situation has influenced the country to concentrate endovours on water problems, search for additional sources of water resources to accommodate the rapidly expanding rural-regional development needs. Gallagher (1972, p.1) observed that "much less attention has been given to the problem of utilizing the available supply of water more efficiently among the competing uses and users"; rather Australian water policy has emphasized the development of new sources of water supplies.

Following the construction of Keepit dam in 1961, most of the farmers adopted irrigated agriculture in the Namoi valley. As a result, considerable changes have occurred in land use patterns. The landowners realised the possibilities of using irrigation water to support a wide range of crop enterprises including cotton, wheat, vegetables and a varieties of oilseed crops. The Water Resources Commission Report (1984b) showed that about 90 per cent of all surface water used for irrigation purpose was extracted from regulated flows. In recent years, the use of ground water has also been increased in the valley. About 75-80 per cent of the irrigators, particularly in the lower Namoi valley, where most groundwater irrigation occurs, have both bore and surface water licenses. Consequently, change in surface water use in the area has been reflected in groundwater use and shortfalls in surface water allocations are made up from groundwater. With a situation of surface water being over-committed, groundwater has been extensively developed almost to the point of maximum extraction. This compelled the Commission to declare the lower Namoi valley as a 'restricted sub-surface water area' in 1980.

In view of the relatively higher returns, allied to suitable soils and climatic condition, irrigated cotton has been established as a principal crop in the valley and production of cotton has been stabilized at peak alongwith cereal production. Evidence suggests (Verdich, Bryant and Buffier 1984) that irrigation licenses in the valley have become heavily utilized. This high level of utlization is a matter of great concern to the present Namoi water users in general, and the cotton industry in particular, due to the fact that the Keepit dam does not have sufficient capacity to service existing licensee irrigators in the most economically efficient way. Moreover, there have been growing demands from the dry landholders for irrigation water for their crops. Under such a situation, the New South Wales Government responded with a decision to construct Split Rock dam across the Manilla river at a total cost of $47.17 million with the purpose of developing its water resource mainly for agricultural uses (Split Rock Dam Act 1983 (Revised)).

1.2 The Problem

In spite of the fact that irrigation has been an integral part of the development of rural Australia, the concern of economists is to look at the social profitability of irrigation projects in terms of efficiency in public investment. Investment decisions regarding the use of scarce resources by irrgation projects should be made only after a range of possible alternative options have been considered. This is particularly so in the field of water resource development, which is capital intensive in nature, and highlights the importance of ensuring the initial correctness of investment decisions. Clearly, once capital has been expended on the construction of a dam, there is no way to turn back, even if the project is a complete failure. If uneconomic projects are not undertaken, the capital fund could be invested elsewhere in the economy, which would benefit the community from increased income through wiser alternative investments.

In recent years, there has been controversy regarding the viability of the construction of dams on the rivers of New South Wales. A growing body of professional and public opinion feels that the planning of water resources development has often been based on inadequate data, investigation and research (Blandford et al. 1977). A case in point is the Split Rock dam now being constructed. The dam is expected to provide an additional source of about 50,000 megalitres of water. This additional supply from the regulated stream flows will help the Namoi irrigators to derive increased farm income. On the other hand, the dam, apart from a significant amount of public investment for its construction and operation, will diminish all possibilities of agricultural and grazing practices in the upstream areas needed for storage and construction purposes. Therefore, vital questions arise from this controversial investment decision. What are the costs and benefits associated with the construction of the dam ? What policy should be adopted to maximise the efficiency of invested public resources ?

In a country like Australia, where the rate of growth and development depends greatly on sound investment of a scarce stock of capital resources, an effective appraisal of development programs and projects is of great importance. In the past, investment appraisal of water development projects, designed especially for irrigation purposes, seems to have been inadequate (Wesney and Woolcock 1978). It is perhaps relevant to quote the comment of the Vernon Committee, which is still true twenty years after the Committee published its report.

> " We cannot safely continue to assume that the development of irrigated lands is economically desirable, and we should consider that before new irrigation works are proceeded with, the most accurate possible assessment of costs and benefits

> should be made, if the nation is to get the best value from its capital expenditure, and if an informed body of opinion is to be brought to bear on discussions on such matters" (Vernon et al. 1965, para 3.25).

Against this background, the present study is designed to undertake an <u>ex-ante</u> assessment of costs and benefits of the Split Rock dam primarily from the viewpoint of the society as a whole.

1.3 Objective of the Study

This study attempts to formulate an effective policy-guide for maximising the efficiency of resources being invested in Split Rock dam based on a partial equilibrium approach. It focuses attention on the direct effects of the project; that is, the benefits are measured as the total willingness to pay by all individuals for the direct inputs of the project. Based on the problem discussed in the previous Section, the specific objectives of the study are as follows :

i. to assess the increased financial returns to individual farmers;

ii. to assess the profitability from the viewpoint of society;

iii. to determine the implications of the project; and

iv. to suggests policy guidelines/recommendations.

1.4 Hypotheses

The following hypotheses are tested.

i. Construction of the dam is not socially profitable.

ii. The rate of return to participating individual farmers is less than the opportunity cost of capital.

1.5 Justification of the Study

In a competing economy it is important to examine the efficiency of resource use inter alia with other competing economic opportunities. It is understood that the Water Resources Commission had conducted a benefit-cost analysis of the dam. That study was confidential and has not been made available for general public use. The present study is designed to conduct both an economic and a financial analysis, including sensitivity analysis, with key parameters and extended over 50 years of economic life of the project. This study should provide useful information to understand the worth of the public investment made in constructing the dam and to create awareness in investment decision making in future projects of a similar nature. This study should, therefore, be useful at both the national and farm levels.

1.6 Plan of the Study

This study comprises seven chapters. Chapter 2 provides the background of the project: land, climate, beneficiaries, capacity of dam, financing, operational policy etc.. It also provides information on the present land use pattern and probable crops to be grown on the completion of the dam. Chapters 3 and 4 briefly review the available methods of project appraisal, the theoretical basis of benefit-cost analysis and the conventional efficiency analysis (Gittinger 1982) and its application technique for project appraisal. Chapter 5 presents the analysis of the profitability of the dam from the viewpoint of the individual farmer and that of the society. Chapter 6 embodies the results of the appraisal and discusses the implications of the project. Chapter 7 presents a summary of the conclusions of the study, discusses policy issues and outlines suggestions for further research.

Chapter 2

BACKGROUND TO THE PROJECT

2.1 Introduction

Irrigated agriculture in New South Wales has dramatically incressed in recent years. This has happened for a number of reasons, of which the main ones are the regulation of surface water flows in major rivers, an increase in the expertise of farmers in irrigation agriculture and the relative strength of incentives to produce at a higher level. The principal sources of irrigation water are rainfall, surface water and groundwater. The area irrigated each year depends on the availability of water from various sources and is significantly affected by the magnitude of rainfall. Irrigation absorbs about 75 per cent of total water usages in New South Wales. The typical water use in New South Wales is shown in Table 2.1.

The table shows that in a normal climatic year, over 7000 gigalitres of water is used in the New South Wales. About 90 per cent of this water comes from surface water sources and the rest basically from groundwater (Water Resources Commission Report 1984b).

As in other states, the water economy of New South Wales has two distinguishing features. One feature is the irrigation areas, irrgation districts and irrigation trust districts developed and operated by Government departments under the banner of closer settlement. The other feature is the use of water by private irrigators. A high degree of irrigated agriculture has been taking place through the private diversion of water from the inland rivers such as the Namoi, Gwydir, Macquarie, Lachlan etc.. The irrigation development along these rivers, apart from the construction of the main storage facilities, is undertaken with private capital. The main aspects of the development of water use have been identified by Davis (1968, p.663) in which he suggests the following.

Table 2.1

Typical Water Use in New South Wales

Region	Irrigation		Urban		Rural Domestic and Stock		Industrial		Total	
	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW
North Coast	46	1	48	6	33	19	1	2	128	28
Hunter	85	58	75	25	10	12	66	*	236	94
Sydney-Woll.	35	2	706	*	5	3	45	16	791	21
South Coast	13	1	24	2	12	2	1	*	50	5
Murry	1680	12	15	*	16	5	2	*	1713	17
Murrumbidgee	1800	38	30	13	107	16	*	1	1937	68
Lunchlan	290	18	13	3	55	17	2	*	360	38
Macquarie	400	12	38	7	51	35	2	*	491	54
Namoi	180	170	10	10	23	50	*	*	213	230
Gwydir	400	10	3	4	21	11	*	*	424	25
Boarder Rivers	68	2	2	2	16	7	2	*	88	11
Darling	100	*	12	1	66	64	*	*	178	65
Total	5097	324	976	72	415	241	121	19	6609	656

* Less than one gigalitre.
SW = Surface Water
GW = Ground Water

Source : Water Resources Commission Report, 1984 "(a) Adequate provision of regulated water supplies by construction of large storage reservoirs;

(b) Conversion of area from dryland farming or supplimentary irrigation to incentive irrigation by one or more of the following methods :

(i) compulsory water charge for a minimum quantity of water whether used or not; and

(ii) land distribution for the purpose of closer settlement.;and

(c) Control of water diversion, land use and irrigation systems by a central state agency."

2.2 Water Rights in New South Wales

The water rights system, which controls the allocation of private diversions in New South Wales, is specified in the Water Act 1966 (Lesueur 1969, Part 2, Section I and II). The irrigators must make application to the Water Resources Commission, the administrative authority in the New South Wales irrigation water industry, to acquire a water license. Hence, the control component of the New South Wales water rights system is limited to individuals who have been granted licenses. A basic irrigation license is given for a maximum of 972 megalitres for a period of four years. Water licenses do not guarantee the availability of water. The actual allocation of water is determined before the start of cropping season each year by the Water Resource Commission depending on the storage situation. Each license holder then has a coequal right to use the available supplies. Off allocation of water often becomes available in specific time periods during times of surplus river flows. The licensee may then lift any quantity of water from the stream flows during that period without debit to their allocation (Lesueur 1969; Musgrave 1968; Gallagher 1972).

2.3 Development of Irrigation in Namoi Valley

The prospects for irrigation in the Namoi valley have been discussed sporadically since the beginning of the nineteenth century. Until the 1950's, no significant development had taken place towards irrigated crop production in the valley. In 1958, an experimental farm was established between Narrabri and Wee Waa by the New South Wales Department of

Agriculture with the purpose of determining the general agronimic, economic, and water requirements of various potential crops in the region. Field trials were conducted with various crops including cotton, grains and fodder sorghums and pasture species under irrigated condition in the experimental farm. The results achieved showed that irrigated cotton could be the most profitable to farmers. The Keepit dam study (1969, p.54) quoted an observation of the Water Resources Commission that "a study of the economics of the irrigated production indicates that, with the present guaranteed price, cotton production under irrigation in the Namoi valley in the vicinity of Wee Waa will be remunerative and with experience and improvement of strains, it will become highly remunerative, even with a substantial reduction in the guaraneed price ".

The first commercial crop of 26 hectares was produced by two immigrant farmers from U.S.A. in 1962 just after the completion of the Keepit dam. Their success attracted more American farms and investors, while forty Australian farmers also turned to irrigated cotton production. The irrigation technology imported by the Americans in cotton growing rapidly spread not only to Australian cotton growers but also to irrigators of other crops. The most spectacular land use change has been the successful cotton growing in the Namoi plain particularly in the Narrabri-Wee Waa areas (Lea et al. 1977). In the 1970's, the demand for irrigation water in the valley had been increased significantly due to the high profitability of irrigated crops, cotton in particular. Some farmers had even installed bores and recirculating systems to supplement their surface water allocation, while others had constructed on-farm storage to avail themselves of surplus river flows. Importantly, there there has been an extensive development of groundwater extraction in the lower Namoi valley (Water Resources Commission Report 1984b). The area under surface and groundwater irrigation in Namoi valley during the period from 1973/74 to 1982/83 is given in Table 2.2.

2.4 Nature and Purpose of the Project

The original Split Rock Dam Act was passed by the New South Wales Parliament in 1974, but did not undergo implementation until 1983, when its purpose was redefined as follows:

Table 2.2

Area under Surface and Groundwater Irrigation in Namoi Valley

Year	Lucerne	Pasture /fodder	Cereal /Wheat	Oilseed	Veges	Cotton	others	Total Area	Water Used (ML)
Surface Water Irrigation (Ha)									
73/74	1369	2611	3402	-	91	15094	588	23155	136297
74/75	1342	2313	7554	-	53	16511	610	28383	169299
75/76	1669	2153	11435	-	86	13726	284	29353	114984
76/77	1271	1202	9242	-	77	13726	410	25928	124165
77/78	1496	1943	13241	-	150	15938	479	33247	168090
78/79	875	1667	3312	-	80	18874	4273	29081	163559
79/80	1336	1688	4877	3634	17	19518	266	31336	213756
80/81	1114	2378	4286	326	27	15100	190	23421	107553
81/82	2141	1030	5984	1157	33	17868	595	28808	146706
82/83	1416	814	2411	85	25	9145	655	14551	56456
Ground water Irrigation (Ha)									
75/76	313	513	5801	-	85	2216	959	9887	37737
76/77	269	653	5377	-	53	1334	2313	9999	35525
77/78	278	821	5864	-	59	3812	2770	13604	53416
78/79	303	430	6349	-	165	8463	2135	17844	56383
79/80	514	2129	7280	-	38	5362	4388	19711	89225
80/81	874	2750	10466	-	59	15741	3412	33302	150596
81/82	1220	2826	11477	-	149	15306	2608	33586	121200
82/83	1333	3015	18436	-	164	17890	4544	45387	204484

Source : Water Resource Commission Report, 1984b.

"Works for or associated with conservation of water for improvement of supplies for irrigation, stock, domestic, urban and industrial purposes in the Namoi River Basin, comprising the construction of (a) a dam accross the Manilla River about 19 kilometres north of town of Manilla,..............., of a height sufficient to store about 372,000 megalitres of water, with subsidiary banks accross saddles in the storage rim" (Split Rock Dam Act, No. 143, 1983, Schedule 1, Section 1).

It is envisaged that a total quantity of 50,000 megalitres(approx.) will be available for irrigation use annually (Verdich, Bryant and Buffier 1984).

2.5 Location and Project Area

Split Rock dam is located about 19 kilometres north of the township of Manilla on the western slopes of the eastern uplands and lies approximately in the centre of the New England region (Lea et al. 1977). All together 14,500 hectares of private land have already been acquired for the construction of the dam, storage, catchment management and foreshore protection purposes. The storage of the dam would innundate 2,050 hectares of farming land at full supply level. Twelve properties would be fully affected and a further 18 properties would also be partly affected by the project. The beneficiaries of the dam are mainly the farms located downstream of Split Rock dam as well as Keepit dam in the Northwest slopes and plains of New South Wales. The location of the Split Rock dam and beneficiary farms is shown in the attached Maps.

2.6 Physio-Climatic Characteristics

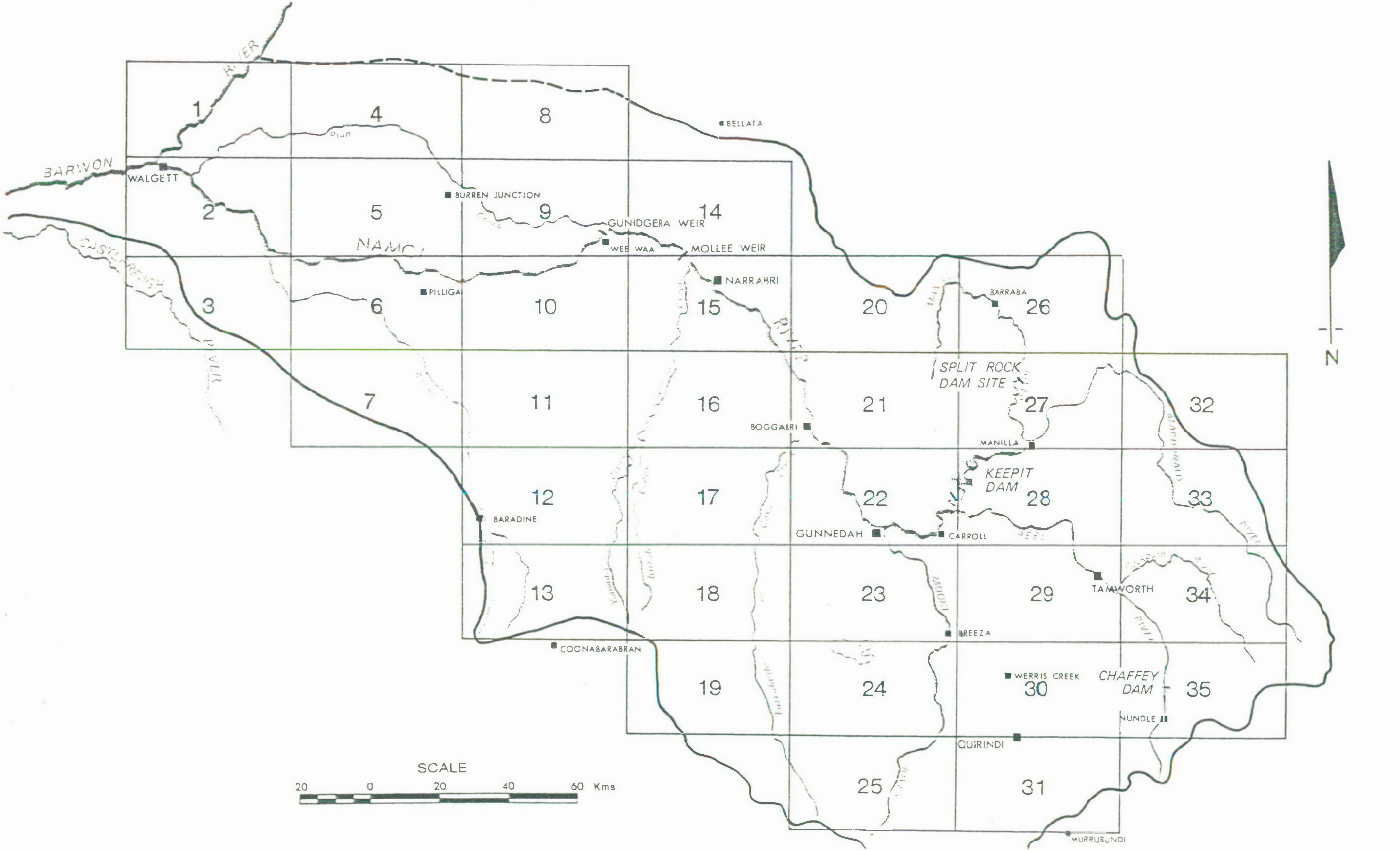
It has already been mentioned in Section 2.5 that the dam site and storage facilities, and the water users are located in two different areas. The physio-climatic characteristics of these two areas are, therefore, varied and distinct. A brief discription of the physio-climatic characteristics of the project area is provided in the following sub-sections :

Map 2.1

STATISTICAL AGRICULTURAL AREAS
of
NEW SOUTH WALES
SCALE
50 0 50 100 200
Kilometres
Kilometres
REFERENCE
Statistical Agricultural Areas ...... WESTERN PLAINS
Boundaries ......
Statistical Subdivisions .... 11a.Upper Murray
Boundaries ......
Local Government Areas*
Cities and Municipalities .... Dubbo 105
Shires 147
Boundaries ....
†Local Government Area Boundaries are as at 30 June 1984.
See overleaf for Numerical and Alphabetical Indexes.
STATISTICAL AGRICULTURAL AREAS
and component Statistical Subdivisions
(or Divisions – S.D.)
NORTHERN COASTAL
4. Richmond-Tweed (S.D.)
5a. Clarence
5b. Hastings
CENTRAL COASTAL
2. Hunter (S.D.)
SYDNEY AND SOUTHERN COASTAL
1. Sydney (S.D.)
3. Illawarra (S.D.)
9a. Lower South Coast
NORTHERN TABLELAND
6a. Northern Tablelands
CENTRAL AND SOUTHERN TABLELAND
8a. Central Tablelands
9b. Snowy
9c. Southern Tablelands
NORTHERN SLOPE
6b. Northern Slopes
7a. Central Macquarie
CENTRAL SLOPE
8b. Lachlan
SOUTHERN SLOPE
10a. Central Murrumbidgee
11a. Upper Murray
NORTHERN PLAINS
6c. North Central Plain
7b. Macquarie-Barwon
SOUTHERN PLAINS
10b. Lower Murrumbidgee
11b. Central Murray
WESTERN PLAINS
7c. Upper Darling
11c. Murray-Darling
12. Far West (S.D.)
Queensland
South Australia
Victoria
TASMAN SEA
NORTHERN COASTAL
NORTHERN TABLELAND
NORTHERN SLOPE
NORTHERN PLAINS
CENTRAL COASTAL
CENTRAL SLOPE
CENTRAL AND SOUTHERN TABLELAND
SYDNEY AND SOUTHERN COASTAL
SOUTHERN SLOPE
SOUTHERN PLAINS
WESTERN PLAINS
UNINCORPORATED
Project Area

Map 2.2

NAMOI VALLEY FLOOD PLAIN ATLAS



2.6.1 Soils

Sedimentary rocks comprise the larger portion of the dam site and storage area. The geology has had a strong controlling influence on its physiography. The soils are generally hard silting loams with clay subsoils occurring west of Manilla, incorporating weathering products from the tertiary basalts and from the earlier volcanic interbed within the poloeozoic sediments (Lea et al. 1977). Pigram (1968) summarised the results of one detailed survey conducted in the area, part of which is at present under cotton cultivation, with five distinct soil associations in the Namoi Valley. The most important and widespread of these associations were comprised of soils principally of the Helebah and Gundemain series. Soil of the Helebah series occur on the extensive open treeless plains (black soils plains) and in timbered depresions and shallow troughs subject to flooding. The grey-brown soils of the Gundemain series occupy very slightly elevated areas, with better surface drainage. Both these series are characterised by grey or greshish-brown soils of heavy textured and undifferentiated clay. Although the dark soil colouring would appear to indicate a high initial organic matter content, it has become evident that intensive cropping requires the application of nitrogeneous fertilizers to sustain normal plant growth. The terrain of the valley consists of flat or very gently sloping land to the north-west at an average fall of 56.8 cm per kilometre which is considered suitable for irrigation.

2.6.2 Climate

Climate within the project area is affected by its physical location and the varying altitude and topography of the area.The critical elements which influence the growth and yield of agricultural production are temperature, sunshine and rainfall. The annual climatic data of selected stations of the Namoi valley is provided in Table 2.3.

Temperature in the valley varies seasonally with the change in solar radiation. Temperature tends to be lower at regions of high altitude. Forests occur more frequently at higher altitudes and cold air drainage occurs within the valley (Lea et al. 1977). The average frost-free period is about 234 days at Narrabri area with temperature greater then

Table 2.3

Monthly Climatic Data of Selected Stations of the Project Region

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
				Daily Maximum Temperature (c)									
Barraba	30.9	30.5	28.7	25.8	20.1	17.3	16.6	17.6	20.6	25.0	27.4	29.8	24
Gunnedah	32.4	32.1	29.8	26.6	20.9	17.9	17.2	18.6	22.0	26.2	28.2	31.0	25
Narrabri	34.0	33.8	30.7	27.0	21.3	18.6	17.8	19.3	22.8	26.9	29.7	32.1	26
				Daily Minimum Temperature (c)									
Barraba	15.8	15.7	12.4	7.4	3.3	1.3	0.7	1.9	3.9	8.4	10.5	13.9	7.8
Gunnedah	18.3	18.3	16.0	11.8	7.3	5.1	3.0	5.1	7.3	11.6	13.7	16.8	1.2
Narrabri	18.6	18.4	16.2	11.4	7.1	4.7	2.9	4.7	7.3	11.4	13.9	16.9	11
					Rainfall (mm)								
Barraba	84	76	57	40	39	48	43	42	43	64	70	74	680
Gunnedah	66	65	48	37	40	43	39	45	38	56	58	64	599
Narrabri	79	71	61	39	48	54	45	42	41	53	63	66	662
					Raindays (number)								
Barraba	7	6	5	4	5	6	6	6	5	7	7	7	71
Gunnedah	6	6	4	4	5	6	6	6	5	6	6	6	66
Narrabri	6	5	4	4	5	6	5	5	5	5	5	6	61
					Humidity 9.00 a.m. (%)								
Barraba	56	57	58	60	71	78	74	66	64	59	51	53	62
Gunnedah	49	56	54	59	67	80	69	74	69	60	45	48	61
Narrabri	52	57	58	61	64	77	65	67	59	53	54	52	60

* Monthly average is calculated based on data of 70 years or more.

Source : Department of Science and Consumer Affairs Bureau of Meteorology, 1975.

2.2° C and the average number of days with minimum temperature of 0° C or less is 11.7 per annum. Soil temperature conditions are usually ideal for planting from mid-October to early November. During the period, November to March ,mean daily temperatures are well within the range 21.1° C to 32.2° C considered to be favourable for cotton plant growth, flowering and fruiting (Pigram 1968). In general, areas with more then 50 per cent cloudiness are regarded as unsuitable for cotton production. The main water user area of Narrabri/ Wee Waa experiences a high value for hours of sun-shine and solar radiation. The average total hours of sun-shine over a year at Culgoora, close to the centre of the cotton growing districts have been calculated as more than 3000 hours, while during the balling period, December-February, the total is about 875 hours (Pigram 1968, p.12).

The average rainfall varies within the valley from 3,048 mm over the bordering mountain ranges in the east decreasing to about 1092 mm in the flat western section of the valley. On average, the highest rainfall occurs in summer. In the growing season, November - March, the average rainfall of 343 mm is insufficient for competitively profitable agriculture (Water Resources Commission Report 1984a).

2.7 Present and Proposed Land Use Pattern

2.7.1 Present land use

Land use in the storage area comprises predominantly semi-improved native pastures with about 5 per cent of the area being in its natural state. Most of the storage area is currently used for sheep and cattle grazing with limited intensive farming along the fertile river flats. About 81 per cent of the acquired land were used for cattle and sheep grazing ; and 14 per cent for crop production. Dryland crops including wheat , barley, forage oats and the improved natural pastures etc. were normally grown in the flat lands. Most properties were between 1000 and 2000 hectares in area, with a maximum carrying capacity of 4 sheep per hectare. Irrigation licenses were held by the landowners along the Manilla river and the Barraba-Eumur creeks authorising irrigation up to 330 hectares. Water Resources Commission records show that in recent years, less than 34 per cent of the authorised area has been used for irrigation (Water Resources Commission Report 1984a).

The Split Rock dam catchment area falls within the proclaimed area of Keepit dam. Agricultural industries in the area have been relatively stable since the early 1970's with cotton, wheat and cattle grazing being dominant land uses. Many properties are not confined to only one of these land uses, and it is not unusual to find cattle grazing or wheat growing adjecent to cotton fields. In addition, vegetables and a wide variety of oilseed are currently grown. Table 2.4 provides information on the number of establishments, total area, land under crops and grasses and covers in the project and its adjecent areas.

2.7.2 Future land use

Split Rock dam would predominantly increase irrigation supplies to the lower Namoi valley. This water is likely to be used for the development and improvement of the cotton industry. The Water Resources Commission has not yet decided its allocation policy. However, there are several options under consideration by the Commission regarding the allocation of the additional supply of water as a result of the construction of Split Rock dam. These options include :

i. provision of all additional regulated flow for expansion of irrigated area;

ii. increasing the reliability of supply to the existing irrigators in the lower Namoi valley; and

iii. sharing of additional supply of water between new and existing irrigators.

On the basis of the first option, it has been estimated that about 200 hectares of additional land could be irrigated downstream of Split Rock dam along the Manilla and Namoi rivers to Keepit dam through the provision of regulated flows. It has been assessed by the Commission that any additional area developed for irrigation would require only few channels to convey water flow downstream of Keepit dam, even without clearing of natural bushlands. Importantly, most water is likely to be used for cotton irrigation and the over all expansion of the cotton industry.

Table 2.4

Number of Establishments, Area and Land Use in the Project and Adjacent Areas, 1983/84

Name of the Shires	Estbt. with agri-cultural activity at 31 March		Land use on estbt. with agril. activitiy	
	Number	Total Area	Land Use for cropping(a)	Area under sown grasses and covers(b)
	(Nos.)	(Ha)	(Ha)	(Ha)
Barraba	218	258 921	16 742	12 513
Manilla	212	163 948	25 893	5 715
Gunnedah	635	441 061	191 325	1 557
Narrabri	784	819 834	293 599	4 246
Moree	711	1 542 100	490 844	2 010
Walgett	428	2 070 856	180 483	1 980
Parry	880	357 854	71 877	29 211
Tamworth(city)	96	12 165	3 827	260

(a) Includes lucerne, pastures and grasses cut for hay, green feed or silage and harvested for seed;

(b) Excludes pure lucerne, native grassess and naturalised paspalum.

estbt. = establishments

agril. = agricultural

Source : Australian Bureau of Statistics, N.S.W. Office, 1984.

2.8 Description of the Dam

2.8.1 Technical details

The Split Rock dam is to be built as a concrete faced rock structure with a full storage capacity of 372 000 megalitres. At full supply level the reservoir area will be 2 050 hectares. The main wall will rise 66 metres above the river bed. The upstream face of the dam will be concrete lined. There will be a 5 metres wide crest, 480 metres long, for use by the operation and maintenance vehicles as well as for foot access by the public. The ungated spillway will feature an ogee crest 99.86 metres long with a partially lined spillway chute. It will be capable of discharging up to 500,800 megalitres of water per day, which is estimated to be the maximum probable outflow from the storage. Release of water from the storage up to 6,400 megalitres a day will be possible through the outlet works. To contain storage, two saddle dams will be built in a low lying area approx. 3.5 kilometres north-west of the main wall. The earth and rockfill structures will be a total of 2.8 kilometres and a maximum height of 20 metres.

Apart from the construction of temporary offices, a storehouse and camp etc., it has been proposed that the permanent establishments at the dam site will include the Commission office, two cottages and a workshop-cum-storage for the operation and maintenance of the dam. Besides, Oakhampton road will be upgraded, including the construction of a new two-lane bridge and new roadworks up to the dam site. It is expected that all materials needed for the construction of the dam and related works will be available through domestic industrial production (Water Resources Commission Report 1984a). Details of technical information of the dam is provided in Appendix 1.

2.8.2 Period of construction and cost estimates

The construction of the dam started in the 1983/84 financial year. It is envisaged that the construction of the dam will be completed over a period of 5 years and will be operational in year 6 for irrigation purposes.

The total investment cost of the dam is estimated at $47.17 million based on 1984 prices. It is also estimated that an amount of $140,000 will be needed annually for operation and maintenance costs. Besides, an additional amount of $50,000 will be required in every tenth year of operation for the replacement of machinery, equipment etc. The item-wise breakdown of cost estimates of investment is provided in Table 2.5 , while the annual operating and maintenance cost of the dam is given in Table 2.6.

2.8.3 Financing of the Project

The project will be financed from the Consolidated Reserve Fund of the Water Resources Commission and a grant from the Department of Treasury at an interest rate ranging from 11.50 to 13.25 per cent per annum. The interest is payable at the end of every six months until the completion of the project with a grace period of an initial six months. According to the current financial system, repayment of principal is not necessary for any non-revenue earning Government Department such as the Water Resources Commission.

3.9 Operational Policy

In view of the fact that the regulated flows from Keepit dam are fully committed, the construction of the Split Rock dam will improve irrigation water supply in the Namoi valley. It is, therefore, inevitable that the Split Rock dam will be operated in conjunction with Keepit dam in order to make available additional water supplies to the Namoi irrigators. The Water Resources Commssion has been considering the following options in allocating the additional supply of water as a result of the construction of the Split Rock dam :

i. to provide more secured irrigation supplies for the established cotton industry in the Namoi valley ;

ii. to allow water supplies to new areas for irrigated cropping ;and

iii. to provide a reserve of water for augmentation of supplies for the townships of Manilla, Barraba and Tamworth ; and for industrial development in the Namoi valley.

Table 2.5

Investment Cost of the Split Rock Dam

(Figures in '000 $ Aus)

Item of works	Years					Total
	1	2	3	4	5	
1.Pre-construction:						
Expenditure incurred upto 1983/84	9 509					
Land acquisition		3 000	1 500	100	-	4 600
2.Construction works:						
Dam	-	3 000	7 900	8 510	2 896	22 306
Road	-	200	500	500	100	1 300
3.Equipment and machinery:						
Machanical contact	-	500	754	980	150	2 384
Plant and vehicles	-	100	100	100	50	350
4.Other costs:						
Establishment	-	250	86	140	10	486
Local office cost	-	750	970	970	375	3 065
H.O. Administration	-	400	400	500	300	1 600
H.O. Diary Branches(a)	-	470	570	430	100	1 570
Total	9 509	8 670	12 780	12 230	3 981	47 170

(a) Include expenditures on survey drafting, drafting and design of the project.

Source : Water Resources Commission, 1984.

Table 2.6

Annual Operating/ Recurring Cost on completion of the Split Rock Dam

(Figures in '000 $ Aus)

Item of expenditure	Year 6 to year 50 (each year)
1. Salaries and wages	98 130
2. Transport/vehicle running cost	7 850
3. Store / materials	15 700
4. Others :	18 320
Stationery, electricity, telephone etc.	
Maintenance of building and structures etc.	
Repair and maintenance of machinery/equipment	
Total	140 000

* An amount of $ 50,000 (approx.) will be needed for replacement of equipment and machinery in every 10th year from year 6 onward.

Source : Water Resources Commission, 1985.

The operational policy will largely depend on the supply options to be chosen. Bearing in mind the overall objectives, the operation of Keepit and Split Rock dams will be influenced by the needs to achieve optimum efficiency and maintain water quality. Therefore, the operational management will be regularly reviewed to take account of monitoring system efficiency and water quality assessment in the valley (Water Resources Commission Report 1984a, p.7-8).

2.9.1 Behaviour of downstream flows

Split Rock to Keepit dam

Upstream of Keepit dam along the Manilla and Namoi rivers, stream flows are now unaffected . However, following the construction of the Split Rock dam, the natural stream flow pattern will be altered. Split Rock dam will operate to provide controlled release for irrigation ,domestic and stock needs and thus maintain a minimum flow. Release of water will be made from Split Rock dam to meet downstream demands in the Namoi valley when Keepit storage becomes depleted. During that period, the flow between the two dams is likely to be greater than under normal conditions. Apart from the beneficial increases in the stream flows, there is no significant change in the stream flow behaviour (Water Resources Commission Report 1984a)

Downstream of Keepit dam

On completion of the Split Rock dam, the security of irrigation supplies in the Namoi valley will depend upon the extent of allocation granted. The high demand of water from the existing irrigated areas will marginally increase the frequency of large releases from the Keepit dam. Only a minor increase in the controlled flows is expected if no additional area is licensed. In fact, the Namoi river flow behaviour in its lower reaches will change marginally as a result of Split Rock dam.

2.9.3 Optimal reliability of supply for irrigation

The current reliablity of irrigation supplies in the Namoi valley due to effect of the Keepit dam is about 65 per cent. This indicates that the irrigators can have their 100 per cent allocation in 65 per cent of the irrigation season, that is to say, the remaining 35 per cent of the year the irrigators receive less than 100 per cent allocation.

In the Split Rock dam scenario, it is important to take account of whether pre-Split Rock dam supply reliability in the Namoi valley is the appropriate level of supply reliability in terms of maximising returns from investment made by the state in constructing the two dams. A survey conducted by the Water Resources Commission showed that existing Namoi irrigators have requested that supply from Split Rock dam be used to increase their present supply reliability so that water restrictions are required only during the periods of severe drought (Verdich, Bryant and Buffier 1984). The Commission has developed simulation models using stream flow data for the period from 1924 to 1979 of Manilla river to examine the impact on net revenue at various reliability levels. The Commission has not, as yet, decided which policy option should be adopted.

2.10 Organization and Management

The implementation of the project will be undertaken through various contracts to private companies under the supervision of the Water Resources Commission. The operation of the dam and its maintenance will be undertaken by the Commission, for which two technical staff and two waged labourers will be employed on full-time basis. They will be located in the dam site. Besides, the Commission will be responsible for the overall supervision and management of the project.

Chapter 3

LITERATURE REVIEW, CHOICE OF ANALYTICAL METHOD AND THEORETICAL CONSIDERATIONS

3.1 Introdoction

The basic economic problem of almost all countries is that of allocating inherently limited resources such as land, capital and other natural resources and foreign exchange to a variety of uses in such a way that the net benefits to society are maximal. Given the limitation of resources, a choice must be made among the competing uses. That is to say, the alternative uses must be compared over time, in terms of the net benefits a resource will generate. The real costs of any particular type of resource use consist of benefits that would be realized through other patterns of resource use. In fact, different types of benefit and cost are generated by a pattern of resource use. Some benefits and costs are correctly valued through market prices; some are incorrectly valued in the market system; some have no markets; and for others it is perhaps impossible to find any kind of market value.

In the private sector, individual farmers aim to maximise profit from the investment of capital, by selecting the most efficient uses of that capital. In spite of market imperfections, restrictive trade practices and tariff distortion, decisions to invest or not to invest can be measured in financial terms. Financial analysis thus, demonstrates a project's financial viability in term of its return to the capital invested by private individual farm firms.

In constrast, the situation in the public sector is more complex. Although a substantial proportion of capital expenditure by public authorities is directed to producing services which are not necessarily geared to profit maximisation, there is a need to avoid the wastage of resources. It is argued that public capital investment is not different from private capital investment in making demands on real resources which could otherwise be invested for more profitable uses.

The realization of all proposed project criteria, often called investment criteria, which take account of all costs and benefits, implies a concept of social betterment that amounts to 'pareto improvement'. Dasgupta and Pearce (1972, p.55) defined a pareto improvement situation as a condition in which no one can be made better off without someone being made worse off. The project which is economically sound must be capable of producing an excess benefit such that every one in the society would, by a costless redistribution of gain, be made better off.

In Australia, benefit-cost analysis techniques are widely used for the appraisal of public sector projects for investment decisions. Munro (1974, p.189) stated "In recent years in Australia, benefit-cost analysis has been very fashionable and the Commonwealth Government has even initiated a benefit-cost study of its immigration policy. In national development planning, however, it has been directed mainly to irrigation and agricultural project, ...". Munro (1979) placed emphasis on the aspects of civil engineering required in planning water resource development projects, while Musgrave (1974) stressed the importance of economic analysis of alternative proposals prior to making investment decision. However, the fundamental principle of benefit-cost analysis is the requirement to measure all the economic impacts of a proposed project upon the community so that all significant gains and lossess, whatever they affect, can be calculated and evaluated acccording to appropriate economic criteria.

3.2 Review of Alternative Approaches

In the last decade or so, several analytical methods have been proposed to undertake ex-ante project appraisal. Both developed and developing countries, as well as international agencies, use these methods in analysing development projects. In the economic literature, project appraisal methods are found in Balassa (1976); Goldman (1968); Gittinger (1972); Mishan (1971, 1975); OECD (Little-Mirrlees 1974); UNIDO (1972) ; Dasgupta and Pearce (1974); Squire and Van der Tak (1975); Sassone and Schaffer (1978); Sugden and William (1978); Brown (1979); Pearce and Nash (1981); Yutopoulos and Nugent (1971); and so on. Benefit-cost methods specific to water resource/ irrigation projects are found in Howe (1971); Munro (1974); Bassoco, Norton and Silos (1974); Bergmann and Boussars (1976); Gittinger (1982); and Gray (1984).

Traditionally, benefit-cost analysis is restricted to the evaluation of a project's economic impact on national growth. This approach is very much concerned with direct costs and benefits measured in money terms to the extent that other factors, such as the impact of the project on farmers, regional incomes, environment, transport etc., are not taken into account. The traditional benefit-cost analysis could only provide a partial analysis of project impact on social welfare. Some of the benefit-cost approaches have extended to take into account not only the project's contribution to national income but also on income distribution and savings. Squire and Van der Tak (1975) recommended the same methodology as that of the Gittinger (1982) for project identification and valuation, but Gittinger stopped after determining the economic values on the basis of efficiency prices, while Squire and Van der Tak proceeded further to weigh values to account for income distribution and savings. Gittinger suggested using subjective judgement in choosing between the high yielding alternatives, the one which has the most favourable effects on income distribution, savings and other social objectives. On the other hand, OECD and UNIDO methods allow more precise accounting of social values of commodities involved in the project and give rudiments for incorporation of income distribution, rate of growth and employment objectives in the project analysis. The salient features of the four widely used methods of project appraisal are presented in Table 3.1 .

In recent years, it has been recognised to a great extent that more complete information concerning the interrelationship of the various economic factors generated by a project should be taken into account in the evaluation of a development project, particularly one using public fund, which is beyond the scope of traditional and limited benefit-cost analysis. Contemporarily, a great deal of effort has been devoted by economists and project analysts to the development of expanded economic analytical technique to assist project decision making. The new methods

Table 3.1

Summary of the Salient Features of Project Appraisal Methods

Parameter	Dasgupta (et al.) Method 1972	Little and Mirrlees Method 1968 & 1974	Squire and van der Tak Method 1975	Gittinger 1972
Sponsoring Agency	UNIDO	OECD	IBRD	IBRD (World Bank)
Originally Designed For	Industrial Projects	Industrial Projects	Both Agricultural and Industrial Projects	Agricultural Projects
Numeraire	Present aggregate consumption benefits at domestic prices.	Present uncommitted social (government) income measured in terms of convertible foreign exchange at constant purchasing power.	Freely available public income of constant purchasing power in terms of convertible foreign exchange in domestic currency.	Real net national income change valued in opportunity cost in domestic currency.
Valuation of Traded Commodities	Based on the principle of consumer's willingness to pay.	World prices: that is, c.i.f. or f.o.b. for perfectly elastic supply and demand. Otherwise marginal import cost or marginal export revenue for less than perfectly elastic supply and demand.	World prices: that is c.i.f. or f.o.b. for perfectly elastic supply and demand. Otherwise marginal import cost or marginal export revenue for less than perfectly elastic supply and demand.	Valued in domestic currency by reference to the Shadow Exchange Rate SER = OER x (1 + FX premium).
Valuation of Non-traded Commodities	Domestic prices.	(1) Decompose into traded and non-traded commodities and labour, and value traded commodities as above and labour as below. (2) Apply Standard Conversion Factor (SCF) to minor non-traded commodities: $SCF = \frac{OER}{SER}$ where SER = shadow exchange rate, OER = official exchange rate.	(1) Decompose into traded and non-traded commodities and labour, and value traded commodities as above and labour as below. (2) Apply Standard Conversion Factor (SCF) to minor non-traded commodities: $SCF = \frac{OER}{SER}$ where SER = shadow exchange rate, OER = official exchange rate.	(1) Decompose into traded and non-traded commodities and labour. Traded commodities valued as above. Labour valued as below. (2) Domestic prices used for non-traded commodities.
Accounting (Shadow) Price of Unskilled Labour	Net loss of productive services to the rest of the economy.	Additional resources devoted to consumption MINUS social value of the increase in the workers own consumption and the consumption accruing to others as a result of the workers movement into the new employment.	Labours forgone marginal product at accounting prices PLUS Net social cost of increased consumption PLUS Social cost of reduced leisure.	M.V.P. of labour without project.
Discount Rate	Social time preference rate.	Accounting rate of interest.	Accounting rate of interest.	Opportunity cost of capital.
Decision Criteria	Net present value.	Net present value.	Internal rate of return.	World Bank preference for IRR.
Efficiency Objective	Explicit.	Explicit.	Explicit.	Explicit.
Growth Objective	Present savings more valuable than present consumption - Explicit.	Present savings more valuable than present consumption - Explicit.	Explicit.	Present savings more valuable than consumption - Implicit.
Income Distribution Objective	Implicitly considered.	Implicitly considered.	Explicitly considered.	Implicitly considered
Role of Project Evaluator	Analysis of project only.	Significant and can influence changes in the policy of the government.	Not clear, probably small.	Analysis of project only.

Source: Adopted from Dent, G. (1984), An Examination of Alternative Methods of Project Appraisal with special reference to Naga-Calbanga Irrigation Project, Philiphines, M.Ec dissertation, University of New England, Armidale, p.11 .

involved in the development of a multi-objective planning model are designed to incorporate economic, environmental, political and social goals in a single analytical framework. A Task Force report for the United States Water Resource Council in 1969 proposed principles and standards for multi-objective planning in the development of water resources. The fundamental elements of this multi-objective planning model were to delineate and display alternative plans to maximise the objects of national economic development, environmental quality, regional development and social well-being (BAE 1975, p.9). McColl and Thorsby (1972) followed the concept proposed by the U.S. Water Resource Council and made suggestion for improving project appraisals particularly in respect of the regional aspects of project evaluation and their relationships for measuring the impact of projects on national economic development. Both Candler and Boehlje (1971) and Baumol and Quandt (1975) made use of mathematical programming models to incorporate multiple objectives in project evaluation. Linear programming is well established as a systematic method to assist in the analysis of capital budgeting problems, which is concerned with choices between alternative investment opportunities. O'Brien, Thornby and Atkins (1977) discussed the theory, application and relationship of the multi-objective planning approach to benefit-cost analysis.

Perry and Dillon (1978, p.120) summarised their study as follows:

"A wide variety of methods have been suggested for <u>ex-ante</u> project appraisal. The most logical and complete of these appears to be multi-attribute utility theory (MAUT) which provides a formal procedure for handling the difficulties of ex-ante evaluation due to multiple objectives, uncertainties and time sequence effects".

They listed a broad ranges of decision models for guiding multi-objectives investment decisions :

(i) Weighing methods ;

(ii) Sequential Elimination methods ;

(iii) Mathematical Programming methods ; and

(iv) Spatial Proximity methods.

They examined multi-attribute utility theory in greater detail. Gray (1984) felt that most of the techniques listed by Perry and Dillon are mainly useful in selecting between a number of alternative projects whereas in practice most irrgation projects are evaluated on a one-off basis.

Even though many theoretical models are available, there are serious reservations about the relevance and applicability of the entire range of multi-objective planning approaches. Wesney and Woolcock (1975, p.73) commented- "These (MAUT) innovations for project appraisal work have not been developed to a stage suitable for general application to analytical problems". Musgrave (1974, p.7) has quoted that,

"It is not clear that the structured approach in multi-objective planning along the lines set out in the new U.S. principles and standards will allocate resources to water resource projects more rationally than sound economic analysis. It is often forgotten that sound economic analysis includes consideration of external social costs and benefits. The danger is that it will open the door to a new phase of pork-barrel politics for water resources : facts about environmental and social consequences are scarce and debate about these facts could be manipulated to appeal to sectional interests".

Evidence of detailed economic analyses of irrigation projects in New South Wales are found in the economic literature. These studies had been conducted using mainly the traditional benefit-cost approach. Gibson (1968) studied the economics of irrigation in the Macquarie valley. The International Engineering Service Consortium (1969) conducted a conprehensive economic assessment of Keepit dam after several years of its completion. Dunnet (1972) assessed the impact of irrigation development in the Namoi valley in terms of both economic and social aspects, while Blandford et al. (1977) investigated the economics of irrigation in the Gwydir valley.

At the farm level, a number of studies were undertaken in analysing farm budgets for crops and livestock enterprises in order to determine the most efficient and profitable size of irrigation farms. Dudley and McConnel (1965) evaluated cotton and alternative farm enterprises under irrigation in the Namoi valley. Pigram (1968) studied the development and potential of the Namoi valley cotton industry. Dudley, Howell and Musgrave (1971a; 1971b; 1972) studied optimal acreage within a season, the optimal size of irrigation for a given dam storage and the optimal intraseasonal water allocation. They also considered aspects of optimising economic returns both the farm and the project levels.

Wesney and Woolcock (1978,P.46) suggested that project analysts must continue to use available economic analytical methods and attempt to expand economic infomation by explicit consideration of regional, social and environmental implications of projects, even when monetary values cannot always be specified.

3.3 <u>Choice of Analytical Method</u>

Project appraisal is one of many policy weapons. Criteria for project appraisal and selection can be properly defined within the broader framework of economic policy and planning. Project selection and method should not only be soundly based in economic theory but also should make relevant simplifications about reality; and be simple enough and practical to use , but flexible enough to deal with complex problems in the real world. Whether any one criterion meets all these requirements is indeed a matter of judgement. Provisionally it may be assumed that the ultimate objective and intention of any Government is to provide a high standard of living through the maximisation of efficiency in public investment. Using GNP as a measure of growth, a link might be established between national economic theory and project appraisal theory to adopt an appropriate analytical method for project appraisal.

From the analysis of Australian Government policy, it has been envisaged that growth is the main concern of Government macro-policy. Economic growth is widely accepted as desirable. On this criterion, projects should be selected on the basis of their contribution to total national income. Everyone, of course, will not benefit from growth, but since growth has typically improved average living standards, it is clearly possible, by suitable redistribution policies, to make every one better off as an outcome of economic growth (Lipsey, Langley and Mahoney 1981).

Over the past decade, there had been considerable emphasis in maximizing efficiency in public investment to development projects in Australia. That had led various financial bodies to study various methods of project appraisal particularly from the view point of society as a whole. The evidence suggests that benefit-cost analysis techniques have been widely used as a decision making tool of Government bodies. BAE, WRC, Coommonwealth Treasury, Industrial Assistance Commission etc. use the technique for the appraisal of development projects. Wesney and Woolcock (1978) stated that State Governments followed traditional project appraisal method for the analysis of water resource development projects for financing by the Commonwealth Government. During 1966-72, BAE had undertaken appraisal of some eighty five water resource development projects in Australia adopting the traditional approach of benefit-cost analysis. Keeping in mind the Australian Government's macro-economic policy, the trends in the practice of project appraisal techniques for water resource development projects and the problem of the application of multiple objectives methods, the present study adopts the Conventional Efficiency Analysis method (Gittinger 1982) with modifications.

3.4 Theoretical Considerations

3.4.1 Basic notion of benefit-cost analysis

Benefit-cost analysis systematically informs the decision makers about the gains and losses of a project and measures the extent to which the assigned objectives have been achieved. At the same time, it provides some useful ideas on how the resource use can be made most effective. In assessing the merit of a project, the objectives of a particular society must be accounted for. For example, when society's objective is the maximization of total income of the economy the costs are the reduction of income suffered elsewhere in the economy due to the project's use of scarce resources; and the benefits are the addition in total income generated by the project. If a second objective, say a reduction in income inequality is to be achieved, then project's effects on equity must be taken into consideration, i.e., any increased income disparity due to project would be a cost, and a reduction a benefit, to society. Therefore, the definition of costs and benefits in the economic analysis of a project depend on the national objective.

In evaluating the economic worth of public investment in the form of a development project, the analytical method has always been to measure, based on assumptions and estimates, the incremental benefits and costs against an alternative situation. Thus the analysis is concerned with assessing the difference in net benefits between the expected future with project and without project situations. Net incremental benefits to be realised over future years are to be calculated at present value and expressed in constant prices to demonstrate whether total net benefits over the life of the project are positive or negative. Ideally, benefit-cost analysis evaluates benefits and costs of a project using a common yardstick. The method compares the return on investment at the margin in the economy, that is, the opportunity cost of capital. When the economic rate of return of a project is above the opportunty cost of capital, the project clearly helps the economy; conversely, if it is below, it will be an outright loss to the society.

The essence of benefit-cost analysis is that it does not accept all the actual costs and benefits of a project as adequate measures of social costs and benefits, but it does accept actual costs and benefits which are suitably adjusted by social accounting prices (shadow prices) to reflect social gains or losses appropriately (Gittinger 1982).

3.4.2 Economic basis of benefit-cost analysis

Benefit-cost analysis has been defined as an estimation and evaluation of net benefits associated with alternatives for achieving defined national goals. Benefit-cost analysis is based on the concept of 'economic surplus'. It is shown that the output of a project multiplied by its price is equal to the maximum social benefit of a project; some consumers are willing to pay more than the market prices and so they enjoy excess utility or consumer surplus. This idea led to the concept of net social benefit and it is now basic to benefit- cost analysis (Sassone and Schaffer 1978).

The concept of net social benefit denotes the gain in welfare which accrues to society as a whole in terms of consumer surplus and producer surplus in economic activities. This concept is widely used as a criterion to judge the social desirability of a project in any economic policy. Benefits, or increases in social welfare, are measured by the increased satisfaction or preferences of individuals in a society. Costs are viewed as an outward expression of disutility. Dasgupta and Pearce (1974) defined the net social benefit as :

$$NSB = Bi - Ci \qquad [3.1]$$

where,

Bi = all benefits occur from the project (the total willingness of gainers to pay for the project).

Ci = total cost of the project (willingness of lossers to bribe not to have the project).

Details of the concept of economic surplus and its graphical presentation can be found in any standard text of benefit-cost analysis or welfare economics.

3.4.3 Diagramatic representation of irrigation project

The purpose of this section is to present diagramatically the theoretical basis in estimating the direct benefits of an irrigaton project. The basic concept used by economists to value goods and services is the market demand curve. Some products such as irrigation water are not traditionally brought and sold; and therefore, they do not have a defined market demand curve. Without observable market prices and quality data, the standard practice is to use shadow pricing techniques to estimate direct costs and benefits. For irrigation projects, shadow pricing procedures can be used to estimate the changes in consumer surplus and producer surplus in the agricultural market as the project increases farm output using irrigation supplies (Gray 1984). Figure 3.1 illustrated a conventional price-quantity diagram depicting hypothetical demand and supply curves for an agricultural commodity.

In the Figure 3.1, it is shown that in the absence of the irrigation project the supply curve, BS with the downward sloping demand curve, CD results an equilibrium price P_0 and quantity Q_0. This represents price sensitiveness to changes in output with the assumption that all other prices except the commodity in question remain constant. The implementation of the project causes the supply curve to shift outwards to S_1 with the expansion of output to Q_1 and a reduction in price to P_1. As outlined above, benefit-cost analysis is concerned with measuring the difference in the net benefits between the with and without project situations.

Without project

Consumer surplus = P_0CE

Producer surplus = P_0BE

Net benefit = BCE

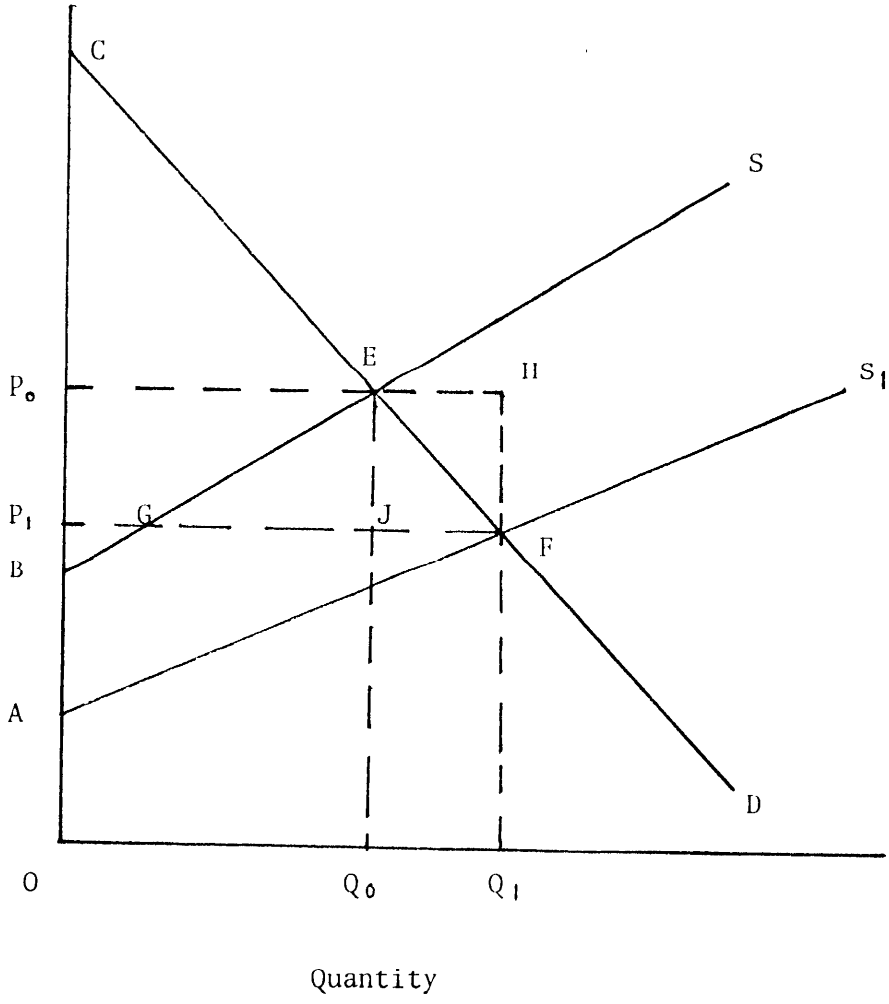


Figure 3.1 : Net benefits from an irrigation project.
(Adopted from Gray 1984, p.73)

With project

Consumer surplus = P_1CF

Producer surplus = P_1AF

Net benefit = ACF

Incremental net benefit

Incremental net benefit = Net benefit with project - Net benefit without project

= ACF - BCE

= ABEF

From the figure, it can be shown that the conceptually correct measure of the increase in net benefit due to the project is the area ABEF, where GEF is the net gain in consumer surplus and ABGF in producer surplus.

3.4.4 Limitations of benefit-cost analysis

Benefit-cost analysis is practiced based on assumptions, postulates and formulae in a framework of economic stability and of steady economic growth in a predominantly capitalistic competitive economy. Benefit-cost analysis originally developed in the United States in the 1930's for the appraisal of water resource and transport projects (Keepit Dam Study 1969; Dent 1984). The function of benefit-cost analysis was defined by Hammond (1966, p.221) as "guesswork with a view to decisions". Benefit-cost analysis has two very clear general limitations of principle which must be recognized. Prest and Turvey (1965, p.685) stated, "First, cost- benefit analysis, as generally understood, is only a technique for taking decisions within a framework which has to be decided in advance and which involves a wide range of considerations , many of them as political and social character. Secondly, cost-benefit techniques, as so far developed, are least relevant and serviceable for what one might call large-scale investment decisions".

If the investment is very large relative to a given economy, it may seriously disrupt the country's output and prices over the whole economy. In case of such large investment projects, which involve significant structural changes, the applicability of the technique is inappropriate. Besides, certain limitations arise in the application of the technique in measuring the present and future benefits from projects and costs incurred in achieving those benefits.