MANAGEMENT TECHNIQUES TO OPTIMIZE REPETITIVE OPERATIONS IN SMALL WATER SUPPLY SCHEMES

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ABSTRACT

Two rural water supply schemes are discussed, one in the Republic of Vanuatu, (formerly the New Hebrides), and one in Kenya, where the application of systems analysis and scheduling techniques assist management in the decision-making process.

By the introduction of simple management techniques both water supply schemes benefited through earlier completion dates, reduction in costs and improved communication involving the public, local authorities, site staff and Government departments.

INTRODUCTION

The first of two rural water supply projects to be discussed concerns the Republic of Vanuatu (formerly the New Hebrides), which comprises an archipelago of some 70 islands covering a land area of 12190 km^2 (4707 sq. miles). The islands range in size from 12 to 3600 km^2 and have rugged mountainous interiors with narrow coastal strips where most of the inhabitants dwell. In the census conducted in January 1979 the population was 111250 of whom 90 per cent were New Hebrideans. The capital is Port Vila and the currency is *vatu* ($1 = 100 vatu).

In Vanuatu there are approximately 2300 villages in 782 localities. 80 per cent of the total population live in the rural areas and only 30 per cent of these in 1982 had access to a relatively safe and reliable water supply system. The remaining 70 per cent obtained water from rivers and streams by the use of various containers over varying distances, or used mechanical pumps to obtain water from catchment areas. In some localities water was obtained by gravity means from various sources. Most of these methods were not hygienic and it was therefore necessary to develop a planned water supply scheme, so that the whole population would have access to covered supply systems.

Policy and Objectives

The policy was to provide a water supply system throughout Vanuatu and the target period to do this was 10 years, 1981–90.

The objectives were two-fold: firstly, to increase the coverage of piped water supplies throughout the Republic, and secondly, to upgrade the existing water supply systems, which did not meet the basic standards regarding health and reliability.

The proposed water supply programme covering the 10 year period had targets set, such that by 1982, 30 per cent of the rural population would have access to a covered water supply, by 1983—37 per cent, 1984—45 per cent, 1985—54 per cent, 1986—63 per cent, 1987—73 per cent, 1988—83 per cent, 1989—91 per cent and by 1990—100 per

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cent. The estimated cost of the projects over the 10 year period was 463.5 million vatu or US$4.63 million. By being included in the United Nations decade for drinking water programme, the estimated cost would then be met both from international aid funds and local funding, to ensure completion within the 10 year period.

The Ministry of Land, Energy and Water Supply was responsible for water supply policies, programmes and installation where villages had more than 50 inhabitants. Where the population was less than 50, then the responsibility was undertaken by the Environmental Health Service (EHS). The EHS, through Health Inspectors and Village Sanitarians, became responsible therefore for the less complex projects and they cover 25 per cent of the rural water schemes put forward for evaluation.

Problems and Programme Implementation

The target for 1983 (set at 37 per cent) was not met, with only 32 per cent being achieved due to the following:

(a) Lack of finance within a reasonable period of time. It was not unusual for a water project to commence four years after the initial request was received from the local population. The higher the estimated costs the longer it might take to secure funding from local or aid sources. Aid funding is the most uncertain source, as the final decision to release funds lies with the donor. Smaller scale projects could be funded locally, but they were in direct competition with other department projects of national interest.

(b) The maintenance of existing piping, valves, pumps and communal taps presented a continuous problem. The departments responsible had a small recurrent budget for administration and yet nothing for repairs and maintenance. Due mainly to frustration, this problem encouraged the local population to put forward and apply for a new water supply scheme. A further, but important, extension to the maintenance problem was that the aid from various sources had given the country a multiplicity of machinery, fittings and equipment which already caused replacement problems through lack of standardization. This problem was forecast to increase for some time to come unless checked.

(c) The shortage of technical staff resulted in projects awaiting engineering studies and surveys, thus delaying any application for finance, whether local or international.

(d) The management responsibility for rural water supply fell under three distinct administrative sections, each responsible to different heads within the government bureaucracy.

(i) The Ministry of Land, Energy and Water Supply provided technical assistance and installed the water supply to villages with more than 50 inhabitants.

(ii) The Local Government then took on the responsibility for maintenance of the installed water supply systems.

(iii) The Environmental Health Service was responsible for the water supply and maintenance needs for villages with less than 50 residents.

Problems then arose through lack of communication between departments and the public, who were often confused as to who to contact, both regarding a supply scheme, either new or for modification, and any maintenance. Figure 1 shows a diagrammatic presentation of the basic policy, objectives and the responsibilities of the Ministry of Land, Energy and Water and the Environmental Health Service departments.

(e) Although not frequent, a further serious source of delay in some planned project installations was the claim of ownership of a water fountain. These are customary claims which are associated with ownership of land on which there is a water source. Resistance in allowing the drawing of water from the source may also be political, in the sense that the beneficiaries may be affiliated to a political party other than that with which the water claimant may associate himself.

(f) There is a dependence on local labourers to assist in the projects, but many were working without financial reward which caused discontentment and led to projects lagging behind targets.

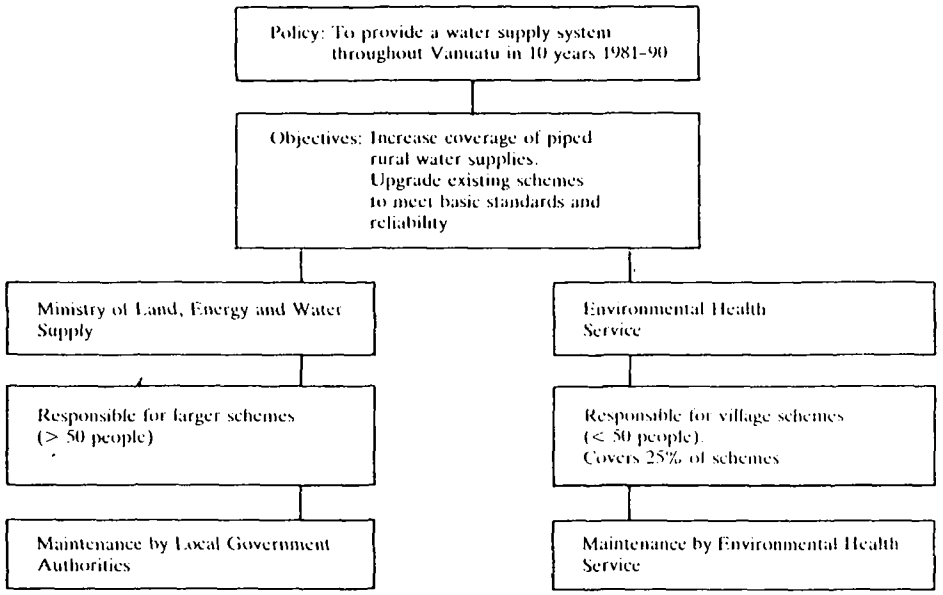


Fig. 1. Basic policy, objectives and responsibilities for 10 year plan

Before proposing any methods to improve ways of keeping programmes to approved target levels and to accelerate any financial support, the existing organizational system concerning rural water supplies was analysed and this is shown in Fig. 2.

Box 1 indicates a request from the local population for a water supply scheme which was usually in a primitive form and forwarded to the Ministry of Land, Energy and Water Supply, Box 2. The requests were then forwarded to the Water Supply Department, Box 9, a process which could take from weeks to months. The Water Supply Department would conduct a survey, Box 10, which in turn was presented back to the Ministry of Land, Energy and Water Supply. The Development Commission, Box 3, would consider the request with other development projects requiring funding. Should the estimated cost be less than 5000000 vatu and if it was approved, it would be put out for local financing, Box 5. Should the estimated cost be greater than 5000000 vatu then it would go forward to the National Planning Department, Box 6, for final approval via the Cabinet, Box 4. An application for external finance would then be made, Box 7. All finance would be co-ordinated through the Accountant General Department, Box 8.

There were no set targets in the system for the assessment and approval of projects, which caused delays running into months, thus affecting any applications for finance and the final ordering of materials.

Improved Methods

Although for constitutional reasons it was not possible to alter the procedure and system shown in Fig. 2, it was agreed that specific target dates at critical points through the system would be agreed by consultation, on the production of a flow chart.

After considerable deliberation, an overall target of 7 months was agreed for small projects involving local financial support and 12 months for those requiring aid from

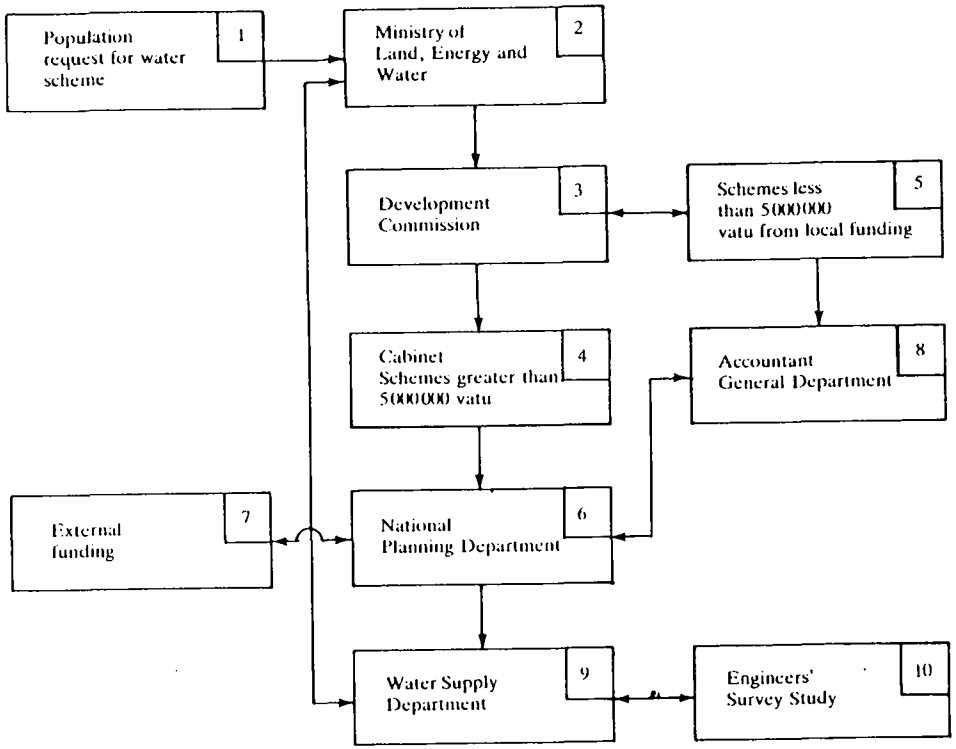


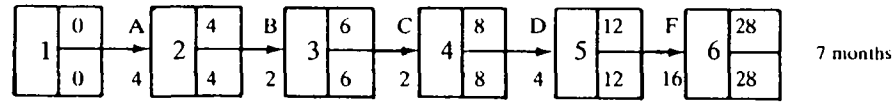
Fig. 2. Existing water supply organizational system

external sources. The agreed target dates were set out in a simple manner as shown in Fig. 3. All parties realized the national crisis that was being faced through lack of co-ordination and the length of time individual activities were taking. By adhering to the targets set, it was agreed that up to 2 years could be saved in the commencement of rural water supply projects.

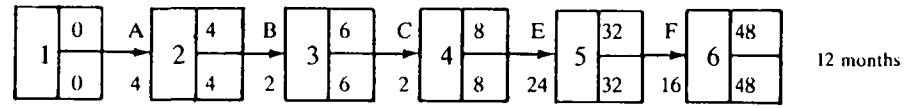
Complementary to the flow chart, it was considered necessary to have some form of central control system for each water supply project, whatever its size. An eight-stage cycle was developed to ensure that control would be kept at each level. The cycle developed is shown in Fig. 4. Items 1–4 were to be completed in the target times set out in Fig. 3 and the actual implementation of each project, items 4–8, would be controlled by well-tested management scheduling techniques.

A campaign would be launched to educate the population regarding the types of water schemes that were available, ranging from bore holes to a pipe running through the centre of a village with taps at various points, which are often adequate in many cases. Some appreciation of basic costs for various water supply methods and assistance with standard procedures for the presentation of schemes for approval would be issued in literature and visual form.

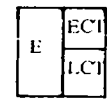
For the first time a special budget would be made available to local government for the maintenance of any installed water supply system. Any major technical assistance required by the local authority in the course of a breakdown would be provided by the Energy and Water Supply Department Engineer.



Time to implement small project



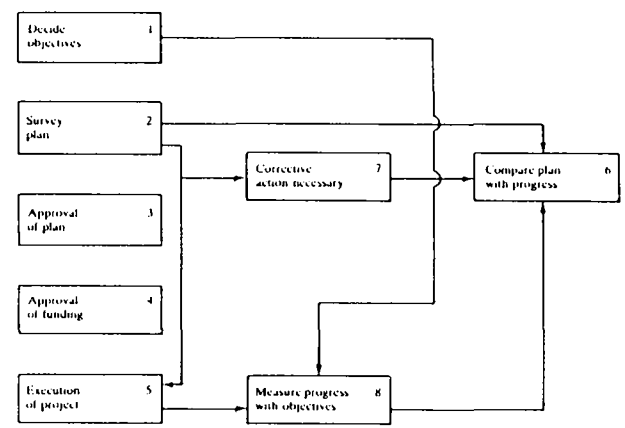
Time to implement large project



ECT: Earliest Completion Time
LCT: Latest Completion Time
E: Event number

Code:
A—4 weeks required to complete engineers' study and submit in project form to Ministry of Land, Energy and Water Supply
B—2 weeks required for the process of approval by Ministry of Land, Energy and Water Supply
C—2 weeks for the process of submission to the Development Commission for approval
D—4 weeks to secure funding from local source
E—24 weeks for the process of Cabinet approval and funding for projects costing more than 5000000 vatu
F—Water Supply Department, ordering and delivery of materials, 16 weeks to arrive in capital.

Fig. 3. Flow chart for setting targets



1—Decide on objectives following the requests and needs for water supply.
2—Carry out survey and costing for the project.
3—Approval of cost estimate by the ministry concerned with water supply in accordance with objectives.
4—Seek approval for funding from local and aid sources.
5—Implement approved projects.
6—Compare the progress of work to see how it fits with the programme planned.
7—Modify plan if necessary to meet the changing circumstances during execution.
8—Measure progress to see if it meets with the set objectives.

Fig. 4. Control for rural water supply projects

Each project was to receive a Water Supply Team headed by a trained engineer, to whom three supervisors would be responsible. The engineers would be mainly concerned with survey work, ordering of materials and organizing transport from one island to another, although in practice they could be involved with any problem arising.

This was to be the agreed system at the commencement of 1984, which would be reviewed at the end of that year.

Review of Methods

The shortfall in reaching the 1983 target of 37 per cent by such a large figure of 5 per cent meant that pressure on the system to reach 45 per cent of the population by the end of 1984 was considerable. In fact, 42 per cent was achieved. The organizational and control systems proved satisfactory and the well publicized targets were helpful at each stage.

One major cause for not meeting targets was the process of obtaining funds from abroad, as always with international organizations, but applications were being processed more quickly as a result of the educational programme taking effect, for example:

(a) Improved applications were being received with greater details and more realistic estimates.
(b) Attempts to standardize water systems were gradually being accepted where applicable.
(c) Better communication between villagers and Government authorities was being achieved.

However, it became obvious that other improvements in the system would be necessary to achieve the targets set. The local population were still reluctant to participate in the schemes, therefore rates of pay for the hours worked were agreed, resulting in an overall improvement both in achieving completion times for individual activities and general motivation.

It was easy to state that each project would have an engineer qualified to supervise, but projects were often held up through lack of qualified staff. The recruitment of engineers had been neglected and those from abroad had not been replaced on completion of their contracts. A planned training programme over a ten year period to train suitably qualified engineers was commenced but a crash programme involving recruitment from the Australian Army was already having an effect on morale.

It had proved possible to obtain drilling rigs for boring water holes in specified areas where villages were some distance away from the river, and this proved an additional boost in meeting targets. Furthermore, a mobile force was set up which would make itself available for any emergency call regarding maintenance and also projects falling behind in implementation. A qualified engineer was contracted for this purpose.

A further improvement to the system was introduced in 1984, where projects estimated to cost over 5000000 vatu were reviewed, in an attempt to break the project up into smaller units where possible, which would enable local funding to be utilized. This revised system had enabled projects to be commenced much earlier.

Evidence has shown that the use of simple systems analysis and flow charts has been of great assistance in presenting the problems to various authorities and giving visual targets to be achieved.

KENYA PROJECT

The second rural water supply project concerns Kenya. The approach to the implementation of development projects in Kenya before and after independence in 1964 to 1983 was basically sectoral. During this period, the planning, funding and implementation had been the responsibility of individual ministries, situated in the capital Nairobi and represented in the Provinces and Districts by Field Officers.

In the new system, planning, funding and implementation would no longer be the responsibility of individual ministries or departments. In each of the 41 districts a District Development Committee (DDC), which hitherto had had few defined responsibilities, would have the responsibility of planning, implementation, monitoring and recommendation for funding. This would apply to all government and development agency programmes.

In the management of government programmes or projects, the DDC is expected to observe existing (and amended) financial regulations regarding spending within the budgets. For those DDCs showing slow progress in the implementation of projects the central treasury would reduce allocations, resulting in the slow development of the district. It is important for the DDCs not only to utilize the funds allocated but to show the beneficiaries and the central government that projects have been completed to time and are in use. The DDCs' involvement in the management of development resulted in the increased interest in, and use of, techniques or methods that aided the decision making process and control of projects.

The Problem

The DDCs were undertaking the implementation of a water project in an administrative division of a district in Northern Kenya, with a population of 100000. The source of water in the this semi-arid district was a series of boreholes.

As part of the National Master Water Programme, local consultants, who were familiar with the geology of the district, had put forward a report on the possibility of drilling bore holes to find suitable drinking water. To enable a plan to be developed so that target dates could be obtained, the district water engineer drew up the various activities that would need to be undertaken, with a time schedule to each activity.

The local population (beneficiaries) were to assist in unskilled work on the project which was in line with Government policy. The Government were also very concerned about the completion date. Through the increased participation of the local population in the implementation of development programmes it was envisaged that development would increase at a faster pace, and that the beneficiaries would consider these projects as the 'people's programme', rather than governmental, bureaucratically identified projects. Many projects in the past had been implemented without careful consultation with the local beneficiaries.

Project Planning and Implementation

The first part of the project, which was the search for water, was agreed both from a planning and cost point of view. The second stage involved identification of the main activities for implementation of the plan to bring the supply of water to the local population, and costs.

The Headquarters Project Division requested the District Water Engineer to supply a list of the main activities from design to completion, and duration times. The costs would be calculated and a final decision made as to whether the overall amount came within the budgeted figure.

The list of main activities and estimated duration times was forwarded to HQ; these were as shown in Table 1.

Lack of communication and cohesion between the District Water Engineer and Headquarters resulted in the project being rejected in the first instance due to cost.

The decision to reject the project was based on the estimated overall completion time being 55 weeks at a cost of £20000. Much of this cost was for rented equipment etc., being on site for this period of time.

TABLE I. MAJOR ACTIVITIES FOR WATER PROJECT

Job label	Activity	Activity time (weeks)
A	Design of project	6
B	Advertisement of tenders	4
C	Award of tenders	3
D	Digging trenches	16
E	Construction of storage tank	4
F	Construction of public water points	8
G	Laying of pipes	5
H	Order and delivery of materials	2
I	Installation of pumps/engines	2
J	Testing the system	2
K	Cover trenches and clear site	3
	TOTAL	55

TABLE II. ACTIVITY LIST REVISED

Job label	Activity	Activity time (weeks)	Preceding Activity
A	Design of project	6	—
B	Advertisement of tenders	4	A
C	Award of tenders	3	B
D	Digging trenches	16	A
E	Construction of storage tank	4	H
F	Construction of public water points	8	G
G	Laying of pipes	5	D and H
H	Order and delivery of materials	2	C
I	Installation of pumps/engines	2	H
J	Testing the system	2	I, E and F
K	Cover trenches and clear site	3	J

The final conclusion was, that unless the overall time could be reduced by at least 25 per cent there was little likelihood that the decision would be reversed. It was agreed that the District Water Engineer would produce a further plan within one week.

The District Water Engineer was near retiring age and although having had many years of practical experience he had not been exposed to any modern planning methods. His assistant, however, although lacking the same experience, was conversant with such planning techniques and was given the task of presenting a plan within the time period, after consultation with the local population and other technical staff. Using the previous table of activities and producing a column for Preceding Activity (Table II), the network shown in Fig. 5 was produced.

Network Planning was introduced here for the following reasons:

(1) It can assist in the effective and efficient use of resources such as money, labour and time.
(2) It can determine the earliest time the project can be completed.
(3) It establishes which activities are critical and non-critical, thus enabling the Engineer to see the effect of any delay.
(4) In this instance, the required 25 per cent reduction in over-all time was achieved by the logical planning of activities.
(5) It enables the engineer to control the project from start to finish.

On receiving the plan within the stipulated 7 days it was decided, reluctantly so it appeared, to reverse the decision. A further decision was also made, that unless the project was completed in the stipulated 40 weeks, further funds would be withheld in 1984.

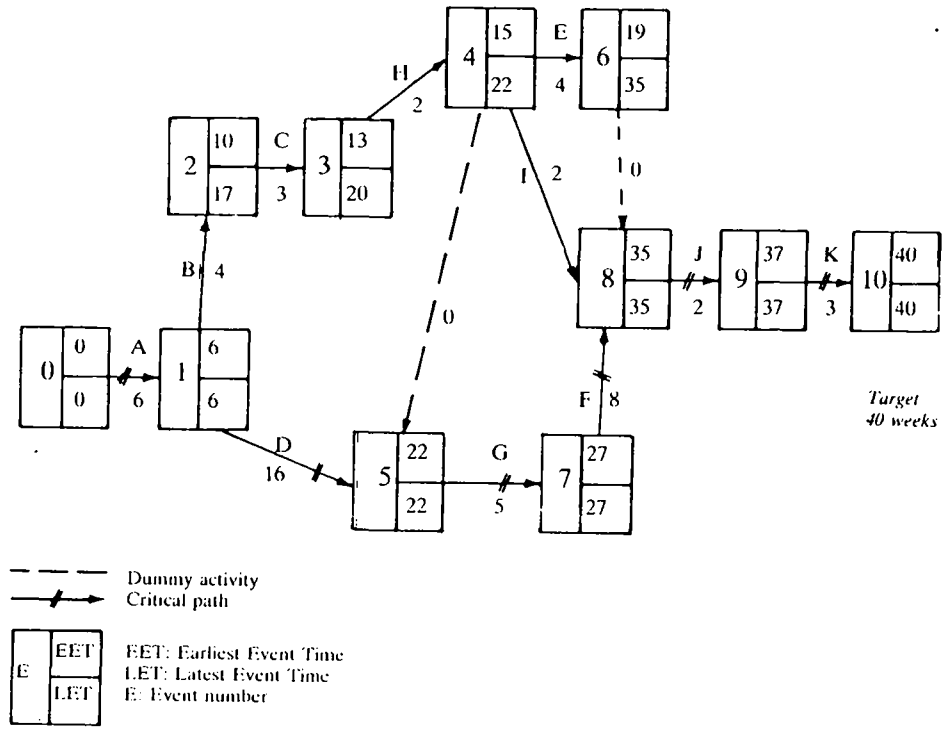


Fig. 5. Network for water project

RESULTS

By concentrating on the critical activities, the District Water Engineer was not only able to complete the second part of the project within the stipulated 40 weeks, but by careful consultation with the local population it was possible to complete activity D (digging trenches) in 14 weeks. This was entirely due to the group working one extra hour per day over the entire period. The project was completed in 38 weeks thus removing the possibility of being penalized for further project work in the area, in 1984.

Final costs for the installation over the 38 week period were £14000, which was acceptable within the budget limits.

CONCLUSIONS

In the application of any model or technique the improvement of the decision making process is the key. The technique or method considered suitable for this small project was based on the use of Network Planning and Control. It was used as an aid, but not as a substitute for intuitive management.

Once the facts of the project had been collected and analyzed it was the District Engineer who made the final decision. He was able to see the implications of alternative decisions and of using resources in a particular way.

In this instance, the Assistant District Water Engineer had the advantage of having been trained in the area of Management Science and realized its potential.

On the final completion of the project, the Headquarters' senior management were so impressed with the outcome that a report was requested on the possibility of further engineers being exposed to a specific training programme in the use of Management Science to the smaller type project.

BIBLIOGRAPHY

Almy, S. W. and Mbithi, P. M. 1972 'Local Involvement in the Special Rural Development Programme', in IDS 1972.
Hirschman, A. O. 1967 'Development Projects Observed'. The Bookings Institution, Washington DC.
Holmquist, F. 1970 'Implementing Rural Development Projects', in Hyden, Jackson and Okumu (Eds) 1970.
Kulp, E. 1970 'Rural Development Planning'. New York, Praeter.
Mansfield, E. (Ed.) 1970 'Managerial Economics and Operations Research'. W. W. Norton.
Owens, A. and Shaw, R. 1972 'Development Reconsidered'. D. C. Heath, Lexington, Mass.
Palmer, C. F. 1980 'Network Planning and Control'. Van Rostron and Reinhold, Wokingham, UK.
Palmer, C. F. and Innes, A. E. 1980 'Operational Research by Example'. Macmillan Press Ltd, Basingstoke, UK.
Waterson, A. 1969 *International Development Review* 1, 3, 'An Operational Approach to Development Planning'.
United Nations Department of Economic and Social Affairs 1965 'Development Plans Appraised'. United Nations, New York.