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PERFORMANCE ANALYSIS OF SCARP-I

BY

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The results show that the initial impact of the increased irrigation supplies from tubewells was lost in 1969-70 when the yields started to decline after reaching a peak. Since then there has been a continuous downward trend in crop yields/acre except during the late 1970's when timely rainfalls, both in Kharif and Rabi seasons, gave some rise. The cropping intensity has almost followed the fluctuations in irrigation supplies although there is a time lag between the two. The contribution of private tubewells is noticeable in later years because the cropping intensity increases when there is a decrease in canal and public tubewell supplies.

It has been found that brass is the best of all strainer materials including Fibreglass. There is a rapid decline in tubewell discharge in the first one to two years for all strainer materials. An average reduction of 3-4 percent is obtained after fifteen years of operation.

The Project has been an economic failure because of the high operation and maintenance cost of public tubewells. This can be attributed to frequent changes in the management of the Project. The framers prefer the integrated " Project Approach".

1. INTRODUCTION

The Salinity Control and Reclamation Project No.1 (SCARP-1) was developed to preserve/restore/improve and develop the land and agricultural water resources for national welfare through:

1) Tubewells to lower water table and to provide more water for extensive and/or intensive agriculture;

2) Reducing Salinity Hazard by leaching, adding amendments, increase cropping intensity, but avoiding land deterioration by hazardous tubewell waters.

3) Helping the farmer by

   a) extension of recent technical information to them;

   b) removing their financial hurdles through loans, subsidies etc; and

   c) ensuring correct return for agricultural produce sent to markets.

The targets set to achieve the above objectives were as follows:

1) To increase cropping intensity to 150 percent.

2) To increase crop yields/acre three times the one that existed during the pre-project period. Yields/acre for main crops were prescribed in the feasibility report.

3) To reclaim an affected area of 0.425 million acres. (0.100 million hectares).

The Project embodied construction of some 2200 tubewells (actual varied from 2068 to 2073) and appurtenant power facilities in the Punjab. It represented culmination of many years of study and investigation of means to alleviate problems associated with waterlogging and salinity. The investigation of the Project was first undertaken by the Irrigation Department and then by the Water and Power Development at the bottom of the table (columns 5 and 9). If the canal supplies are multiplied by 0.7 and added to the tubewell supplies, the average water allowance for the whole Project would be 157 acres/cusecs, which is slightly lower than the designed allowance of 150 acres/cusec.

3. MATCHING WATER DEMAND TO SUPPLY

Table-2 shows analysis of utilization of tubewells as a source of supplemental irrigation supplies in the Project. The Culturable Command Area (CCA) of the Project is 1.14 million acre. In the review by Tipton and Kamback (T&K) an initial cropping intensity of 85%, distributed as 35% for Kharif and 50 percent for Rabi seasons, was taken. The Annual Reports of SCARP-1, however, quoted 74 percent with 38 percent for Kharif and 36 percent for Rabi. The later intensity has been used in the analysis in Table-2. There is likely to be small increase for 85% cropping intensity.

The Review Report reported average canal supplies equivalent to 2.6 ft. at the head of watercourses during the pre-project period. It was estimated on the basis of work by Blanney and Criddle that optimum water application in the Project should not be less than 4.8 ft. per year. The seasonal distribution of irrigation supplies,on the basis of the cropping pattern that could best fit into the available supplies,was worked out in the Review Report for an intensity of 85%. The same distribution has been used in Table-2 to determine water requirements in million acre feet (maf) and in cusecs for various cropping intensities. The seasonal distribution of water supplies remain constant. At the most these could increase to the designed supplies which would be the actual supplies given in Table-2 divided by 0.7 the canal capacity factor, considered in the Project Report to determine tubewell water requirements.

It is apparent from Table-2 that in the pre-project period the seasonal shortage of irrigation water was 0.55 million acre feet (.63 maf for intensity of 85%) and 0.25 maf during the Rabi season (.29 maf for 85% intensity) Maximum utilization is 4500 cusecs out of the absolute maximum available supplies of 8631 cusecs (sum of the values given at the bottom of columns (5) and (6) of Table-1). Therefore, the utilization factor is 48 percent.

Table-2 also shows seasonal distribution of irrigation supplies for an intensity of 150 percent which is the target intensity for the Project. The Kharif/Rabi ratio has been assumed to be 60:90. On this basis maximum utilization is 7200 cusecs out of 8631 thus giving a utilization factor of 83.5%. Tubewell utilization factor is 89.5 percent, which is difficult, if not impossible, to achieve.

Total irrigation water requirements per year have been worked out 3.86 million acre feet for Kharif/Rabi ratio of 60:90 percent. It must be noted that maximum authorised canal discharge rate is 2600 (Table-2) cusecs. If water is available at this rate throughout the year maximum canal supplies would be 1.87 million acre feet. This would leave 2.0 million acre feet for supply from tubewells.

On the basis of the available data for the years 1959-60 to 1974-75, the Kharif/Rabi ratio for an intensity of 150 percent has been estimated to be 70.80 percent. Seasonal requirements for this ratio have also been computed in Table-2.

the five main crops are also given in Table-3 for the post-project period. These estimated percentages are based on the recent (1981) cropping pattern in the Project. The cropping intensity is thus derived as 150 percent with 70:80 percent as Kharif/Rabi ratio. This average cropping intensity has not been achieved so far. The data collected during the survey of the Project in 1981 has indicated an average cropping intensity of 138 percent. It goes to 156% for farmers having their private tubewells and tractors. The details of the survey are given in the comprehensive report given in the reference.

The progressive increase in the cropping intensity to the target value of 150 percent was not determined at the planning stage of the Project. Later, however, reviews and evaluation studies of the project presented various values of the cropping intensity. The studies have shown doubts on the achievement of the target values. Ultimate cropping intensities were presented which differed not only from one study to another, but was also proposed to be achieved in different lengths of time.

Fig-5 compares planned with the canal cropping intensity of the Project. The figure shows that the planned intensity was achieved upto the year 1965. This was the time when high yielding varieties of wheat and other crops were introduced which gave impetus to cultivating a large part of the culturable command area due to availability of additional water from tubewells. The actual irrigation supplies have also been plotted in the same figure (Fig.5). There is an interesting correlation between the actual cropping intensity and the actual irrigation supplies. This is evident from almost similar trend of the two curves. The rise in the irrigation supplies in one year is followed by a rise in the cropping intensity in the succeeding year. Same is the case with the fall in irrigation supplies and its consequent effect on cropping intensity continues to increase in spite of reduction in irrigation from canals and public tubewells upto 1975. This should be possible because of the development of private tubewells. Higher cropping intensity is likely to occur in areas where farmers have their private tubwells to meet shortage from canals and public tubewells. This has been confirmed from the field data collected during the survey of the Project.

5. WATER TABLE BEHAVIOUR

One of the main objectives of the Project was to reclaim the area affected by waterlogging and salinity. Since no rational approach was made to relate productivity of the area with salinity status and the changes brought about in this relation as a result of drainage and supplemental irrgation by tubewells, an area was considered to have been reclaimed if the water table was lowered to 10-15 ft. below the ground surface. Fig-6 shows the effect of tubewell pumpage on average water table depth below the ground surface.

It may be apparent from the figure that the rate of decline of water table depth decreases when the pumpage is reduced. It is also interesting to note that the water table, in some years (1976-79), rises when pumpage increases. This indicates higher rates of recharge than the rate of pumpage.

Groundwater recharge is a function of the water table position below ground surface. It should normally increase with increase in water table depth below the ground surface. The Investigation Report and the Review by Tipton and Kalmback failed to establish this relationship because of non-availability of adequate data. However, now that twenty years of operational data of the Project is available, the same has been plotted in Fig.7. The recharge rate has been computed from the observed average changes in water depth and storage co-efficient of 0.30. Total recharge (inflow) is equal to pumpage (outflow) minus/plus change in storage depending on whether water table is falling or rising.

Fig.7 shows that the rate of recharge increase, non-linearly with the decline in water table below the ground surface, reaches a stable position at recharge of about 1.50 million acre feet year. Therefore, the recharge rate/year increases with the rise in water table. The zone above the 1.50 million acre feet line is for the rising water table and below it is the falling water table. The average water table during the twenty years of the operation of the Project is 13.80 ft. below the ground surface at an average pumping rate of 1.80 million acre feet/year. Now for 1.50 million acre feet,the average water table from Fig.7 is 16 ft. Water table decline is therefore 2.20 ft. The corresponding withdrawal from storage would be 0.80 million acre feet on gross area. Therefore, the net recharge is 0.70 million acre feet/year. From Fig.7 the corresponding water table is 13.5 ft. The curve in Fig.7 is, therefore, a true reflection of the aquifer behaviour in the Project. The average water table during 1970-74 is 16.5 ft. and that in 1974-77 it is 14.8 ft. The average pumpage during 1970-74 is 1.6 maf. The change in storage for a rise from 16.5 ft. to 14.8 ft. is 0.66 maf. giving net recharge of 2.25 maf. The curve in Fig.7 gives a water table of 14.5 ft. in the rising water table zone.

The observed decline of water table is compared with the theoretical curves in Fig.8. These curves have been prepared by Jacob for Tipton and Kambach in the Review Report. The observed values lie on the curve for draft of 0.25 ft/year over the gross area. This is the vertical depth of water to be drawn from groundwater storage. To get this draft the rate of pumpage/year should be 1.85 i.e. (1.50 +.25x1.22) million acre feet. With this average pumpage rate the water table will decline to 22.2 ft. below the ground surface by the year 2000. The water table will be shallower if pumpage is lower than the rate of recharge given above. There are already signs of rising water table as shown in Fig.8 from 1975-80.

While the conclusions drawn above are as accurate as they could possible be made, the limitatins of consistency of data cannot be overlooked. In any dry year or deficit irrigation the recharge from surface irrigation is diminished causing more decline of water table for the same rate of pumping. On the otherhand, in a wet season or when there is surplus irrigation over demand, the rate of recharge will increase. Consequently the rate of fall of water table will be smaller. The water table data analysed above is a response of all such varied conditions. The curves, however, show only trends which have been used to draw some quantitative conclusions.

Jacob, while reviewing the Investigation Report for Tipton and Kamback, concluded that if water is pumped from groundwater storage at a rate corresponding to 0.75 feet depth of water per year, the groundwater table would descend by the year 2000 to a level approaching that which existed prior to irrigation in the Project. This would require pumping at the rate of 2.25 million acre feet/year assuming that the rate of recharge would be 1.5 million acre feet/year. The experience shows that this pumping capacity was attained only in the first two years after the installation of tubewells in early 1960's. Thereafter the pumping rate gradually reduced, partly due to encrustation and corrosion problem and partly due to failure of tubewell components and mismanagement. Practically, it would be difficult to revert to 1960's pumpage rate unless most of the tubewells are rebored and remedial measures are taken to reduce the effect of corrosion and encrustation. The target tubewell discharge reported by the Central Monitoring Organization (CMO) of the Water & Power Development Authority (WAPDA) is 3.65 million acre ft/year which has never been achieved so far in the Project. The probability of obtaining this rate is 16 percent on the basis of the last eighteen years of record.

6. PERFORMANCE OF TUBEWELL STRAINERS

Performance of strainer material has enormous effect on the performance of tubewells. The Consultants first proposed mild steel strainers for most of the tubewells in the Project. However, poor performance of these strainers became apparent soon after the operation of the tubewells. It was therefore, decided to try brass, PVC, galvanised pipe, coir rope and finally fibre glass epoxybound strainers. The last material was used in all SCARPS following SCARP-1. In SCARP-1 it was used in some new wells, Fig.9 shows performance of mild steel (M.S), PVC and brass strainers. It may be noted that maximum discharge reduction in all strainers occurs during the first three years. The rate of decline/year in discharge progressively decreases with time until it is almost 3 percent/ year after fifteen years. In terms of performance, brass is the best followed by PVC and lastly mild steel. For example, after five years the rate of reduction in discharge is 13, 16 and 19 percent per year for brass, PVC and mild steel. The difference is more in the initial two years and reduces with the passage of time.

The reduction in specific capacity of brass and fibre glass strainers is indicated in Fig.10. The plotted data is for one year after the acceptance test. It is clear from the figure that the performance of brass strainer is better than that of the fiberglass. For example, 40 percent of the tubewells with brass strainers had less than 10 percent reduction in specific capacity in one year. On the otherhand, 20 percent of the tubewells with fiberglass strainers had more than 40 percent reduction in specific capacity. This amply proves that if deterioration of strainer material is the only factor affecting the performance of tubewells, fibreglass is no better than the brass strainer. It must be noted that 42% of the brass strainers show positive change in specific discharge as compared to nil in case of figreglass. It is due to this reason that 58% of the tubewells have been shown to have zero change in specific capacity in Fig.10.

The rapid initial decline in discharge/year of all strainers cannot be attributed to corrosion and encrustation as is generally believed, because such chemical action cannot occur so quickly in a few months after the operation of a tubewell. It has been observed that 12 to 17 percent discharge reduction occurs in the first three months.

A study was conducted by Tipton and Kamback on the performance of mild steel strainers in Upper Jhelum and Khadir Projects. They were of the opinion that a number of corrosion elements were involved in the destruction of steel in an unpredictable manner by the activity of sulphate reducing bacteria, the local character of the sediments and groundwater, and difference in metallurgy of the steel. The Consultants were of the view that, although corrosion was a universal hazard, the degree of corosive activity on mild steel could not be anticipated in advance of installation of a well, nor evaluated quantitatively afterwards by any known field measurements. They referred to computer studies of water quality data by the U.S. Geological Survey which indicated that most of the groundwater is saturated with calcium carbonates and iron. These constituents were believed to have choked screen slots and also formed corrosion cells on mild steel. The Consultants therefore, recommended that future tubewells should be constructed of material that would be immune to destructive corrosion. They suggested no modification in the specifications of pumps or in the design of wells. This study gave rise to shift from the traditional strainer materials to epoxy-bound fibreglass. The Consultants agreed that this was improved material for the sub-surface environment in Pakistan, but at the same time, they emphasised that it met all technical requirements, was attractively priced, and could be produced in Pakistan.

The fibreglass strainers have also been reported by the

Institute of Geology, U.K. to have shown an unacceptable rapid decline in performance. This resulted in a high incidence of premature tubewell abandonment. Besides, it was not possible to rehabilitate fibreglass strainers because of the possibility of excessive damage to the pipe. A number of attempts have been made to identify effective remedial measures with little success.

The corrosion and encrustration cannot have a rapid effect on the decline in performance of tubewells as discussed earlier. It is, therefore, clear that some other unknown factors may be operating within or around the well. The two main factors are construction of gravel pack around the well screen; and the disturbance in the aquifer fabric.

A study was conducted by the Institute of Geological Sciences, U.K., in Muridke Unit of SCARP-IV on tubewell MDK 504. It was observed that the gravel pack was almost 3 to 5 times coarser than a pack design using generally accepted criteria. It was, therefore, thought that this might have resulted in poor filtration action and consequent sand pumping. Significant sand contents were noted when the tubewell was pumped at below design discharge. This preliminary and isolated study suggested the possibility that an important cause of rapid decline in tubewell performance might be damage to the aquifer fabric. This damage was conceived to result in a significant fall in permeability of the formation around the well. Samples of gravel pack were also obtained by jetting and by using split tube drive sampler. The gravels obtained were observed to be wholy consolidated and no evidence of cementation was found.

The fines content of the pack, however, was not assessed during this study. The study was inconclusive and seems to have been carried out to pave the ground for a more comprehensive study which could identify the causes of discharge reduction with greater degree of confidence.

The experience in the Project shows that yields of wells can be increased considerably by rehabilitating the strainers by various methods, such as surging, blasting and acid treatment. Such rehabilitration method should not have improved tubewell performance if the same had deteriorated due to reduction in permeability of the aquifer fabric within a radius of 25 ft. from the well. Therefore, it can reasonably be believed that major cause of rapid reduction in discharge soon after the operation of a tubewell is the decrease in permeability of the gravel pack due to suction of finer aquifer material which later acts as a cementing agent in combination with the dissolved salts in water. The finer aquifer material travels towards the well screen under high drawdowns and gradually blocks screen slots. This hypothesis requires detailed substantiation by conducting a large number of studies on tubewells located in different schemes within the Project.

7. SOCIAL IMPACT OF TUBEWELL LOCATION

The Consultants considered that the nature of the Project aquifer is such that high discharge tubewells could be used anywhere. Where one tubewell served one watercourse, it was located at the head near the canal outlet. Such an arrangement facilitated desired mixing of tubewell water before reaching the point of use,thus minimising the problems where tubewell water was of inferior quality than the canal water.

Where two or more watercourses were served by one tubewell, the tubewell was located near the head of the upstream outlet on the side of the canal receiving the largest share of tubewell water. This eliminated construction of channels to convey water back to the heads of watercourses.

Both the tubewell locations discussed above created water distribution problems which accumulated into major social problems later on in the utilization of water for irrigation. For example, the location of a high capacity tubewell at the head of a watercourse necessitated enlarging watercourses which were previously designed only for canal supply which was less than one-fourth the combined tubewell and canal discharge. Remodelling of the watercourses being the responsibility of the farmers, took a long time with the result that wastage of water had increased. Farm efficiencies already being low during the canal irrigation period had decreased further. Moreover, high discharge from the tubewells raised the level of water in the head reaches of watercourses and correspondingly reduced the head difference in the distributary and the watercourses. Consequently the discharge through the outlet was reduced because of small head difference.The farmers are constantly making complaints against the Irrigation Department on reduction of canal supplies. The backwater effect at the head reach of a watercourse also assists accumulation of silt and hence raising of the bed level in this reach. Therefore, the farmers do not receive the authorised canal supply. Neither there is proper mixing of marginal groundwater and the canal water.

In situations of one tubewell serving more than one watercourse, the tubewell water from one side of the canal is conveyed to the other side through a pipe siphon. This gets choked by silt and debris floating in the watercourse. As a result, the farmers on the side of the distributary opposite to the tubewell get less discharge. This had led to disputes between farmers on the two sides of the distributary as well as among those on one side, especially when a watercourse serves two to three villages.

The above social problems could have been eliminated had the tubewells been of small capacity and dispersed over the whole length of a watercourse. This would have reduced the large investment made by the farmers in enlarging their watercourses and at the same time ensured equitable distribution of groundwater from the head to tail of a watercourse. Also it would have reduced the watercourse losses and improved farm efficiency. This could be one alternative which needed economic analysis to explore justifiability in relation to the various advantages enumerated above. There is no doubt that this could have resulted in increase in cost of tubewell motors and pumps because of increase in the number of small capacity tubewells. However, the cost of drilling, casting and strainer could be reduced because of shallower depth required for small capacity tubewells. The cost of power distribtion would have increased, but this extension could also have set rapid pace for development of private tubewells and provided a base for replacing public tubewells with private tubewells after the former had lost their economic life. Because of the involvement of huge O&M cost of these large capacity public tubewells and non-availability of their spare parts in the local market, the farmers are not prepared to take their operational responsibility. Another reason for reluctance in this regard is the low price that the farmers have to pay to the Government for unit volume of tubewell water. The farmers are aware that they will have to incur more expenditure in running public tubewells for a unit volume of groundwater than they are now paying to the Government.

Before closing the discussion on this topic it would be relevant here to mention the apprehension expressed in some circles about the financial limitations of small farmers to install private tubewells and the social imbalance that the absence of public tubewell development would create in the Project. Table-3 below shows percent distribution of private tubewell development according to land holding. The data given in column (2) has been obtained from the records of the Directorate of SCARP-1 which is responsible for the operation of the Project. This column gives the percentage of farmers who were permitted to install private tubewells.

TABLE-3

DISTRIBUTION OF PRIVATE TUBEWELLS

Land holding in acres. (1)	% applied for Licence (2)	Actual Survey data % (3)
<5	0.5	0.0
5-5	30.5	48.0
>25	69.0	52.0

There is a significant percent difference between the recorded and surveyed data. This is due to the fact that farmers with landholdings in the range 5-25 acres apply jointly and show combined holding to be able to get loans from Banks or other loan-giving agencies. The joint application is usually made by brothers or close relatives. During the survey each farmer quoted his own holding, although tubewells were shared. There was thus a shift of 17% from >25 acres to 5-25 acre holding.

Farmers apply for a tubewell licence to get power connection. However procedure for getting this connection is so lengthy that many farmers use diesel engines with their private tubewells. The survey of the Project showed 64% diesel wells and 36 percent electric wells. This would give some indication of how difficult it is to get power connection for a private tubewell in spite of the fact that a large number of villages in the Project are supplied with electric power.

Recent increase in oil prices has led to the use of diesel wells more sparingly than in the past. The increasing oil prices are expected to decrease the rate of development of private tubewells in the Project provided immediate steps are taken to simplify procedure to get power connection at reasonable cost to the farmers.

It is clear from Table-3 that small farmers (<5 acres) have not been able to make any contribution in the development of private tubewells. They would be worst affected if they are not provided loans on very easy terms. This would not be difficult because the Government is already subsidising tubewell water. This subsidy can partly be diverted in providing loans to small farmers on easy terms if the public sector relinquishes operational responsibility of the Project tubewells. This assistance can be used in organizing farmers into Water User's Associations.

8. CONCLUSIONS

The analysis discussed thus far leads to the following conclusions.

(1) Tubewell pumpage increased upto 1969 and continuously declined thereafter. The crop yields also reached to a peak in the same year. Cotton and maize crop area has considerably reduced due to water shortage.

(2) The record of last twenty years of operation of the Project shows that a recharge of 1. 5 million acre ft/year occured at water table depth of about 16 ft. below the ground surface. This can be considered as a steady-state tubewell pumpage to maintain water table depth at 16 ft.

(3) The brass strainer performs better than PVC, mild steel or even fibreglass.

(4) Tubewell locations created a number of social problems. The Project can be better managed by means of low capacity tubewells.

(5) Pilot Project study should be carried out to determine feasibility of smaller tubewells before embarking upon the "SCARP Transition Programme" recommended in WAPDA's Revised Action Programme on Irrigated Agriculture.

TABLE -1

PROPOSED SCHEMEWISE CANAL AND TUBEWELL DISCHARGE RATES
(IN CUSECS)

Sr. No.	Scheme	Cross area (acres)	Culturable commanded area (CCA) in acres	Canal Supplies Authorised Cs.	Canal Supplies C.C.A/ Cs.	Tubewell Supplies No. of Wells.	Tubewell Supplies Capacity (Cs.)	Tubewell Supplies C.C.A/ Cs.
1	2	3	4	5	6	7	8	9
1	Pindi Bhattian	8,305	7,969	118.00	-	21	53.19	149.8
2	Chichoki Mallian	7,122	6,556	(only for 3 months) 17.61	372.3	12	38.50	170.3
3	Chuharkana	10,770	9,255	16.00	578.4	25	51.00	181.5
4	Jaranwala	90,873	83,235	237.00	351.2	141	355.90	233.8
5	Shahkot	2,47,183	2,31,387	546.22	423.8	385	1089.90	212.5
6	Shadman	79,252	74,436	199.11	374.0	151	442.50	168.4
7	Zafarwal	2,34,602	2,20,933	469.96	470.1	394	1166.00	189.5
8	Hafizabad	1,71,169	1,64,047	283.15	579.4	321	940.00	174.5
9	Khanqah Dogran	1,21,810	1,14,083	190.18	600.0	213	649.50	175.6
10	Sangla Hill	1,38,971	1,28,622	312.72	411.3	234	688.50	186.8
11	Beranwala	81,124	75,232	160.44	468.9	128	407.50	184.6
12	Harse Sheikh	26,043	24,921	50.64	493.1	144	148.50	167.8
	Total:	12,17,224	11,40,676	2600.93	438.6	2069	6030.09	189.1

TABLE-2

PRESENT AND FUTURE IRRIGATION SUPPLIES FOR THE PROJECT
(Culturable Command Area = 1140676 acres)

Total Supplies at 74% intensity
Pre-project (Kharif/Rabi ratio = 38:36)

Kharif Irrigated area = 425477 acres
Rabi Irrigated area = 414442 "

		A	M	J	J	A	S	Kharif	O	N	D	J	F	M	Rabi
a)	Total required supplies at a delta of 4.8 ft														
i)	1000 Cs.	2.1	2.7	3.7	4.1	4.5	4.1	-	2.9	2.1	1.5	1.2	2.3	2.4	-
ii)	Million acre feet.	0.12	0.16	0.22	0.26	0.29	0.25	1.30	0.19	0.12	0.09	0.07	0.14	0.15	.75
iii)	Delta (ft)							3.00							1.80
iv)	Rainfall (maf)			.03	.09	.09	.05	0.26							-
b)	Total available canal supplies														
i)	1000 Cs.	1.3	2.4	2.5	1.9	1.8	2.3	-	2.1	1.8	0.6	0.7	1.3	1.8	-
ii)	Million acre feet.	0,07	0.15	0.15	0.12	0.11	0.14	0.75	0.14	0.11	0.04	0.04	.07	.11	.50
iii)	Delta (ft)							1.72							1.21
c)	Shortage of Supplies without Tubewell in Million acre (ft)							0.55							.25
i)	1000 Cs.	0.8	0.3	1.2	2.2	2.7	1.8	-	0.8	0.3	0.9	0.5	1.0	0.6	-
ii)	Million acre feet.	.05	.01	.07	0.13	0.18	0.11	.55	.05	0.02	.05	.03	.06	.04	.25
iii)	Delta (ft)							1.28							.59

TABLE-2
(Contd)

Total post-project supplies at
150% cropping intensity with
Kharif/Rabi Ratio of 60:90

Kharif = 0.684 million acres
Rabi = 1.026 million acres

		A	M	J	J	A	S	Kharif	O	N	D	J	F	M	Rabi
a)	Total requited supplies at delta of 4.8 ft														
i)	1000 Cs.	3.4	4.2	5.8	6.5	7.2	6.5	-	7.1	5.3	3.8	3.0	5.7	5.0	-
ii)	Million acre feet.	.20	.26	.35	.39	.44	.39	2.00	0.44	.31	.23	.18	.32	.35	1.80
iii)	Delta (ft)							3.00							1.80
b)	Total available canal supplies														
i)	1000 Cs.	1.30	2.40	2.50	1.90	1.80	2.30	-	2.6	1.80	0.60	0.70	1.30	1.8	-
ii)	Million acre feet.	0.08	0.15	0.15	0.12	0.11	0.14	0.75	0.13	0.11	0.04	0.04	0.07	0.11	0.50
iii)	Delta (ft)							1.10							0.80
c)	Tubewell Supplies														
i)	1000 Cs.	2.1	1.8	3.3	4.6	5.4	3.2		5.0	3.5	3.2	2.3	4.4	4.1	
ii)	Million acre feet.	.12	.11	.20	.27	.33	.25	1.28	.31	.20	.19	.14	.25	.24	1.30
iii)	Delta (ft)							1.90							1.30

TABLE-2
(Contd)

Total post-project supplies at 150% cropping intensity with Kharif/Rabi Ratio of 70:80

Kharif area = 0.798
Rabi area = 0.912

Total required supplies at delta of 4.8 ft

		A	M	J	J	A	S	Kharif	O	N	D	J	F	M	Rabi
i)	1000 Cs.	3.9	4.9	6.8	7.6	8.3	7.6	-	6.3	4.6	3.3	2.7	5.1	5.2	-
ii)	Million acre ft.	.23	.31	.42	.46	.51	.46	2.39	.39	.27	.28	.17	.28	.31	1.62
iii)	Delta (ft)							3.00							1.80
b)	Canal Supplies														
i)	1000 Cs.	1.30	2.40	2.50	1.90	1.80	2.30	-	2.60	1.80	0.60	.70	1.30	1.80	-
ii)	Million acre ft.	.08	.15	.15	.12	.11	.14	.75	.13	.11	.04	.04	.07	.11	.50
iii)	Delta (ft)							.95							.55
c)	Tubewell Supplies														
i)	1000 Cs.	2.6	2.5	4.3	5.7	6.5	5.3	-	3.7	2.8	2.7	2.0	3.8	3.4	-
ii)	Million acre ft.	.15	.15	.25	.36	.41	.32	1.64	.23	.17	.17	.13	.21	.21	1.12
iii)	Delta (ft)							2.05							1.25

PERFORMANCE ANALYSIS OF SCARP-1

(List of Figures)

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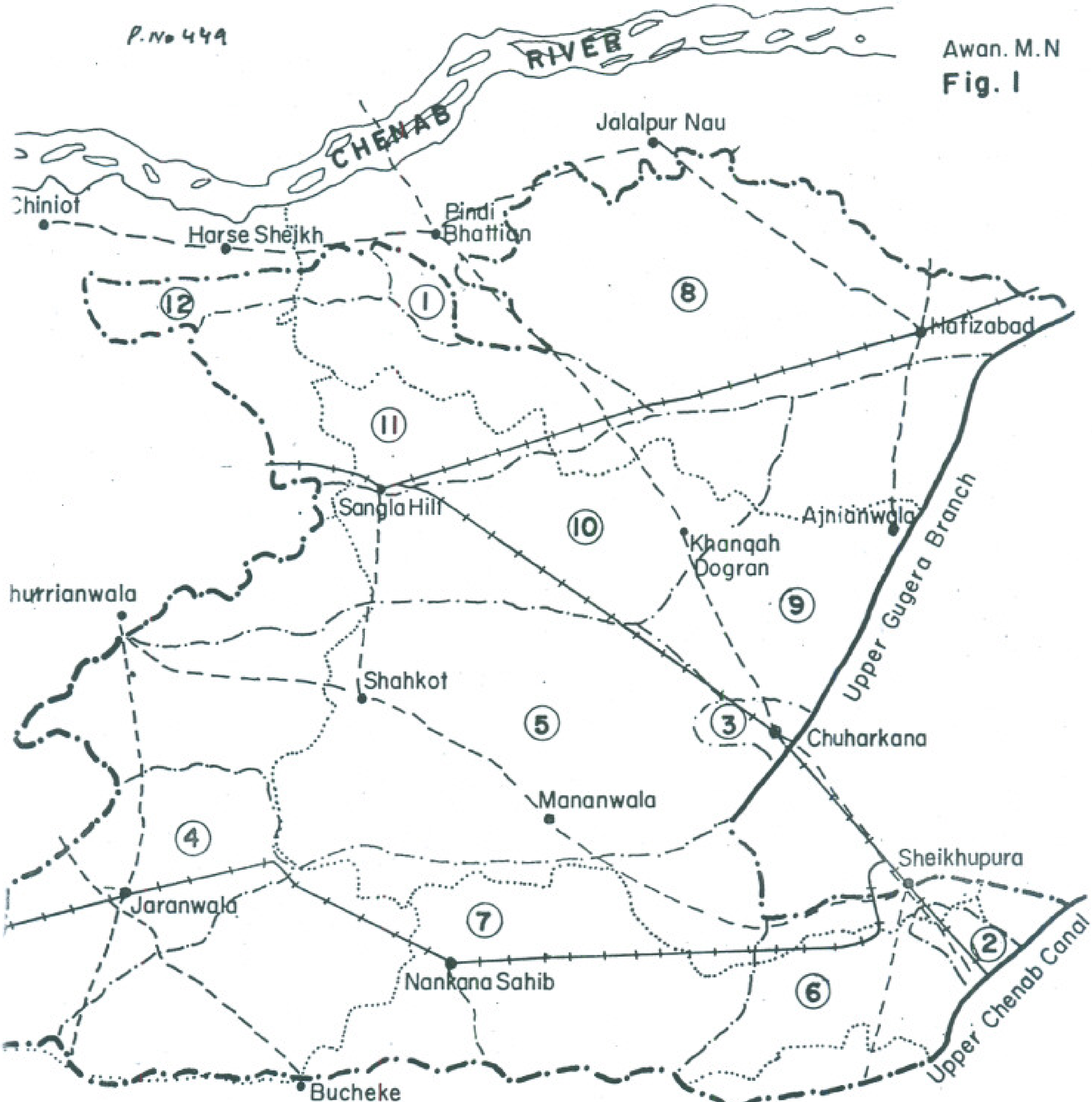
Awan. M.N

Fig. I



Reclamation Scheme Areas

NO	NAME
1	PINDI BHATTIAN
2	CHICHOKI MALLIAN
3	CHUHARKANA
4	JARANWALA
5	SHAHKOT
6	SHADMAN
7	ZAFARWAL
8	HAFIZABAD
9	KHANQAH DOGRAN
10	SANGLA HILL
11	BERAN WALA
12	HARSE SHEIKH

Conventional Signs

- BOUNDARY OF SCARP-I
- SCHEME BOUNDARY
- RIVER
- MATTLLED ROAD
- RAILWAY LINE
- TEHSIL BOUNDARY

Awan. M.N
Fig. 2
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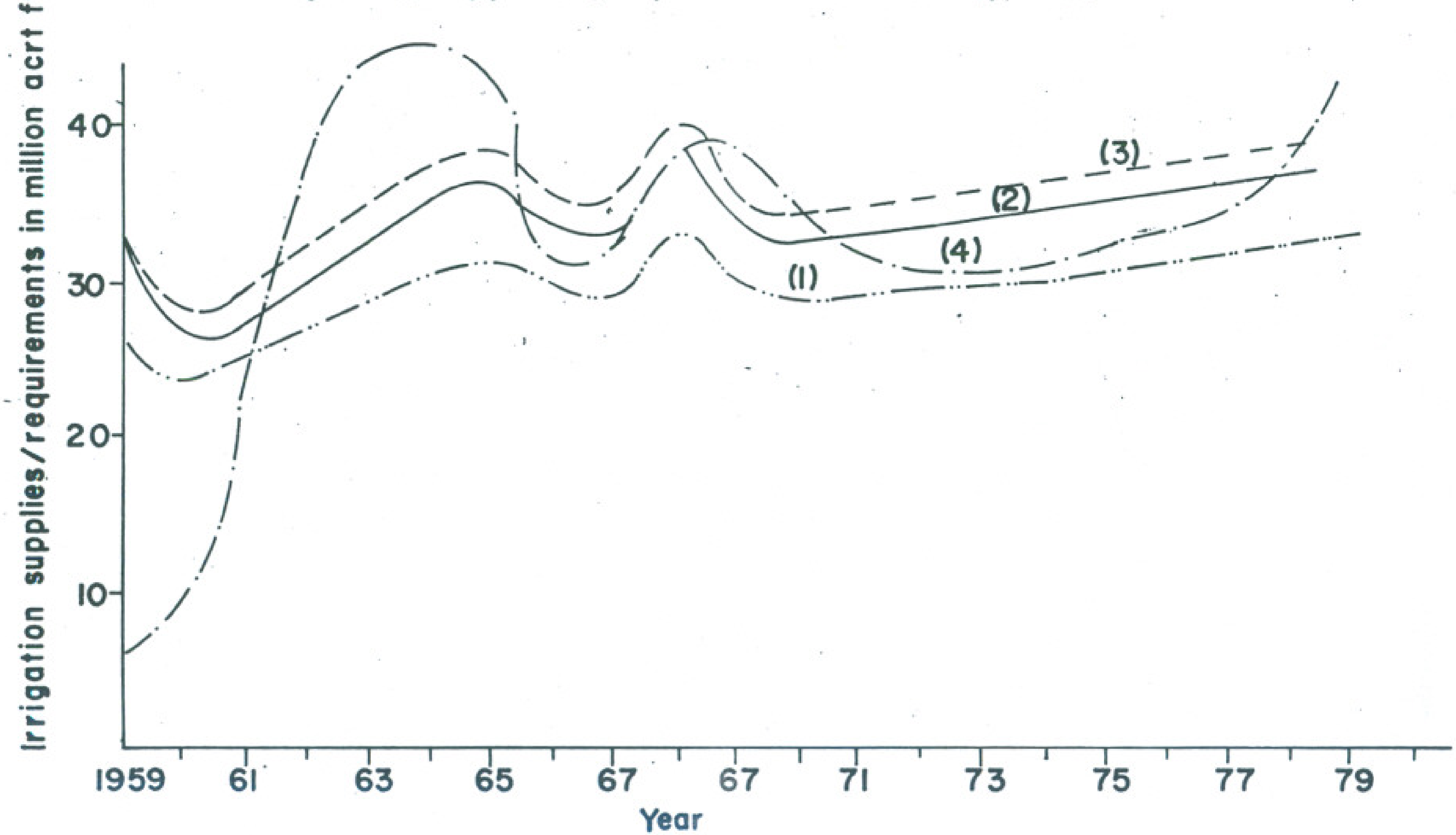
1 – Water requirement based on T & K review report (Average delta 4·8 ft.)

2 – Water requirement based on Haji Muhammad's report (1971 – 72 Average delta 5·8 ft)

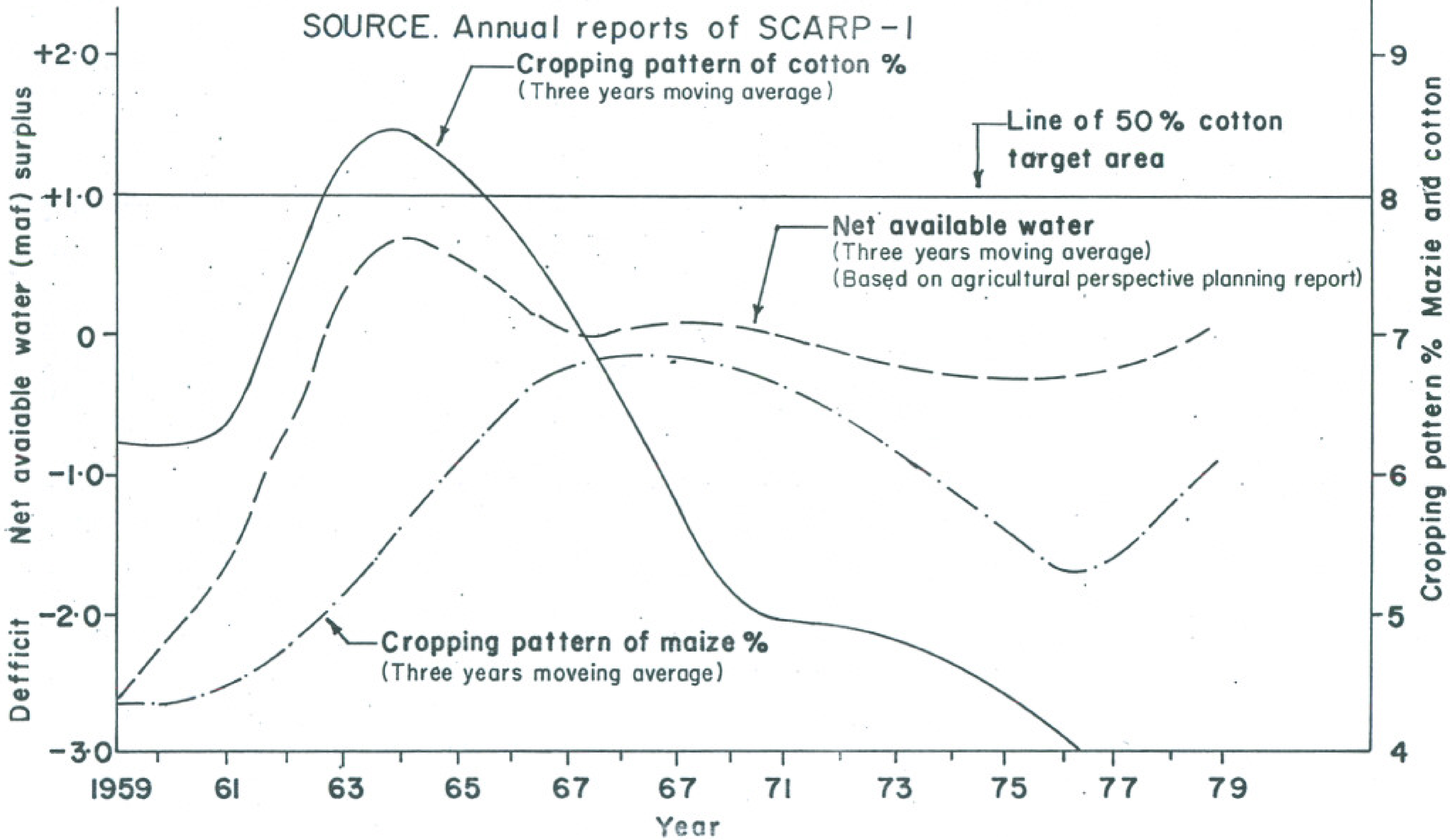
3 – Water requirement based on crop delta recommended in Agricultural perspective planning proceedings (1977 Average delta 6·6 ft)

4 – Actual irrigation supplies (Reported in annual reports)



Awan. M. N
Fig. 3
P. No 449

EFFECT OF EXCESS + OR DEFFICIT − IRRIGATION WATER ON CROPPING PATTERN OF MAIZE AND COTTON



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Awan. M. N
Fig. 4

EFFECT OF WATER DEFICIT ON COTTON YIELD (Maund /acre)

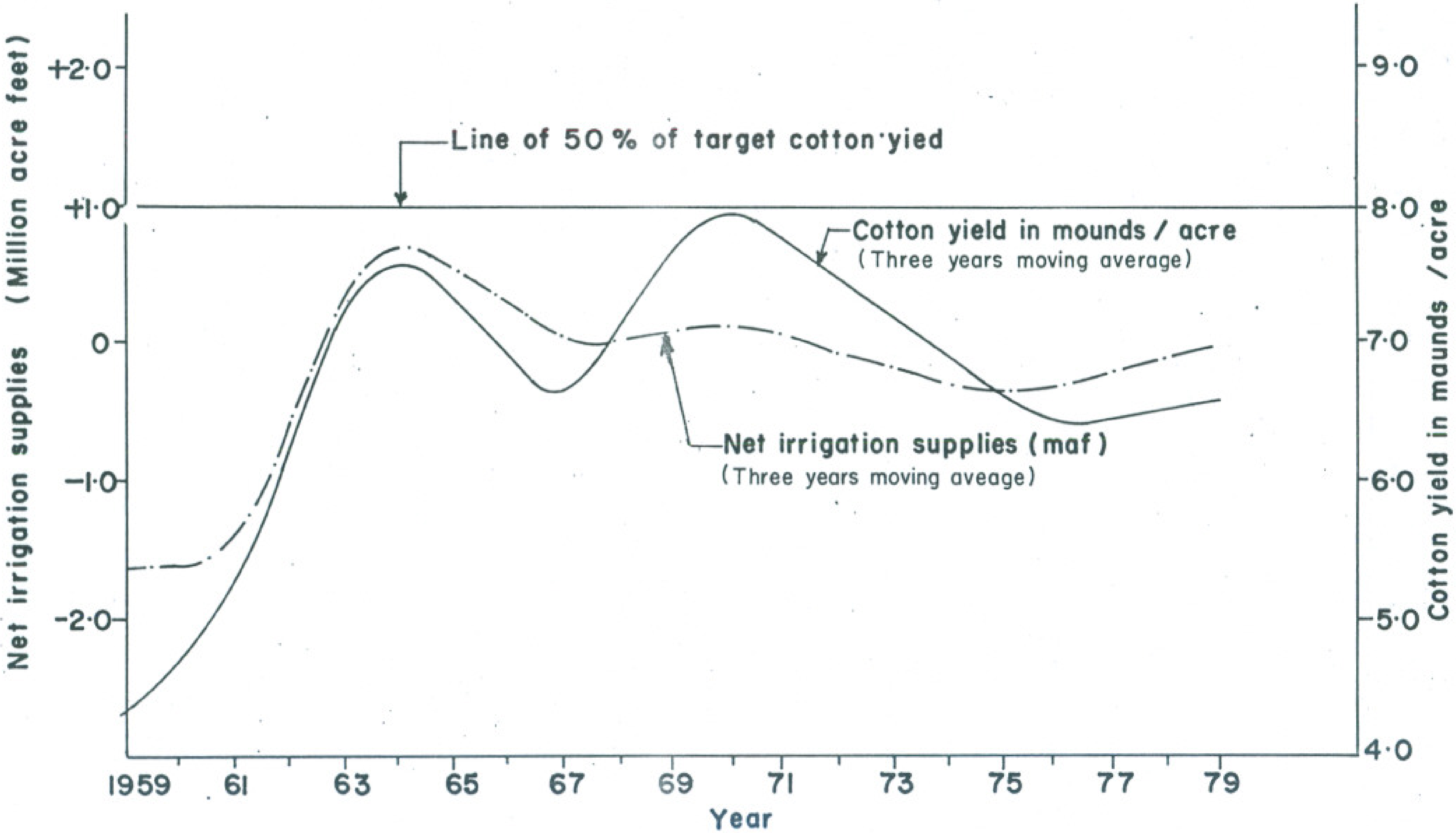

FIG. 5

AWAN N.M.

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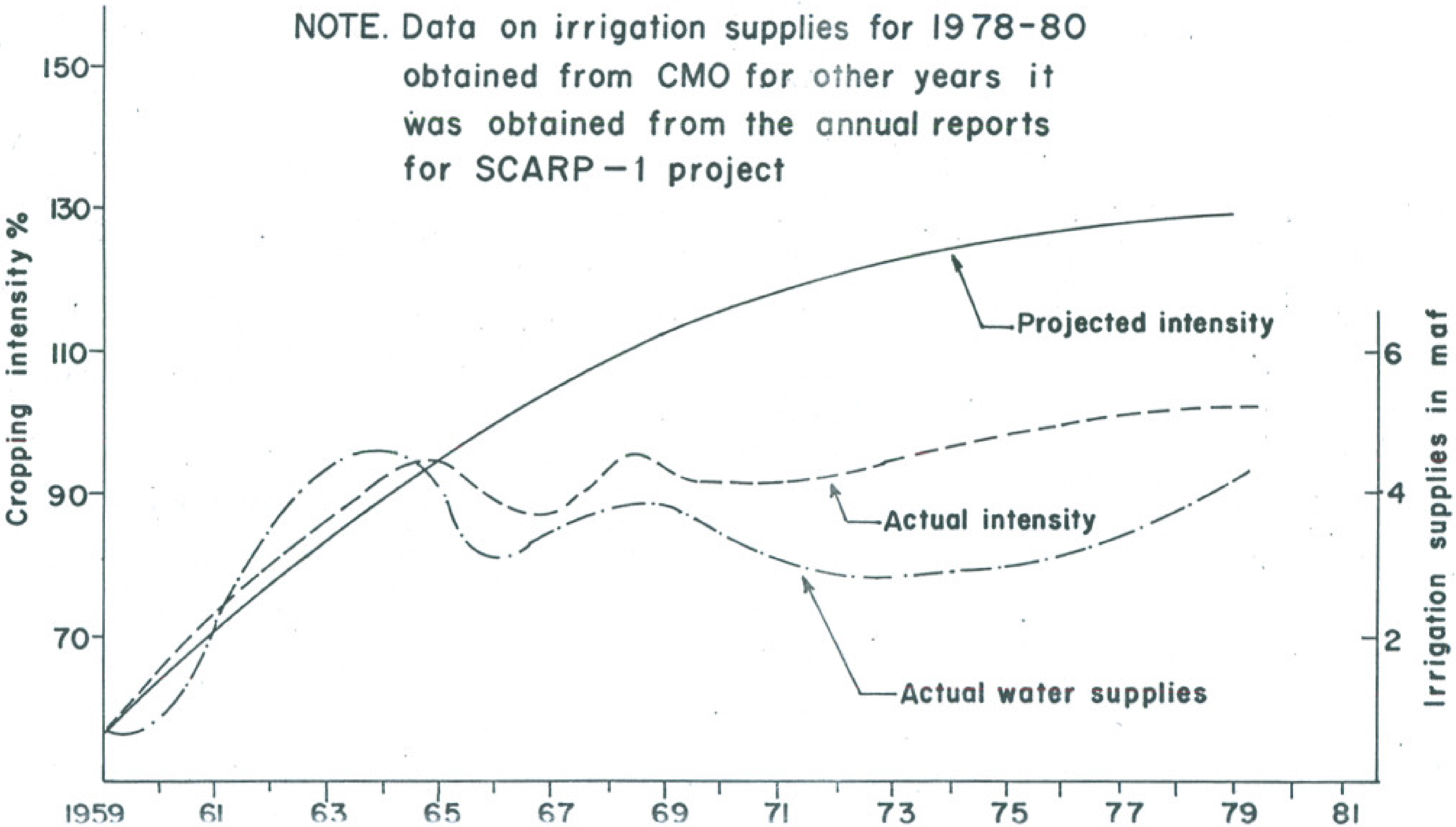
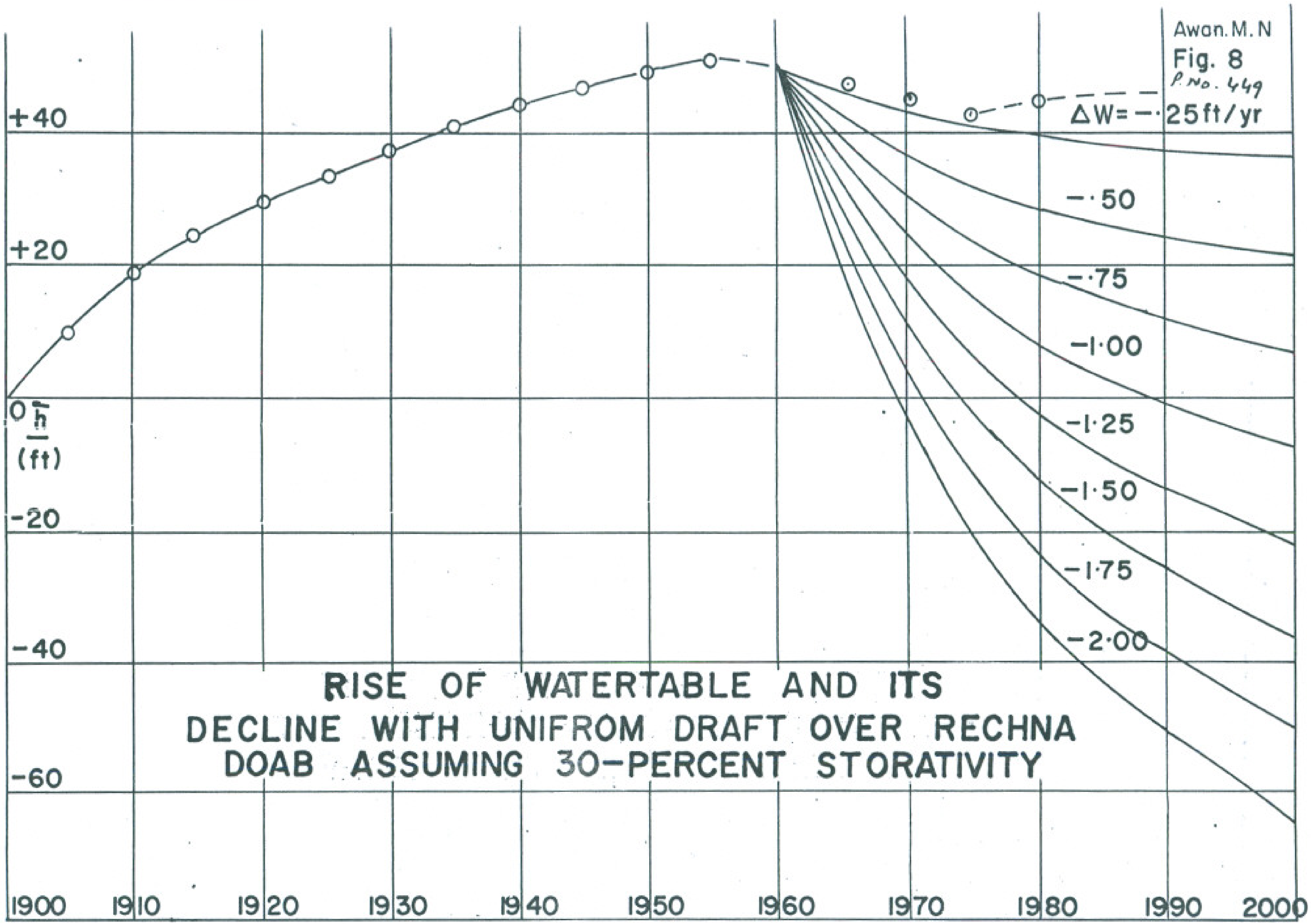
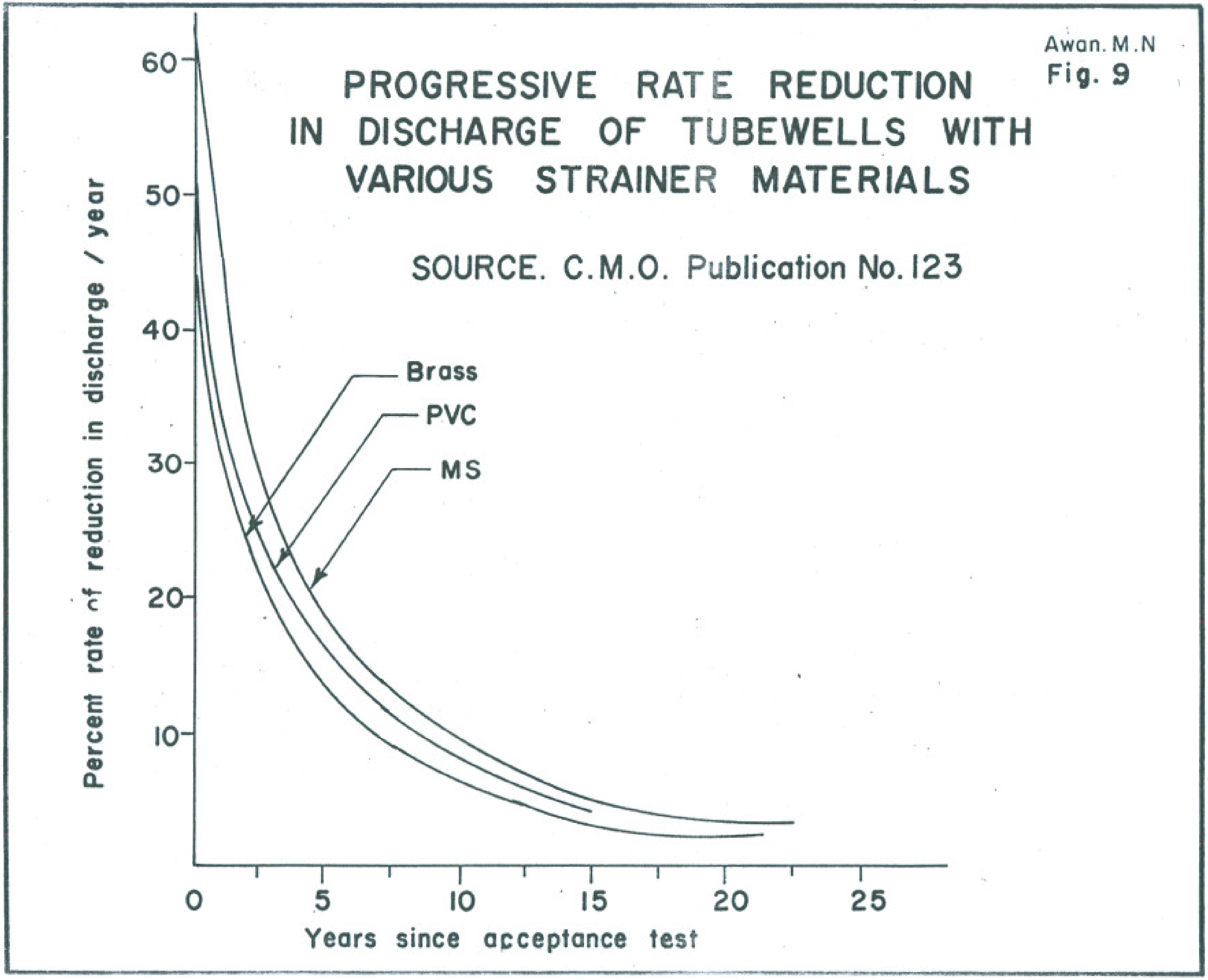
COMPARISON OF CROPPING INTENSITY WITH ACTUAL IRRIGATION SUPPLIES





RISE OF WATERTABLE AND ITS DECLINE WITH UNIFROM DRAFT OVER RECHNA DOAB ASSUMING 30-PERCENT STORATIVITY

Awan. M.N
Fig. 9


PROGRESSIVE RATE REDUCTION IN DISCHARGE OF TUBEWELLS WITH VARIOUS STRAINER MATERIALS
SOURCE. C.M.O. Publication No. 123
Brass
PVC
MS
Percent rate of reduction in discharge / year
60
50
40
30
20
10
0
5
10
15
20
25
Years since acceptance test