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WATER PUMPING TECHNOLOGY

(MALAYSIA) - PHASE II

BY

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JABATAN KEJURUTERAAN MEKANIKAL
Fakulti Kejuruteraan
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DEPARTMENT OF MECHANICAL ENGINEERING UNIVERSITY OF MALAYA KUALA LUMPUR

DEVELOPMENT OF A SMALL SCALE HANDPUMP FABRICATION UNIT

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COLLABORATING AGENCY : ENGINEERING SERVICES DIVISION
MINISTRY OF HEALTH
MALAYSIA.

PROJECT PERSONNEL

1. Principal Investigator

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Associate Professor Tan Bock Thiam	University of Malaya
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Mr. K. Rishyakaran	Ministry of Health

3. Production Consultant

Mr. Chee Kim Meng	Private Consultant

4. Project Officer

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5. Project Secretary

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Mr. Chan Hon Weng	IDRC Sponsored

7. Project Technicians

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8. Laboratory Assistant

Mr. K. Kandasamy	University of Malaya

9. Student Assistants

Mr. Encik Lee Sew Ah	IDRC Sponsored
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Mr. Yong Min Sen	IDRC Sponsored

1. INTRODUCTION

The 'Water Pumping Technology - Gobal (Malaysia)' Project, a joint research project between the University of Malaya, the Ministry of Health (Malaysia) and the I.D.R.C. was initiated in 1979 with the objective of developing a handpump which could be produced from locally available materials, is cheap and easy to maintain at the village level.

The First Phase of the research project which involved a laboratory investigation to determine the optimum design of the plastic handpump and field testing of prototype handpumps in the rural areas was completed in 1981.

The second phase of the research project i.e. "Development of A Small Scale Handpump Fabrication Unit" was approved by the I.D.R.C. in September, 1983. The primary aims of this Second Phase research project are to acquire empirical experience in the manufacture and assembly of handpumps, and to assess the technical and economic viability of duplicating the experience of the pilot plant on a commercial production scale.

Concurrent with these aims, the research effort also seeks to refine the design of the various components of the handpump in order to reduce production cost and to conduct further field tests to verify its performance as well as its acceptance at the village level.

2. OBJECTIVE AND IMPLEMENTATION SCHEDULE

To facilitate measurement of the progress achieved by the Project Team, the objectives of the Second Phase Project as outlined in the original project proposal are enumerated below:-

(a) To investigate the problems associated with the development of a small scale fabrication unit for handpumps and to determine the most appropriate manufacturing process.

(b) To conduct development work in the methods of fabrication of handpump to improve quality as well as production efficiency.

(c) To fabricate 550 pumps and to evaluate the technical and economic performance, and social acceptability of the handpump.

(d) To conduct a socio-economic survey of user and potential user groups to identify problems in adoption of this technology.

(e) To conduct an economic analysis of the cost of operating the small scale handpump fabrication unit and to use this knowledge for a feasibility study of a full scale manufacturing plant and determine strategies to realise this objective.

(f) To develop appropriate manuals providing detailed guidelines and instructions for installation, monitoring

and maintenance procedures.

To ensure effective monitoring of the project, the 3-year duration of the project is broken down into the following implementation stages:-

IMPLEMENTATION STAGE	MAJOR ACTIVITIES/PROGRAMS	DURATION
First Stage	Planning & Development	Sept. 1983 to Feb. 1984.
Second Stage	Organising A Pilot Fabrication Unit	March 1984 to August 1984
Third Stage	Pilot Production, Field-Testing, Sociological-Survey & Extension to Commercial Production.	Sept. 1984 to August 1986

For ease of presentation, the activities and achievements are discussed under the appropriate headings of Technical Aspects, Sociological Surveys, Instruction Materials and Manpower Training, Complementation Activities.

3.1 Technical Aspects

3.1.1 Research Study Trip

The Second Phase project commenced with an I.D.R.C. sponsored study trip by the Principal Researcher Prof. Goh Sing Yau and the Local Consultant Mr. K. M. Chee to

tap Canadian know-how in the field of plastic technology with the aim of improving the Malaysian developed PVC handpump at reduced cost.

Subsequent to the study trip, the Project Team reviewed the entire PVC handpump in respect of:-

(a) its basic design

(b) selection of appropriate material for the various components

(c) manufacturing process for the various components

(d) injection moulding and tooling equipment to explore cost reduction opportunities by having most of the component parts moulded in plastic and simplifying the entire production process to encompass only the basic workshop skill like machining, cutting, welding and assembly work.

3.1.2 Material Substitution and Process Changes

To achieve reduction in production cost, the following material substitution and process changes were effected:-

Component	Original Material Production Process in Prototype Design	Substitute Material & Revised Process in Mark I & II Design
Bolt & nut sets For the piston & footvalve assemblies	Machined out of brass	Injection moulded using acetal plastic
PVC piston	Machined out of solid PVC Block	Injection moulded usng PVC
Piston rings	Machined out of polyethylene	Injection moulded using polyethylene

Above ground steel pipe stand	Roll-formed from steel sheet	Cut from standard pipe size available commercially
PVC flange	Purchase commercially available flanges	Developed mould to specially injection mould the PVC flange to dimensions to suit handpump design
Bearing plate for lever system	Timber block used as bearing plate	Steel bearing plate flame-cut from steel plate

The manufacturing operations and equipment used for the Mark I and II designs are presented in Table 3.1.2(a).

Further simplifications and cost reduction were achieved through the development of the Mark III design. In this later design, the number of parts for the pump cylinder and leverage system was reduced and the manufacturing operations simplified. The number of pieces of machinery was also reduced from 11 to 9. The detailed components, manufacturing operations and equipment required the the Mark III design are presented in Table 3.1.2(b).

3.1.3 Development of moulds & jigs

The mould and jigs developed during the project are as presented in Table 3.1.3. It may be noted that the moulds are redesigned and upgraded as and when necessary to incorporate improvements in the handpump design. Some of the moulds or jigs may became obsolete as and when new ones replace them. For example since the Mark III design does not use timber parts, the jigs for working on the timber lever arms and bearing blocks are no longer used. Also since the Mark III stand is completely

different from the Mark I and II stand, a new set of jigs is required to produce the later Mark III design.

3.1.4 Equipment

The following equipment which were donated by the Canadian High Commission were received in March, 1984:

Equipment	Quantity	Price (M$)
Universal Centre Lathe Model SN40B/1000	1 unit	$18,500
Roundo Plate Bending (Rolling) Machine Type PA 130	1 unit	$23,000
Hitachi Band Saw Model B 750 A	1 unit	$ 4,480
Shaping Machine Model B 6050 B	1 unit	$12,440
Radial Drilling Machine Model RBM 28 B	1 unit	$11,000
Drilling & Milling Machine	1 unit	$ 2,300
Hitachi AC Arc Welder Model A7 SS5	1 unit	$ 976
		$72,696

3.1.5 Plant Layout

As all injection moulded parts are produced by a contract manufacturer, the pilot fabrication unit concentrates on the more basic production skills like cutting, welding and assembly work. Based on this division of labour between the pilot fabrication unit and the contract manufacturer, the layout of the fabrication unit is shown in Appendix A.

3.1.6 Pump fabrication

A total of 550 handpumps was produced during the months of March, April and May, 1985. These handpumps were installed in all states of Malaysia including Sabah and Sarawak by Ministry of Health Staff.

The distribution of the 550 handpumps to each state is as follows:-

States	Lift Pumps	Suction Pumps
Negeri Sembilan	1	18
Johore	1	28
Pahang	14	65
Trengganu	-	63
Kelantan	9	90
Sabah	-	10
Sarawak	-	10
Kedah	11	88
Perak	6	130
Melaka	-	4
Selangor	2	-
Total	44	506

3.2 SOCIOLOGICAL SURVEYS

A survey questionaire was drawn up to study the following

sociological aspects:

(a) Rural household attitudes and preferences regarding well water as opposed to stream or other water sources

(b) The effects of different arrangements regarding the use of handpumps, for example, the sharing of pumps among groups of households as opposed to individual ownership of handpumps

(c) Sociological factors affecting the maintenance cost and economic life of handpumps

(d) Impact of handpumps on rural health and well being

Two sites were chosen for this sociological survey. They are in the districts of Termeloh, Pahang and Alor Setar, Kedah. The survey questionaire and results of the sociological survey are presented in Appendices B, C, and D.

3.3 INSTRUCTION MATERIAL AND MAN-POWER TRAINING

3.3.1 Instruction Material

Two thousand manuals for the installation and maintenance of the Mark I suction handpump were printed - one thousand in English and one thousand in Bahasa Malaysia. A copy of this manual is distributed with each of the 550 pumps sent for installation by the Ministry of Health. A new manual for the

installation and maintenance of the Mark III suction handpump has also been printed.

3.3.2 MAN-POWER TRAINING

The Ministry of Health has incorporated into their regular training courses a training session on the installation and maintenance of the PVC handpump. During the three years, the project team has participated in six such course which caters for a total about 215 Ministry of Health staff consisting of Public Health Overseers, Public Health Inspectors, Public Health Engineers and medical officers.

		No. of Participants
1.	10th Rural Water Supply Seminar for Health Inspectors at Batu Rakit, Kuala Terengganu, Terengganu from 14th - 28th April, 1984.	35
2.	1984 Annual Meeting for Enivoronmental Cleaniness Program at Kuala Lumpur from 8th - 10th October, 1984.	35
3.	11th Rural Water Supply Seminar for Health Inspectors at Alor Setar, Kedah on 6th July - 19th August, 1985.	35
4.	One day special course on	50

		No. of Participants
	installation and maintenance of PVC handpump for Health Inspectors, Health Overseas and Medical officers at Kampong Meriang, Malacca on 26th November, 1985.	
5.	One day special course on installation and maintenance of PVC handpumps at Kampong Paya Batu 4, Segamat, Johore on 17th December, 1985.	30
6.	Short course on installation and maintenance of PVC handpumps for Health Inspectors at Ipoh, Perak on 25th - 26th June, 1986.	30

The project also provided training for visitors from other projects in the IDRC network in the fabrication, installation and maintenance of the handpump.

	Project	No. of personnel	Duration
(a)	PDA, Thailand	2	2 weeks
(b)	PBSP, Philippines	2	2 weeks
(c)	Yayasan Dian Desa, Indonesia	2	2 weeks
(d)	Costa Rica	3	2 weeks
(e)	Institute of Medical Research, Kenya	1	1 week
(f)	EWWA, Ethiopia	1	1 week

3.4 Complementation Activities

A total of 184 sets of below ground components have been sent to complementary projects in the region - 40 to PDA, Thailand, 36 to PBSP, Philippines, 50 to Sarvodaya, Sri Lanka and 40 to Yayasan Dian Desa, Indonesia. In addition to the above, 12 complete handpumps were sent to a project in Kenya , 4 to Botswana and another 2 to the Consumer Association for testing.

4.0 Concluding Remarks

The major objectives of the project have been achieved. A small-scale handpump fabrication unit has been set up at the University of Malaya. A new handpump design has been developed which not only has a superior performance than the original proto-type handpump design but also can be mass-produced at a lower cost. Handpump performance and endurance testing facilities were also established to provide for quality control checks on the technical performance of the mass-produced handpumps.

The economic analysis and results of the sociological survey on acceptability of the handpumps are presented in accompanying papers by Dr. Tan Bock Thiam and Mr. K. Rishyakaran.

APPENDIX A

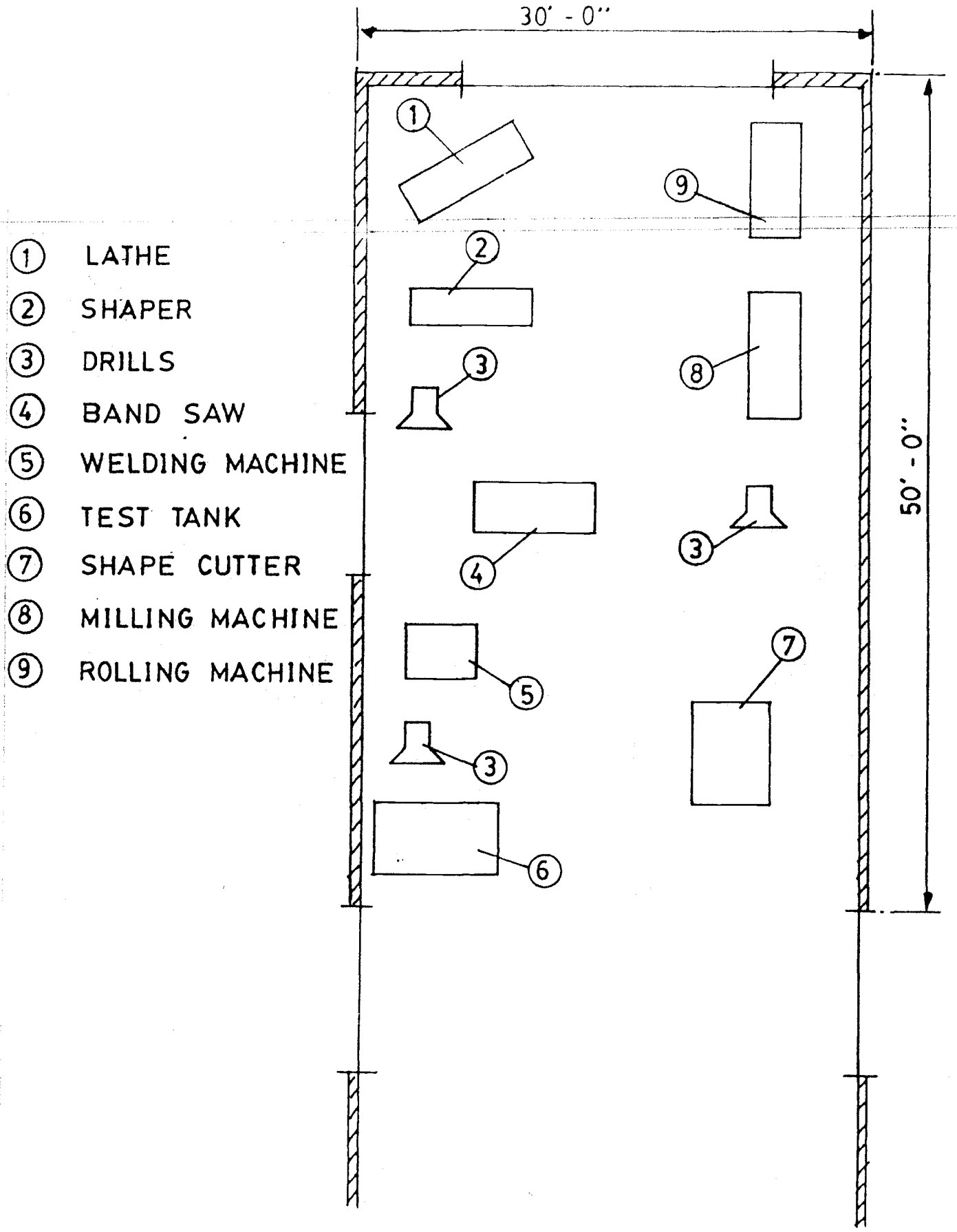
30' - 0"
50' - 0"
1 LATHE
2 SHAPER
3 DRILLS
4 BAND SAW
5 WELDING MACHINE
6 TEST TANK
7 SHAPE CUTTER
8 MILLING MACHINE
9 ROLLING MACHINE

TABLE 3.1.2(a) : COMPONENTS, MANUFACTURING OPERATIONS AND EQUIPMENT FOR MARK I & II DESIGNS

UNIMADE MARK I & II MODELS

Ref No.	Component	No. Reqd	Material	Manufacturing Operations
1. 1.1	Piston & Footvalve Barrel	4	PVC	- Injection moulding
				- Facing of valve seat
1.2	Bolt set	2	Acetal	- Injection moulding
1.3	Nut set	2	Acetal	- Injection moulding
1.4	Valve falp	2	Rubber	- Compression moulding
1.5	Double-lip seal	1	Rubber	- Compression moulding
				- part Assembly
2. 2.1	Pump Cylinder Pump cylinder	1	PVC	- Cut-off
				- Drill outlet hole
				- pvc welding of outlet pipe
				- Taper cylinder top
2.2	Flange	1	PVC	- Injection Moulding
2.3	Reducer	1	PVC	- Injection Moulding
				- Part assembly
2.2	Spout set	1	PVC	- Part assembly
3. 3.1	Pump Stand Stand	1	Mild steel	- Cut-off
				- Copy-cut flange
				- Drill outlet hole for spout
				- Drill holes in flanges
				- Weld flanges and spout to stand
3.2	Top flange plate	1	Mild steel	- Copy cut
				- Drill holes
3.3	Legs	4	Mild steel	- Cut-off
				- Drill holes
4. 4.1	Leverage Assembly Handle	1	Wood	- Cut-off
				- Shaping
				- Drill holes
4.2	Lever arm	1	Mild steel	- Cut-off
				- Drill holes
				- Weld
4.3	Connecting rod/arm	1	Mild steel (galvanised)	- Cut-off
				- Drill holes
				- Weld
4.4	Pivot & Connecting arm	4	Wood	- Cut-off
				- Drill holes
4.5	Bearing Bushes	6	Brass	- Part off

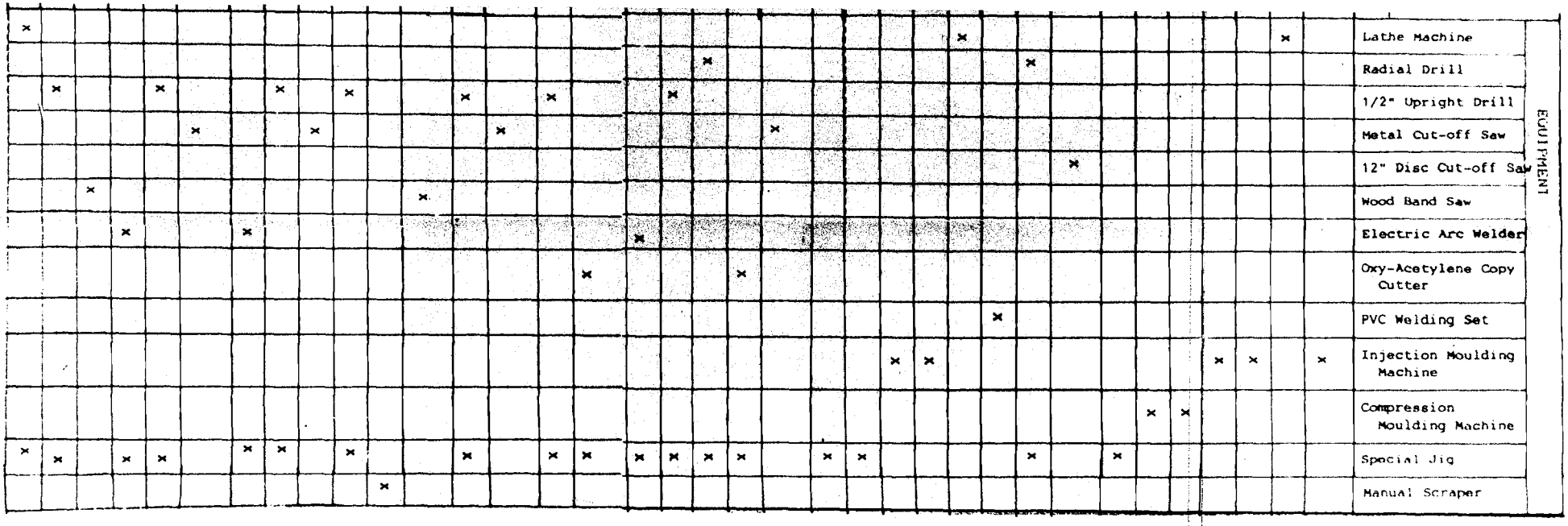
EQUIPMENT
Lathe Machine
Radial Drill
1/2" Upright Drill
Metal Cut-off Saw
12" Disc Cut-off Saw
Wood Band Saw
Electric Arc Welder
Oxy-Acetylene Copy Cutter
PVC Welding Set
Injection Moulding Machine
Compression Moulding Machine
Special Jig
Manual Scraper

TABLE 3.1.2(b) : COMPONENTS, MANUFACTURING OPERATIONS AND EQUIPMENT REQUIRED FOR MA

UNIMADE MARK III MODEL

Ref No.	Component	No. Reqd	Material	Manufacturing Operations
1. 1.1	Piston & Footvalve Barrel	4	PVC	- Injection moulding
				- Facing of valve seat
1.2	Bolt set	2	Acetal	- Injection moulding
1.3	Nut set	2	Acetal	- Injection moulding
1.4	Valve falp	2	Rubber	- Compression moulding
1.5	Double-lip seal	1	Rubber	- Compression moulding
				- Part assembly
2. 2.1	Pump cylinder Cylinder	1	PVC	- Cut-off
				- Drill outlet hole
				- Taper cylinder
2.2	Flange	1	PVC	- Injection Moulding
2.3	Reducer	1	PVC	- Injection Moulding
				- Part assembly
3. 3.1	Pump Stand Stand	1	Mild steel	- Cut-off
				- Cut flanges
				- Drill holes in flanges
				- Weld flanges
3.2	Spout	1	Mild steel (galvanised)	- Cut-off
				- Cut flanges and spout
				- Drill holes in flanges
				- Weld flanges and spout
3.3	Cover	1	Mild steel	- Cut-off
				- Cut flanges and webs
				- Drill holes
				- Weld flanges and webs
4. 4.1	Leverage Assembly Handle	1	Mild steel (galvanised)	- Cut-off
				- Drill holes
				- Weld
4.2	Connecting rod/arm	1	Mild steel (galvanised)	- Cut-off
				- Drill holes
				- Weld
4.3	Bearing Bushes	4	Stainless steel	- Part off
		4	Acetal	- Injection moulding

RK III HANDPUMP

EQUIPMENT									
Lathe Machine	Radial Drill	1/2" Upright Drill	Metal cut-off Saw	12" Disc Cut-off Saw	Electric Arc Welder	Oxy-Acetylene Copy Cutter	Injection Moulding Machine	Compression Moulding Machine	Special Jig
							X		
X									X
							X		
							X		
								X	
								X	
									X
				X					
	X								X
X									
							X		
							X		
									X
			X						
						X			X
		X							X
					X				X
			X						
		X							X
					X				X
						X			X
			X						
		X							X
					X				X
			X						
		X							X
					X				X
X									X
							X		

APPENDIX B

IDRC-UM-MOH HANDPUMP PROJECT
WATER AND SANITATION SURVEY

INDIVIDUAL HOUSEHOLD RECORD

Question	Description	
1.	Name of head of household *Nama Ketua rumahtangga*	.....
2.	Age (year) *Umor*	.....
3.	Sex *Jantina*	.....
4.	Date of Interview *Tarikh*	.....
5.	Household Number *Nombor rumahtangga*	.....
6.	Village *Kampong*	.....
7.	Mukim *Mukim*	.....
8.	District *Daerah*	.....
9.	State *Negeri*	.....
10.	Name of Interviewer *Nama pegawai banci*	.....

Question

Baseline and Sanitary Data

11. Number of people in household
Nombor orang dalam rumahtangga

- Male (persons)
  Laki-laki .....
- Female (persons)
  Perempuan .....
- Total
  Jumlah .....

12. Amount of land cultivated by household (Acres)
Jumlah ekar tanah menanamkan .....

13. Estimated household net income ($/year)
Anggaran pendapatan bersih rumahtangga

- ☐ <$2000
- ☐ $2001 - $4000
- ☐ $4001 - $6000
- ☐ $6001 - $8000
- ☐ $8001 - $10,000
- ☐ > $10,000

14. Number of people in household with education level
Nombor orang dalam rumahtangga yang berpelajaran

- Standard 6 or lower
  Darjah 6 atau bawah .....
- Above Stardard 6
  Lebih dari Darjah 6 .....

15. Main household occupation
Perkerjaan yang utama di rumahtangga

- Farmer
  Pertani .....
- Agriculture labourer
  Buruh ladang .....
- Government Service
  Perkhidmatan kerajaan .....
- Other (Specify)
  Lain-lain .....

16. Is there any laterine in your house?
Adakah tandas didalam rumah

- Yes
  Ya

- No
  Tiada .....

17. If Yes, specify the number of each type of latrine available.
Jikalau ya, berapa unit dan jenis tandas

Type (Jenis)	Number (No.)
- Flush *Tandas tarik*	.....
- Pour Flush *Tandas curah*	.....
- Bucket *Tandas angkat*	.....
- Pit Latrine *Tandas lubang*	.....
- Village Peripheries *Sekeliling kampong*	.....
- River/Stream/Canals *Sungai/parit/taliair*	.....
- Others (Specify) *Lain-lain*	.....

(b) Distance from house to toilet ..... yards.
Berapa jauh tandas daripada rumah ..... *ela*

18. If No, would you like to have one?
Jika tiada, sukakah anda ada satu

- Yes, because *Ya, sebab*
  (1) convenient
  Senang .....
  (2) Prevent spread of diseases
  Mencegah melarat penyakit .....
  (3) Recommended by friends
  Perakuan oleh kawan .....
  (4) Others (Specify)
  Lain-lain .....

18. - No, because / *Tidak, sebab*

(1) Not necessary / *Tidak perlu* .....

(2) Not willing to pay / *Tidak mahu membayar* .....

(3) Not willing to maintain / *Tidak mahu selenggara* .....

(4) Others (Specify) / *Lain-lain* .....

19. If you have latrine and do not use it, why? (Most important reason)
Jika ada tandas tetapi tidak gunakan ia, apa sebabnya

- No need for it / *Tidak perlu* .....
- No water/too much trouble to flush water / *Tidak air/banyak kesusahan cerah air* .....
- Latrine is dirty / *Tandas kotor* .....
- Not willing to maintain / *Tidak mahu selenggara* .....
- Out of order / *Rosak* .....
- Others (Specify) / *Lain-lain* .....

WATER RESOURCE DATA

20. Type of drinking/cooking water supply:
Jenis air minum/masak

- Piped water / *Air paip* .....
- Public standpipe / *Paip umum* .....
- Protected well / *Telaga terkawal* .....
- Unprotected well / *Telaga tak terkawal* .....

- River/Stream/Canals
  Sungai/parit/taliair .....

- Rain water
  Air hujan .....

- Others (Specify)
  Lain-lain .....

21. Distance from house to source of water ..... yards.
Berapa juah sumber air daripada rumah ..... *ela.*

22. Approximately how many gallon does your household use daily?
Berapa galon air rumahtangga ini guna tiap-tiap hari?

- Drinking and cooking
  Minum dan masak .....

- Washing and bathing
  Cuci dan mandi .....

- Other (Specify)
  Lain-lain .....

23. How many gallon can the water containers store in your household?
Berapa galon boleh tong air simpan? .....

24. How much time (hours/day) do you spend in carrying water?
Berapa jam/sehari awak gunakan untuk mengangkut air?

.....

25. Do you pay for the water?
Adakah anda membayar untuk air?

- Yes
  Ya .....

- No
  Tidak .....

26. If yes, how much are you paying for your water monthly?
Jika, ya, berapa anda membayar untuk air tiap-tiap bulan?

.....

27. Do you think the cost of water is
Adakah anda fikir harga air itu

- High
  Tinggi .....
- Normal
  Biasa .....
- Low
  Rendah .....

28. Would you be willing to spend more money in order to obtain better quality water for drnking and cooking?
Adakah anda sanggup membayar lebih wang untuk mendapat air yang lebih baik untuk minum dan masak?

- Yes
  Ya .....
- No
  Tidak .....

29. If yes, how much are you willing to pay for improved water quality monthly?
Jika ya, berapa banyak wang anda sanggup bayar tiap-tiap bulan?

.....

30. Are you using handpump as a source of water?
Adakah anda guna pamtangga ?

- Yes
  Ya .....
- No
  Tidak .....

If NO, proceed to question 35?
Jika Tidak, pergi ke soalan 35

31. What are the types and trade marks of these pumps? How much was the purchase price and installation cost per pump? How much was the maintenance cost for the past year (1984)? (If privately owned, ask the owner).
Apakah jenis pamtangan, harga dan kos pemasangan untuk pam ini. Berapakah kos senggaraan untuk tahun 1984? Jika dimilik sendiri, tanya pemilik.

Type/Trade Mark *Jenis*	Purchase Price *Harga membeli*	Installation Cost *Kos Melengkapkan*	Maintenance Cost *Kos selenggara*

32. How far is the pump from your house?
Berapa jauh pam daripada rumah?

- less than 100 yards
  Kurang dari 100 ela .....
- more than 100 yards
  Lebih dari 100 ela .....

33. What is the conditons of the pump?
Apakah keadaan pam ini?

- Working and in good condition
  Baik .....
- Working but needs minor repair
  Boleh digunakan tetapi perlu dibaiki (kecil) .....
- Working but needs major repair
  Boleh digunakan tetapi perlu dibaiki (besar) .....
- Dried up already
  Sudah kering .....
- Broken down already
  Sudah rosak .....
- Others (Specify)
  Lain-lain .....

34. Source of this pump
Sumber pam

- Deep (more than 60 feet)
  Dalam (lebih 60 kaki) .....
- Shallow (less than 60 feet)
  Cetek (kurang dari 60 kaki) .....

35. Would you like to have a handpump?
Sukakah anda mendapat satu pamtangan

- Yes
  Ya .....

- No
  Tidak .....

36. Are you able to contribute for the installation of handpump? (In terms of:)
Bolehkah anda menolong melengkapkan pamtangan ini?

- Cash
  Wang tunai .....

- Labour
  Buruh (tenaga) .....

- Others (Specify)
  Lain-lain .....

37. How much are you able to contribute for the installation of handpump?
Berapa banyak anda sedia bayar untuk melengkapkan pamtangan ini?

.....

38. How much are you able to contribute monthly for repair and maintanence of handpump?
Berapa abnyak anda sedia bayar tiap-tiap bulan untuk membaiki dan senggaraan pamtangan ini?

.....

39. Are you able to repair and maintain handpump?
Bolehkah anda membaiki pamtangan?

- Yes
  Ya .....

- No
  Tidak .....

WATER TREATMENT DATA

40. Before drinking the water, what do you do?
Sebelum minum air, apa anda buat

- Nothing
  Tidak buat apa-apa .....
- Allow sediment to settle
  Tunggu sampai air keladek .....
- Add Alum
  Tambah tawas .....
- Filter
  Tapis .....
- Add chloride of lime/chlorinate
  Tambah kimia .....
- Boil
  Masak .....
- Others (Specify)
  Lain-lain .....

41. What are your major problems with your water supply?
Apakah masalah utama dengan bekalan air anda?

- Water is insufficient
  Tidak cukup air .....
- Poor water quality/lack means to purify water
  Air kotor/tidak boleh membersihkan air
- Distance from house to water resource is far/inconvenient
  Juah sumber air .....
- Water resource is in degraded state/lack of repair
  Sumber air rosak dan perlu diperbaiki .....
- Others (Specify)
  Lain-lain .....

42. Do you boil water for drinking?
Adakah anda masak air untuk diminum

- Always
  Selalu .....

- Sometimes
  Kadang-kadang .....

- Never
  Tidak .....

43. Why do you boil drinking water?
Kenapa anda masak air untuk diminum?

- Kills germs
  Hapuskan kuman .....

- Prevents illness
  Mencegah penyakit .....

- *Recommended by own children/friends/relatives (including husband)
  Dinasihat oleh anak/kawan/saudara (termasuk suami) .....

- Others (Specify)
  Lain-lain .....

(*Probe for reasons given by children/friends &/or relatives)
Catitkan sebab yang diberi oleh anak/kawan/saudara

44. Do your children wash their hand before they eat?
Adakah anak anda cuci tangan sebelum mereka makan?

- Yes
  Ya .....

- No
  Tidak .....

45. If Yes, why do they wash their hands?
Jika ya, apa sebabnya?

- To clean their hands off dirt
  Membersihkan tangan .....

- To prevent illness
  Mencegah penyakit .....

- Recommended by own children/friends/relatives (including husband)
  Dinasihat oleh anak/kawan/saudara (termasuk suami) .....

- Others (Specify)
  Lain-lain .....

46. Do your children wear slippers outside the house?
Adakah anak anda pakai kasut/selipar diluar rumah?

- Always
  Selalu .....
- Sometimes
  Kadang-kadang .....
- Never
  Tidak .....

47. If yes, why do they wear slippers/shoes?
Jika ya, apa sebabnya?

- To keep feet clean
  Menjaga kaki supaya bersih .....
- To prevent worm infestation/sores
  Mencegah cacing/luka .....
- Recommended by own children/friends/relatives (including husband)
  Dinasihat oleh anak/kawan/saudara (termasuk suami) .....
- Others (Specify)
  Lain-lain .....

48. Do your children brush their teeth everyday?
Adakah anak anda berus gigi tiap-tiap hari?

- Always
  Selalu .....
- Sometimes
  Kadang-kadang .....
- Never
  Tidak .....

49. If you bottlefeed your infant, how do you wash the bottles?
Jika anda memberi tepong susu kepada bayi, bagaimana anda cuci botol susu?

- Boiling or hot water
  Air masak/air panas .....
- Cold water
  Air sejuk .....

- Others (Specify)
  Lain-lain .....

50. Where do you obtain the water from?
Dimana anda dapat air ini? .....

51. Garbage Disposal
Membuang sampah

- Bin (collected)
  Dalam tong .....
- Burn
  Bakar .....
- Bury
  Menanam .....
- River
  Sungai .....
- Surrounding the house
  Dikeliling rumah .....
- Others (Specify)
  Lain-lain .....

HEALTH DATA

52. Disease which the children in the family suffer most often.
Penyakit yang dialami selalu oleh anak-anak anda

- Malaria, haemorrhage fever
  deman, deman kura-kura .....
- Diarrhoea, digestive and parastic disease
  Cirit .....
- Fever, cold
  Deman, selesema .....
- Others (Specify)
  Lain-lain .....

53. For the past 12 months, is there evidence of the following in your community?
Dalam tahun yang lalu, adakah penyakit yang berikut berlaku dalam kampong ini?

- Diarrhoea
  Cirit .....
- Cholera
  Kolera .....
- Intestinal flu
  Sakit usus .....
- Others (Specify)
  Lain-lain .....

54. What are the measures you usually do to cure these diseases?
Apakah tindakan yang diambil untuk menyembuhkan penyakit ini?

.....

.....

.....

55. Where do you go for treatment of these diseases?
Dimana anda mendapat rawatan untuk penyakit ini?

- Self-medication (use drug)
  Rawatan sendiri dengan ubat .....
- Self-medication (use herbs)
  Rawatan sendiri dengan ubat jamu .....
- Traditional healer
  Bomoh .....
- Private clinic
  Doktor swasta .....
- Hospital, government clinic
  Hospital, Klinik kerajaan .....
- No treatment
  Tidak ada rawatan perubatan .....
- Others (Specify)
  Lain-lain .....

FAMILY HEALTH DATA

To be answered for all members of the family.
Mesti dijawab untuk semua ahli keluarga .

In the past month, have any members of your family suffered from the following diseases:-
Dalam bulan yang lalu, adakah ahli keluarga anda mengalami penyakit yang berikut:-

Sickness *Penyakit*	No. of person sick *Berapa ahli sakit*	No. of days sicked *Nombor hari sakit*	Treatment* *Rawatan Perubatan*
Fever *Deman*			
Cold *Selesema*			
Diarrhoea *Cirit*			
Intestinal flu *Sakit usus*			
Vomitting *Muntah*			
Others *Lain-lain*			

* (1) Self medication using drugs
Rawatan sendiri dengan ubat

(2) Self medication using herbs
Rawatan sendiri dengan ubat jamu

(3) Traditional healer
Bomoh

(4) Government clinic
Klinik kerajaan

(5) Private clinic
Klinik swasta

(6) Others (Specify)
Lain-lain

(7) No treatment
Tiada ada rawatan perubatan

APPENDIX C

EVALUATION OF LARGE-SCALE IMPLEMENTATION PROGRAMME OF THE IDRC-UM HANDPUMPS IN MALAYSIA

K. RISHYAKARAN

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AND

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1 Background

In Malaysia, water supply, being the responsibility of the various state governments, is undertaken by the Public Works Department of the State or the State Water Authorities. In rural areas, where the villages are unlikely to be supplied with potable water supply within the framework of the state department's programmes, the Ministry of Health has been assisting these villages to obtain some water supply facilities, under the Rural Environmental Sanitation Programme, which was initiated in 1974.

The types and levels of services provided for rural population consist of one of the following:-

(a) piped water supply (fully/partially treated) with individual house-connection;

(b) piped water supply (fully/partially treated) with public stand pipes or stand posts;

(c) community well water supply consisting of shallow or deep sanitary wells fitted with handpumps, serving 5 to 15 households (some of these wells have further developed to provide house connection, operated with handpumps);

(d) rainwater catchment systems, which are designed to provide sufficient water for drinking and cooking requirements only (the villager has to use other sources for washing and other uses); and

(e) other point source systems such as infiltration gallery, etc.

The project implemented through the Ministry of Health involves the rural community, on a voluntary community participation basis not only in the planning and construction of the physical facilities but also in the operation and maintenance of the facilities. As such, the facilities provided need to be planned and designed for village level operation and maintenance.

2. Well Water Supply

Under the Rural Water Supply Programme, the Ministry of Health provides well water supply system to villagers which has no access for the public potable water supply for the next 5 years. Generally, one well is provided for every 5 to 15 households. The government provides all materials including the handpump at no cost for the construction of the communal wells, while the villagers provide the voluntary labour for the construction of wells. The wells are either dug wells, up to 1 m in diameter (lined with precast concrete ring or brickwall) or borehole wells (augered, driven or drilled wells). Most of the wells are within the practical suction lift (6.7 m), except in the hilly terrain areas, whereby lift pumps (with submerged cylinders) are required.

Where community are willing to operate and maintain a system with pipe

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The unit of currency used in this paper is the Malaysian Dollar.

In 1985, M$2.50 = US$1.00.

connection to each household, one well is provided for every 5 houses or less (depending on the distance from the well). In this case, the community has to make a further nominal contribution towards the cost of pipes and elevated storage tank, amounting to $20.00 per housekole.

Since the inception of the above-mentioned programme in 1974, the Ministry of Health has installed 17,075 community sanitary wells fitted with handpumps, serving 873,000 rural population. Of these, 1,403 wells are provided with individual house connections.

3. Previous Experiences On Handpump

Due to the large numbers of handpumps used in the Ministry's programme, the Ministry has a central contract for the supply of handpumps. Prior to 1985, the handpumps made available under this central contracts consisted of the Dragan, Gibson and Bulaji pumps. In addition to these, the Dempster, India Mark II and Rover pumps has been supplied to the Ministry by UNICEF and other international agencies. Some communities have also installed other pumps like Fuji, Thien Thean, Jetmatic and the like, on their own initiative, using funds provided by the other government agencies.

These imported pumps are cast-iron or cast-bronze bodied, using the plunger type suction valve assembly. Apart from the contractual problems of the supplier in supplying the pumps in time, various other problems were faced with these pumps. In terms of mechanical failures, the frequent problems include the rubber/leather cap or clark for the plunger valve, rubber/leather flap, footvalve, inner lining for the cylinder and grease packing at the pump head. In addition to this, due to the difficulty in quality control, many pumps also faced defects in the body construction.

A nationwide survey carried out in late 1983 indicated that at least 55% of the wells constructed under the Ministry of Health's programme were non-functioning due to various reasons. Of these only 10% of the wells could be put back into function by repairing the handpumps. In all other cases, the handpumps required total replacement, since they were beyond repairs, due to inavailability of spare parts.

4. Ministry of Health's Experience with PVC handpumps

In 1979, the Ministry of Health agreed to co-operate with University of Malaya in the IDRC funded research project to develop and test a suitable handpump utilizing pvc materials, similar to the Waterloo model. A total of 17 pumps were manufactured by the University of Malaya and installed in 2 villages in seperate locations. After 3 years of testing in the field, the Ministry found that these pumps were suitable for the rural water projects. Hence, the Ministry further cooperated in the Phase II project whereby 550 handpumps were manufactured on commerical basis and installed in various locations throughout the country (Annex I). The feed-back from our sanitarians indicated that the IDRC-UM pumps were better received by the villagers, easier to install and faced fewer mechanical problems/defects.

5. Training Programme

In order to ensure proper installation of the IDRC-UM handpumps under the Phase II project, a network of training activities were instituted. These include the following:-

(a) Training at National Level

(i) A one-day training seminar held in 1984 at Kuala Lumpur, in conjuction with the annual meeting between the Programme coordinators and implementors at State Levels. this training programme included theorectical aspects of the IDRC-UM handpump design and the practical aspects of installation. This training was provided to the Public Health Engineers and Chief/Senior Health Inspectors from all the States. These officers are responsible for the implemention of the Rural Water Supply Programme at their respective States, and hence provide the necessary training to the Health Inspectors and Public Health Overseers at their State levels.

(ii) The Division of Engineering Services also included in their annual training programme for Rural Water Supply Systems, 2 sessions in the IDRC-UM handpumps: the first session is on the design and construction of the handpump and the second on the installation of handpumps. The training programme, which covers the design and installation of various water supply systems, is attended by Health inspectors and Public Health Overseers.

(b) Training at the State Level

(i) The various States had in turn organised training programme similar to that of national level (as a(i) above), for the various officers at the district levels, which includes Senior Health Inspectors, Health Inspectors and Public Health Overseers. Some of the States obtained the assistance of University of Malaya (Prof. Goh Sing Yau) in conducting the training programme.

(ii) Ad-hoc training was provided to Public Health Overseers/Health Inspectors who encountered specific problems with the installation of handpumps. The University of Malaya provided valuable assistance in this area of training.

(c) Training at the Village level

While formal training programmes are not organised at the village level, the Public Health Overseers do provide informal training to the caretakers of the pumps. The training activities covered installation, maintenance and repairs of the pump. The caretakers are given instructions on various components of the pumps, and on how to use the operation and maintenance manuals which are supplied together with the pumps.

6. Survey of Non-handpump users

A survey of 61 rural households in two villages in the district of Temerloh was carried out in May 1985. The two villages selected - Bintang and Lebak Seberang - represent different stages of development in terms of the provision of social infrastructure. Bintang is currently being served with electricity, telephone, schools and rural clinics, whereas the children of Lebak Seberang have to cross the Pahang River to attend school.

Another survey of 58 rural households in the district of Alor Setar was carried out in December, 1985. it covered two villages - Belukar and Derang, both of which are approximately 20 kilometres from the state capital of Alor Star. The residents of Belukar are mainly farmers, each with about one hectare of land, while the residents of Derang are primarily school teachers or those working as supporting staff in the nearby schools.

All the four villages surveyed revealed some similar characteristics. They are as follows:

(a) these villages are located away from the main road and do not have access to piped water supply;

(b) the residents'incomes are below the poverty line income of $4,500 per household per year;

(c) these villages are served by the rural health unit of the Ministry of Health, that is, they are provided with rural clinics and are given assistance and advice on health care and sanitation; and

(d) these villages have been selected to receive a few units of the IDRC-UM plastic handpumps in 1985 and/or 1986. At the time of the survey, only one village - Bintang in Temerloh district has received and installed one of these handpumps.

The analysis of the major finding of this rural water supply and sanitation survye is given below.

6.1 General Information (Table 1)

The average age of the respondents is 47.0. It is higher for the villagers in Temerloh than those in Kedah. The average family size is 5.38, with the smallest in Bintang (4.80) and the highest in Lebak Sebarang (6.06). The average figures for age and family size found in this survey are quite typical for villages in Malaysia, where many of the farmers tend to be above 40 years of age. Many of the rural youth have migrated to urban centres in search of more lucrative employment.

The villages have relatively small plots of land and the average size of land area per family is only 1.3 hectares. Their average yearly income - $2,447 is low, and this is well below the government poverty income level of $4,500 per family.

6.2 Source of Water Supply (Table 2)

The main source of water supply for these villages are the rivers and unprotected wells. The collection of rain-water is only important in one village - Sebarang in Kedah. Only 13 percent of the respondents indicated that they obtained some of the water from handpumps. Approximately 15 percent of the respondents use pumps to obtain their water from nearby rivers. The use of protected wells is the least important source of water and is only utilised by 12 percent of the respondents. Most of them rely on at least two sources of water supply - the most widely reported combination being the unprotected well and the river.

The average distance that the villagers have to travel for their water supply is 82 metres. It is furthest for Bintang (107 metres) and shortest (64 metres) for Sebarang.

6.3 Water Usage (Table 3)

The average household uses 9.3 litres per capita per day for drinking and cooking, and 48.1 litres per capita per day for washing and bathing. These figures are well below the figure of 401 litres per person per day used by the Malaysian Government in planning the coverage for treated piped water. All the respondents have water containers to store some water in their houses. The average size of these containers is 237 litres. However, this figure is not a good indication of the actual situation prevailing in these villages, since it is inflated substantially by a few households that have constructed large ponds to store water. More than half of the respondents (62 out of 119) have water containers with a capacity of less than 50 litres.

The average time spent in collecting and carrying water is 1.4 hours per household.

6.4 Improvements in Water Supply (Table 4)

Over 78 percent of the respondents indicate a willingness to pay for improvements in their water supply. The average monthly payment that they consider reasonable is $7.60.

There is good response to the question whether they would like to have a handpump installed near their homes. 85 out of the 119 respondents would like to have handpumps. Of this number, 61 are willing to pay for the installation, monthly repairs and maintenance of these pumps. The majority are willing to pay 25 percent of the installation cost of the pump, and between $5.00 to $8.00 per month for repairs and maintenance. Virtually all respondnets are willing to contribute the labour required for the installation of the handpump.

6.5 Water Treatment (Table 5)

Nearly all the respondents boil their water before drinking. A few villages allow it to settle before boiling. Chemical such as alum and

others are used by only four respondents. Four villagers in Kampong Derang do not treat their water at all, and drink it directly from the source.

The major problem encountered is insufficient supply (21), followed by distance to water supply (20) and the poor quality of the water (15).

7. Survey of Handpump Users

The IDRC-UM handpump was first field-tested in the sub-district of Terachi (district of Kuala Pilah) in the 1980 - 1981 period. A total of 23 of these pumps are now installed in this area, and the bulk of them have been used continuously over a five-year period.

In the survey conducted in September 1986, a total of 40 households were selected at random for further investigations. Information on their family income, sources of water supply and their views on handpumps were obtained.

The main findings from the analysis of their response are as follows:-

(a) Average Income

The average income of these villagers is $3,200 per year or 31 percent higher than the villagers in the two areas surveyed, where the IDRC-UM handpumps have not been installed.

(b) Source of Water

The main source of water for the villagers in Terachi is from handpump (47 pecent) and piped water (44 percent). This is in contrast to the other two areas surveyed where the main sources of water are from wells (37 percent), rivers (35 percent) and rain (19 percent). Many of the households (45 percent) in Terachi have both piped water and handpumps, while 62 percent of the households provided with handpumps five to six years ago are now also having access to piped water.

(c) Payment for Water

The average monthly payment for water supply is $6.35. There is no significant difference in the monthly water bill for those villagers who have and those without access to handpumps.

(d) Condition of the Handpump

All the 28 handpumps in this sub-district appear to be in satisfactory condition. Only seven of these pumps need some minor repairs.

(e) Preference for Pumps

Over 72 percent of the villagers interviewed would like to possess their own handpump. This preference for individually owned and operated handpumps is an indication that the present

arrangement where each handpump is shared by four or five households is not ideal. The main complaint relating to the current situation centres on inadequate water supply for all users and the distance from the house to the handpump.

(f) Problem of Wate Supply

Nearly 24 percent of the villagers are unhappy with the quality of water supplied to them through piped water and handpumps.

(g) Willingness to Pay

More than 80 percent of the villagers indicated a willingness to pay for their individually operated handpump. The mode of payment preferred is a monthly charge of $5.00 to $10.00 per month.

(h) Ability to repair handpumps

Only 40 percent of the villagers with handpumps indicate that they are able to repair their own handpump.

8. Some Benefits derived From the Projects

Some of the benefits derived by the Ministry of Health from the Phase I and II projects in the development of the PVc handpump include the following:-

(i) closer cooperation between the University and the Ministry in terms of research projects.

(ii) better understanding and appreciation of the design and manufacture of handpumps.

(iii) regain of the confidence of villagers and hence the implementation of the well water projects.

Following the completion of Phase II project, the Ministry entered into a 1-year contract with the University of Malaya for the supply of the various types of PVc handpumps. To date about 900 pumps have been purchased and installed.

MINISTRY OF HEALTH - EXPERIENCE WITH 550 HANDPUMPS MANUFACTURED IN PHASE II OF THE IDRC-UM HANDPUMP DEVELOPMENT PROJECT

State	Suction	Lift	Total	Problems Experienced with Installation, Operation and Maintenance of Pumps	Response of Community
Kedah	88	11	99	1. Installation 1.1 Suction Pumps - no problems 1.2 Lift Pumps - piston rings originally got stuck between the delivery pipe joints. But this problem was readily solved by chamfering the inner edge of pipes prior to jointing 1.3 Piston rings - affected by silt in water : solved by proper well development and improved ring design 2. Operation & Maintenance - No problem	1. Generally well received and satisfied with performance 2. Some communities still depend on Health personnel for maintenance - hopefully with the instruction manuals and training, this will be lessened in the future. 3. There is an increasing demand by villagers for installing their own handpumps. This will require the University to look into the marketing of the pumps.
Perak	130	6	136		
Selangor	-	2	2		
Negeri Sembilan	18	1	19		
Melaka	4	-	4		
Johor	28	1	29		
Pahang	65	14	79		
Terengganu	63	-	63		
Kelantan	90	9	99		
Sabah	10	-	10		
Sarawak	10	-	10		
Total	506	44	550		

Table 1 : GENERAL INFORMATION

Location	Number of respond-ent	Average age	Average family size	Average land area/ respondent (ha)	Average yearly house-hold income ($)
Alor Star					
Belukar	30	43.1	5.37	1.00	2,770
Derang	28	41.2	5.25	0.65	2,200
Temerloh					
Bintang	30	52.2	4.8	1.13	2,790
Sebarang	31	50.8	6.06	1.97	2,290
Total/ Average	119	47.0	5.38	1.30	2,447

Table 2 : SOURCES OF WATER SUPPLY

Location	Number of respondent	Source*					Average distance source to home (m)
		Protected well	Unprotect-ed well	River	Rain	Pump	
Alor Star							
Belukar	30	2	28	-	-	-	77
Derang	28	9	3	19	-	4	81
Temerloh							
Bintang	30	1	15	11	3	7	107
Sebarang	31	-	5	28	29	4	64
Total/ Average	119	12	51	58	32	15	82

*Some households have morethan one source for their water supply.

Table 3 : WATER USAGE AND AVERAGE TIME SPENT IN WATER COLLECTION

Location	Number of respondent	Water usage			Average size of water container in household (l)	Time spent in carrying water (hour/day)
		Drinking and cooking	Washing and bathing	Total		
		(litres/person)				
Alor Star						
Belukar	30	12.5	18.3	30.8	72	0.5
Derang	28	11.3	72.0	83.3	808	0.5
Temerloh						
Bintang	30	4.4	72.8	77.2	188	3.7
Sebarang	31	9.2	31.5	41.7	40	0.7
Total / average	119	9.3	48.1	57.4	237	1.4

Table 4 : IMPROVED WATER SUPPLY AND HANDPUMPS

Location	Number of respondent	No. willing to pay for better water supply	Average payment per month ($)	Number requesting for handpump	Number able to pay for handpump	Average payment Installation ($)	Average payment Monthly repair ($)
Alor Star							
Belukar	30	30	9.7	30	27	25% of cost	8.3 *
Derang	28	11	6.0	15	8	25% of cost	8.0 **
Temerloh							
Bintang	30	23	5.5	12	9	12.8	1.8
Sebarang	31	30	7.6	25	17	23.8	5.2
Total / average	119	94	7.6	85	61	-	-

* Average of only 3 respondents

** Average of only 5 respondents.

Table 5 : WATER TREATMENT AND MAJOR WATER PROBLEMS

Location	Number of respondent	No. reporting water treatment			No. reporting major problems		
		Boiling	Allow sediment to settle	Others	Insufficient supply	Poor quality	Distance to supply
Alor Star							
Belukar	30	24	3	-	8	2	5
Derang	28	25	8	-	5	8	6
Temerloh							
Bintang	30	29	-	4	8	5	9
Sebarang	31	31	-	-	-	-	-
Total / Average	119	109	11	4	21	15	20

APPENDIX D

SOCIO-ECONOMIC ASSESSMENT OF HANDPUMPS IN ASEAN COUNTRIES

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Table 1 : SUMMARY OF STATUS AND GOALS OF COUNTRY PROGRAMMES

Items	Indonesia	Malaysia	Philippines	Thailand
Population in 1983 (millions)	158	15	52	51
Percent of population in rural areas	78	63	68	75
Estimated number of rural households (millions)	20.54	1.58	5.89	6.38
Water supply				
Percent served with potable water				
Total - 1983	31	66	53	42
Urban - 1983	50	91	66	65
Rural - 1983	25	57	47	34
Total planned - 1990*	66	95	82	na
Urban planned - 1990*	75	100	100	na
Rural planned - 1990*	60	90	70	na

*For Philippines, this target is for the year 2000.
na - not available.

Source : Indonesia (1984)
Malaysia (1984)
Philippines (1982)
AIT (1984).

2. INDONESIA

Public water installation in the rural areas in Indonesia can be classified into six major types. The number of units constructed from 1969 to 1981 is given in Table 2.

Table 2 : NUMBER OF UNITS OF PUBLIC WATER INSTALLATION CONSTRUCTED IN RURAL INDONESIA

Water system	1969-74	1974-79	1980-81	Total
Well with handpump	2,882	84,682	48,000	135,564
Deep well pump	-	1,061	4,500	5,561
Rain-water collector	24	2,108	1,000	3,132
Protected spring	16	1,000	400	1,416
Simple piping system	108	692	300	1,100
Artesian well	3	188	100	291
Total	3,033	89,731	54,300	147,064

Source : Indonesia (1984).

From this table, it can be seen that a large section of the population is provided with drinking water from wells with handpumps. These 147,064 installations, however, cater to only about 3 percent of the total rural population, the majority of whom secure their supply of drinking water from either private installations or from shallow hand-dug wells, rivers and irrigation canals.

The problems of accessibility to adequate supplies of potable water are, in many cases, more serious in urban centres than in rural areas. Out of the 140 cities which have installed piped water supply, only four of them--Jakarta, Bandung, Semarang and Surabaya have their own treatment plants.

Urban consumption in Indonesia is estimated at 200 litres per capita per day, while rural use approximates 60 litres per capita per day. Based on this assumption, the total demand for potable water will rise from 4,900 million m^3 in 1981 to 11,037 million m^3 in the year 2001. If this demand for domestic water is added to that of irrigation, hydro-power generation, industry, navigation, fishing, mining and recreation, it is envisaged that a shortage will occur in the year 2001 in such areas as Java, Bali and Nusa Tenggara. This shortfall will, in all probability, reduce the land area that can be irrigated, and hence lead to a reduction in food production.

Between the years 1981 and 1984, the Directorate of Clean Water Supply in the Ministry of Public Works was allocated a sum of $26 million for the provision of potable water to 390 small communities. Nearly 20 percent of this allocation was from foreign sources, and it was either in the form of loans or grants. For the period from 1984 to 1989, the Directorate plans to spend an additional $315 million to supply water to another 1,800 small communities.

The three primary types of water supply planned are gravitational systems, deep wells with pumps, and piped distribution systems with household connections. In all these projects, the users are expected to pay for 50 percent of the construction and maintenance cost. The average cost of these systems for the rural sector is given in Table 3.

Table 3 : MONTHLY CHARGES FOR WATER SUPPLY BORNE BY USER

System	Construction cost	Maintenance cost
Spring - gravitational	32 ct - 72 ct	10 ct - 24 ct
Deep well - pump	$2-30 - $4.00	77 ct - $1.36
Household connection	$3.00 - $4.87	99 ct - $1.63

Source : Indonesia (1984).

The range in the charges shown in Table 3 is due to the varying quantities of water supplied daily to different communities.

The Ministry of Health is responsible for improving the quality of water supply and the sanitary environment of the rural population who live outside the small communities of 3,000 to 20,000 people. It plans to construct, by the end of 1988, potable water sources to serve an additional 67 million people. By then, 47 percent of them will be provided with shallow wells, and 21 percent with deep wells.

The unit cost of different types of water supply systems is given in Table 4.

Table 4 : UNIT CONSTRUCTION COST FOR DIFFERENT WATER SUPPLY SYSTEMS AND SANITARY TOILETS

System	Construct-ion cost	Yearly main-tenance cost	No. of users	Construct-ion cost per user	Mainten-ance cost per user
	($)				
Dug well	200	6	100	2	0.06
Shallow well and pump	90	15	100	0.9	0.15
Deep well and pump	400	17	100	4	0.17
Artesian well	6,000	200	500	12	0.40
Deep well and pump with distribution systems	40,000	270	3,000	13.2	0.09

Sources : Indonesia (1983).

3. MALAYSIA

By the end of 1983, 66 percent of the country's total population had been supplied with potable water. This supply reached 91 percent of the urban and 57 percent of the rural areas. But, on the whole, the figures vary substantially for different regions of the country, for example, the percentage of the rural population supplied with water in the states of Kelantan, Sabah, Sarawak, Trengganu and Johore is 24, 29, 29, 33 and 39 percent respectively.

The government had in the Fourth Malaysia Plan (1981 - 1985) invested a sum of $550 million to expand water supply to both the rural and urban sectors. About 70 percent of this sum was for urban water supply. An additional $464 million was spent in 1984 under a similar programme.

Between 1981 and 1983, a total of 2,037 projects to supply treated piped water to the entire nation was completed, thereby benefiting one million people or 167,000 households. Their total capacity was 368 million litres per day or 401 litres per person per day.

Besides this piped water programme, the government, during the same period, also constructed 78 production wells (benefiting 120,000 people in rural Malaysia), and completed 4,279 wells with handpumps, 325 wells with reticulation systems, 611 gravity water supply schemes, 47 pumped water supplies and 9,837 rain-water collection systems. The latter was installed in Sabah and Sarawak.

The aim is to increase the percentage of the rural population supplied with potable water to 70 percent in 1985, and to 90 percent by the year 2000. This 90 percent target represents the maximum figure that can be achieved, after which, it would be considered uneconomical to supply the remaining 10 percent of the population residing in the remote pockets of Peninsular Malaysia, Sabah and Sarawak.

For the years 1984 and 1985, the government plans to construct the following waterwork facilities for the rural areas :

- 5,319 shallow wells with handpumps,
- 1,762 deep wells with reticulation systems,
- 666 gravity water supply systems, and
- 1,363 rain-water collection systems.

These are projected to benefit 469,000 people or 78,000 rural households in Peninsular Malaysia, Sabah and Sarawak.

The Public Works Department (PWD) located within the Ministry of Public Works is responsible for the provision of treated water to all urban centres in Malaysia, including rural areas which are located on the main roads and are linked or adjacent to urban centres. Unlike the Ministry of Health, its rural water supply is confined to mobile tanks which operate during periods of drought, and to static tanks which serve peat areas where the surface water is unfit for human consumption, and areas where piped water is currently unavailable.

The PWD also oversees water supply projects for government land development schemes such as the Federal Land Development Authority (FELDA) and regional development schemes.

The Ministry of Health has, for some years, been involved in the Rural Environmental Sanitation Programme which provides gravity-feed piped water supply systems, shallow wells with handpumps and rain-water catchment systems to the more remote rural areas which are currently not covered by the Public Works Department. Households in some rural areas where both the PWD and the Ministry of Health have

installed piped water systems or completed water projects have a choice of opting for whichever system they prefer.

One important difference between the Ministry of Health and the PWD programme lies in the former's non-imposition of any charges on users to recover the investment, operations or maintenance cost. Some of its projects are undertaken on a self-help basis, that is, it supplies the material while the villagers provide the labour required. The PWD on the other hand, levies some kind of payment on users for the piped connection between the main line and their homes, and a monthly charge which varies with the amount consumed. Water rates in the country, however, differ from area to area, depending on the decision of the local authorities, but they, as a rule, do not cover the full cost of water supplied due to the considerable amount of government subsidy which compensates for the cost of construction, yearly operations and maintenance.

Until the last two years, financial investments in water projects do not pose as a serious constraint in achieving the goals of supplying treated piped water to 100 percent of the urban and 90 percent of the rural areas. However, the current government trend of exercising greater fiscal restraint on public spending will, in all probability, cause some delays in realising these targets.

The cost of supplying treated piped water to both the urban and rural sectors is relatively high. For example, between 1981 and 1983, the government spent $546 million to supply piped water to 200,000 households. This works out to a cost of $2,730 per household. It includes the cost of supply to industrial users.

In contrast, the Ministry of Health's rural water supply programmes for the period from 1981 to 1985 incurred the government the sum of $8 million only. Table 5 shows the cost figures per household for the different water supply systems.

Table 5 : INVESTMENT COST PER HOUSEHOLD FROM DIFFERENT SYSTEMS

System	$ / household
Shallow wells with handpump	152
Rain-water catchment	174
Gravity feed system*	280
Deep well with pump and household connection	348

*Assuming each system serves 40 households.

Source : Malaysia (1983).

It is important to note that the water supplied under the Ministry of Health programme is untreated water, while that of the PWD is treated. In view of this, it can be assumed that the Malaysian government regards the Ministry of Health programme as only an interim measure, and in the long-term, it intends to supply treated piped water to all except the most remote rural households.

4. PHILIPPINES

From 1975 to 1981, only approximately 30 percent of the total public investment expenditure for infrastructure was spent on water projects, with the bulk of the allocation--80 percent going to the urban sector.

The government has constructed about 15,600 deep wells with an average drilled depth of 60 metres in rural areas, but only 13,700 of these are still operational. On an average, each well serves 470 people. The majority of them are between ten to twenty years old, and 40 percent require rehabilitation.

In addition to deep wells, 3,000 springs were developed in the rural sector, with each serving the needs of 1,800 people. The other main source of rural potable water supply is the public standpipe system. A total of 1,100 standpipes are in operation, and each supplies water to 670 inhabitants.

Based on the results of a survey carried out in 1981 by the Ministry of Local Government (Philippines, 1982), public sources of potable water represent only 13.5 percent of total water sources in the Philippines. The majority of private sources are from 250,000 drill wells,41,000 dug wells and 8,000 springs. The number of rain collectors in the country is only 190, indicating that they are not an important source of potable water for rural Philippines.

The average depth of drill and dug wells in ten metres, and less than 4 percent of the pumps utilised are electrically driven or powered by diesel engines.

The government's target is to provide communal faucet systems with public standpipes which are situated not more than 25 metres

from the furthest user to 70 percent of all rural communities by the year 2000. The plan is to provide the remaining 30 percent with protected wells or spring sources without any distribution systems. In these cases, the furthest users will not be more than 250 metres from a potable water source.

From 1981 to 1985, the investment required for the country's water supply projects is estimated at $541 million. It is envisage that 36 percent of this allocation will be funded by foreign source either in the form of loans or grants.

The following factors determine the government's priorities in the selection of and investment in rural water supply projects :

(a) communities who form rural waterworks and sanitation associations, and are willing to contribute to the required equity, and pay for the annual service fees;

(b) communities who experience the greatest inadequacy in quantity, accessibility and quality of water supply;

(c) areas with economic potential, but are currently in poor or depressed conditions;

(d) projects whose costs entail the lowest project investment per capita for a given level of service; and

(d) communities whose existing wells and springs can, through rehabilitation, prolong their usefulness, and thereby reduce the need for costly new projects.

Philippines' Rural Water Supply and Sanitation Master Plan (1982) indicated that the problems encountered in implementing government programmes are relatively minor in nature. This is due mainly to the increased government allocation for water supply and sanitation works in recent years. In 1982, $79 million was given for rural water programmes. Of this amount, $53 million was from foreign loans and grants. For the next five years, it is envisaged that rural water supply programmes will receive 1.6 percent of the government's total infrastructure budget.

Co-ordination among the agencies involved in rural water supply is undertaken by the National Water Resources Council which identifies potential projects and draws up a framework for their implementation by the relevant agencies. In this manner, they can better appreciate the issues and problems which arise outside of their own areas of responsibility. However, the National Economic Development Authority exercises budgetry control over water resource development and regulation. The budget development procedure is primarily planning from top-down rather than from bottom-up.

The government provides some kind of subsidy for rural water supply projects, and it can take the form of engineering and technical services, grants or loans at lower than commercial interest rates. The subsidy can range from 10 to 100 percent, depending on the agency involved. The government also extends a maximum of 90 percent grant to construct wells and springs which are without distribution systems. The remaining 10 percent is drawn from equity contribution of the local waterworks association as an indication of its commitment to the project. In areas where villagers are provided with communal faucet systems, they are expected to provide 10 percent of the total cost, while the other 90 percent is extended in the form of a government loan, repayable at an annual interest rate of 4 percent.

The monthly water fees for individual households range from 2.5 cents to 5 cents for areas which receive 90 percent grant, and 25 cents to 50 cents for those receiving 90 percent loan.

The following gives the investment cost per household, and the volume of water supplied under the three kinds of services :

(a) Level I -- where the point source constitutes shallow or deep wells or developed springs suited to small communities. Each shallow well serves about 5 to 40 households, while a deep one serves about 40 to 100 families. The construction cost for shallow and deep wells is $60 and $750 or $12 to $19 per household respectively. The yield or discharge ranges from 40 to 150 litres per minute, and each family is provided with 30 litres of water a day.

(b) Level II -- where water from a point source is pumped into a storage tank and distributed via a network of pipes until it reaches the public faucets, each of which serves 4 to 6 households. Each household is provided with 40 to 80 litres of water per day. The construction cost is $50 per household.

(c) Level III -- where each family is connected with the conventional system, metered or unmetered, and it is suitable for small urban communities. The average cost of construction is $105 per household, and each household is provided with 100 litres of water per day.

The monthly cost of operation and maintenance per household for these three levels of service is 2.5 cents to 5 cents for Level I, 25 to 75 cents for Level II and 30 cents to $1.00 for Level III.

5. THAILAND

The Asian Institute of Technology (AIT, 1984) estimated that by 1983, 69.4 percent of the rural populace would have been supplied with water for domestic consumption. Nearly half of this supply originates from supplementary agricultural water projects, that is, as a result of the construction of ponds, irrigation canals and reservoirs designed primarily to provide water for agricultural crops. Table 6 shows the percentage of the population served by different water sources. It is interesting to note that if the water (which is untreated and hence may not be safe for domestic use) from ponds, irrigation canals and reservoirs is deducted, only 35.9 percent of the rural population can be considered as having access to potable water.

In 1982, a study by Mahidol University revealed that more than 95 percent of villagers do not drink deep well water because of its unpleasant, brackish and insipid taste and odour. They also do not drink piped water because of its strong chlorine taste. This study also noted that of the 80 percent of deep wells currently in use, only 12.4 percent are used for drinking water. Villagers prefer water from traditional sources such as shallow wells, canals, swamps and rain-water. Table 7 gives the results of this survey on the villagers' preferences for water from various sources.

The decision on the type of water source to develop will, however, depend on individual villages and the technical and economic feasibility of each type for different areas of the country. Factors such as the characteristics of the locally available water source, villagers' preferences, and the cost of installing the system for a particular village are important considerations. On a regional basis, it has been found that deep ground water and surface water are most appropriate for the nothern region, surface water for the north-east

Table 6 : PERCENTAGE OF POPULATION SERVED WITH WATER, 1983

Water source	Government	Private	Total
Wells			
Deep	14.37	1.35	15.72
Shallow	5.96	0.89	6.85
Tube	3.12	-	3.12
Rain - water cisterns			
$150m^3$ RFC	0.23	3.28	3.88
$150m^3$ metal tank	0.25		
$3m^3$ RFC/$5m^3$ BFC tank	0.09		
Jar/water supply	0.03		
Piped water supply			
Rural	0.29	-	0.29
Small-scale	3.43	-	3.43
Supplementary			
Small pond	0.13	-	0.13
Standard pond	0.38	-	0.38
Natural pond	18.68	-	18.68
Irrigation canals/ reservoir	16.89	-	16.89
Total population coverage	63.85	5.52	69.37

Source : AIT (1984).

Table 7 : PREFERENCES OF VILLAGERS FOR DIFFERENT WATER SOURCES AS DRINKING WATER (%)

Region	Rain-water	Shallow wells	Deep wells
North-east	65	35	-
North	82	15	3
Central	54	36	10
South	30	70	-

Source : AIT (1984).

region, shallow ground water, deep ground water, surface and rain-water for the central region, and rain-water, surface and shallow ground water for the southern region.

The amount of water consumed per capita from the various water sources varies considerably. It ranges from 4 litres per capita per day for rain-water to 30 - 40 litres per capita per day for piped water.

Table 8 shows the investment and yearly operating costs of the different water supply systems. They are lowest for shallow wells and highest for rain-water collectors ($150m^3$) and deep wells with handpumps.

Table 8 : COST COMPARISON FOR RURAL WATER SUPPLY SYSTEMS

Type of facility	Investment cost per capita (US$)	Operations and maintenance cost per capita per year (US$)
Shallow wells (unprotected)	13	0.06
Shallow wells with handpump	17	0.30
Deep wells with handpump	103	0.30
Deep wells + motor pump + distribution system	23	2.50
Rain-water collector $5m^3$	50	4.00
Rain-water collector $150m^3$	190	0.40
Spring capitation with gravity distribution system	14	1.40
Slow sand filter + distribution system	36	2.30
Horizontal filter + slow sand + distribution system	30	2.50
Conventional treatment distribution system	37	4.10

Source : AIT (1984).

However, an analysis of all water used by villagers in 1981 revealed the following :

	Excellent	Fair	Poor
	(%)		
- bacteriological content	16.5	3.5	80.0
- chemical and physical content	20.2	67.0	12.8

This indicates that only less than 20 percent of the water currently used by villagers are considered safe for domestic consumption.

Table 9 gives the targets for the different projects and their average cost.

Table 9 : TARGETS AND COSTS OF VARIOUS PROJECTS

Projects	Targets for 1983 (No.)	Total cost (US$M)	Average cost (US$)
Deep well -drilling	5,140	16.89	3,286
Deep well - maintenance	26,800	3.03	113
Shallow well	1,250	0.33	266
Piped water system	270	2.97	11,012
Water storage tank	4,030	0.69	172
Dredging of natural pond	644	3.96	6,149
Standard pond	94	1.13	12,060

ESTIMATED POTENTIAL DEMAND FOR HANDPUMPS

Data on the number of handpumps installed in these four Asean countries are not readily available. Estimates obtained from published sources and from interviews with senior government officials involved with rural water supply programmes often vary quite considerably. In view of this, the estimates presented in Table 10 should be regarded as only preliminary in nature.

The number of handpumps installed by the governments of these four countries each year is based on the figures supplied by the main implementing agency. However, these figures show the number of pumps that these agencies plan to instal and not the actual number installed. The actual number is usually 20 to 50 percent less than the planned figure.

The estimated public demand is obtained by assuming that the existing pumps will have to be replaced after 6.67 years, that is, 15 percent of existing pumps will be replaced annually.

Table 10 shows that Philippines and Indonesia have the largest number of handpumps--approximately 300,000 for both deep and shallow wells in each country. The estimated number in Thailand and Malaysia are 60,000 and 15,000 respectively.

The number of handpumps installed by the government each year varies from 2,000 in Malaysia to 30,000 in Philippines. The Philippines has the most active handpump installation programme, and the estimated annual demand for them for this country is 75,000. The comparable figures for Indonesia, Thailand and Malaysia are 56,000, 12,000 and 4,250 respectively.

Table 10 : ESTIMATED NUMBER OF HANDPUMPS INSTALLED AND POTENTIAL ANNUAL DEMAND

Country	Estimated number of handpumps installed in the country	Potential annual demand		
		Public	Private	Total
Indonesia	300,000	20,000	45,000	65,000
Malaysia	15,000	2,000	2,250	4,250
Philippines	300,000	30,000	45,000	75,000
Thailand	60,000	3,000	9,000	12,000
Total	675,000	55,000	101,250	156,250

Source : Tan (1982).

Notes and assumptions :

1) Includes handpumps for shallow and deep wells.

2) Potential annual public demand is based on the individual country's government targets for providing potable water to a large proportion of the rural population over the next 10 years.

3) Potential annual private demand is based on an estimated 15 percent of the existing pumps being replaced annually.

4) In the case of Philippines, nearly 4,000 pumps are installed annually with assistance from international organisations such as the World Bank, UNICEF, Asian Development Bank, Australian Development Assistance Bureau and the Overseas Economic Corporation Fund.

IDRC - UM HANDPUMPS IN MALAYSIA, PHILIPPINES AND THAILAND

Over the last two years, the IDRC - UM handpumps have been installed and field-tested in these three countries. In Malaysia, both the above and below ground components are made locally, whereas, for Philippines and Thailand, the below ground components are made in Malaysia and sent to the co-operating agencies in these two countries. These two agencies then fabricated the above ground components locally.

The cost of the IDRC-UM handpump in these three countries is shown in Table 11. It can be observed from this table that the cost is $65.84 for Thailand, $73.46 for Malaysia and $92.37 for the Philippines. Thailand is able to produce the above ground components at 27 percent cheaper than Malaysia, whereas in the case of the Philippines, this cost is 33 percent higher than in Malaysia. For the Philippines, it would appear that that unless the agency is able to reduce the cost of manufacturing the above ground components, it would be cheaper to buy the complete unit from Malaysia than to attempt to make part of the pump locally. This conclusion, however, does not take into consideration the import duty that may be charged on importing the complete unit.

A brief report of the handpump testing programme in these three countries is presented below :

(a) Malaysia

A total of 2,000 pumps have been purchased by the Ministry of Health and installed as part of the rural water supply project. The cost of installing these pumps is also borne by the Ministry of Health, and the beneficiaries are only expected to provide some labour for installation, after which, the personnel from this Ministry are made responsible for the maintenance of these pumps.

Table 11 : COST OF IDRC-UM SUCTION PUMP IN MALAYSIA, PHILIPPINES AND THAILAND

Pump components	Malaysia	Philippines (US$)	Thailand
Above ground			
Metal stand	21.15	19.03	12.45
Lever arm assembly	8.08	4.45	3.72
Misc	5.77	3.61	3.51
Labour	7.69	9.70	11.54
Overhead	-	20.00	-
Sub-total	42.69	56.79	31.22
Below ground			
Piston and footvalve	13.46	13.46	13.46
Pump cylinder	17.31	17.31	17.31
Transport	-	4.81	3.85
Sub-total	30.77	35.58	34.62
Total cost	73.46	92.37	65.84
Labour-mandays/pump	0.9	3.4	5.0

Source : Figures supplied by the University of Malaya, Malaysia, Population Development Agency, Thailand and Science and Technology Research Centre, Philippines.

Note and assumption :

1) Exchange rate used is US$ 1.00 = M$ 2.60,
= P 20.00
= 26.00 Baht.

In this instance, the villagers' participation in terms of cost-sharing and maintenance is minimal. The Ministry of Health can also turn to the University of Malaya for assistance in overcoming any minor problems experienced in the operations and maintenance of these pumps.

No major problems have been reported in the IDRC-UM Handpump Programme in Malaysia. The main factor determining the number of handpumps that the Ministry of Health will install in the next few years is the budget allocated to this programme by the federal government.

Between 90 to 95 percent of these pumps installed were suction pumps designed for shallow wells.

(b) Philippines

A total of 28 handpumps have been installed and monitored for more than a year in Camarines Sur province of the Philippines. These pumps were all suction pumps, and each was to be used by 4 to 5 households. These households are to repay the sum of $64.80 per pump over a period of two years. To meet this repayment schedule, one or two pump group leaders are charging the user either on a per pail basis or a per pump basis. The rate charged varies from 0.0075 cent to 0.0125 cent per two-gallon pail and from 0.05 cent to $4.50 per month. This cost is quite high considering that the average income of these villagers is in the range of $40 to $100 per month. The contributions from the beneficiaries of these IDRC-UM pumps are considerably higher than those borne by the beneficiaries of the

government handpump programme. For the pumps provided by the Rural Waterworks Development Corporation, the beneficiaries have only to pay 10 percent of the material cost and provide some labour during installation.

The major problem encountered in these pumps is the damage to the piston ring. This is quite a serious problem, and in the field visits made in August this year, it was observed that six of the pumps were completely out of order. They cannot be repaired since no spare parts are made available. The delay encountered in securing spare parts from Malaysia poses as a serious problem for the future expansion of this programme, and points to a need to seriously consider manufacturing both the above and below ground components in the Philippines.

Besides the performance of the pump, another important factor that will affect the large-scale acceptance of this pump is its price. The two most common suction pumps used in Philippines at the moment are the pitcher pump and the jet-matic pump. Both these pumps are made of cast iron and the cost ranges from $8.50 to $22.00 per unit. Thus the IDRC pumps are three to eight times more expensive than those which are widely used.

However, the cost of the Clayton pump commonly used in the Philippines for deep wells, that is, those of more than 12 meters is $165.00. [1] The IDRC-UM lift pump which can be used for deep wells costs

[1] There is a made-in-Philippines Clayton pump which costs only $32.00. The PBSP has been offered a special price of $50.00 for the imported model of the Clayton pump.

only $81.00 when made in Malaysia. Thus, on a cost basis, the IDRC-UM lift pump appears to have an edge over the Clayton pump.

(c) Thailand

A total of 42 IDRC-UM suction handpumps have been installed in Thailand. Unlike the case in Malaysia and Philippines, nearly all these pumps are individually owned and operated. There does not appear to be any serious problem with the operations and maintenance of these pumps, and the villigers are generally quite satisfied with their performance. All of them are installed in hand dug wells, and in one or two cases, they have run dry.

The cost of alternative suction pumps ranges from $11.50 for the Abadah pump to $23.90 for the Lucky pumps, and $36.60 for the Ace pump. All these pumps are made locally from cast iron. A new factor determining the choice of pumps is the recent introduction of an electric pump made in Thailand. This ½ horsepower pump costs only $50.00 which is less than that of the IDRC-UM pump. The operating cost of this pump is only about $4.00 per month. During field visits, it is observed that some households have added the electric pump to existing wells served by handpumps. This gives them the option of using either the handpump or the electric pump. The latter is usually connected to a pipe leading to a storage tank in the user's household, and this pump needs only be operated for short periods of 20 to 30 minutes each time to fill the storage tank.

CONCLUSION

Among these four countries, the IDRC - UM pumps have only been introduced on a large-scale in Malaysia. Here, the Ministry of Health has accepted this pump as its standard model for its rural water supply programme. An important factor in the selection of the IDRC - UM handpump lies in the fact that there are no suitable locally manufactured pumps available, and the imported pump tested is more expensive and less reliable than that of the IDRC - UM pump.

The market for this handpump in Malaysia is, however, quite limited given that the government intends to supply virtually all urban and rural households with piped water within the next ten years. Thus, handpumps will only be a temporary source of potable water until piped water systems are implemented.

In the case of Thailand, the availability of relatively lower cost handpumps and electric pumps of comparable cost raises some doubts regarding the possibility of establishing a large market demand for the IDRC - UM handpump. Since nearly 80 percent of Thailand's rural population are being supplied with electricity, it appears highly likely that many rural households will prefer to buy electric pumps vis-a-vis similar priced handpumps.

The market potential for this handpump in the Philippines, on the other hand, appears to be very promising. This country has a long history of using handpumps for potable water. In addition, there are large numbers of existing handpumps that will be requiring replacement annually. The government is also actively involved in promoting the use of handpumps in their rural water supply projects. The cost of the IDRC - UM suction pump, however, will need to be lowered in order for it to be competitive with the existing cast iron pumps used in government programmes. However, the IDRC - UM lift pump has a

cost advantage over the currently used deep well pumps, and this factor should be exploited in promoting the greater use of the IDRC - UM lift pump in this country.

Other factors that will assist in the further utilisation of the IDRC - UM handpumps in the Philippines are :

(a) the local manufacture of the pump, and

(b) the local research and development capability to modify these pumps to suit the local needs such as resistance to rust as well as to use locally available material that can lower the cost of these pumps.

Both these factors should be given serious consideration in future programmes to promote the widespread adoption of this handpump in the Philippines.

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TABLE 3.1.3 : MOULDS AND JIGS

	MOULDS	PART MATERIAL	YEAR 1	YEAR 2	YEAR 3
1.	Piston rings	Polyethylene	Mould no. 1	Improved mould No. 2	-
2.	Bolt set	Acetal	Mould no. 1	Improved mould no. 2	-
3.	Nut set	Acetal	Mould no. 1	Improved mould no. 2	Mould no. 2 upgraded
4.	3" dia. flange	PVC	Mould no. 1	Improved mould no. 2	Mould no. 1 upgraded
5.	Piston barrel	PVC	Mould no. 1	Improved mould no. 2	Mould no. 2 upgraded
6.	3" to 1.5" reducer	PVC	-	Mould no. 1	-
7.	Footvalve extractor	Acetal	-	Mould no. 1	-
8.	Bearing bushes	Acetal	-	-	Mould no. 1
9.	Footvalve double-lip seal	Rubber	Mould no. 1	-	-
10.	Valve flap	Rubber	Mould no. 1	-	-
	JIGS				
1.	Assembly of piston & footvalve		Jig no. 1	Improved Jig no. 2	-
2.	Drilling of spout hole in steel pump stand		Jig no. 1	-	-
3.	Positioning and welding of steel spout and base flange to pump stand		Jig no. 1	Improved Jig no. 2	-
4.	Oxy-acetylene copy-cutting of steel base flange		Jig no. 1	-	-
5.	Positioning and drilling of holes in timber lever arms and bearing blocks		Jig set no. 1	-	-