TRACTOR USAGE IN

WADI RIMA'

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INTRODUCTION

At the request of the Agricultural Engineering Project in Taiz (A.E.P.) a survey of tractor usage, of farming activities in general and cultivation practices in particular was carried out in the Wadi Rima during April 1981. The survey formed part of the feasibility studies undertaken for a proposed pilot tractor hire scheme. This report is to set out the results of the survey and present an analysis of such a hire scheme based on those results. The author would like to acknowledge the assistance generously offered by the following individuals and organisations: the managers of the Zabid and Bayt al Faqih branches of the Agricultural Credit Bank, the Hudaydah offices of the Adhban, Aqil, BaSalamah and Tihama Trading Companies, the officials of Zabid Zakat tax office and the people of Wadi Rima, in particular Shaykh Muhammad Abkar of Basat. Muhammad Nu'man of the Dhamar Agricultural and Forestry Research Station assisted most ably in the greater part of the fieldwork.

BACKGROUND

The A.E.P. estimated in January 1981 that tractor powered cultivation accounts for about 15% to 20% of the total cultivated area in the Yemen Arab Republic and employs between 4,000 and 5,000 tractors. Most of the tractors employed have only been in use since 1975. The rapid expansion in tractor use between then and now is the result of emigration to Saudi Arabia and the ensuing shortage of labour in the Y.A.R. Purchase of tractors has largely been financed out of remittances from Saudi Arabia although latterly the Agricultural Credit Bank (A.C.B.) has been making an increasing number of loans for tractor purchase, at present supporting about 20% of annual sales.

It is considered that tractors so far purchased in the Y.A.R. are poorly selected for local conditions. Pield sizes are small, less than half a hectare usually, yet large 70 to 80 h.p., 4 wheel drive tractors are common. These are inadequately loaded with the single and two furrow mouldboard ploughs which are most common. Farm sizes in Yemen are small, the average below five hectares, and tractors cannot be fully employed on one farm. Equipment is therefore hired out with an operator on an hourly basis and it is estimated that private contract work of this kind accounts for more than 90% of annual use.

Analysis by the A.E.P. has shown that current hire rates are uneconomic and that tractor owners are losing money; at they are not making adequate allowance for depreciation or repair costs. As most tractors are still fairly new operators may not yet be feeling the full impact of these costs. However, there has been a fall in tractor sales during 1980 and other factors such as a fall in remittances and natural limits to tractor cultivation are being felt. It is considered that tractor operators are beginning to appreciate that the income from contract work is inadequate to cover their true costs. On the other hand agriculture as a whole is under considerable financial pressure due to high wage costs and farmers may well be unwilling to accept any increase in tractor hire charges to a more economic level. There is a danger that land will be taken out of cultivation if input costs including mechanical cultivation cannot be reduced either directly or by more efficient operation.

The encouragement of the second of these, more efficient operation, is a central goal of the A.E.P.'s work. To date this has been done by extension, training courses and by liason with the A.C.B., Ministry of Agriculture (M. of A.) and other projects. However the evidence is that

the changes towards more efficient operation, in particular through the selection of more appropriate machinery and implements, have been slower than hoped for even under the current increasing economic pressures. For these reasons the A.E.P. is seeking a more positive practical approach to encourage the wider use of recommended agricultural machinery. One method that has been suggested is the establishment, in a suitable area, of a commercially based tractor and equipment hire service. The Wadi Rima has been suggested as a likely area for such a scheme.

0BJECTIVES

J.F. Williams, project manager of the A.E.P. has laid down, in his memorandum of 20/1/1981 the following principal objectives of a small pilot agricultural machinery hire service on a commercial self-funding basis:

a) To provide farmers in an area where there is a need for improved agro-mechanical services with a reliable and effective land preparation, planting and threshing service at commercially self-funding and profit making charges. (Calculations of tractor hire charges for various operations, using equipment more suitable for the work than that in current use, indicate that a reduction below present contract charges to the farmer will not be possible because these are already sub-economic and existing contractors are losing money in the long term. However, by selecting equipment suited to the working conditions and by managing this more efficiently it should be possible to maintain charges at about their present level, whilst those of other contractors will inevitably rise).

b) The successful use of suitable equipment and improved field operational procedures on a pilot hire scheme will, it is hoped, effectively and practically demonstrate to farmers and other contractors in the area the advantages which the better selection of equipment and efficient field use can bring and enable power threshing, planting and other new techniques to be introduced.

c) A pilot scheme of this type, if properly monitored, will enable actual field performance and costs to be obtained, reveal operational constraints more clearly, and indioate through its success or failure the advisability of extending similarly based schemes into other areas.

REQUIREMENTS OF THE AREA SELECTED

Williams specified that the area selected for such a scheme should ideally be as follows:

a) It should have field sizes and cropping systems fairly well suited to the use of tractor powered cultivation, levelling, planting and threshing operations.

b) It should be preferably situated in the Tihama and have irrigation services from wadi flow and pumps to enable a wider spread of seasonal cropping to be achieved which in turn will be capable of supporting the fuller seasonal use of agricultural machinery required for the operations described.

c) Ideally the area selected should be within two hours motoring distance of Taiz and/or Hudaydah and be reasonably accessable to the main asphalt road. This will enable adequate supervision of the scheme to be undertaken by A.E.P..

d) The selected area should preferably be served by an agricultural extension service who can assist with information relative to the feasibility study and with cooperative assistance later.

e) The A.C.B. should have a branch near to the selected area, preferably with an existing crop loan service. It is envisaged that loans to support the cost of mechanized work for farmers will be advanced to them by the bank branch and retrieved when the crop is harvested. (In many areas there is a serious problem for existing contractors securing payment from farmers for services rendered).

f) It is imperative that farmers in the selected area should show interest and be willing to support a pilot scheme of this type, and that the area is not already provided with adequate contracting services acceptable to the farmer.

If all the above criteria can be met then there will be the need for discussions with local authorities and other interested bodies such as the M. of A., the Tihama Development Authority (T.D.A.) and the Zabid extension service.

AIMS AND METHODOLOGY OF THE SURVEY

As far as Wadi Rima is concerned, requirements b,c,d, and e are met, hence its selection for further study. The main aims of this survey were to gather information on cropping systems and their effect on tractor use requirements (a) and to some extent (b) and to assess the current level of mechanised cultivation capacity available (requirement (f); In short to assess the relative levels of supply and demand for tractor services.

The survey was carried out in two parts: interviewing 37 farmers and 14 tractor owners. In addition available data was collected from the A.C.B. branches in Bayt al Faqih and Zabid, both of which cover a section of Wadi Rima and from major tractor suppliers in Hudaydah.

Unfortunately the only possible sampling frame for farmer interviews, Zakat tax lists, could not be made available without formal request from the M. of A. As this would have been extremely time consuming it was decided not to pursue a rigorous random sampling approach to selecting farmers for interview. Instead six villages were chosen and the 'Aqil[1] in each village asked to nominate nine farmers for interview: three from among what he considered to be the better off farmers, three from among intermediate farmers, and three from among the poorest. Inevitably only a proportion of those nominated could be found for interview. However overall the spread between the three classes was maintained and they appeared to be fairly representative of the range, if not the distribution, of the scale of operations to be found in the area. The villages themselves were chosen from among the three major cropping areas of the wadi: two from each of the wadi irrigated, pump irrigated

[1] Roughly: village headman

and rainfed areas. (See L.R.D.C. Project Report 16: Y.A.R.-01-29/REP/-16/77 page 49 for details of these areas and their definition). For comparability in the pump irrigated and rainfed areas the same villages were surveyed as those selected (randomly) and surveyed intensively by the M.P.W.R. project (L.R.D.C. op. cit.) Unfortunately this was not possible for the wadi irrigated area, in one case because rain and spate had rendered the village inaccessible, in the other case because the village turned out to be a base for Akhdam, casual labourers and threshers, rather than a farming village.

Table I : The Pattern of Agriculture in Wadi Rima' (1976)

SOCIAL FRAMEWORK	Pump Irri-gated	Wadi Irrigated			Rainfed		
		Peren-nial	Regular	Irreg-ular	Runoff Supple-mented	Purely Rainfed	Oppor-tunistic
Farm Holdings	1100	300	800	1400	500	1100	-
Holding size –ha	3.5	2.5	3.0	3.5	3.5	10.0	-
sharecrop %age (1)	35	80	65	30	80	30	-
Emigration %age(2)	6.4	12.7	22.9	19.5	17.3	25.9	-
CROP AREAS	HA	HA	HA	HA	HA	HA	HA
Sayf sorghum	1600	260	1555	765	530	1040	-
Qayra' sorghum	2200	300	1915	3085	1310	3640	-
1st Ratoon	800	75	725	1230	-	-	-
2nd Ratoon	800	-	-	-	-	-	-
Cotton	1000	75	345	90	-	-	-
Millet	600	-	710	900	260	1560	700
Sesame	600	-	195	255	260	-	-
Maize	125	1540	450	-	260	-	-
Watermelon	175	-	-	-	-	-	-
Tomatoes	125	-	-	-	-	-	-
Tobacco	75	-	-	-	-	-	-
Vegetables	150	-	-	-	-	-	-
Total	8250	2250	5695	6325	2620	6240	700
'Summer' crops (3)	(2200)	(260)	(2265)	(1665)	(790)	(2600)	
% of Total	21	12	40	26	30	42	

Notes: 1)In the pump irrigated zone 80% of the area is irrigated with 'sharecropped' water i.e. the owner of the well and pump set receives a share for the irrigation service.
2) As at 1975 census:- Proportion of adult males (16+) elsewhere.
3) i.e. sayf sorghum and millet.

Source: L.R.D.C. Irrigation and Agricultural Development in Wadi Rima: Vol I, Y.A.R.-01-29/REP/16/77

RECENT CHANGES IN CROPPING AND PRODUCTION

The range of crops grown is narrowest in the rainfed areas where sorghum and millet dominate to the exclusion of all else and widens in the wadi irrigated areas where maize, cotton and sesame are also important. In the pump irrigated area greater control over irrigation timing allows the addition of tomatoes and watermelon, which are important cash crops, and more locally tobacco. Table I (derived from L.R.D.C. op. cit. p98 ff) shows the distribution of crops in 1976 amongst the three main areas and seven subdivisions defined by L.R.D.C. As well as the number of holdings, the average holding size and the % of the land sharecropped in each category, the Table shows the emigration ratio: as much as a quarter of the adult male workforce overseas. This loss of labour, and the counterflow of remittances have been important influences on the market for tractor services.

Although there have been no significant additions to the range of crop enterprises in the wadi since 1976 there are strong indications of significant changes in the mix. A steady decline in the proportion of cotton grown since 1975 is widely reported although a very substantial price rise for the current season may have slowed or even halted this. In contrast the last year saw very strong demand for fodder and a considerable increase in the acreage devoted to sorghums grown for fodder, and probably also a greater tendency to ratoon sorghums once or even twice for the same reason. Concentration on fodder production has considerable advantages in that it economizes on costly inputs, bird scaring, weeding and especially harvest labour. It also allows quick and relatively inaccurate cultivation and seeding practices and hence a shift to tractor operation. Ratooning in particular offers a further crop with little or no additional cultivation, and it extends the cropping season into the unproductive summer months. However the recent rains have

already collapsed the fodder market and farmers all reported their intention to cut back on this enterprise. The other major change noticeable during the brief survey period was an evident expansion in tomato and watermelon production on pump irrigation - substantial if memory has served this observer well. This has been accompanied by considerable improvement in methods; ridge and furrow, unknown in 1976, having completely replaced basin irrigation for these two crops. It has also resulted in a new trading centre for watermelon on the main road at al Husayniah. A particular attraction of watermelon and tomatoes appears to be that although they require more frequent irrigation than other, basin irrigated, crops a greater area can be irrigated in a given time; an important feature when water yields from irrigation wells are low.

There appears to have been a considerable increase in the number of pumps both within the previous pump irrigated area and, less importantly, scattered through the other areas. However the area irrigated has probably not increased to anything like the same extent. Over-extraction seems to have strongly affected the water table. Most pump owners report having had to deepen their wells and falling yields even after deepening. This combined with rising labour and fuel prices has led to a substantial decrease in the area irrigated on each pump. This trend seems likely to continue especially after a particularly sharp rise in the price of diesel early this year. The net effect on the area cropped is difficult to assess. The only indication available is in the Zakat[2] tax returns for the southern bank of Wadi Rima. Of the seven districts recorded three can be definitely placed in the pump irrigated area and three in the wadi irrigated/rainfed areas.

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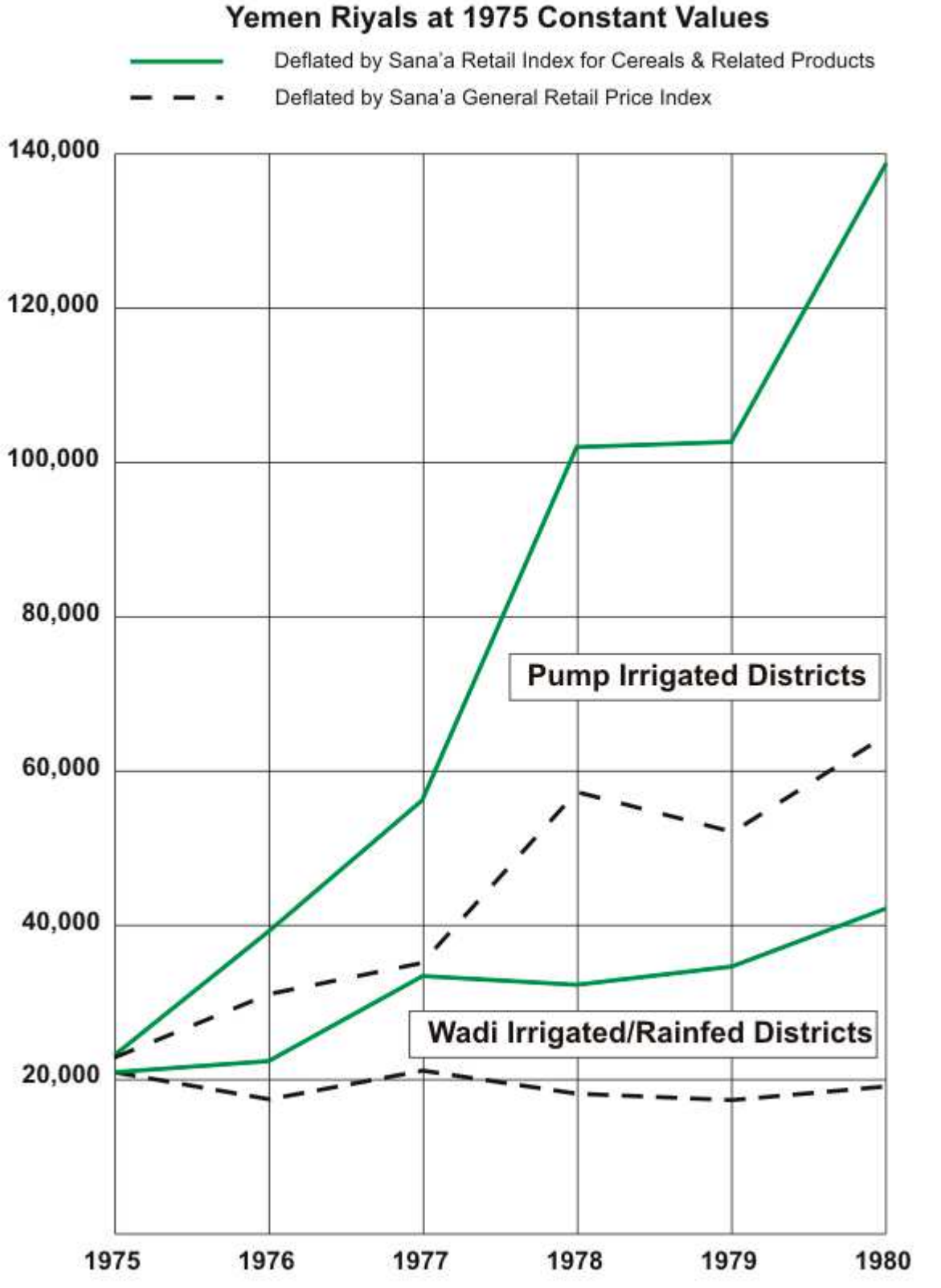
[2] Zakat tax is a religiously ordained levy on agricultural production. Paid on farmers' self-assessment the rate is 10%, except where irrigation is by animal or, now, mechanical lift when the rate is 5%.

Figure 1 shows the movements in Zakat returns for the two groups between 1975 and 1980. (As the returns are in cash values some allowance must be made for inflation. No good index is available so upper and lower limits to the trends have been drawn, deflating the returns using two indices, rather than one single trend line).

Given that it is most unlikely that farmers are overpaying tax any upward movement in tax paid can be taken as a good indication of rising production. Figure 1 gives good grounds therefore for believing that expansion of production on pump irrigated land has been substantial. In the wadi irrigated and rainfed areas production has been steady; possibly rising slightly, certainly not falling substantially. What proportion of the rise in production on pump irrigation is due to increased area and what due to increased yields is unknown. One point that should be emphasised is that both the scale and size of movement of the pump irrigation production relative to wadi/rainfed production is greatly understated by the tax figures since tax on pump irrigated crops is only 5%, not 10% as for wadi or rainfed crops.

Figure 1 Zakat Returns for Wadi Rima' Districts



Source: Zabid Nahiya Tax Records. Deflators from Central Bank of Yemen Statistics Bulletins

CROPPING PATTERNS

The Rainfed Area

Cropping patterns within the rainfed area are not quite as simple as the dependence on sorghum and millet shown in Table I might imply. The particular ratio between the two crops and the variety of sorghum chosen depend on the timing of adequate rainfall. Further complications are raised by awkward decisions such as whether to abandon hope of adequate rain for a grain crop and cut early for fodder, and how much land to commit on good early rains instead of waiting for the main autumn wet season.

Up to four planting seasons are recognised and the mix of crops sown depends on where rain comes relative to these. The earliest crop planted may be either sayf sorghum, a reddish variety, or millet or the two mixed. It is planted in May, or early June, after May rain. If the rains are somewhat later then millet only will be sown in June or July. If the main rains (July/August) are good then Qayra sorghum, white, is sown in August. Lastly for late rains Hamra sorghum, another red variety, may be sown in November. Ten farmers interviewed in this area sowed a total of 12 ma'ad early crop mixed sayf/millet; 52 ma'ad June millet; 77 ma'ad August Qayra', and 3 ma'ad November Hamra. [3] (One ma'ad = 0.36 ha).

Unsurprisingly, given the riskiness and low yield of rainfed agriculture inputs are low. Even with oxen second ploughing before sowing is rare. If resources are scarce the first plough may be omitted, if the rain softens the ground sufficiently and it is light enough to allow direct sowing. In general however the aim is to have

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[3] There is a sharp difference in price between preferred food grains, Qayra' sorghum and millet, and the lower quality red varieties of sorghum.

the fields, which are all carefully levelled and bunded to capture whatever rain there may be, ploughed prior to the rain so that the land absorbs as much as possible and is ready to sow straight after the rain. Even this first plough may involve tricky decisions on the area to be ploughed since fields which are left unploughed act as water harvesting catchments for the ploughed. Cultivating too much will spread light rains too thin. At present however the areas left fallow are large and this constraint may not be binding.

On difficult land the first plough is either by oxen for those with the labour, animals and time available, or now, predominantly, by tractor with disc plough. Oxen ploughing such land is extremely slow and may require a second plough as well, hence the attractions of disc ploughing even for those with oxen. Where land is lighter, either by its nature or through having been disc ploughed but not cropped in previous years, oxen ploughing is not so slow. A first, disc plough; may be replaced by tined cultivator which is quicker and cheaper per unit area. Some farmers who did this implied that they still would have preferred to disc plough if they could have afforded it.

Seeding is carried out by oxen or, increasingly by tractor. Tractor seeding is done using a tined cultivator with six locally made seed tubes lashed to the rear tines. Three boys sit on the tool bar and each feeds two tubes from a basket of seed. This method is a direct extension of the oxen seeding technique in the area, where a single tube is lashed to the plough and fed by a child walking beside the plough. Some attempts have reportedly been made to use seed drills but they are generally regarded as a failure, perhaps through lack of setting up skill.

Apart from the seeding operation the only other input, and that only by some farmers, is one inter-row cultivation. The purpose of this, which is done when the crop is well on its way, one to two months after sowing, is to break the surface and to earth up so that the crop can absorb any further rain. Farmers are well aware that by doing this they risk drying out the crop, even as fodder, if there is no rain.

Table 2 gives details of the number of crops on which the various operations were carried out and the methods used in the rainfed area.

Table 2: Operations on Rainfed Crops**
Number of plots reported: 16

	1st Plough	2nd Plough	Sow	Inter-Row
Tractor **	6.5[d] + 5[t]	0	11.5	0
Oxen	4.5	2	4.5	6.5
None	0	14	0	9.5

Notes: * 0.5 indicates a plot only partially covered by the operation
** 1st plough by disc [d] or tined cultivator [t].
Tractor sowing by tined cultivator

The Wadi Irrigated Area

The availability of wadi irrigation allows farmers in the wadi areas to extend the rainfed cropping pattern both in the crops grown and their timing. While the May and August crops of the rainfed system are retained the June/July crop is dropped. In its place there comes an early March crop, and most important of all a late main crop in October. Some of the farmers in this area also have rain-fed land and follow the rainfed cropping pattern more closely on that land.

Table 3 sets out the planting seasons, with their names derived from the Arabic months, the crops sown and the area in ma'ad sown by 13 farmers in two villages in 1980. Both villages were in the perennially

irrigated sub-section, where water is flowing all year. Much larger areas depend on spate irrigation during the rainy season. Over the wadi irrigated area as a whole cropping patterns may be expected to range between the perennially irrigated at one extreme and the rainfed at the other as irrigation water becomes progressively more scarce.

Table 3
13 Farmers from 2 Villages

Crop	Name	Area Sown
1. Adhari (Adhar = March)	Sayf sorghum	65 ma'ad
2. Mabkari (Mabkar = May (Irrigated 86 ma'ad, rainfed 80 ma'ad)	Sayf sorghum, millet or Qayra'/Hamra' sorghum for fodder.	136 ma'ad
3. Ab (Ab = August) (Irrigated 15 ma'ad, rainfed 37 ma'ad)	Qayra' sorghum	52 ma'ad
4. Tishrini (1st Tishrin = October)	Maize, often under-sown with Hamra' sorghum and/or cow peas.	156 ma'ad
5. Tishrini (2nd Tishrin = November)	Cotton	4 ma' ad
	148.7 ha =	413 ma' ad

The mix between the various crops depends on the availability of irrigation water. In the perennially irrigated zone the system largely revolves around the main, October maize crop. Earlier crops are timed so as to leave the land free for the maize. The perennial or regular irrigation area was classified by L.R.D.C. as largely triple cropped. This survey would tend to indicate that it is more nearly double cropped. Irrigation water is regularly available by right during certain seasons but for much of the year only by purchase from the Government.

The security and higher yields offered by irrigation lead to a higher level of inputs. Secondary cultivation is the norm even where the first plough was by tractor and a third cultivation may be made. There

is no difference between the cultivation regimes preferred for the different crops. However, if resources are scarce the maize crop appears to have priority for a second cultivation. First ploughing is now predominantly by disc plough. This is normally followed by an irrigation, a second cultivation either with oxen or tined cultivator, and sowing. A certain amount of inter-row work with oxen was reported apparently after harvesting sorghum in order to open up the soil to a ratoon irrigation. It was stressed that maize was never inter-row cultivated.

Table 4 gives details of the number of plots on which the various operations were carried out and the methods used in the wadi irrigated area.

Table 4: Operations on Crops in the Wadi Irrigated Area
Number of plots reported: 32

	1st Plough	2nd Plough	3rd Plough	Sow	Inter-Row
Tractor*	27	10.5 + 2.5**	1	13.5	0
Oxen	3	7.5 + 2.5**	0	18.5	6
None	2	9	31	0	26

Notes: (1) *:1st Plough with disc, 2nd/3rd plough & sowing with tined cultivator.
(2) ** represents plots with a 2nd plough pre-irrigation.
(3) 0.5 represents plots only partially covered by the operation.

The Pump Irrigated Area

Although the staple grain and fodder sorghums remain important in the pump irrigated area complete control of irrigation timing has allowed a more complex agriculture to develop. The range of crops is greater and the level of inputs much higher. Crop timings are more flexible and farmers do not appear to have well established planting seasons as in the other two areas. This is perhaps not surprising given

the recent development of pump irrigation. Cropping mixes and timings also appear to vary quite markedly between different villages within the pump complex.

In general the midsummer heat and wind damage are such that only the hardier sorghums and millet are planted in the spring to grow through the summer. Attempts are being made to widen the range of summer crops notably by growing tomatoes. Results are reportedly not very good but seasonal price shifts may still make the effort worthwhile. Bird damage is also reportedly a major problem for the summer grains so much of what is planted goes for fodder -especially with the recent strong market for the crop. The main crops are planted between August and December. First to go in are cotton and the higher quality Qayra' white sorghum. In November, December and even January the higher value cash crops are sown: watermelon, tomatoes and less importantly okra. Tobacco is also planted during this autumn/winter period. [4]

A much more intensive agriculture is both justified and required by pump irrigation, even relative to the irrigated areas of the upper wadi. Particularly heavy labour inputs are required to prepare the land for irrigation off the rather low yielding pumps. Considerable attention is also given to levelling. At its most intensive a pump irrigated crop may be given three cultivations, one levelling and two basin forming operations. A more general pattern for grain crops and Sorghum would be a first cultivation, almost always with disc ploughs, followed by basin forming and an irrigation. After sowing a certain amount of rebuilding of basins has to be done. Both the first and second basin forming

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[4] In 1992, significant areas of an entirely new crop, Papaya, were observed.

operations are done by a two-man team with a scraper board operated between them.

Grain crops and sesame are irrigated four to six times and cotton five to seven times. Grains are often ratooned for fodder and this may involve an inter-row cultivation. A major attraction of watermelon and tomatoes would appear to be that they can be ridge and furrowed using a disc plough and then hand planted, thus dispensing with repeated basining operations. Against this must be set the greater number of irrigations and more intensive weeding required by these crops. As has been noted however repeated but less heavy irrigations does enable a greater area to be covered off low-yielding pumps. One farmer reported that his pump took 12 hours to irrigate one ma'ad of cotton, 6 hours/ma' ad of tomatoes and 4 hours/ma' ad of watermelon. Tomatoes and watermelon are irrigated every 3 days initially rising to every week and thence every 10 days as the crop is established.

Tobacco is locally important as a crop in the westernmost sections of the pumped area. This is perhaps the most intensive crop of all. As well as pre-planting levelling and basining of the field crops, it also takes the same level of post emergence care as tomatoes, mainly because of the repeated flower deheading. Tobacco is irrigated some 6 or 7 times.

Table 5 gives details of the number of plots on which the various operations were carried out and the methods used in the pump irrigated area.

Table 5: Operations on Crops in the Pump Irrigated Area
Number of Plots Reported: 29

	1st Plough	2nd Plough	Furrow	Level	Basin	3rd Plough	Sow	Re-Basin
Tractor*	27.5	4	6**	3	0	4	1	0
Oxen	1	2	0	10	0	3	19	0
Hand	0	0	0	1	16	0	9***	20
None	0.5	23	23	15	13	22	0	9

Notes: (1) * Tractor: 1st plough, furrow with disc. 2nd Plough, sow with cultivator. Levelling with rear blade.
(2) ** for watermelon or tomatoes
(3) *** 3 watermelon hand seeded + 3 tomatoes, 3 tobacco transplanted.
(4) 0.5 represents a plot only partially covered by the operation.

Tractor Usage: Farmer Survey Results

As the discussion of cropping systems has already revealed the use of tractors has become the norm for certain operations, noticably primary cultivation and in certain areas sowing, throughout the Wadi Rima. Of the 37 farmers interviewed there was not one who had not made some use of tractors. However, the extent to which farmers made use of tractors as opposed to oxen for their cultivation and the precise mix of mechanised operations in use is highly variable both within the three areas of the wadi and across those- areas.

Table 6 sets out a statistical analysis of the crop hectares reported by 32 farmers and the tractor inputs rate per crop hectare. The input per crop hectare is calculated as the total tractor hours reported divided by the total crop area reported, whether ploughed by tractor or oxen. It is an indicator therefore not of differing tractor working rates between areas but of the differing importance of tractor draught as a part of total draught input. This approach is possible because throughout the area standard working rates for tractors are used. Most farmers in fact calculated the tractor hours input by multiplying the

crop area ploughed by tractor by the standard rate. The standard rates are 2 hours per ma'ad with a disc plough and 30 minutes per ma'ad with a tined cultivator. It is to be noted therefore that 1.39 /crop ha in the rainfed area represents as great a dependence on tractors for sowing, as 4.72 hours/crop ha disc ploughing for primary cultivation in the pump irrigated area.

Table 6 Statistics of Tractor Usage Among 32 Farmers of Wadi Rima[5]

Irrigation Area	Crop ha/ Farmer	1ary Cultivation	2ary Cultivation	Sowing	Total
		Tractor Hours Per Crop Hectare			
Wadi (n=9)					
Average	5.68	3.42	0.64	0.94	4.86
Std Dev'n	4.02	1.44	0.94	0.89	2.72
% Total Hrs		70	12	18	100
Pump (n=12)					
Average	4.92	4.72	0.92	0.14	6.06
Std Dev'n	3.15	1.19	0.94	0.44	2.44
% Total Hrs		78	15	2	100
Rainfed (n=11)					
Average	5.01	2.69	0.00	1.39	4.08
Std Dev'n	2.89	2.28	0.00	0.94	2.75
% Total Hrs		66	0	34	100
Overall					
Average	5.16	3.64	0.54	0.77	5.02
Std Dev'n	3.24	1.86	0.85	0.93	2.70
% Total Hrs		73	11	15	100
Variation between areas	In-significant	Significant @ 5% level	Significant @ 5% level	Significant @ 1% level	In-significant

It is clear from the analysis that although the acreages cropped per farmer are little different between the three areas, and although any differences in total tractor inputs between them are insignificant, the actual mix of operations for which tractors are used is very

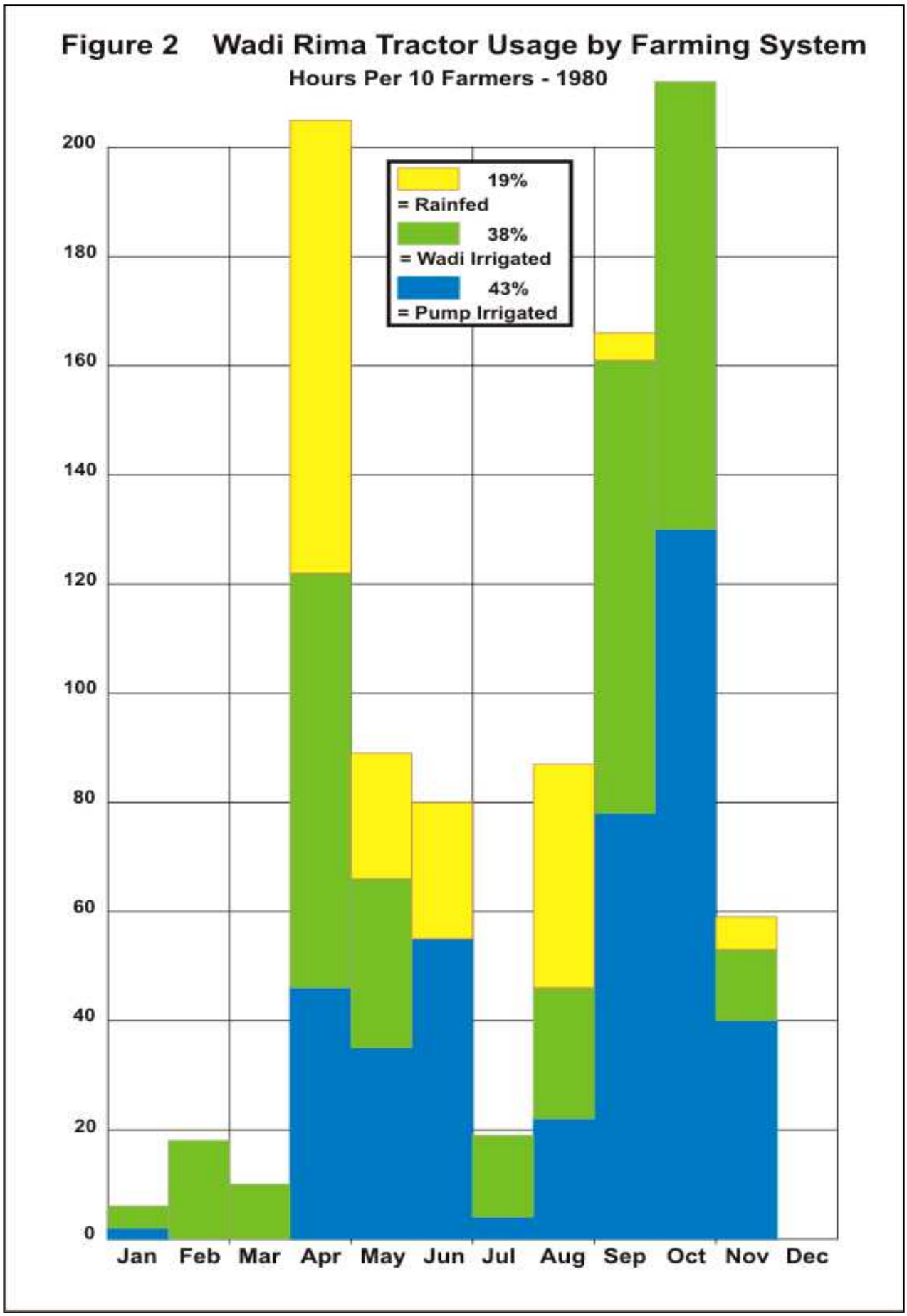
[5] The five largest farmers interviewed were excluded from the analysis as the acreages they reported were in excess of the 0 to 20 ha range into which the L.R.D.C. reported that almost all holdings in the Wadi Rima' fell. The high proportion in the sample of such larger operators is explained by the selection bias inherent in asking a village leader to nominate interviewees. The figures reported by these five do not affect the mean values, although they do raise the variability.

different. This is revealed in statistically significant differences between the tractor hours per hectare devoted to primary cultivation, secondary cultivation and sowing across the three areas. While all three areas principally rely on tractors for primary cultivation, at 78% of total hours, the degree of reliance is greatest in the pump irrigated area and least in the rainfed area. Conversely, the rainfed area depends most heavily on tractor powered sowing (34% of total hours), while virtually none is done in the pump area. As has been mentioned the risk and low yields of rainfed agriculture discourage heavy inputs and this is revealed by the total absence of secondary cultivation in this area. In all cases the wadi irrigated area falls midway between the other two. This may be partly because the yields to inputs in this area fall midway between the other two, but it also reflects a greater availability of fodder and hence of draught oxen to substitute for tractor cultivation. Tractor usage in this area is also constrained by the deeper and more delicate terraces and the flood irrigation which leaves fields too wet for machinery for longish periods.

Despite the varied pattern of tractor usage across the different areas there is a marked seasonality to tractor work. Figure 2 illustrates this. The two peaks fall in April/May and September/ October. There are five months in which negligible work is available: December to March and July. It should also be noted that the early peak season is dependent on work in the rainfed area. Should the early rains fail and the autumn rains succeed the autumn peak would become even more marked. To fully capture the seasonal profile for the wadi as a whole the pattern of each area should be weighted by the number of holdings in it. However, it is impossible to judge how the number of holdings in the pump area has changed since 1976. Tractor usage in the large spate

irrigated area falls somewhere between the rainfed and perennially irrigated areas but the exact pattern is unknown. For these reasons it is felt best to present all three areas on an equal footing in the figure. (Table I shows the 1976 distribution of holdings.)

Figure 2 Wadi Rima Tractor Usage by Farming System



The farmer survey results show that tractor cultivation has nade phenomenal advances in the Wadi in recent years. In 1976 the L.R.D.C. (op. cit.) knew of only 9 machines in the area and did not consider that there was much probability of any great increase on that limited number, largely restricted to the pump irrigated areas. In this they were wildly wrong. High wage costs and high fodder costs have made the cost of maintaining oxen for cultivation unattractive for the more marginal rainfed areas and for the intensive pump irrigated areas. In the former the cost would be borne in the form of bought-in fodder during drier periods, in the latter in the form of productive land, and, especially, scarce water held back from cash cropping in order to maintain oxen. In the wadi irrigated areas where the cash cropping opportunities are more limited fodder remains relatively abundant. This is shown by a greater degree of livestock rented into the area on a share crop basis from outside. It also appears that the wadi irrigated areas, at least those with reliable water, have been able to retain more labour for ploughing and other jobs as well as for sharecropping.

It is worth emphasising that labour and oxen are closely interlinked in the sharecropping system. Essentially the shares are determined on the basis that the owner provides the land and the tenant their own labour and more importantly cultivation services. With sharply rising wages sharecroppers have been seeking a greater return to their own labour either by an increased share or by a reduction in the cultivation input required of them. There is evidence of both taking place, especially in the pump irrigated areas where the tenant share has reportedly risen in some cases from one quarter to one third and where many pump owners - who effectively have the landlord's role - are now

providing tractor draught to their sharecroppers, albeit against costs recoverable after harvest. Even in the wadi areas the tenant's draught costs are reduced in that he can usually buy in the landlord's share of the fodder at favourable rates. Naturally this pressure on the landlords' share is being reflected by an increase in the areas which landowners cultivate for themselves.

Demand for the Different Tractor Operations

1. Primary Cultivation

Demand for primary cultivation by tractors, mainly with disc ploughs, is much greater than for any other operation; 73% of the average hours/crop hectare input. (Table 6). This is partly explained by the slower operating speed with discs relative to cultivation but more importantly it reflects the greater advantages of the tractor over oxen for this operation: speed, depth and the ability to handle tough soils. Local farmers appreciate the depth mostly for the greater water penetration offered and possibly also for weed control. However this may also be seen as simply part of the time factor in that oxen could probably achieve a similar quality but only by two or three cultivations. The capacity to handle harder soils is particularly important since once these have been broken up further operations' can be carried out by cows or even camels. Disc ploughing therefore makes possible the disposal of the oxen pair altogether without necessarily committing the farmer to wholly tractorised operation. Although the difference between the rainfed and wadi area is not statistically significant, the lower level of primary input per hectare in the rainfed area may reflect the lesser importance the speed of primary cultivation is less important in this area. Given sparse rainfall and the need to use part of the farm for water harvesting, cropping intensity is low. Farmers can thus spread

their primary cultivation over two or more years and leave their fields ready for the rains whenever they may occur. This means that the slow pace of oxen is not so critical. It does however also mean that the tractor primary cultivation per crop hectare figure for this area may be an underestimate. Farmers were only asked to recall operations within the previous year and disc ploughing carried out prior to that, on land left fallow, and only cropped within the year of record has not been accounted for. The last reason for the lower primary inputs recorded for the rainfed area is that some farmers in the effort to reduce their costs to a minimum used cultivators not discs. The difference in primary inputs/ crop hectare between the wadi and pump areas is statistically significant. As well as the greater availability of labour and oxen in the wadi area the lower input may also reflect the difficulty of using tractors on the deep wadi terraces, especially when wet. Some farmers also appeared aware of the risks of compaction and of clodding. On the other hand wadi farmers have less control over their water timings and a rather tight gap between the summer and main crop which would give the speed of tractor operation considerable importance. A complex trade off has to be made between these various factors.

There were no significant differences between the areas in the reported rates charged for 1980 - the mean was 62 YR per hour. An almost universal rule of thumb was that with discs it took two hours per ma'ad ie 5.56 hours per hectare. Some farmers did indicate that they might expect a somewhat quicker rate from new machinery with a good driver but the rule of thumb clearly represented what is the acceptable basis for charging.

2. Secondary Cultivation

Two different operations have been lumped together as secondary cultivation in Table 6. A second ploughing with a tined cultivator and ridge and furrowing for tomaties and water melons. The latter is restricted to the pump area where the hours recorded for ridging with a disc plough make up 50% of the total secondary cultivation recorded. This apart all secondary cultivation is carried out with the tined cultivator. If the ridge and furrow work in the pump area is excluded it becomes clear that secondary cultivation is most important in the wadi area, where a second plough is the norm (see table 4), especially for the main maize crop. The total lack of secondary work in the rainfed area reflects again the push to minimise inputs on low yielding land.

The mean reported charge rate, for 1980, for cultivator work was 92 YR per hour. As for the disc plough there is a general rule of thumb as to what would be an acceptable speed of operation, in this case half an hour per ma'ad, ie an hour and twenty to thirty minutes per hectare.

3. Sowing

The differences in the level of tractor inputs between the three areas is greatest for the sowing operation. For the pump areas they are negligible. In the wadi areas they are probably, in terms of the area covered, on a par with the primary cultivation, while in the rainfed areas the area covered by tractor seeding considerably outweighs that covered by tractor ploughing. The contrast between the heavy dependence on tractors for primary cultivation and on non-mechanical seeding in the pump areas and the exact opposite in the rainfed areas is marked.

In the multi-cropped pump area speed of land preparation between crops is important but smallish plots, especially if basin irrigated, are

difficult to seed mechanically. Mechanical seeding techniques are in any case not available for the higher value horticultural crops. Even sorghum is sometimes hand seeded rather than by oxen or tractor in this area. In the rainfed area long dry periods are available for primary cultivation but once rain has fallen it is important to put down relatively large areas quickly and for this tractor seeding is ideal.

Tractor charges for seeding are as for the tined cultivator. However the three boys are extra, some 5-10 riyals per hour each, so the total seeding charge is 115 YR per hour. Acceptable working rates are the same as for the cultivator: half an hour per ma'ad.

Although the benefits of tractor seeding as far as speed is concerned are considerable many farmers reported that there was a price to be paid in the form of less accurate seeding in terms of both depth and the seed rate. This, together with the low manoeuvreability and the inability to work on wet soils, may explain why tractor seeding is not so popular in the higher yielding wadi and pump areas. One wadi farmer went so far as to specify his favourite cultivation regime as: disc plough, tined cultivator secondary cultivation and ox seeding.

A further disadvantage of tractor seeding is that many farmers believe that it is not possible to inter-row cultivate tractor sown crops even with oxen. They may be right in this given the apparent disregard tractor operators have for the possibility of changing the tine settings.

However with the current emphasis on cropping for fodder this may not he important since the inter-row appears to be designed to maximise grain yields. It may also be that primary tractor cultivation being deeper and more powerful than oxen renders inter-row work less important.

TRACTOR OWNERSHIP AND OPERATION

As must by now be clear there has been a massive increase in the number of tractors in Wadi Rima' as compared to the 9 of 1976. During the course of the survey, from interviewees and from the records of the Agricultural Credit Bank, Al Aqil Volvo dealers and Adhban Renault dealers, it has been possible to positively identify 65 tractors in the area. It is not believed that many more have escaped notice during the survey so it is estimated with some confidence that between 70 and 75 tractors are currently in operation.

Agricultural Credit Bank Loans

The Agricultural Credit Bank has made 27 loans for tractor purchase to farmers from Wadi Rima': 24 from the Zabid branch and 3 from Bayt al Faqih. As this was such a high proportion of the total a first investigation was made of the A.C.B. records on these loans. The results of this were used as a cross check on the survey of 14 operators which was carried out later, as well as an indication of the main concentrations of tractor ownership in which the survey could be carried out.

The central conclusion from the A.C.B. records is that without exception all loans were made to farmers with land-holdings well above the average and with only one exception those farmers were pump owners as well. The average holding among the 19 borrowers whose files were examined was 54.5 hectares. 18 of the 19 had pump irrigated land, an average of 21.7 hectares each, but only 12 also had wadi irrigated land. A large proportion the remaining land was rainfed lands, held by seven borrowers. Almost all holdings were considerably in excess of the security required by the A.C.B. for the loans. The loans were

concentrated in the pump irrigated area and amongst a few villages within that area. 17 of the 26 A.C.B. tractors are concentrated in five villages. On average the borrowers had more than one pump set (mean value 1.58 sets per borrower) and one had six.

The boom years for tractor loans were 1978 and 1979. 20 of the 26 loans fell in those years. The Bank maintained that this was because of their running short of funds in 1980, not because of a drop in demand. However the evidence from non-bank borrowers was that there had been such a drop. If anything most non-bank tractors predated 1978. Overall, of 32 tractors for which ages could be reasonably estimated only four were purchased after 1979 and more than half dated from 1978 or earlier.

It is to be noted that the proportion of tractors bought on A.C.B. loans in Wadi Rima’, 37%, is considerably-higher than for the Yemen as a whole: 20% on A.E.P. estimates. It is further remarkable that although Wadi Rima' is well under half the area covered Zabid A.C.B. branch, Wadi Zabid alone having a much larger crop acreage, it has received over 50% of all tractor loans made by that branch - 22 out of 38.

Owner Survey Results

14 owners were found for full interviews and information was gathered about more tractors which were seen at odd moments - in particular it was possible to identify the make of 45 out of the known 65 tractors. The distribution was as follows:

MAKE	TYPE	NO.
Massey Ferguson	185	14
	165	4
Volvo	650	12
Landini	7500	5
Steyr	768	4
Renault	651	3

Belarus	?	2
Fiat	?	1

45

Often when the owner was interviewed the tractor was not present. This presented problems when discussing technical details, such as maintenance, which fell within the drivers' competence, not the owners'. It further meant that the hour clock could not be checked. However by checking the clocks on tractors whenever seen it was possible to collect figures for 15 machines on which the clocks were still working.

The mean value was: 3669 hours (SD = 1887)

Divided by the mean age of all tractors for which the age is known this gives an average of 1334 hours per annum.

1. Make of tractor:

Of the 14 owners surveyed the makes owned were as follows:

Massey Ferguson: 6
Steyr: 3
Volvo: 3
Renault: 1
Landini 1

In general opinion appeared to be that for straight forward cultivation operations the Massey Ferguson was perhaps the best but that it lacked the power for heavier operations - notably using 3 disc ploughs and front blade work. For the latter in particular, the Steyr and Landini, both with four wheel drive were preferred.

2. Credit:

The sources of capital for the purchase were as follows:

A.C.B./Own: 6 Supplier/Own: 4 Other/Own: 4

A key factor in the buying choice appeared to be credit. M.F. do not offer credit and A.C.B. credit is now viewed as expensive. Supplier credit, although shorter term, is seen as cheaper and more

flexible, and Renault and Landini are becoming popular because they offer such credit.

3. Equipment:

All owners had a disc plough (11:2 furrow, 3:3 furrow) and twelve of the fourteen had cultivators. The two who did not have cultivators both came from the western section of the pump irrigated area, the village of al Bukayriyyah. There were four tractors in this village and only one had a cultivator which confirms that farmer surveys indication that tractor sowing is not popular in the pump area. Of the less common implements there were two trailers, four rear blades and three front blades. The rear blades were concentrated in the central sections of the pumped area where farmers appreciate the speed of the levelling operation for intensively cultivated irrigated crops. The front blade is concentrated in more easterly sections. Although the owners here still have pumps they have access to hire work in the wadi and rainfed areas where bunding work is available. However some operators are very chary of using their front blade fearing that they overstress even fairly powerful 4 wd tractors such as the Steyr, which has a blade specifically designed for it. Trailers were reported as useful mainly for transporting diesel; less important now that there are more petrol stations on the main road. They can also be seen loaded with cotton but in general there appears to be little requirement for the bulk transport facility they offer - derelict trailers are to be seen in several places in the area.

Although none actually owned one a few owners expressed mild interest- in a tipping bucket - apparently for spreading fertiliser.

Most operators reported that for disc ploughing, cultivation and rear blade work they would use first gear, high ratio.

4. Driving:

In almost all cases most of the driving work is done by the owner's son, or another family member. Sometimes another driver is also hired. Hire rates are variously given as so much per hour (usually 15 or 20 YR), or as one hour in so many (usually four) of the total hire to the driver. This works out, for discing, at much the same: 60 YR for four hours work.

5. Pumps:

The A.C.B. records indicated that tractor ownership is closely tied to pump ownership. This is confirmed by the survey in that all owners interviewed had one or more pumps - on average 1.93 each. However simply in order to make enough interviews the survey was concentrated in the pump area. There are known to be a few operators, in particular on the north bank of the wadi who do not have pumps but they remain the exception. The north bank has access to the largest proportion of the perennial irrigation waters of the wadi which may explain the presence of tractors among non-pump owners.

6. Allocation of work:

It is clear from the A.C.B. records that their borrowers must be buying largely for their own holdings rather than for hire. Given a cultivation regime of one disc, one cultivation and one seeding, at A.E.P. rates, the average holdings recorded would require 575 hours work even without allowance for between field time. With this in mind operators were asked whether work on their own land took up more than 50% of the tractor's hire. Ten of the

thirteen who answered agreed that it did. Two did no hire work at all,

Of those who did do hire work several said that it was confined to nearby farms, A great deal of tractor work is carried out by the owner for his water sharecroppers, that is those for whom he is also irrigating from his pump. He may charge this work at cost, ie to cover diesel alone, or at current hire rates. Either way payment is usually recoverable after harvest.

To the extent that travelling hire work is a significant factor it appears to be confined to some operators in the eastern section of the pump area who travel to the wadi and rainfed areas, to one operator on the north bank, who exceptionally has three tractors and relatively little of his own land, and to the few tractor owners in the eastern rain-fed area who move into the wadi area for work.

Owners were reluctant to estimate the hours or even the days of work available per annum. They were generally agreed however that apart from the September/October peak, any work available was intermittent and did not exceed a few hours every few days. During the peak by contrast they would expect to work for up to 15 hours per day, largely at night with six hours in the morning before the heat builds up.

7. Charging:

As throughout the Y.A.R. tractor hirers in the Wadi Rima' charge by the hour. As mentioned before both they and their customers had a clear idea of what acceptable rates of work should be and what area should be completed per hour. Generally farmers

said that they would leave it up to the tractor owner to calculate the hire, on ‘trust’; Amanah was the word often used. They have the security of knowing that they can check against the 'rule of thumb' working speed if they feel overcharged. Since many farmers have to ask tractor operators for work on credit it is not in their interest to be too aggressive about the pricing. In any case a degree of give and take is clearly expected, even where operators are from outside the immediate locality. Farmers do not press too hard on prices, and often provide extras such as lunch and in return operators are expected to charge reasonably, not press too hard for payment and perhaps knock off any odd quarter hours of work there may have been. In principle, however, operators were adamant that charges were calculated to the minute and several volunteered that even tea breaks etc. were to be deducted from the calculation. All calculations are based on the entry to the field and in no case was it suggested that travelling time might be charged.

Prices appear to be determined fairly competitively based on a 'going rate', known as Qanun. (Literally: 'Law' but clearly used here as a vaguer 'general rule').

At the same time some operators appear to wish to avoid direct competition, at least between areas. One operator put this most plainly by saying that he would not expect work in an area where other tractors were closer. The more alert operators are however well aware of the competitive pressure oxen ploughing represents and also of the fact that there is considerable consumer resistance to too steep prices. This awareness has been strengthened by an apparent inability to raise prices to compensate for the recent sharp rise in the cost of fuel without losing all their work. As a result

of this the prices quoted for current work were sometimes rather hesitant and also varied between operators. It seems as though there has been so little work since the cost rise that new prices have yet to become established. One operator would not quote for disc ploughing explicitly because he had had no work since the diesel price rise. Overall the prices quoted seem little above those for 1980 if at all. The mean quote for disc ploughing in April 1981 was 60 YR per hour and for cultivator work 90 YR per hour; almost exactly the same as the average rates quoted by farmers for their 1980 work.

8. Costs:

The mean estimated cost of diesel fuel, inclusive of transport to the village was 1.69 YR per litre. Estimated hourly consumption was 5.21 litres. Almost all operators reckoned on changing oil every 50 hours, and the oil filter every 100-150 hours (say 130). There was much less agreement on fuel filters. The mean estimate was every 3 months but the suspicion is that it is longer in reality. The estimated lives and annual costs of more major items are set out in'table 7.

Table 7

Item	Life	Annual Cost (May 1981 prices) YR
Battery	1 yr 5 mths	396
Dynamo	1 yr 11 mths	715
Front tyres	2 yr' 2 mths	598
Rear tyres	3 years	1833
	Tractor Total	3542
Discs	2 yr 2 mths	598
Disc bearings	3 yr 6 mths	97

Disc furrow follower	2 yr 3 mths	178	(est.)
	Disc Total	873	
Tines	2 years	376	
	Equipment Total	1249	

Annual oil and filter costs work out at a further 3312 YR.

From those who could, or would, remember details of what they had paid for various repairs and replacements to their tractor, a mean annual estimated cost of 4,720 YR was calculated. This compares reasonably well with the figure of 3,542 YR given in Table 7. The difference between the two is explained by the cost of labour to fit the various items. This labour cost is relatively low because operators go to great lengths to avoid the expense of using the suppliers' mechanics. Many items are fitted by the drivers and, if at all possible, jobs which are beyond them go to local mechanics, self taught as they are. However since both the above estimates are for relatively major items only it seems reasonable to assume a figure of some 6,000 YR as the annual repair bill on the tractor and similarly slightly raised figures for the disc plough and cultivator: 1,000 YR and 500 YR respectively.

All these figures are below what would be assumed under professional management in developed countries, in the case of the tractor very substantially so. (6,000 YR as against say 12,800 YR, ie 75% of capital cost spread over seven years). This may be partly explained by the strenuous efforts of operators to minimise these costs by doing as much fitting as possible themselves, by putting up with faults that would not be tolerated elsewhere and by buying cheap alternatives, eg Toyota car tyres instead of proper tractor front tyres and Toyota dynamos instead of Massey Ferguson. However this low figure may also reflect the relative newness of the tractor fleet, mostly 4 years old or less. None of the owners interviewed reported a major operation such as a

rebore (current cost 15,000 YR) for example. (One had purchased a second hand tractor cheap and had it rebored on purchase but that is a different case).

However operators are far from unaware of the threat to their profitability from repair and maintenance costs. These costs, especially the price of spares, were second only to the price of diesel on their list of complaints. Their fear of major repair costs lies at least partly behind their refusal to load tractors as heavily as they might; their preferences for two rather than three disc ploughs and their conviction that the front blade in particular is too heavy an implement for any except the largest machines.

9. Attitudes

Many of the points drawn out in more general discussion with tractor owners have already been touched on. In general operators feel that the combination of a greatly increased tractor fleet and higher costs has turned the position quite seriously against them. The diesel price rise has affected them both directly and indirectly through the depressing effect it has had on pump irrigated agriculture as a whole. Cheaper fodder has also made the competitive draught option - oxen - more attractive again. Of the 14 interviewed 6 were positively dissatisfied. One is having serious trouble meeting his A.C.B. loan repayment. Of the three who expressed satisfaction, two stressed that this was for their own land, not for hire. Among other comments volunteered was the remark that no one could now meet his loan repayments out of his hire income. How far this general gloom is a short term reaction to the diesel price rise, which will disappear when the next busy season arrives, is unsure

but analysis of costs and returns (see below) show good ground for pessimism.

The current unstable state may be best illustrated by one family where the son was adamant that if it were up to him he would sell the tractor, while the father was contemplating new implements.

SUPPLY AND DEMAND FOR TRACTOR SERVICES

The two sets of interviews were in conflict on the current state of the tractor hire market in Wadi Rima'. The farmer survey indicates that there is a strong demand for tractor work. All farmers used some tractor time and the average inputs per crop hectare set out in Table 6 would, if weighted according to the crop hectarages in each area (see Table 1), indicate a total tractor usage, for the area, of 148,000 hours per annum. (That is on the basis that the irregularly irrigated area can be aggregated with the rainfed and that opportunistic cropping areas are excluded altogether). Even at 100% efficiency such a total would imply work for over one hundred tractors at the average annual hours clocked of 1300 hours. There are however several reasons for believing that this is considerably overestimated. First is the probable bias towards larger farms and more progressive farms inherent in the interview selection method used. Second is the possibility that the crop hectarages reported by the L.R.D.C. have fallen since 1976 with the rising cost of inputs, especially labour. Rainfall in 1975/76 was also possibly above average raising the crop areas recorded. The high degree of variation on the estimates of input per crop hectare means that, in any case, the range of probable error is large and that figures derived from them must be treated with caution.

Looking at the supply side, the average annual hours clocked on the tractors seen, 1300, together with the probable fleet of 75 and an assumed efficiency of hours clocked to hours worked of 75% gives a total annual supply of 73,125 working hours.

Although these two estimates indicate a large shortfall of supply there was no evidence at all to confirm this. Most tractor owners took the view that the market was over-supplied and certainly no farmer reported any particular difficulty getting work done. The lack of any sign of a rise in price, even after a sharp rise in costs would also indicate that there is no excess demand. Prom pure observation there were certainly more tractors seen idle than working. Tentatively it is therefore concluded that although they are a good indication of the differences in pattern between areas, the input figures derived from the farmer survey are over-estimates and that there is a reasonable balance between supply and demand.

The view is also taken that whatever the position in 1980, the year to which the farmer survey relates, the market for tractor work in 1981 will be less favourable. All the various cost factors, which have to date been in favour of tractors are now reversing. Fuel prices are going up, fodder prices are dropping and most importantly there are signs that the flow of remittances from Saudi Arabia is drying up. These funds have made capital relatively cheap for tractor operators and have played an important part in enabling farmers, especially in rainfed areas, to pay for their cash inputs, like tractor work. (See Table 1 for figures on the proportion of adult males abroad in the various zones - The Emigration Ratio).

COSTS OF TRACTOR OPERATION

Table 8 sets out the costs of operating a typical Wadi Rima' tractor set up at current 1981 prices. The equipment chosen as representative is the Massey Ferguson 290 -latest model equivalent to the most widespread M.F. 185 - with a two furrow disc plough and an eleven tine cultivator. For the tractor two sets of estimates are used, low cost based on operators' own estimates, as set out above, and high cost based on A.E.P. figures. (In only one aspect, lubrication costs, are operators' estimates above those of A.E.P.)

Table 8: Tractor Operating Costs

1. Tractor M.F. 290

Capital Cost:	110,000 YR
Assumed Life:	7 Years
Scrap Value:	Zero
Annual hours clocked	= 1300
Working hours	= 975 (75%)

Fixed Costs	- YR -
Depreciation (Straight line)	15,714
Opportunity Cost of Capital (Av. Value: 10%)	5,500
	21,214
Required contribution to fixed costs:	
YR per working hour:	21.76

Average Variable Costs (AVC)	Low YR	High YR
Wages 18 YR (1)	17,550	23,400
Fuel (2)	11,446	16,477
Lubricants/Filters (3)	3,312	1,648
Repairs/Spares (4)	6,000	11,786
	38,308	53,311
At assumed efficiency (ie hours worked/hours clocked) of 75%:		
AVC = YR/hour worked	39.50	54.68

Notes:

(1) Since owners calculate the drivers wage at the rate of one working hour in four it is assumed for the low estimate that the pay is for working hours only. For the high estimate hours clocked are used.

(2) Low estimate 5.21 litres/hour 1.69 YR/litre. High 7.5 litres/hour.

(3) Low: see survey results above. High: 10% of fuel cost.

(4) Low: see survey results above. High: 75% of capital cost spread over 7 years.

2. Disc Massey Ferguson 2 furrow

Capital Cost:	12,500 YR
Annual Use:	775 hours (80% of tractor time. Table 6)
Assumed Life:	7 years
Scrap Value:	Zero

Fixed Costs	- YR -
Depreciation (Straight line)	1,786
Opportunity Cost of Capital (Av. Value: 10%)	625
	2,411
Required contribution to fixed costs:	
YR per working hour:	3.11
Average Variable Cost (5)	1,000
Total Annual Cost	3,411
AVC = YR/working hour	1.29
Total Cost = YR/working hour	4.40

(5) See survey results'above

3. Cultivator Massey Ferguson 11 tine

Capital Cost:	11,000 YR
Annual Use:	200 hours
Assumed Life:	7 years
Scrap value:	Zero

Fixed Costs	- YR -
Depreciation (Straight Line)	1,571
Opportunity Cost of Capital (Av. Value: 10%)	550
	2,121
Required contribution to fixed costs:	
YR per working hour:	10.61
Variable Cost (6)	500
Total Annual Cost	2,621
AVC = YR/working hour	2.50
Total Cost = YR/working hour	13.11

(6) See survey results above

Profitability

Given the estimates of 60 YR per hour for disc work and 90 YR per hour for cultivator work, it is clear from the above costings that tractor operators are correct in their view that their operation is becoming uneconomic. On the basis of the high estimates of cost the hourly average variable costs (A.V.C.) of disc work is 55.97 YR. This is perilously close to the 'shut down' position at which the A.V.C. is equal to or greater than the price which can be charged. At such a point it is better for the firm to stop operating altogether and accept a loss on the fixed costs rather than incur further losses from variable costs which exceed revenue. The effect of this is clearly shown in the number of tractor operators wondering whether to do hire work at all.

For cultivation work the position is better in that the hourly revenue exceeds the A.V.C. by 32.82 YR. However even this is only just adaquate to cover the required contribution to fixed cost of the cultivator and of the tractor of 32.37 YR (ie 21.76 + 10.61). For the cultivator work to be sufficient to bring the whole enterprise to the break even point, on the high cost assumptions, It would have to make up 758 hours of the 975 working hours assumed. Even if the working hours are raised to 1250 there would still need to be 720 cultivator hours and only 530 disc hours. The farmer survey has shown that it is currently impossible that more than 50% of hire work could be found for the cultivator.

Even if the lower variable cost estimate is accepted the total revenue on 775 hours disc and 200 hours cultivator net of the total variable cost is inadequate to cover the total annual fixed cost (net revenue = 24,488 YR, Fixed Cost = 25,746 YR). In this case however a

less drastic shift towards cultivator work, to 244 hours out of 975, suffices to reach the break-even point.

There are some plausible adjustments which might be made to ease this pessimistic picture. The first is to reduce the opportunity cost of capital by say a half. There are good reasons for believing that the flow of remittances from Saudi Arabia has been such that capital is cheap in rural areas and the returns to investment low. One tractor owner for example claimed to have borrowed some 300,000 YR from emigrants at little or no direct interest cost for various investments. Presumably these borrowings are more against equity in his various ventures than as loan capital but the fact remains that it is cheap capital. A second possible adjustment is to depreciate the tractor over a longer period given that it is a fairly large model and perhaps underloaded. Lastly it may well be that the drivers wage cost is greatly overestimated, even at the lower figure. Several operators could not quote a wage since the work was all done within the family, often by young boys. One owner actually said that the work depended on when his son was at school. Under these circumstances the true rate at which the drivers time should be costed is the opportunity cost of the earnings that he could achieve elsewhere. For younger members of a family in rural areas this may well be very low.

There are also plausible adjustments which might be made in the other direction. In particular the efficiency rate of 75% of hours worked to hours clocked is generous. Furthermore the figure for overall hours clocked which has been used, 1300, is an average over several years as well as across different machines. Given that the number of tractors has increased during these years it may well be an overestimate for the hours likely to be achieved in 1981, Lastly there are some operators who do

not even have a cultivator. Certainly most in the western areas are unlikely to achieve even the 200 hours cultivator work assumed.

Clearly different operators will fall into different categories. Some will still be making a reasonable business out of their tractor. Overall however it seems certain that the marginal operator is in difficulty and likely that it is not just the marginal one either but perhaps even a majority. The long term effect must remain obscure at least until the coming peak season. Only then will it be possible to ascertain for sure whether tractor operators can obtain the 15YR per hour increase in rates which would be necessary to allow even those operators facing costs equal to the higher estimate to break-even (given all the other assumptions - 975 working hours, 20% cultivation work etc).

VALUE OF A TRACTOR HIRE SCHEME

Three goals have been specified for the proposed tractor hire scheme. In summary as follows:

1, To provide farmers who need them with mechanical services at economic rates subject to the scheme being fully self financing.

2, To demonstrate better methods and more suitable machinery to farmers and tractor operators.

3, To provide information on operational realities prior to consideration of further schemes.

It should be stressed at the outset that there is an inherent conflict between the requirement to be fully self funding, ie to be commercially successful and the second goal of demonstration. The more quickly other tractor owners learn from the hire scheme the more effectively they will compete against it. Provided they are equally efficient technically private operators are always likely to be more

competitive than a formal, administrated, scheme with its associated higher overheads and a lack of both local knowledge and flexibility.

Commercially, moreover, it would be preferable for the scheme to concentrate work as narrowly as possible whereas demonstration would benefit from more extensive working.

Setting aside the third goal, which is a research aim not immediately open to economic evaluation, the underlying purpose of the scheme is to reduce the price of cultivation and of other farm operations by offering cheaper and more efficient mechanical performance of these tasks.

The economic benefits of success in this aim might acrue in one of two ways - through an expansion of the market for farm work by an increase in the area cropped or by the release of resources currently absorbed in farm work to other parts of the Y.A.R. economy. The precise degree to which either will take place depends on the elasticity of demand for farm work and on the elasticity of supply of that work. For example if, the demand for increased cultivation work is inelastic any cheapening of the price will not result in increased work but rather in forcing out of business the more inefficient operators, be they tractor or oxen hirers, who cannot work at the lower price. If supply is inelastic then it will take a relatively large price cut to induce operators to cease business and hence the main effect will be seen in an increase in work. If both demand and supply are inelastic then a given lowering of the price will result in little overall change beyond a transfer of welfare from the supplier, in this case the tractor or oxen owner, to the customer, the farmer.

There is no data on which a quantified analysis of these possibilities can be made. There are however reasons to believe that the latter case - low elasticities of both demand and supply - applies for cultivation work in the short to medium future. To a very large extent the demand for cultivation is determined by the availability of other resources, critically water, more than by its own price. The availability of labour also has a powerful effect on the area cropped and hence on the demand for cultivation work. The price of labour is such as to discourage any great expansion in production. On the supply side the elasticity is determined largely by the openings available to which the resources used can be diverted as the returns in tractor operation fall. The generally low opportunity cost of capital in the Y.A.R. has already been mentioned and this indicates that alternative openings for the capital tied up in tractor operations are very restricted and, hence, that it will require a substantial price fall to persuade operators to withdraw from the market. To do so would require them to realise what value they could make for the machinery they already have. Current indications are that second hand prices are very low and unattractive to those wishing to sell. Under these circumstances the capital costs of the machinery in the Wadi Rima' must be largely regarded as a sunk cost to the Y.A.R. Forcing prices down so far as to put owners out of business would thus release no capital resources to the economy as a whole. As against this there would be benefits derived from more efficient use of expensive variable inputs, labour and fuel. The value of these would again be restricted by a low elasticity of supply of tractor services.

Against this background it is clear that any hire scheme, to be effective, must realise as large a reduction as possible in the price of cultivation work, per unit of work done not per hour. The ways in which

it is suggested this may be achieved are by better selection of equipment and by more efficient working mainly reflected in faster working rates.

As far as implements are concerned the normal combination for Wadi Rima' of disc plough and cultivator with a proportion of both rear and front blades would appear to be almost exactly as the A.E.P. would recommend. (J. Williams, Y/B A.E.P. April 1980 p27). The single exception might be the introduction of a proper cultivator seeding attachment in place of the improvised method currently in use. As far as costs are concerned however the estimated hourly cost of such a unit of 13 YR (J. Williams op. cit. p117) compares very closely with the 15 YR paid to the three boys under the local system. The advantage would appear negligible especially given the reported difficulties with seeders in the area.

The benefits of better selection thus come down to the reduced capital, depreciation, fuel and repair costs of turning to smaller tractors than are currently the norm. In itself the reduced repair cost is debatable given that smaller size implies heavier loadings. Be that as it may Table 9 sets out the comparative cost schedules for the Massey Ferguson range under assumptions that would be applicable for a hire scheme.

Table 9 Tractor Hire Scheme Costs

Tractor	M.F. 290	M.F. 265	M.F. 240
Capital Cost	110,000	105,000	79,500
Fixed Costs			
Depreciation (1)	15,714	15,000	11,357
Cost of Capital (2)	5,500	5,250	3,975
Wages (3)	24,000	24,000	24,000
Sub Total	45,214	44,250	39,332
Variable Costs			
Fuel (4)	16,478	14,940	11,864
Oil (10% of Fuel)	1,648	1,494	1,186
Maintenance (5)	11,786	11,250	8,518
Sub Total	53,912	51,684	45,568
Revenue (6)	58,468	54,468	54,468
Total Annual Cost	- 75,126	- 71,934	- 60,900
Profit/Loss	- 16,658	- 13,466	- 2,432

Notes: (1) Straight line, 7 year life, zero scrap value
(2) Average value @ 10% pa
(3) 12 mths @ 2,000 YR, assumed fixed cost as Government employee
(4) Wadi Rima' cost: 1.69 YR/litre
(5) 75% of Capital Cost over 7 years
(6) 775 hours disc work @ (60 YR – 4.4YR implement cost)
200 hours cultivator @ (90 YR – 13.11 YR implement cost)

It is clear from table 9 that even with the smallest model of the range it is going to be far from easy to break even on the hire scheme at current hire rates, even where absolutely no allowance is made for higher overhead costs which are likely. With the M.F. 240 it will be necessary to work, and be paid for, 1105 hours (80% disc 20% cultivator) to break-even; an increase of 13% on the likely average for private contractors, most of whom have a guaranteed market on their own and their sharecroppers' land. In short all the benefits of better selection of equipment will be absorbed in the higher wage, capital and repair allowances which under professional management must be made where private contractors can seek cheaper capital, use family labour and skimp on repairs. It should also be pointed out that while there is an economic cost to larger tractors it may be that the owners are paying this for a reason. In particular it is possible that more powerful machinery is

less burdensome on the driver, especially when short operating seasons mean that very long days have to be worked in hot and dusty conditions. Several operators expressed interest in power steering for this reason. It may also be that in the operators' eyes, the extra expense of a reserve of power and of 4-wheel drive is outweighed by the possibility that heavy rainfall and spates will make them useful if only for a short time, when access is difficult and demand for bunding work is high.

The other possible area of more efficient operation lies in raising working rates so that, although costs per hour remain fixed, costs per hectare are lowered thus making the scheme's services more attractive to farmers. There is no doubt that in Wadi Rima' farmers are fully aware of the effect of working rates on their input costs, witness the general use of 'rule of thumb' hours-per-ma'ad figures. However it must be questioned whether the hire scheme could, on average, do any better than local operators. Most of these have now been in the business for 3 or 4 years and they are increasingly feeling and reacting to the economic pressures to more efficient operation. Table 10 compares A.E.P. estimated working rates both with the 'rule of thumb' rates and with measured rates.

Table 10 Tractor working rates: ha/hour Wadi Rima'

	A.E.P. Estimate (1)	Wadi Rima' 'Qanun' (2)	Measured (3)
Disc	0.13	0.18	0.19
Cultivator	0.71	0.72	0.31

Notes:(1) J. Williams April 1980
(2) Disc: 2 hr/ma'ad at 0.36 ha/ma'ad. Cultivator: 0.5 hr/ma'ad
(3) Disc: 3.75 km/hr (measured over 250 metres) x 0.083 x 0.6 metres width. Cultivator: 5.50 km/hr (measured over 250 metres) x O.O83 x 2.0 metres width. (Conversion factor - O.O83 - standard U.K. figure)

Clearly there are doubts about the overall validity of 'rule of thumb' estimates such as the Wadi Rima' 'Qanun'; and the measured rates were only taken from one example for the disc and one for the cultivator. However the fact that both the measured and 'rule of thumb' rates exceed the A.E.P. estimate gives rise to the possibility that private operators do not work as slowly as is often estimated. It is strongly recommended that before any final decision is made to go ahead with a hire scheme this point is checked preferably by field measurement of a substantial number of operators. This might be best done during the next peak season.

In the meantime, to test the likely effect of improved working rates it will be assumed that current operators are achieving an average of 0.10 ha/hour with the disc and 0,5 ha/hr with the cultivator and that the hire scheme operators will be able to achieve the A.E.P. estimated rates on average. On that basis and assuming that the scheme charges the same hourly rate as private contractors the implicit price drop, weighted between the two implements, would be 24%. To do this and still break even, the scheme will need to cover a greater area than local operators do: capturing the equivalent of 1,459 local working hours per tractor unit. This allows both for the need to raise the hours worked to break even with the M.P. 240, and for the increase in area per hour worked. Should the scheme be set up as planned with two tractors the total required market would be 2,918 working hours. This would be in a total market of 73,125 working hours (75 tractors x 975 hours) and represents 4% of the total. However the scheme could not hope to operate, commercially at any rate, through-out the area. The market it would effectively have to penetrate would be perhaps one quarter of the whole: say 18,000 hours work. The market proportion which must be-captured then

becomes 16%, This will have to be achieved either by generating new demand or by taking work away from local operators. It should be remembered that a significant proportion of the market is in effect captive; land owned by tractor owners and their sharecroppers would be inaccessible to a hire scheme. Other customers would need more flexible credit than the scheme could offer. These points apart, the effective price cut of 24% should be sufficient to allow of adequate market penetration even at low elasticities of demand and supply. However, to repeat this is on an assumption for which there is no hard evidence, that the scheme's operators can achieve, overall, a 30% improvement in work rate with the disc plough and a 40% improvement with the cultivator. Should this not be possible and the improvement be so much less that the implicit price drop falls below 15% the scheme would only find a market if the elasticities of supply and demand are larger than seems likely.

Conclusion

There must be grave doubts about the likely success of a tractor hire scheme in Wadi Rima. The area undoubtedly meets the technical requirements of a scheme admirably, having field layouts and irrigation regimes as suited to mechanisation as anywhere in Yemen. The conclusion from the survey work is that a hire scheme will fail on the following points:

1. It is unlikely to meet the requirement of financial viability at current prices. While there is a wide range of cropping patterns in the area, demand for tractor services remains relatively highly peaked and large sections of the market are tied to current operators so that it will be difficult to achieve the heavy utilization necessary to cover costs and generate a profit.

2. The need for tractor services in Wadi Rima' is already adequately met. It is unlikely that any price reductions the hire scheme may achieve will generate adequate extra demand to justify the service offered.
3. Given that the market for tractor services is already tight and that financial targets will be difficult, the demonstration/extension effect of the scheme will be limited. Private contractors will be resentful of the schemes' competition and hence less willing to learn. The scheme itself, in order to make profits, will do best to focus its work narrowly both in area and range of operations thus minimising its demonstration impact.
4. While the scheme will undoubtedly generate data on actual field performance and on operational constraints it appears most likely to indicate by its failure that similar schemes elsewhere are inadvisable. The data generated will therefore be of minimal value.

Lastly it remains very much open to question whether a hire scheme is the best way to develop a more positive practical approach to encourage the wider use of A.E.P. recommended agricultural machinery or to raise the efficiency in use of the machinery currently in operation. The hire scheme as envisaged will initially, at any rate, require T.C.O. and trained Yemeni manpower. Yet its only advantage over an extension/evaluation operation using the same manpower would appear to be the introduction of competitive pressure towards cost efficiency. The justification for this might logically rest either on the belief that private operators were acting in cartel, or that they are just so resistant to the idea of efficiency that only by arm twisting can they accept it. There appears to be little evidence for either position. Operators are drawn from several parts of the wadi. In the past they

have come in from outside as well. A large proportion of their customers are in no way beholden to them by ties of landownership or tribal status and many farmers use two or three different operators as they are available. Under these circumstances a cartel seems unlikely. As far as the tractor operators' willingness to learn is concerned it should be realised that they have developed a large and active market entirely on their own resources and without benefit of any technical help within three or four years. No attempt has been made to offer any encouragement, towards more efficient operation. To impose a hire scheme in the name of efficiency without at least considering a less adversative approach would seem more than a little unjust.

RECOMMENDATIONS

1. It is not recommended that a hire scheme be set up in Wadi Rima'.

2. Should the conclusion of this report fail to be accepted and the hire scheme proposal be further pursued it is strongly recommended that no action should be taken until:

   a) The price which operators are able to charge is more clearly established during the coming peak operating season.

   b) A rigorous survey of current operating speeds is carried out to establish exactly how much of an improvement an A.E.P. sponsored hire scheme can be confident of achieving.

3. If the hire scheme proposal is to be pursued it is recommended that it be established on the south bank of Wadi Rima’ in or near the triangle between al Madan, Basat and Darban, (see L.R.D.C. Y.A.R. -

01-29/REP-16/66 Text Map 6). Such a position would allow maximum access to pump irrigated, wadi irrigated and rainfed land.

4. If the conclusions of this report are accepted and the hire scheme proposal is dropped it is strongly recommended that consideration be given to alternative methods of achieving the goals of wider and more efficient mechanization in Wadi Rima'. It is believed that an extension/ evaluation exercise would achieve the goals of the hire scheme at no greater cost and much more effectively. The very fact that stands in the way of the hire scheme - namely the relatively large supply of existing tractor services - would make the Wadi Rima' an ideal location for an intensive regionally-specific exercise in the evaluation and extension of mechanised techniques. In addition to endeavouring to encourage more efficient operation of tractors in the current range of activities, mainly cultivation and seeding, the primary aim of such a project would be to identify other areas of agricultural activity, where current constraints might be broken by appropriate mechanised techniques. Such an approach would offer benefit to both farmers and to tractor operators, whose potential market could be considerably widened if they could break out of the limited range of activities available. The hire scheme offers benefits to farmers only at the expense of operators. (An appendix is attached in which the extension/evaluation approach is discussed in more detail).

APPENDIX

EVALUATION AND EXTENSION OF MECHANISED TECHNIQUES IN WADI RIMA

The two critical constraints on agricultural production in Wadi Rima' are water and labour. While improvements in primary cultivation and seeding techniques through mechanisation have undoubtedly allowed production levels to be maintained or even raised, at a time when labour has been leaving the area in unprecedented numbers, there are limits to what improvements in these two activities can achieve if there are no comparable improvements in other areas where the constraints are binding with equal or greater force. Although there may be scope for further improvements in mechanised ploughing and seeding, as would be pursued under the hire schemes, the effect will be marginal so long as there is no progress in those other areas. It is believed that this is very much the case in Wadi Rima: cultivation and seeding are now a relatively unimportant item in the total costs of operation and production is being severely limited by other costs, notably irrigation water and harvest labour.

Table I sets out estimates of the costs and returns to four major Wadi Rima crops based on discussions with farmers during the hire scheme survey. It is emphasised that the estimates are extremely crude. However the relative importance of the various cost items is clear.

Table 1: COSTS AND RETURNS TO FOUR MAJOR WADI RIMA' CROPS

	Maize Wadi Irrigated		Qayra' Sorghum Pump Irrigated		Tomatoes Pump Irrigated		Millet Rainfed	
Yield Per Ma'ad (= 0.36 Ha)	10 Qadah / 400Kg		10 Qadah / 400kg + 500 bundles Fodder		40 cases – 600 kg		1.15 Qadah – 46 kg	
Price – Tihama Markets, Dec. 1980	120 YR/Qadah		128 YR/Qadah + 2 YR/bundle		8 YR/kg		160 YR/Qadah	
Income	1,200 YR		2,280 YR		4,800 YR		184 YR	
COSTS	YR	%	YR	%	YR	%	YR	%
1ST Plough (1)	120	17	120	7	120	6	120	48
2nd Plough/Furrow* (2)	45	6	-	-	30*	1	-	-
Basin (3)	-	-	140	8	-	-	-	-
First Irrigation (4)	-	-	131	8	-	-	-	-
Sow/Transplant* (5)	55	8	80	5	70*	3	55	22
Re-basin (6)	-	-	70	4	-	-	-	-
Irrigations (7)	-	-	483	33	1,312	55	-	-
Weeding (8)	-	-	-	-	350	16	-	-
Harvesting (9)	240	34	356	20	-	-	37	15
Threshing/Picking (10)	120	17	178	10	160*	7	18	7
Tax (11)	120	17	89	5	240	11	18	7
Total Costs	700	100	1,747	100	2,282	100	248	100
Gross Margin	500	-	533	-	2518	-	-64	-

Notes to Table 1:

(1) Disc plough @ 60 YR/hour, 2 hours/Ma'ad

(2) Cultivator @ 90 YR/hour,0.5 hours/Ma'ad. Furrowing* for Tomatoes: Disc plough @ 60 YR/hour 0,5 hours/Ma'ad.

(3) 2 man team at 70 YR/team day. 2 team days/Ma'ad

(4) The maize crop is assumed on free water, although most farmers buy water from Government at - 10-50 YR/ Ma'ad. Irrigation labour costs for this crop are not known. Given the flood method used they should be fairly small. Pump irrigation costs are calculated at 9.23 YR/hour pumping costs (A.E.P. est. updated for fuel costs - Williams, April 1980) and 35 YR per 12 hours labour costs.

(5) Maize and Millet: Cultivator + 3 boys @ 110 YR/hour 0.5 hours/Ma'ad. Qayra': Oxen + 1 sower @ 80 YR/day, 1 day/Ma'ad. Tomatoes: 2 men @ 35 YR to transplant into one Ma'ad. N.B. Tomato nursery costs not known.

(6) The second basin operation is easier than the first (see note (3)). 1 team day/Ma'ad @ 70 YR/team.

(7) Wadi irrigations assumed free. Qayra' 4 x, @ 12 hours /Ma'ad per irrigation. Tomatoes 18 x, @ 6 hours/Ma'ad per irrigation (see note (4) for cost per hour).

(8) Tomatoes 5 x, @ 2 man days. 35 YR/man day.

(9) Harvesting = Cutting or Heading. The average quoted rate paid was approximately one fifth of the total crop for grain crops (including fodder).

(10) Threshing. Average quote one tenth of total grain produced. Picking tomatoes: 4 YR per case.

(11) Tax. Zakat is paid at 10% for Wadi or rainfed land, 5% for pump irrigated.

From Table 1 it is clear that only in the rainfed areas are ploughing and seeding a dominant cost factor (70% of total costs). This is because low yields restrict both the level of other inputs and the need for harvest labour. The negative gross margin underlines the riskiness and marginal nature.of the rainfed operation. Although a relatively small improvement in yield would bring the crop into profitability a prolonged run of bad years would put considerable pressure on the farm's resources.

As far as the other areas are concerned, currently tractorised, or tractorisable, activities make up a minor proportion of total costs. In the Wadi area first and second plough and seeding may be mechanised, although few farmers do all three with tractors. The proportion of total costs for these three operations is 31%, outweighed by the cutting/ heading operation especially (34%). In the pump area only 7% of sorghum costs are currently mechanised (first plough) and the same for tomatoes (first plough and furrow). For sorghum four other operations are more costly: basining (2 x), threshing, harvesting and above all irrigation. Similarly for tomatoes weeding and and irrigation are both more than twice as expensive as the mechanised operations. Irrigation in particular makes up 55% of total costs.

Against this background it is suggested that the evaluation and extension of a range of mechanised techniques designed to break down the critical constraints where they are binding and to widen the range of activities which can be handled mechanically would be of inestimable value in wadi Rima. Among the techniques to which early consideration might be given are the following:

1. Mechanised cultivation and irrigation techniques for field crops on pump irrigated land, to reduce the heavy labour input on basining and most importantly to raise irrigation efficiencies.
2. Techniques for entering and working fields more quickly after irrigation or rainfall.
3. Minimal input methods for marginal rainfed land.
4. The proper use of seeders, so as to improve the control of depth and seed rate to meet the standards set by oxen ploughing.
5. The setting of seeding cultivators so as to allow mechanical methods of inter-row cultivation.
6. Mechanised methods of harvesting.
7. Work is currently under way to implement a new wadi irrigation scheme based on Dutch consultancy work. Details are not known but it is likely that greater control of the wadi flow will considerably alter the shape of wadi irrigated farming. There may well be a need for new mechanical techniques to take maximum advantage of the new irrigation regime.

In addition to work on the above a small mechanisation team would be able to advise operators directly on setting up their machinery to improve both the quality and rate of work. It might also be of benefit if the team held a wide range of implements for loan or hire to local operators, initially under supervision perhaps, in order that they can experiment with new implements without committing themselves to their purchse. The capacity to offer advice on repair and maintenance would also be of great use. Most operators carry out a large proportion of their own servicing and even repair work. There are also semi-professional, self trained mechanics in the area. The potential market for low level workshop training and advice is thus larger.

To sum up there would appear to be more than adequate work to be done in Wadi Rima’ to occupy a formal evaluation and extension team. The range of cropping systems and crops and the complexity of challenges which the farmers face is enough to occupy a full time mechanisation team for up to two years. Such a presence would have almost all the advantages of a hire scheme and few of the drawbacks. For example the team should be able to gain as good an idea of operating costs and constraints by cooperating with tractor operators as by competing against them. Just as a successful hire scheme would allow similar operations to be set up in other sections of the Y.A.R., so a successful evaluation and extension programme would show the- way for similar exercises throughout the country. In the final analysis it is felt that the latter approach is more likely to be successful, the former perhaps a dead end.

RECOMMENDATIONS

Should the evaluation and extension approach be accepted for further consideration the following points are put forward as a framework for discussion:

1. There should be a Wadi Rima' mechanisation team consisting of at least one TCO, two A.E.P. trained Yemeni staff and appropriate backup. (It is worth mentioning that if established the scheme would make an ideal training ground for A.E.P. students).
2. The team should have its own land for trials and demonstration work. Initially the area of greatest potential would appear to be pump irrigated. The land should therefore be pump irrigated. It is recommended that close consideration be given to reviving the L.R.D.C. proposals for an irrigation scheme based on al Shadhiliyyah.

(L.R.D.C. Project Report 16. Irrigation and Agricultural Development in Wadi Rima'. Volume 2. pp44 ff. YAR-01-29/REP-16/77).

The proposal was for a largish area of borehole irrigation. If this scheme was revived it would be an ideal context in which the mechanisation team might make an evaluation of the techniques developed. The farmers supplied with water by the scheme would provide a well integrated 'market' for the initial extension of those techniques. Al Shadhiliyyah has the added advantage of being in the rainfed area and close to the wadi irrigated, Lastly it should be noted that it is currently one of the poorer areas of the Wadi dependant almost entirely on rainfed agriculture (and emigration to Saudi Arabia),

Should there be inadequate resources to revive the complete scheme, which involved 8 boreholes and 600 ha, consideration should still be given to siting the mechanisation team in the area, where there is one borehole already drilled around which an experimental station might be based. (If it has not suffered too severely from neglect between 1975 and 1981),

3. It is recommended that the team's terms of reference be so drawn that there is no risk of their effort being dissipated over an area larger than Wadi Rima', A central goal should be to evaluate a relatively intensive mechanisation input as compared to the extensive approach that A.E.P. has, perforce, had to adopt to date.

Subject to 3, it is clearly necessary that the closest possible cooperation be developed with the other development agencies in the area - notably the Tihama Development Authority and their extension service,

which is already established in Wadi Rima', and the Agricultural Credit Bank.