MANAGEMENT DEVELOPMENT PROGRAMME

Management Development Branch
International Labour Office
CH-1211 Geneva 22

Telephone 98 52 11
Telex 22 271
Cable address: INTERLAB GENEVA

RURAL MGT/6

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Rural Development Managers

Management Training Cases in Rural Technological Choice:

Low-Lift Irrigation Pumps

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This set of draft training cases and teaching notes has been prepared for testing and modification under the ILO/NORWAY Programme on Rural Development Management.

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INTRODUCTION

Many people now recognise that rural development efforts often fail when insufficient attention is given to technology. Increased attention to rural technology has revealed several gaps. Engineers and technologists have attempted to introduce many seemingly appropriate improvements, but often with limited success. Economists and planners have tried to analyse the economic and social consequences of various alternatives, also with limited success.

However, it is managers, from peasant farmers to national programme administrators, who must select, modify and implement rural technologies. Consequently, this small, experimental set of management training cases has been drafted to help bridge this gap between economists, planners, engineers and technologists.

John I. Reynolds prepared these training cases and teaching notes from research carried out by the ILO Technology and Employment Branch.[1] John Wallace of the ILO Management Development Branch edited the cases and prepared supplementary material.

We believe that these cases can be used with little or no modification with managers concerned with farm-level water management. The cases illustrate one method for sharpening the decision-making skills of managers who are concerned with planning and implementing rural development projects. Trainers and consultants often have difficulty finding and preparing relevant materials for such managers. Much of the research in rural technology, while of interest to planners and researchers, is difficult to use when training managers. The act of analysing and solving the problems presented in the cases is intensely involving. In the process of discussing their solutions with each other, managers can learn much from each other.

We hope that trainers and consultants, having worked with this set of cases, will be encouraged to develop similar sets based on the problems of managers in their own countries.

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[1] D.R. Birch and J.R. Rydzewski: Energy options for low-lift irrigation pumps in developing countries: the case of Bangladesh and Egypt. (ILO, Geneva, 1980, ISBN 92-2-102368-0).

PART ONE

CASES AND NOTES FOR MANAGERS

A handout about the case method[1]

The cases you will be working with are short descriptions of realistic (sometimes actual) management situations. They stop short of presenting all the actions taken by a manager in the real world. Thus it is for you to select the actions which should be taken. In so doing you will increase some of your management skills.

You will be expected to come to your own conclusions about what should be done, and you will probably be asked to defend your conclusions with other managers and the discussion leader. There is almost never just one correct conclusion to such cases. However, some conclusions are much better than others. Your task is to find the best one you can.

The cases in this set are in a sequence. They move to more difficult problems and thus build on one another. The decision-making focus also shifts; from the farmer, to a group of farmers, to a district officer, and finally to a national programme manager. This "bottom-up" sequence is important because successful service managers must understand how decisions are made by others whose productivity it is their job to improve.

To use the case method to successfully increase your management skills you will need feedback about the quality of your analysis and the probable value of the actions you propose. If the other people working on these cases are practising managers you may be able to learn a great deal from them by comparing your analysis with theirs in discussion sessions. The more effort you put in, the more you are likely to learn.

The teacher or discussion leader has a special responsibility to make sure your ideas are appraised, both in oral discussion and on written papers you may be asked to prepare. Finally, you may be asked to draw out and clarify the general concepts illustrated by the cases that can be applied to similar on-the-job situations you may face. Usually, you and your colleagues will do most of the generalising, but an alert discussion leader will make sure this is done.

Since you are being asked to use the case method you deserve to know its advantages and limitations. Compared to many other methods of teaching and learning it is very interesting. Thus you are likely to be willing to spend extra time learning. It is intense and generates emotions. Thus you are likely to remember the "lessons" longer and to be able to apply the concepts to solve the problems you face.

The group work and discussions are good practice for the human side of management. Since it involves learning by discovery, you may be better prepared to discover new concepts to solve tomorrow's problems. Thus the case method, which may be a new experience for you has advantages over common methods which merely require you to memorise existing concepts and methods.

How to study a case

First, read it through quickly and become familiar with people in the case and the "main actor" whose role you will play as you analyse the case. Next read it thoroughly, take notes on the important facts and think about the quantitative exhibits. Make a brief statement of the problem. Finally, recheck the important facts and begin to prepare your analysis.

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[1] Based on Part I of "Case method in management development: guide for effective use" by John I. Reynolds (Mangement Development Series No. 17, Geneva, 1980, ISBN 92-2-102363-X).

Case: Hassan Ali's irrigation decision (A)

Hassan Ali was a small farmer of the Comilla District of Bangladesh. He grew rice on his 0.4 hectares of land. It was possible for him to grow two crops of rice per year. One crop was grown during the monsoon season, and required no irrigation. The other crop, grown during the dry season, required irrigation. Ali's land was located on a river bank so it was possible for him to irrigate it for no more than the cost of owning and operating water-lifting equipment.

Two recent developments had caused him to look for advice about his irrigation equipment and procedures. His sons had just told him that they had secured year-round employment in a nearby village at wages of Tk.10 per day.* Also Ali had just become responsible for managing an additional full hectare of land next to his farm, which belonged to his elder brother's widow.

From the time he had inherited his farm from his father, Hassan Ali had irrigated with four dhones, operated in two sets of two. A dhone (see figure 1) is a traditional pump consisting of a hollowed log, one (open) end of which is fixed on the side of the field; this end acts as a pivot. The other (closed) end of the log is lowered into the river and filled. The filled end is then raised by the operator, with the help of a counterpoised weight, to a level slightly above the fixed end. The water then flows down the log into the field. Ali needed to use two dhones in series because the water level in the river is 4 m below the level of his land, and a single dhone could not raise water that far. He needed two sets of dhones because one set, operated steadily by two men for six hours a day during the dry season, lifts only enough water to irrigate 0.2 hectares.

Until recently Ali's dhones had been operated by his four sons who lived at home and contributed their labour to the family when it was needed. In the two growing seasons per year Ali and his sons were able to grow 3,000 kg of rice, with a total "farmgate" market value, if they had sold it all, of Tk.6,600. Costs of operation were as follows for the two-crop seasons:

	Monsoon crop (Tk)	Irrigated crop (Tk)
Fertilizer	204	204
Pesticide	12	12
Seed	44	44
Miscellaneous cash costs	40	40
Animal labour (at Tk.10/day)	170	170
Human labour (except pumping) (68 man-days per season)	0	400
Human labour (pumping)		252 man-days
Total cash costs	470	870

This case was prepared by Dr. John I. Reynolds of Texas A. and M. University, based on research documents of the ILO. The case is intended for use in teaching programmes, and not as an example either of effective or ineffective management and decision making.

During the monsoon season, Ali and his sons were able to do all the work themselves, but usually he had to hire about 40 days of casual labour, at the local prevailing wage of Tk.10 per day during the dry season. Because he owned no animals, he rented draught cows for animal power at Tk.10 per animal-day. His annual money costs of operation therefore totalled Tk.1,340. He usually sold enough rice to meet these outlays and to provide for other cash needs. The rest of his crop provided food for his family of nine, including his wife and three daughters. Although underemployment of agricultural workers such as Ali and his sons was a great problem in his district, various members of the family occasionally got a few days' casual employment to add to the family's income. Ali's sons were typically needed to operate the dhones for about 63 days each year during the dry season.

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* 100 taka is about US$7 in these cases; i.e. Tk.10 per day is equivalent to US$0.67.

The current situation. It was against this background that Ali first faced a problem when his two eldest sons brought him their good news about their new jobs. They were excited about the chance to earn money year round as well as to be with other people in the village. But Ali was concerned about the cost of paying Tk.10 per day for casual labourers to replace his sons at the dhones.

The situation was further complicated by Ali's new responsibilities for the land next to his. His elder brother had never had a son and his 1-hectare plot had lain fallow during the dry season. Hassan Ali believed, however, that he would need to plant the full 1.4 hectares in rice during both seasons to provide enough food and cash for his brother's widow and many daughters, as well as his own family.

He knew he could irrigate the entire plot with seven sets of dhones. He could make the extra dhones out of virtually free materials from around the farm. But he worried about the expense of hiring casual labour to operate the dhones. He knew that he needed to estimate his revenues and expenses for a dry-season crop, but he did not want to make such a big decision without talking to others. He therefore decided to seek the advice of the local representative of the Bangladesh Agricultural Development Corporation (BADC), Mr. Khan.

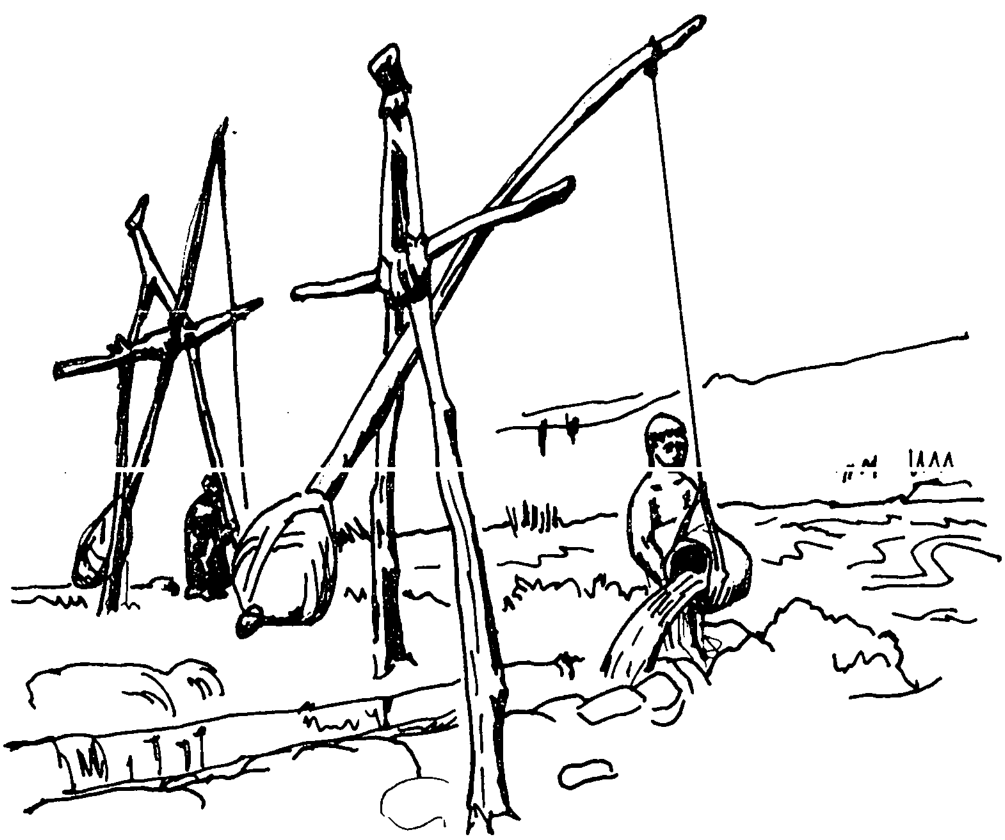


Figure 1. The shaduf as used in Bangladesh, Egypt and elsewhere.

The dhone is the same as the shaduf except that it uses a log rather than a bucket.

Case: Hassan Ali's irrigation decision (B)

When Hassan Ali had given Mr. Khan, the local representative of the Bangladesh Agricultural Development Corporation (BADC), the facts shown in the previous case, Mr. Khan told him more about the Government's irrigation programmes. He said that it might be possible for Ali to arrange for an animal-powered pump if by chance there were enough draught animals in his district. "Of course", he said, "animal-powered pump sets are not conveniently available because few areas in Bangladesh have enough draught animals." When Ali told him that the animals in his district were usually not available for steady daily work during the dry season, Mr. Khan said, "Perhaps you can use one of our rental pump sets, powered by diesel fuel."

Mr. Khan said that the BADC was willing to rent a pump set of 60 l/sec* capacity to any group of farmers who formed a water co-operative. The co-operative was necessary because the pump's capacity was sufficient to irrigate 21.6 hectares for the season and the rental rates were subsidised by the Bangladesh Government as were the cost of spare parts and the prices of diesel fuel. The costs for a typical growing season would be:

	(Tk)
Season's rental of pump set and engine	600
Spare parts	300
Diesel fuel (1,000 l at Tk.2.64/l)	2 640
Lubricating oil	300
Season's pay for operator (paid locally)	1 050
Total season's cost	4 890
Season's cost per hectare (4,890 ÷ 21.6)	226

Ali's first reaction to Mr. Khan's proposal was that he would find it difficult to gather together enough fellow farmers to form the required co-operative. Most of his neighbours were small farmers like himself who typically used unpaid family members to operate dhones during the dry season. He expressed this concern. Mr. Khan told him that in many districts it had been necessary to get a pump into the field before enough farmers could be persuaded to sign up. "In fact", Mr. Khan said, "you may be surprised how few hectares it takes to break even on the use of a pump such as this. Perhaps either you or one of your sons can operate the pump, which further reduces the cash costs of the operation." Ali agreed to think the matter over when Mr. Khan assured him that pump sets were not in short supply for the coming season.

* L/sec or litres per second.

Case: Hassan Ali's irrigation decision (C)

Hassan Ali's cousin Yussuf owned 0.2 hectares of land nearby. Yussuf had several sons and therefore had no difficulty in growing two crops of rice on his land per year, without having to hire labour. His irrigated crop therefore represented the following farmgate price/cost picture to him when Ali came to ask him to join the new water co-operative:

Crop of rice	750 kg
Crop value	Tk.1 650
Cash costs (fertilizer, seed, pesticide, misc. and animal labour)	235
Net return	1 415
Human labour (all family, unpaid)	160 man-days

Yussuf's first question was, "How much will I have to pay in cash as my share of the pump's cost for the season?"

"It depends on how many people join the co-operative. At the moment, if you join, we will have 2.8 hectares covered and the cost to you would be about Tk.350. If we get as many more to sign up, as I hope we would do before I would commit for a pump set, your cash cost would be only Tk.175. Put in another way, if you or your sons can find casual work for only about one day in seven that you are now working the dhones, you would come out even with your present return. If you work more days than that, you are actually ahead. Besides, the pump will do away with a great deal of hard labour for those who now work the dhones."

Yussuf added his name to the list of co-operative members saying, "But only if you get at least 5.6 hectares signed up".

Eventually, Ali got signatures from another 17 landowners, of whom two, each an owner of half a hectare, had previously not grown a dry-season crop. All the others, like Yussuf, either hoped to come out ahead by finding some casual work, or were convinced that the slight cash cost of joining the co-operative was a satisfactory price to pay for giving up the hard work on the dhones.

Case: BADC pumpset programme (A)

The Bangladesh Agricultural Development Corporation (BADC) had for some years offered pumpsets to farmers on attractive terms. The objective was to increase the amount of rice grown in Bangladesh during the dry season. For several years BADC had always had some pumpsets in reserve; despite best efforts, too few farmers formed co-operatives to rent the pumpsets. Events surrounding an individual farmer of Comilla District, Mr. Hassan Ali, as set forth in two previous cases, suggest the decisions faced by the farmers.

A few days after the conversation presented in previous cases, Hassan Ali returned to Mr. Khan's office and told him that he had decided to rent a pumpset for the upcoming dry season.

"Have you formed a co-operative of farmers with enough land to use up the pump's capacity, then?" asked Mr. Khan.

"Not exactly, sir. But I have found enough of my family and friends with nearby farms so that we can afford to rent the pump." Ali looked worried. He had interpreted Mr. Khan's statements about the programme as being flexible regarding the number of hectares that would be irrigated. "We certainly hope that others will join us when they see the pump in place and find out how much water can be available."

Mr. Khan was anxious to see the pump-rental programme succeed in getting pumps out in the field. He did not press Ali for details. When he later examined the form that specified the names and hectares owned by members of the co-operative, he found that there were 20 persons who collectively owned 6.8 hectares of land. Khan recognised from their names that all but a handful of the farmers were directly related to Ali, and he believed it likely that several others were linked to Ali by marriage. As he completed the forms and arranged for the delivery of the pumpset, Mr. Khan wished the farmer and his colleagues a prosperous dry-season crop.

After Ali left the office, Mr. Khan thought about the circumstances in which he found himself. The Government was concerned over shortfalls in use of available pumpsets. He had been encouraged to undertake a quota for getting the pumpsets accepted by farmers. The rental arrangements represented a substantial subsidy to the farmers. Although he did not know in detail how the figures were arrived at, he understood that the fully remunerative expenses for a season's use of the pumpsets would be:

Season's rental	Tk 3 947	(as against 600 charged)
Spare parts	1 050	(as against 300 charged)
Economic cost of diesel fuel	4 650	(as against 2 640 estimated)
Lubricating oil	300	(as against 300 - no change)
Total:	9 647	(as against 3 840)

Mr. Khan wondered whether the rental price could be altered to get more sets accepted. After considering the matter, he decided to make an informal presentation when next he was in Dacca, at a meeting of the various district representatives. He could talk with his fellows, to see if they were having results similar to his, and if they agreed what to do about it.

In fact, at the conference one of the main topics on the agenda was how to get more pumpsets into the field. When he had a chance to get the floor he presented the facts about his renter, Mr. Ali, and pointed out that, a lower price for diesel fuel would make it easier to persuade farmers with even less land to lease pumps. "But we must realise that this would not work primarily on the problem the pumpset programme is meant to solve, which is to get more land under irrigation during the dry season in order to increase the amount of rice grown in Bangladesh, and thus reduce the need for rice imports."

Mr. Fouad, Mr. Khan's superior officer in Dacca, listened to this presentation and others, and pondered what he should do, if anything, as a result of the information he had heard from the district representatives.

Case: BADC pumpset programme (B)

The day after the conference mentioned in BADC case (A), Mr. Khan's superior officer, Mr. Fouad, considered the pumpset rental programme in its broader context. First he reviewed the information on the size of landholdings in the country as shown in exhibit 1. Typical landholdings were extremely small, over 50 per cent of Bangladesh's population was in families which owned no more than 0.4 hectares of land. Mr. Fouad did not have immediate access to data regarding how many of the landholdings of various sizes were adjacent to rivers, and thus could be irrigated by dhones. Nor did he know the patterns of ownership, that is, whether landholdings of various sizes were randomly situated throughout the country or concentrated in certain regions. He knew, however, that a total of 1.04 million hectares were currently under irrigation, of which about 47 per cent were irrigated by traditional means or by gravity-flow. The rest were irrigated by mechanical pumps, most supplied under the programme described here.

He had a record of annual rentals of pumpsets and numbers of hectares under irrigation by the rented pumps for selected years between 1960 and 1977 (exhibit 2). In each recent year extra pumps were available. He asked for a record of whole-sale prices for rice (exhibit 3). He remembered Mr. Khan's question about whether some changes in subsidies might better meet the programme's objectives. He wondered in what terms the Government should measure the programme's relative success. Particularly, he wondered how he might interpret exhibits 1, 2 and 3, to judge something about the success of the programme. He also wondered whether the "success" of the programme would seem different, when he studied the details of Hassan Ali's adoption.

Exhibit 1: Size distribution of landholdings in Bangladesh

Area groupings ha.	Number of persons ('000)	% of persons	Total area ha. ('000)	% of ha.
0	5 713	8.3	0	0
0.0 - 0.4	29 221	42.3	520	6.9
0.41 - 0.8	11 590	16.8	1 117	14.8
0.81 - 2.0	14 213	20.6	2 579	34.2
2.1 - 4.0	5 800	8.4	1 804	23.9
4.1 - 6.0	1 371	2.0	647	8.6
Over 6.0	1 145	1.7	2 184	11.6
	69 053	100.0	7 541	100.0

Exhibit 2: BADC pumpset programme results (selected years)

Year	Pumps fielded	Area irrigated (ha.)	Ha. per pump
1960/61	1 267	25 811	20.5
1965/66	3 420	173 553	20.3
1970/71	24 454	328 030	13.4
1971/72	24 254	345 771	14.3
1972/73	32 924	492 187	14.9
1973/74	35 343	532 324	15.1
1974/75	35 427	518 784	14.6
1975/76	36 372	572 400	15.7
1976/77	28 224	413 731	14.7
1977/78 (Target)	39 000	---	--

Exhibit 3: Wholesale price of rice and demand for pumps

Season	Wholesale price of rice (Tk/kg)	Pumps fielded
1971/72	Tk.1.5	24 254
1972/73	2.6	32 934
1973/74	3.03	35 343
1974/75	6.17	35 427
1975/76	3.78	36 376
1976/77	3.35	28 224
1977/78	4.83	Not available

Case: BADC pumpset programme (C)

Mr. Fouad believed that the results of his appraisal of the BADC pumpset programme were incomplete, so far. For one thing, he knew that the underlying calculations of the costs borne by the Government (see exhibit 1) involved both foreign exchange costs and costs in takas. Furthermore, the locally grown rice represented costs and revenues in takas, whereas any rice that must be imported required foreign exchange. Although it was simple mathematically to convert one currency into another at the official exchange rate, Mr. Fouad wondered whether some other calculations would be useful in evaluating various ways to solve the problem of growing more rice. He knew that some economists advocated using what they called "shadow prices" in circumstances where one must compare costs in terms of two currencies, one of which was scarcer than allowed for in the controlled rate of exchange.

Additionally, there were "costs" attributed to pumpsets in the calculations which he thought should be viewed differently than other costs. One of these costs was the import taxes on diesel engines. Mr. Fouad thought these might be viewed as merely an intra-government transaction, not representing a cost at all. The other cost was that of imputed interest (at 12 per cent) on capital costs. He was not sure whether this cost should be attributed to the pumpset programme, particularly when comparing the costs of pumpsets against other methods of irrigation, where the calculations that had been prepared for him did not attribute an interest cost. When Mr. Fouad adjusted the figures in exhibit 1 to remove import taxes and imputed interest, he found that the capital cost per season became just Tk.1,500, rather than Tk.3,947.

He was also concerned about the calculation of a government subsidy of Tk.5,807 per pump per growing season (as shown in BADC pumpset case (A)), no matter how many hectares were irrigated. The estimate of diesel fuel use was directly determined by the number of hours the pumps operated (see exhibit 2). Because the pumps operated at a constant speed, they should not have to operate as many hours to irrigate (say) 6.8 hectares as budgeted in exhibit 2 at full capacity (which could irrigate 21.6 hectares).

The question of efficiency and underemployment

Mr. Fouad was also sensitive to the potential criticism of programmes like the pumpset programme, that they increased the underemployment problem in the rural areas. He knew that the underlying issue was that human beings are inherently inefficient as suppliers of mechanical power. For example, he had in his hands a comparison of the estimated costs of supplying the equivalent of 1 kilowatt of energy by various means in Bangladesh (see exhibit 3). In comparison with animal power, for example, this comparison meant that a man would have had to accept Tk.1.25 per day in order to be cost-competitive with a cow in delivering energy. The comparison with diesel engines was even less encouraging, unless the shadow price of foreign exchange were somehow very high.

Exhibit 1: Cost of owning a BADC pumpset (imported engine)

Capital costs	Taka	Foreign exchange
Engine cost in the UK	12 030	12 030
Transport cost, the UK to Bangladesh	1 200	1 200
Import taxes at 34 per cent of capital cost	4 095	--
Pump, trolley and fittings cost (local manufacture)	7 500	--*
Local transport and handling	975	--
Expected engine life, 12 years		
Total capital cost of engine	17 925	13 230
Expected life of pump, trolley and fittings, 20 years		
Total capital cost, pump, trolley and fittings	7 875	--
Seasonalised capital costs, with imputed 12 per cent interest	3 947	

* Doubtless some portion of all local manufactures should be thought of as bought with foreign exchange, but little purpose is served by following this cost into greater detail.

Exhibit 2: Season's operating costs, BADC pumpset

	Total cost	Cost borne by operator	Foreign exchange
Pay of pump operator	Tk.1 050	Tk.1 050	--
Spare parts	1 050	300	Tk.1 050
Diesel fuel (1,000 litres)	4 650	2 640	4 650
Lubricating oil	300	300	300
Season's total	7 050	4 290	6 000

Exhibit 3: Estimated costs of producing energy by various means

Power source	Taka per kWh
Manpower, using legs to pedal (Tk.10 wage)	24
Cattle power (Tk.10 per day)	3
Diesel engines (subsidised)	0.75
" " (unsubsidised)	1.35
Mains-powered electric motors[1] (subsidised)	0.60
" " " " (unsubsidised)	0.90

[1] Electric motors were out of the question in the short run as power for pumps, since existing distribution networks could not reach most pump sites.

Mr. Fouad was aware, however, that the dhone irrigation system was not even as efficient as other man-powered systems in use elsewhere, but which were suitable for use in the conditions of Bangladesh. For example, the Chinese chain-and-washer pump, whose costs are shown in exhibit 4, was a definite possibility, since it would allow two men to irrigate 0.45 hectares of rice in the circumstances of Comilla District, where Hassan Ali's land lay. The season's cost per hectare, paying full wages, would be Tk.5,000.

Finally, intrigued by the obvious superiority of animal power over manpower, as shown in exhibit 3, Mr. Fouad asked for exhibit 5 to be prepared, which showed what the situation might be if cattle were more generally available for powering pumps in Bangladesh. Using the current daily rental for cows, the season's cost per hectare would be Tk.1,140. The farmer who undertook to own cattle in order to provide himself with cattle power for irrigation would face nearly the same expense, when his capital costs for the cattle and cash costs for a cattle boy were taken into account. As usual, the farmer whose unpaid family member could watch over the cattle would be able to save proportionally.

Exhibit 4: Cost of owning and operating a man-powered chain-and-washer pump in Comilla

Capital cost (expected life 10 years)	Tk.8 250	
Seasonalised capital cost		Tk. 825
Season's maintenance cost		165
Manpower (two men for 63 days)		1 260
		2 250
Area irrigated, 0.45 hectares		
Season's cost per hectare		5 000

Exhibit 5: Cost of owning and operating a cattle-powered chain-and-washer pump in Comilla (cattle rented)

Capital cost of pump (expected life 20 years)	Tk.9 750	
Seasonalised capital cost		Tk. 488
Pump maintenance		195
Boy to look after cows		330
Rental of cows (4 x 63 x 10)		2 520
		3 533
Area irrigated, 3.1 hectares		
Cost per hectare		Tk.1 140

Although Mr. Fouad knew that various energy sources were under development which might well change the relative costs some years in the future, he believed that the four irrigation methods for which he had information were completely illustrative of the choices he had available. He listed them in common terms, as shown below in exhibit 6.

Exhibit 6: Comparison of costs and returns, various methods of irrigation, using hired labour

Irrigation method		Cost/ha.	Net benefit/ha. (excluding irrigation)	Net return
Dhones		Tk.6 300	Tk.5 490	(Tk. 810)
Man-powered chain and washer		5 000	"	490
Cattle-powered chain and washer		1 140	"	4 340
BADC pumpsets[1]				
at capacity	(subsidised)	226	"	5 264
	(unsubsidised)	510	"	4 980
at 6.8 ha.	(subsidised)	719	"	4 771
	(unsubsidised)	1 620	"	3 870

[1] Using cost and subsidy figures without adjustment.

Mr. Fouad wondered whether any of the additional figures he had generated, and the questions he had asked, would lead him to suggest any changes in the BADC pumpset programme.

Technical note on low-lift pumps*

Man-powered pumps

Different types of human-powered pumps have been developed over the centuries in different countries.

The shaduf

This consists of a lever in the form of a pole pivoted near its centre like a seesaw. At one end is a bucket made of skin, clay or a large tin can. At the other end is a counterweight made from either stone or clay. By rocking the pole the bucket is alternatively lowered into the water to fill, and raised to field level where it empties. The counterweight is adjusted to match the weight of the full bucket - most of the work is then done in lowering the bucket to the water. In the Sudan the average output of a shaduf has been estimated at 0.83 l/sec with one man working continuously over a six-hour day and lifting water 2.5 m.

The shaduf is still used extensively in Egypt, mostly for the irrigation of vegetable gardens rather than for field crops. The shaduf is used in some areas of Bangladesh, again mostly for vegetable production. It is used mostly for lifting water from dug wells, since the sloping sides of the rivers make it difficult to operate. The cost of operating a shaduf in Middle Egypt is estimated at US$562 per season per hectare. The capital cost is very small and all operating cost consists of labour cost and therefore, in areas where landholdings are very small, it has the advantage that a small farmer will be able to own and operate this pump without hiring any labour.

The dhone

This is similar to the shaduf except for the bucket. Instead of the bucket a hollowed log is used (occasionally a modernised version is seen consisting of a half cylinder made from sheet steel). One end of the log is fixed on the side of the field and acts as a pivot. The other end (which is closed off) is lowered into the water and filled. This end is then raised (with the help of a counterpoised weight, as with the shaduf), to a level slightly above that of the field. The water then flows down the log to the field. The dhone has a low lift, probably 2 m at most, and can discharge 0.9 l/sec when operated by one man working a six-hour day. It is frequently used for irrigating small plots next to rivers in Bangladesh. It has the advantage that it moves the water across the sloping banks of these rivers, as well as up them. It is most used for irrigating the low-level flood plains adjacent to the rivers but occasionally two or three are used in series to gain a higher lift. The cost of owning and operating two dhones in Bangladesh to lift water against an average lift of 7 m is US$463 per hectare per season. There is very little capital cost involved, labour cost accounting for the bulk of the total cost.

The Chinese chain and washer pump

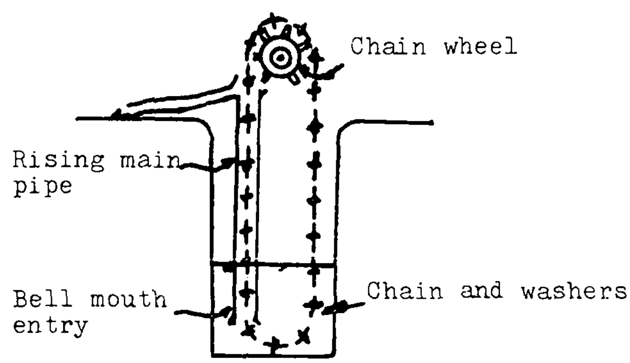
This pump, or pater-noster pump, has been used for many centuries in both China and Europe. The chain and washer is pulled in a continuous loop up inside a closely fitting pipe, then over a geared wheel and then back down to the bottom of the pipe. It is a large and bulky machine. Water is carried up between each washer from the mouth of the submerged pipe to the top where it is discharged into a trough. The maximum practical lift for this type of pump is 15 to 20 m; several chain and washer assemblies can be fitted to the same axle to increase the discharge. It can be described as a high mass/low power ratio pump because each component is under a light load and is not highly stressed. Thus relatively soft materials, such as wood or rope chains and oiled wood bearings, can be used.

There are many different forms of the chain and washer pump. They differ in complexity of the gearing system, type of washer and chain, and the power source (e.g. hand-cranked, pedal-powered, windmill-powered and engine-powered). The simplest form (figure 1), is hand-cranked, capable of lifting 0.35 l/sec through a lift of 5 m by one person working a six-hour day. Twice this quantity can be obtained if two people operate the machine.

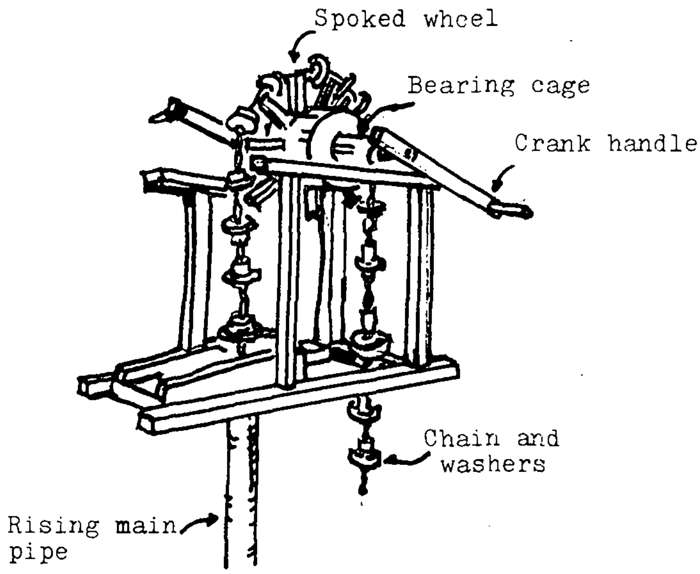
* For more information see "Energy options for low-lift irrigation pumps in developing countries" by Birch and Rydzewski (ILO, 1980, ISBN 92-2-102368-0).

These pumps are not used in Bangaadesh. There the most sophisticated man-powered pump currently used is the dhone. Chain and washer pumps could prove to be useful there since two men can raise nearly twice as much water by this method than they could with a dhone (against the average head). It could be used in Bangladesh to pump from dug wells or from surface water. If used from surface water the pipe and chain would either have to be laid on the slant down the bank, or else a certain amount of earthworks would be necessary to inlet the water to a point vertically below the top of the bank. Since this pump is not used in Bangladesh, its costs were estimated using current prices of material and manufacturing. The expected life and maintenance costs are also rough estimates. The chain and washer is nearly 40 times more expensive to construct than a dhone but the increased efficiency means the over-all operating cost is slightly lower.

Figure 1. The chain and washer pump



(a) Principles of operation



(b) Structure for hand-operated spoked wheel pumps

PART TWO

NOTES FOR THE TRAINER

(NOT TO BE GIVEN TO PARTICIPANTS)

In as much as these cases have not been fully tested in the classroom, you should work through each one carefully to be sure that you understand it thoroughly before using it. Participants should receive only the cases; you have the whole packet. The cases would be handed out one at a time. Participants would usually prepare their analyses outside of the classroom. They could be asked to do the analysis alone, or in small groups of two or three. You could ask one or two individuals to present their analyses and conclusions at the beginning of the following session. You feel that most of the participants will be on the right track. A course leader skilled in the case method will usually refrain from giving his solution as the only or best one. You should hand out the next case only after being satisfied that the group has understood everything of the previous case. Solution sets might be prepared and given to the participants after discussion to help them review the analysis.

Ali case (C) has no teaching note and would usually be given to the participants after discussion of Ali (B), along with BADC (A). It mainly provides data that are useful in the later cases. However, if the participants are not yet skilled at making the computations to support their analyses, you may want to use Ali (C) to build up their calculating skills. For example, the participants can be asked to compute various ways of sharing the cost of a BADC pump set.

Participants who have never used the case method before will need some explanation. A note summarising the case method has been included in the packet for you to give to them.

If you have not used the case method very much you will find the book, Case Method in Management Development by John Reynolds (ILO, Geneva, 1980), very useful.

Technical material on which the cases are based is contained in Energy Options for Low-Lift Irrigation Pumps in Developing Countries: The Case of Bangladesh and Egypt by D.R. Birch and J.R. Rydzewski (ILO, Geneva, 1980). It contains useful material to supplement the cases.

As a trainer you may find that this package is most useful in the long run in demonstrating one way of taking technical and research work and turning it into material from which managers can learn new skills.

A list of sources of additional material is included at the end of this packet.

Selecting cases to fill course objectives

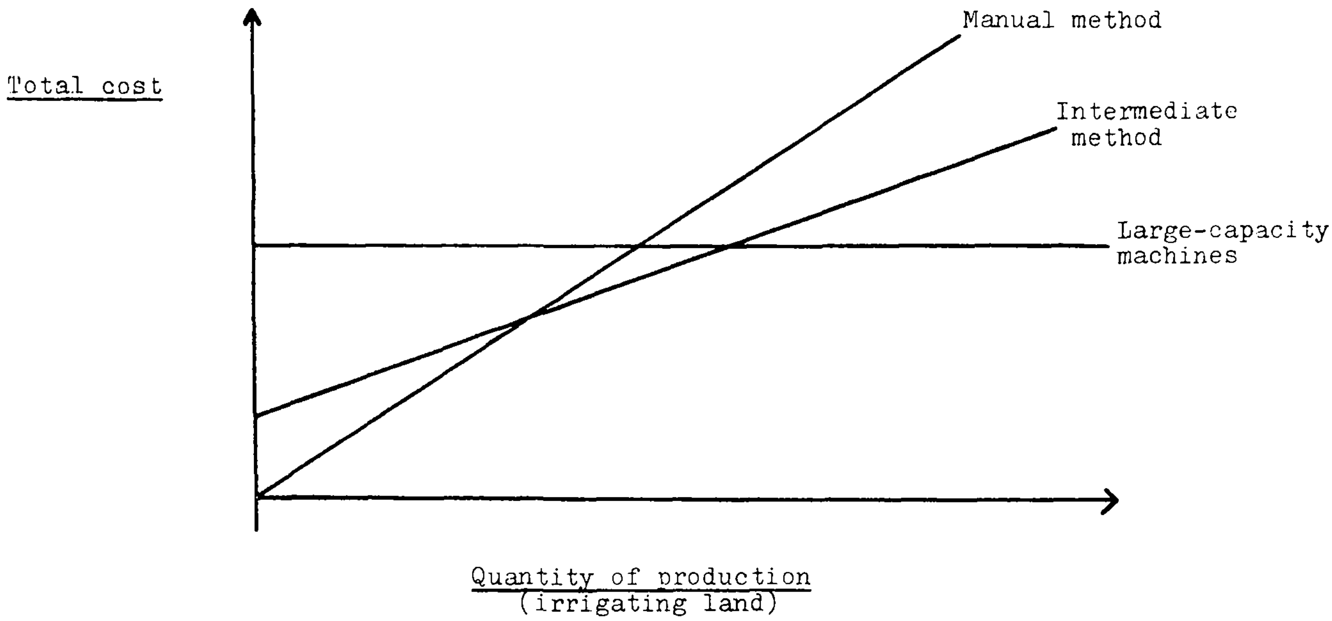
At this time we have very little information to help us determine the training needs these cases might help fill.

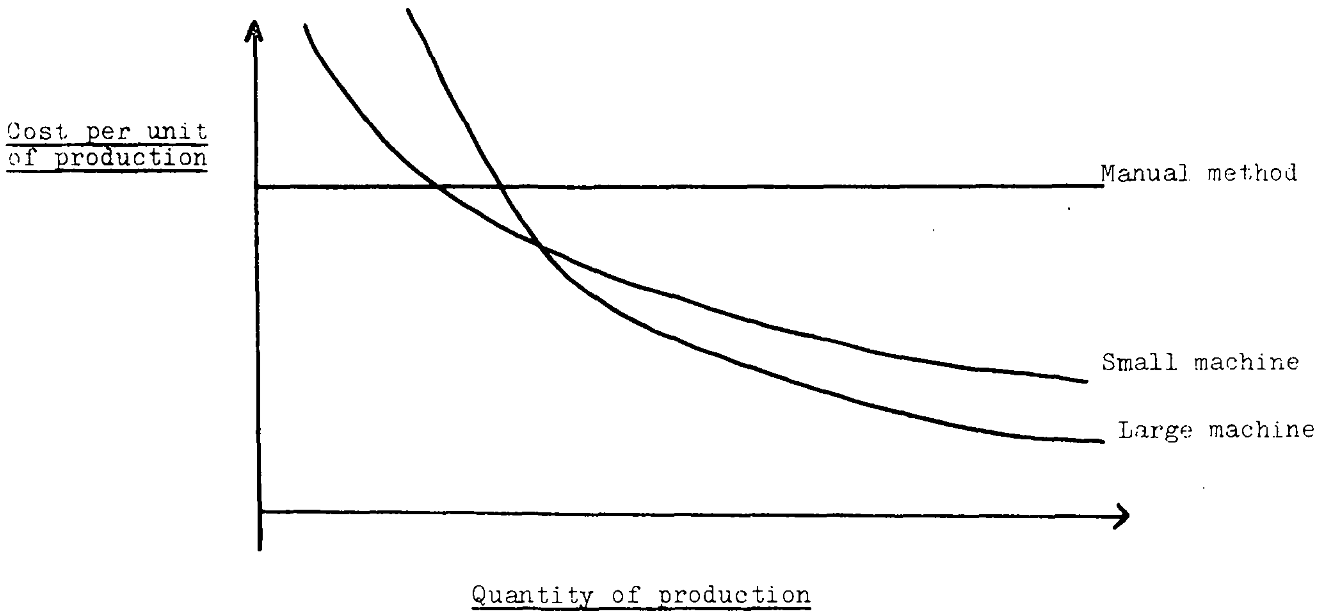
Rural project managers are often faced with problems of selecting machinery and equipment. By working out solutions to these cases, such managers can build up skill and confidence in how to analyse such problems. They may, therefore, be in a stronger position to influence others who must approve such procurement decisions.

Extension agents and rural service managers (such as Mr. Khan in these cases) must often advise small farmers on what tools, equipment, seed, fertilizer, etc., to use to improve yields. These cases can be used to help such agents and managers improve their ability to help farmers analyse their situations and make choices. If participants in a course need to improve their ability to advise farmers, it may be important to help them prepare forms and checklists that they can use with the farmers.

National programme administrators are often faced with decisions about the best mix of inputs to provide farmers. For example, Mr. Fouad, the BADC Administrator, is trying to find a better mix of technologies in the BADC pump set cases. Such administrators may be able to improve their decisions by using capital-budgeting analyses, break-even analyses, etc.

The participants may be able to remember better their conclusions from some cases like this one if they are asked to draw diagrams that illustrate the principles discussed. For example, the cost of alternatives such as the dhone, the chain and washer pump and the diesel pump can be looked at as in the figures below:





See Chapter 7 of An Introduction to Rural Project Management (ILO, 1980), for additional examples. You may find that Chapter 7 is useful background reading for these cases.

Teaching note for Hassan Ali's irrigation decision (A)

It is important to get participants to work out the revenue and cost implications of Ali's options. One way to start is to get the participants to agree that the problem arises in the dry season only, since the revenues and expenses of the monsoon crop will remain about the same, no matter what Ali decides to do about the dry-season crop. Furthermore, participants should be persuaded that it is appropriate to value the rice crop at "farm-gate" prices, which implies that Ali could buy rice from neighbours, if necessary, at the same price (Tk.2.2 per kg) at which his rice is sold. (In a later case it will become apparent that "wholesale" prices are much higher than "farm-gate" prices, which is an issue for government officials, but not for Ali.)

There are at least two ways to develop the relevant numbers in this case, depending on the sophistication of the participants. The first is to create separate projected income and expense statements for three different plot sizes, as below:

Items of revenue and expense, irrigated crop	Plot size 0.2 ha.		0.4 ha.		1.4 ha.	
Kg of rice[1]	(750)		(1 500)		(5 250)	
Revenue value		Tk.1 650		Tk.3 300		Tk.11 550
Costs:						
Fertilizer		102		204		714
Pesticide		6		12		42
Seed		22		44		154
Miscellaneous		20		40		140
Animal power		85		170		595
Labour, non-pumping (man-days)	(34)		(68)		(238)	
Cash costs[2]		60		400		2 100
Labour, pumping (man-days)	(126)		(252)		(882)	
Cash costs[2]		0		1 260		7 560
Net return:		1 355		1 170		245

[1] Early in the discussion the assumption should be established that yields and costs (except human labour costs) are directly proportional to the size of the plot.

[2] Since the cash costs of human labour are the crucial figures, and because these are the costs that are changed by Ali's changed circumstances, these estimates should be established with care. The figures shown above assume that Ali's two remaining sons work "free" at the dhones in all three plot sizes. Ali's own work is expected to save 28 days of non-pumping labour (just as it has on his present plot), no matter what size plot is being worked. Other assumptions could be made, but the differences in outcomes would be minor.

Another way to demonstrate the relationships is to show that the revenue minus all costs except pumping costs for Ali's present holdings (i.e. Tk.3,300 - 869 = 2,440) is not sufficient to pay the going rate for 252 man-days of pumping (Tk.2,520). In other words, as long as the cash (or the resulting crop) stays in the family, operating the dhones is a good way for a son to contribute to the family if he does not have an opportunity to work elsewhere at Tk.10 per day or more.

It is important to be sure that participants recognise that it is not in Ali's best economic interests to refuse to let his older sons accept the village jobs. Because they are year-round jobs they will pay about Tk.2,500 to each son, to offset the Tk.630 dhone-working wages plus some small amount of other casual wages foregone. Not only the sons but the family are better off to the extent each son's increased living expenses are less than about Tk.1,800 per year.

The general conclusion that should be reached before going on to the next case is that, at prevailing farm-gate rice prices, wages and other costs, Ali would be wise to plant only 0.2 ha. in rice during the dry season, if he could only use dhones for irrigating. An alternative way of putting the matter is that dhones are only satisfactory when operated by family members, and then only by family members for which no other occupation is available at prevailing wages. . Therefore, a rational farmer will only plant a dry-season crop as large as his family can irrigate, with dhones.

Teaching note for Hassan Ali's irrigation decision (B)

First there is no completely "logical" way to decide how many hectares it would take to make a farmer (or group of farmers) willing to rent a pumpset. The participants are likely to approach this case in several acceptable ways. It is easy to show that the arrangement is a good "deal" at the capacity operation, via the following reasoning:

Assume that Hassan Ali's crop size and cash costs are typical, then the following would be the projected costs and returns from 1 hectare:

Crop size (kg of rice)		3 750	
Revenue (at Tk.2.2 per kg)			Tk.8 250
Costs:			
Fertilizer		Tk. 510	
Pesticide		30	
Seed		110	
Miscellaneous		100	
Animal power		425	
Human labour (non-pump) (man-days)	(172)		
Cash costs		1 440	2 615
Margin before irrigation			5 635
Season's irrigation costs			226
		Net return per ha.:	5 409

Another way to put it is that pumpset irrigation would cost just Tk.0.06 per kg of rice grown, less than 3 per cent of the farm-gate price. On all scores it seems cheap, when used to capacity.

It is easy enough to analyse the other extreme, as well. That is "break even". It would take less than a hectare of rice crop to "break even" on a season's rental of the pumpset, even ignoring the fact that the pump would surely be used less, and therefore require far less fuel, than when operating at capacity. None the less, no farmer by himself would be willing to rent a pump in order to break even, quite apart from the obvious risks of crop failure, price breaks, and the like.

One good starting point for analysing this case is to compute Hassan Ali's decision regarding the 1.4 ha. plot. For the teaching note in the Hassan Ali (B) case we find that the revenues and costs other than human labour are Tk.11,550 and Tk.1,645, leaving a margin, to cover human labour and irrigation costs, of Tk.9,905. If we assume that Ali plans to operate the pumpset, and that his two younger sons, freed from the dhones, will be able to offset some of the non-pump human labour costs (say Tk.280), the net return from 1.4 hectares would be: Tk.9,905 - 1,820 (human labour) - 3,840 (pumpset costs) = Tk.4,245.

This Tk.4,245 must be compared with Ali's best alternative return, which would be to irrigate only 0.2 ha., from which (from previous note) he would realise 1,355. His net return would thus be Tk.4,245 - 1,355 = Tk.2,890, if he were to think of taking a pumpset by himself. This may be thought of as about a "1.8:1 gamble". That is, Ali would put up Tk.3,840 in return for a chance to gain Tk.6,730.

If Ali can attract other farmers into the co-operative, he could reduce his risk (improve his odds), both by reducing his share of the gamble and by increasing the net return on his 1.4 ha. plot. For example, at 2.8 ha. and 5.6 ha., the project would yield "odds" of 3.8:1 and 1.8:1, via the following calculations:

	2.8 ha.	5.6 ha.
Ali's share of pump costs	Tk.1 920	Tk. 960
Ali's net return on rice from 1.4 ha.	4 810	5 770
Ali's cash pay as pump operator[1]	525 (1/2 total)	788 (3/4 total)
Total return:	~~7 255~~ 5335	~~7 518~~ 5770
"Odds"	3.8:1 (7 255:1 870)	1.8:1 (7 518:935)

[1] This assumes that other participants are charged proportionally for Ali's labour as pump operator.

The above figures are "conservative" in estimating costs, since the underuse of the pump would save on fuel.

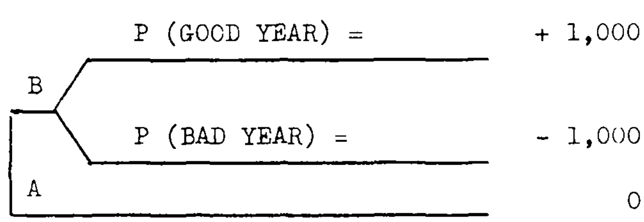
We can conclude, therefore, that powerful economic forces are at work to encourage Ali to persuade neighbours to join in a co-operative. None the less, it becomes a fairly attractive gamble at substantially fewer hectares than the pump could irrigate at capacity.

If the discussion reaches this stage, the discussion leader can ask participants to give their own estimates of how many hectares it would take to get farmers to form the co-operative.

If the participants are not familiar with thinking in terms of odds, likelihoods and probabilities, it may be useful to pose questions such as:

"You are a farmer who is married with two sons and you have 0.4 hectares of land which you plant in rice. During the dry season you can (A) let the land lie fallow which costs you nothing and generates no income; or (B) you can plant 0.2 hectares in rice. In a good year you make a net return of Tk.1,000. In a bad year you lose the money you invested in inputs, about Tk.1,000. What is the lowest probability of a good year that you would consider acceptable for planting a dry-season crop?"

Problems like these can be visualised as below:



Expected value of (B) = 1,000 x P(GY) + (- 1,000) x P(BY).

The willingness of the participants to take risks can be highlighted by putting their answers to such questions on the chalkboard. This, in turn, will probably generate a good discussion about their assumptions.

Teaching note for BADC pumpset programme (A)

Here it is important to develop the various parts of the picture as seen from Mr. Khan's viewpoint, with the data available to him. Since he has already "bucked up" the issue to his superior, the signal has been given that Khan could not, by himself, do much beyond what he has done. It is still important for discussants to recognise this fact, and to work out the quantitative and qualitative statement of the dilemma facing the lowest-level bureaucrat.

A first step would be to convert the subsidy per pumpset into taka per kg of rice, both at pump capacity and at the 6.8 hectares of Ali's operation.

	Area served	
	21.6 hectares (capacity)	6.8 hectares
Rice grown	82 080 kg	25 840 kg
Subsidy	Tk.5 807	Tk.5 807
Subsidy per kg of rice	Tk.0.07	Tk.0.22

Discussants should be sure to recognise that there is no "objectively correct" amount of subsidy, just as was realised earlier that there is no clear way to determine, from the farmer's viewpoint, at what point it "pays" to rent a pumpset.

This may also be good to develop the qualitative rationale behind government subsidy. Why should the Government subsidise pumpsets, at the expense of increased underemployment in the agricultural sector? Could it accomplish a similar result by using the money to subsidise wages of dhone operators? Are there other actions, either of intervention or reduction of intervention, which the Government might take to improve the situation?

Teaching note for BADC pumpset programme (B)

One can analyse this case several ways. Exhibit 3 shows that the acceptance of pumps grew from 1971 to 1975, as the wholesale price of rice grew from 1971 to 1974. After rice prices fell in 1975/76, the demand for pumps fell drastically in the following year. The farmers seem to act rationally in response to price trends, but they decide based on the crop prices of the previous year. From this exhibit we are for the first time aware of the substantial difference between the wholesale price and the "farm-gate" price of rice. Wholesale is more than double farm-gate, yet it is the farm-gate price that seems to influence Ali's decisions.

Thus if the wholesale price of rice is directly representative of the cost of imported rice, the Government has considerable room for allowing the farm-gate price to rise, in order to encourage more local growing.

One can see this more clearly by analysing exhibits 1 and 2 together. This shows that only 5 per cent of farmholdings are currently under irrigation by pumps supplied by the programme. From the text of the case we know that only 1.04 million hectares, or only 14 per cent of all land, receives irrigation of any sort. Although there are not enough data in the case to judge how many more hectares could be profitably irrigated, the number is probably substantial.

From exhibit 2 we can estimate that Bangladesh is paying about Tk.0.10 per kg subsidy for the rice grown under the pumpset programme. This estimate arises from the following analysis of 1976/77 figures:

Hectares irrigated	413 700	
Assumed crops per hectare	3 800 kg	
Total rice crop from pumpset-irrigated land		1 572 060 000 kg
Pumpsets rented	28 224	
Subsidy per pump	Tk. 5 807	
Total subsidy:		Tk.163 890 000, or Tk.0.10 per kg

This subsidy is just 5 per cent of the farm-gate price and only 3 per cent of the wholesale price in that year. One might conclude that this was a bargain, if all the rice grown would otherwise not have been planted.

From exhibit 2 we can calculate the unused potential for rice-growing represented by the additional pumpsets available, at the current number of average hectares per pump. We may assume that the 1977/78 target of 39,000 pumps implies that (39,000-28,224=) 10,776 pumps were available and unused in 1976/77. The unused 10,776 pumps could lead to production of 614 million extra kg of rice, by the following line of reasoning:

10 776	(pumps)
x 15	(hectares per pump, recent years)
161 640	(extra hectares of rice planted)
x 3 800	(kg rice per hectare)
614 232 000	(extra kg of rice grown)
x Tk.2.2	(farm-gate price)
Tk.1 351 310 400	(extra farm-gate revenue value of crop)

Since the Government already owns the unused pumpsets, the capital costs are "sunk", meaning that they are being borne by the Government whether or not the sets are used. Does this mean that the unused sets should be offered at super-concessional rates? (What would be the effect on the co-operatives which have been willing to rent at current rates?)

Is there any strategy which would change the incentives in such a way as to encourage full utilisation of the pumps' capacities? This turns our attention to the circumstances of Mr. Ali's adoption of a pumpset.

One way of analysing the Ali adoption is to measure the changes in land use, weight and value of rice grown, and labour used, with and without the pump deal, as follows:

	Condition	
	Under pumpset irrigation	Without pumpset irrigation
Hectares irrigated	6.8	4.6*
Rice grown	25 840 kg	17 480 kg
Farm-gate value	Tk.56 848	Tk.38 456
Irrigation labour used	63 man-days	2 898 man-days
Non-irrigation labour	1 170 man-days	792 man-days

* This excludes Ali's brother's 1 hectare, the two other 1/2-hectare plots mentioned in case (C), and 0.2 hectares of Ali's land that would have been left idle as his two sons took up their village jobs.

One way of looking at the matter is that the season's subsidy of Tk.5,897 has "bought" just 2.2 hectares of additional rice crop, or 8,360 kg of rice, a subsidy of Tk.0.69 per kg. Use of the pumpset has also reduced the employment of local labour by 2,457 man-days, an unintended consequence. (None the less, it is worth noting that the increase in casual labour demanded by the 2.2 additional hectares planted, 378 man-days, about equals the "one day in seven" required for owners like Yussuf to break even on their share of the pumpset's costs.)

Another way to look at the Ali adoption is to compare the Government's cash revenue and cash expense with and without this "marginal" adoption. For the current season, at least, if Ali had not organised a co-operative, one more pumpset would have remained idle. Idle pumpsets earn no revenue to offset the allocated season's share of capital costs.

Government's cash position

With Ali's adoption

	Receipts	Expenditures	Net
Season's rental	Tk. 600	--	
Spare parts	300	Tk.1 050	
Diesel fuel	2 640	4 650	
Lubricating oil	300	300	
	3 840	6 000	(2 160)

Treating Ali's transaction as the marginal unit, therefore, shows a cash subsidy of just Tk.2,160 for the season, or Tk.0.26 per extra kg of rice grown.

Even this improvement in the subsidy per kg is not very attractive on most scores, given the small amount of additional land brought into planting, and the substantial additional unemployment created by the use of the pumps. It is probably well at this point to turn to a discussion of the next case.

Teaching note for BADC pumpset programme (C)

The issues of this case can be discussed in any order in which they arise from participants' questions or statements. To be concise, however, this note treats the issues in the order in which they arise in the case.

Foreign exchange and "shadow prices"

The issue of scarcity of foreign exchange is a very real problem for many developing countries. Discussion leaders who feel perfectly comfortable with the theory behind shadow prices may want to take this opportunity to deliver a lecture about it, using the case material to demonstrate why the theory exists.

It is not essential to do this, however, since in this instance the prospective savings in foreign exchange are much greater than the costs in foreign exchange. Only if there seems to be a nearly viable alternative which uses less foreign exchange to accomplish the same amount of foreign exchange savings as does the pumpset programme would the question arise, "how much should the shadow price be?"

Each pumpset, which represents a foreign exchange outflow in its first year of acquisition and use of Tk.19,230 (from exhibits 1 and 2 of the case), would result in saving an estimated Tk.221,616 in foreign exchange, if used as planned. Use "as planned" means to irrigate 21.6 hectares of land that otherwise would not be farmed in the dry season. The following calculations support this:

	21.6	(hectares)
x	3 800	(kg rice crop per hectare)
	82 080	(kg rice grown, saving imports of like amount)
x	Tk.2.7	(assumed foreign exchange component of wholesale price of rice in 1976/77, 80 per cent of Tk.3.35)
	Tk.221 616	(total foreign exchange saving in first year)

Since the foreign exchange costs would be repaid elevenfold in the first year, this issue should not becloud the decision.

Import taxes

There seems to be little reason for one government entity to pay taxes of any sort to another. For administrative convenience it may be easiest to charge import taxes against all items that cross the docks, but there is no sense in which the Bangladesh Government, as a whole, has sustained this cost because of the pumpset programme, beyond some very small cost of operating a receipt and inspection function at the docks.

It may be worth while to let participants discuss this point, rather than closing off debate quickly, because it is not at all uncommon for government programmes to "cross-tax" one another in this way.

Imputed interest costs

Imputed interest may, at first glance, seem much the same as import taxes, a transfer from one pocket of government to another. However, imputed interest is a useful device, as a recognition of the "opportunity cost" of committing investment capital to the pumpset programme. If we had in front of us another programme which required the same amount of money for the same length of time, we could use other comparison models to relate pay-offs to investments, and not impute interest to either programme. In this instance, where we do not have immediately at hand such alternatives, it is none the less important that we keep in mind that there are many demands upon scarce investment resources, and not let this investment escape evaluation under some appropriate measure of its scarcity. (Whether 12 per cent is an appropriate rate is open for debate. The Government doubtless borrows at various rates for various purposes, and this programme may qualify for some special rate.)

None the less, in this instance the potential returns to the national economy, although not necessarily to the Government *per se*, are so great as to overwhelm any variation in the interest rate, within reasonable limits.

Diesel fuel usage

Fouad's point about the total cost and relative subsidy on diesel fuel being variable with the amount of land irrigated is valid. To a lesser extent the same reasoning would also apply to spare parts and lubricating oils, as well. It is instructive to work out a new *pro forma* expense statement for Hassan Ali, to demonstrate the effects of reduced use on full costs, subsidised costs and imputed subsidy, as shown below:

	Cost to Govt.	Rent	Subsidy
Total for 21.6 ha.	Tk.9 647	Tk.3 840	Tk.5 807
Per ha., 21.6 ha.	447	178	269
Total (except fuel), 6.8 ha.	5 297	1 200	4 097
Diesel fuel, 6.8 ha.	1 464	831	634
Total, 6.8 ha.	6 751	2 031	4 731
Per ha., 6.8 ha.	993	299	696
Per kg of rice, 6.8 ha.	0.26	0.08	0.18

This changed assumption influences not only the estimated subsidy but also the Government's total costs and foreign exchange cost, and the cost to the farmer, such as Hassan Ali. It may be to the Government's psychological advantage in encouraging adopters to plant more land, if the fuel cost is cited as more or less fixed, as was done in an earlier case. But this approach somewhat discourages adoption, by making the total package seem more expensive.

Man-powered chain-and-washer pump

It is tempting to dismiss the man-powered chain-and-washer pump, since its costs are so far above the alternatives if full human wages are paid. A farmer like Ali, however, with only two sons left at home and 0.4 hectares of land (excluding, for now, his late brother's land) would be slightly better off to plant his entire plot, rather than merely 0.2 hectares, by using a chain-and-washer pump. The calculations follow:

	0.2 hectares (dhones)	0.4 hectares (chain and washer)
Revenue value of crop	Tk.1 650	Tk.3 300
Non-irrigation costs	295	870
Contribution	1 355	2 430
Irrigation costs	0	990
Net returns	1 355	1 440

The gamble Ali would have to take, spending Tk.8,250 for the pump in order to increase his contribution from 1,355 to 2,430 per year, is far greater than his gamble in forming a small co-operative to rent the BADC pumpset. But if the chain-and-washer pump were available and the rental programme were not, he might take the risk, if he needed more grain production greatly enough.

The Government could subsidise the chain-and-washer technology, as it does the diesel pumpsets. If the Government invested in the pump and rented it out to Ali at a concessional rate, it might improve his gamble substantially. Participants may find it interesting to experiment with various plans and percentage subsidies.

In line with our earlier reasoning about imputed interest, we would want to see the Government impute interest to its investment in chain-and-washer pumps, of course. As it turns out, even though the chain-and-washer pump requires no foreign exchange, its cost is so high relative to its productivity, when operated by manpower, that one soon realises that the Government cannot afford to pursue its primary goal of feeding the people if it invests its capital in this way, as long as the diesel pumpset is available. The only initiative that might pay off would be for the Government to help to develop a chain-and-washer pump at a much lower price than Tk.8,250.

Cattle-powered chain-and-washer pump

The economic case for the cattle-powered chain-and-washer pump is stronger. The model shown in the case calls for two five-hour shifts of two cows each to irrigate 3.1 hectares. Two cows, working one five-hour shift, should therefore be able to irrigate 1.55 hectares, just a little more than Ali needs in order to farm his land with that of his late brother. Ali's position would be as follows:

Land irrigated, 1.4 hectares		
Rice grown, 5,250 kg		
Farm-gate value		Tk.11 550
Non-irrigation costs[1]		3 465
Contribution		8 085
Irrigation costs:		
Seasonalised capital cost of pump	Tk. 488	
Maintenance	195	
Rental of two cows	1 260	1 943
Net return		6 142

[1] The same assumptions about Ali and his two sons' labour is made here as was made on p. 27. It is also assumed that some child of the family can serve as cowherd.

This net return is within the range of returns Ali was considering (on p. 31) in relation to the pumpset programme, with small land size. It is true that the cattle-powered alternative requires more investment on the part of the farmer (particularly if he would need to buy cows in order to assure himself of dependable power at irrigation time). None the less he would avoid potential human relations problems associated with organising the co-operative, if the cattle-powered option were available.

This option, we might conclude, warrants added investigation by the BADC, in order to fill in what seems to be a gap between available technologies, the dhone for very small plots and the diesel pumpset for plots of large size. Because the chain-and-washer pumps, and even the cattle, might be developed without substantial commitments of foreign exchange, the Government might think about putting some subsidy money behind this alternative technology.

What would be important to find out, before starting such a programme, would be the total demand for animal power, month by month within any target region. Irrigation demand is seasonal, and occurs, as we have seen, at the same time as other farm-related demands for animal power. Cattle-based irrigation could only be cost-effective if it fitted into a pattern of reasonably steady use of draught animals throughout the year.

Summary

The participants may well conclude that Mr. Fouad's problem is not to choose among alternative technologies (although we may use the situations detailed in the cases to practice making technological choice decisions). Mr. Fouad's problems is to get the pumpset programme working up to its highest potential. Even if no more pumpsets were bought, those already owned by the Government have many years of economic life left in them, and the fundamental problem still remains, how to reduce the need for imported rice.

The participants should be encouraged, at this point, to work up a proposal for increasing the rice grown in Bangladesh, using the variables that might be in the control of the BADC in the persons of Messrs. Fouad and Khan.

APPENDIX

A list of sources of training materials

If you are designing a training programme, seminar or workshop for managers concerned with water supply, find out first whether they are concerned mostly with urban or rural water and if rural, whether the water is for agriculture or drinking, cooking and washing.*

Furthermore, agricultural managers may be concerned about many things in addition to irrigation water. The pump selection cases illustrate the principles involved in the choice of many types of inputs such as seeds, hand tools, tillage equipment, fertilizers, etc., which improve agricultural productivity. These other inputs have been held constant in this set of cases, but the principles and concepts are similar.

The following list is not exhaustive. We have tried to include at least one example of the type of material available from each source. However, we have included many examples of ILO material so you could ask for specific items.

1. Asian Productivity Organisation,
   4-14 Akasaka 8-Chome,
   Minato-ku,
   Tokyo 107.

   Farm Level Water Management in Selected Asian Countries (1980).

   Southeast Asian Agribusiness, 1975, ISBN 92-833-1034-9. This is a four-volume collection of Harvard-style management training cases based on Philippine agricultural experiences.

2. Commonwealth Secretariat,
   Marlborough House,
   Pall Mall,
   London, SW1Y 5HX.

   Training for Agricultural Project Management, report of a meeting in 1979, contains very good material on training.

3. Office of Rural Development and Development Administration,
   Agency for International Development,
   Washington DC 20523 or local US Embassy.

   Policy Directions for Rural Water Supply in Developing Countries, April 1979.

   AID Project Impact Evaluation Reports such as Philippine Small-Scale Irrigation, May 1980.

   Earl Kulp, Basic Agriculture Programme Management, 1973.

4. Development Project Management Centre,
   Office of International Co-operation and Development,
   US Department of Agriculture,
   Washington DC 20250.

   Development Project Management: An Integrated Approach to Project Planning and Implementation (1974). This material is divided into several volumes that contain training exercises, cases and readings. Several volumes are devoted to technology assessment, transfer and adaptation.

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* However there are many successful communities where the sources of clean water are high up. The water flows down through the community so that the lowest quality water is used in agriculture, the farms being down below the city.

5. East-West Centre,
East-West Technology and Development Institute,
Honolulu, Hawaii.

Bangkok Metropolitan Immediate Water Improvement Programme - A Case History, 1977.

The Philippines Rice Self-Sufficiency Programme - A Case History, 1977.

6. Economic Development Institute (EDI) of the World Bank,
1818 H Street,
Washington DC 20433.

The EDI catalogue of training materials contains hundreds of case studies and course notes, many of which are provided without charge. The following may be of particular interest:

Pumping System Networking Exercise (AE-1011-S, 1974).

Irrigation Rehabilitation PERT/CPM Exercise (AE-1003-P).

Bogota Water Supply Case.

Nairobi Water Supply Case.

7. German Appropriate Technology Exchange (GATE),
GTZ Gmbh Postfach 5180,
D-6236 Eschborn 1, FRG.

A Breuer and A. Netzband: "Small-Scale Irrigation", 1980.

"Drawings of Hydraulic Rams", 1979.

8. Food and Agriculture Organisation,
Via delle Terme di Caracalla,
00100 Rome.

Many different departments within FAO produce materials that may be relevant to your needs.

9. Intermediate Technology Publications,
9 King Street,
London, WC2E 8HN.

G.H. Bateman: A Bibliography of Low-Cost Water Technologies, 1977.

Hand Dug Wells and their Construction, 1976.

Hand Pump Maintenance, 1977.

Appropriate Technology, a periodic journal that is an excellent source of information.

10. Health Science Division,
International Development Research Centre,
60 Queen Street,
PO Box 8500,
Ottawa, Canada, K1U 3H9.

IDRC has a large technology reference collection and sponsors courses on topics such as water supply and sanitation in developing countries.

11. International Rice Research Institute (IRRI),
Los Baños,
Philippines.

"Studies in Water Management Economics at IRRI", March 1979.

12. International Labour Organisation,
CH-1211 Geneva,
Switzerland.

ILO Management Development Branch (F/MAN). Note: There are three series of materials of special interest from F/MAN.

Rural management series:

Trainer and Consultants' Guide to the Management of Rural Development Projects and Programmes (RURAL MGT/1, forthcoming 1981).

Introduction to the Management of Rural Development Projects and Programmes (RURAL MGT/2, 1980). Chapter 7 is especially relevant for this set of training cases.

Management Training Needs in Rural Development in Ethiopia (RURAL MGT/3, 1980).

Training Needs of Rural Development Managers and Institutions to Meet those Needs in Ghana (RURAL MGT/4, 1980).

Management of Rural Development Programmes: Strengthening Training Institutions in Kenya, Tanzania and Zambia.

Management Accounting for Managers of Pig Farmers (RURAL MGT/7 demonstrates how to design training material for specific technologies).

Construction management series:

Guide to the Management of Construction Projects (1979).

The Thames Interim Bank Raising Project: A Case Study (1980).

Building Rural Health Centres - A Case Study (1980).

Appropriate technology choice series:

J. Wallace and C. Guthrie: "How to train managers in technological choice - a discussion paper", 1979.

Management development series:

John I. Reynolds, The Case Method in Management Development (ISBN 92-2-102363-X, 1980).

Teaching and Training Methods for Management Development (ISBN 92-2-101006-6, 1972).

ILO Co-operatives Branch:

Training for the Management of Co-operatives (1980). Note: Well-tested management training materials with many examples and exercises relevant to rural development managers.

ILO Technology and Employment Branch:

Energy Options for Low-Lift Irrigation Pumps in Developing Countries - The Case of Bangladesh and Egypt.

Supervisory Training Materials for Rural Road Construction (forthcoming 1981).

Report on the Regional Seminar on the Application of Appropriate Technology in Road Construction (1980).

Application and Upgrading of Indigenous Technology: The Case of Irrigation Works (WEP 2-22/WP 41, 1978).

"Technology for Construction and Maintenance of Irrigation and Drainage Works in Egypt: A Preliminary Assessment" (WEP 2-22/WP 68), September 1980.

13. Swedish International Development Authority (SIDA),
S-105 25 Stockholm,
Sweden
(or your local Swedish Embassy).

"Guidelines for SIDA-Supported Activities in International Water Resources Development, July 1980".

14. UNICEF,
Drinking Water Programme,
866 UN Plaza,
New York 10017.

This unit publishes a very good newsletter on water supply in developing countries.

15. Volunteers in Technical Assistance (VITA),
3706 Rhode Island Avenue,
Mt. Rainier,
Maryland, 20822, USA.

Vita News is a very important newsletter and Vita has many publications and a roster of volunteers who specialise in technology.

Village Technology Handbook is well known and very useful reference.

16. WHO, International Reference Centre for Community Water Supply,
PO Box 140,
Leidschendam,
The Netherlands.

This is one of the best sources of information on water supply. For example:

International Workshop on Hand Pumps for Water Supply, Bulletin No. 8, May 1977.

Selected publications

J. Sanders and J.J. Warford: Village Water Supply: Economics and Policy in the Developing World (Johns Hopkins University Press, Baltimore and London, 1976).

R. Feachem, M. McGarry and D. Mara (eds.): Water, Wastes and Health in Hot Climates (John Wiley and Sons, Chichester and New York, 1977).

S. Caincross (and others): Evaluation for Village Water Supply Planning (John Wiley and Sons, 1980). Economic Bulletin for Asia and the Pacific, Vol. XXVII, No. 2, December 1976.

Gilbert Levine: "Issues in Water Development Decisions", pp. 109-117.

E.W. Coward, Jr.: "Indigenous Irrigation Institutions and Irrigation Development in Southeast Asia: Current Knowledge and Needed Research", pp. 118-125.