The Journal of Animal & Plant Sciences, 20(3), 2010, Page: 211-216
ISSN: 1018-7081

RECLAMATION OF IRRIGATED AGRICULTURE THROUGH TILE DRAINAGE AT FOURTH DRAINAGE PROJECT, FAISALABAD

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ABSTRACT

Fourth Drainage Project (FDP) has been evaluated in terms of improvement in land and groundwater conditions. The investigations revealed that drainage project was capable of controlling watertable between the pipelines at a depth of 100 to 150 cm below the ground level. There was also an improvement in shallow water quality (from *hazardous* to *usable*) due to installation of drainage system. The pre-project percentage of area under *useable* class was 23% which increased to 35% during post-project period. Where as, the area under *hazardous* class decreased from 48% to 34% during the post-project period. Surface and profile salinity levels were also improved. Salt affected area representing surface salinity level, decreased from 42% to 22% during post-project period. Non-Saline Non-Sodic (NS-NS) area representing profile salinity level, increased from 50% to 64% during the post-project period. The cropping intensity increased from 102% to 157% due to project implementation. Hence, subsurface drainage project is performing well in FDP area of Punjab province. However, the benefits of project can further be enhanced by improving O&M facilities, capacity building of staff as well as credit facilities to the farmers.

Keywords: Reclamation, irrigated agriculture, tile drainage, fourth drainage project, waterlogging, salinity

INTRODUCTION

Pakistan's economy mainly depends on irrigated agriculture. Being dominant sector of Pakistan's economy, it contributes about 24% to the country's GDP, employs 48.4% of total workforce and facilitates 70% of export revenues. Almost 68% population of Pakistan is directly or indirectly supported through this sector for their livelihood (Govt. of Pakistan, 2003). Although, the country has a history of successful irrigation, as a results of continuous development in irrigation and resulting seepage from the canal system, agricultural lands of Pakistan have suffered from the problem of waterlogging and salinity, one of the main threats to rural development in Pakistan.

In early sixty's when twin menace of waterlogging and salinity caused threat to crop production and natural environment of country, the GOP through WAPDA assigned high priority to control this problem. As such, a considerable part of past investments (~ Rs.37 billions) of the water-sector has gone to remedy the situation (Azhar *et al,* 2005). Amongst various measures, the subsurface tile drainage technology was introduced in Pakistan about three-and- a-half decades ago to control waterlogging and salinity. To-date, eight subsurface drainage projects (Fig. 1) and more than sixty Salinity Control and Reclamation Projects (SCARPs) have been completed all over the country (Bhutta, 2007). In the past, various aspects of subsurface drainage systems have been investigated (Azhar and Bhutta, 2006; Bhutta, 2007; Azhar, 2009). However, no systematic effort has been made to analyse the data of these systems in terms of performance evaluation. Considering the huge investments incurred in these projects, there was a great need to evaluate the performance of these systems and to suggest improvements for future drainage systems. In view of the foregoing facts, a study was conducted by IWASRI under the National Drainage Programme (NDP). Under this study, four subsurface drainage projects viz., Mardan SCARP (*NWFP*), Fourth Drainage, Faisalabad (*Punjab*), Chashma Command Area Development Project (*NWFP*) and Mirpurkhas Tile Drainage (*Sindh*) were assessed in terms of their effects on land and groundwater conditions in those areas. In this paper, only one site namely Fourth Drainage Project (FDP), Faisalabad has been discussed. Although site-specific, the findings of this study can be very useful for holistic approach based integrated water management improvement strategies focussed towards the poverty alleviation in Pakistan.

Description of Fourth Drainage Project (FDP) Area: The FDP is located in the south western part of Rechna Doab. It covers parts of Faisalabad, Jaranwala and Samundri tehsils of Faisalabad District. It was constructed by WAPDA during 1983-94 to control the waterlogging and salinity in about 0.35 million acres of land. The system was designed to maintain the watertable at an average depth of 122cm (4ft) below the ground surface. The construction plan of the FDP comprised of two units called Schedule-I and Schedule-II consisting of

38 and 41 sumps respectively for disposal of effluent. WAPDA maintained the subsurface drainage component of FDP for 2-3 years, after which the project was handed over to Punjab Irrigation & Power Department (PID).

Data Collection and Analysis: The major aim of drainage system installation is reclamation of waterlogged and saline lands. As the improvements take place in watertable and salinity conditions, the yields are expected to increase. In order to evaluate the performance of pipe drainage system in FDP area, four performance indicators namely: watertable fluctuations, groundwater quality, soil (surface & profile) salinity and cropping intensity were studied. For this purpose, relevant data were collected from various sources such as WAPDA, Provincial Irrigation & Power Departments, Agricultural Departments, and farmers' interviews. The required data were collected for three stages i.e. *before*, *during*, and *after* the installation of drainage system. The collected data were first screened for its integrity, and then processed/analysed in various ways to evaluate the performance of drainage project based on above stated performance indicators.

RESULTS AND DISCUSSION

In this section, the analysis of four performance indicators namely: i) watertable fluctuations, ii) groundwater quality, iii) soil (surface & profile) salinity, and iv) cropping intensity are discussed.

Watertable (WT) Appraisal: The construction period of FDP was mid-1983 to mid-1994. In this area, the watertable depths surveyed during 1984 (Bench Mark) year were at 0-150cm in 71%, 150-300cm in 28%, and >300cm in 1% of the area respectively (Azhar *et al.*, 2004). The percentage of gross area of FDP under different ranges of depths to watertable during the years 1976 to 2000 is graphically shown in Fig. 2. The need for drainage is clearly demonstrated from the depth to watertable over time given in this figure. The advance of high watertables between 1976 and 1981 is evident, while the area with watertables <150cm (5 ft) deep remains nearly constant between post-monsoon 1981 and pre-monsoon 1983. In comparison, the situation in post-monsoon 1992 is less serious, but still points out the need for subsurface drainage in areas where construction had not been completed. *Pre* (year 1984) and *post-project* (year 2000) watertable depth maps of FDP area are shown in Fig. 3. The design watertable depth of FDP was 122 cm (4 ft). A comparison of percentage of pipe drainage area within disaster (0-150 cm) limits for the period 1995-2000 viz. 1984 (i.e. pre-project) year is graphically presented in Fig. 4. It can be observed form this figure, during this period with the exception of year 1997, percentage of disaster area gradually reduced and ultimately became zero in the year 2000.

The land under disaster watertable went up to 70.60% in post-monsoon 1997 when the project was already completed and sumps were working partially. After that, the ground water level rapidly started falling and disaster area disappeared during 2000. The mound of ground water was developed due to extraordinary (807 mm) rains in the area during 1997. However, as can be observed (Fig. 4), this mound of groundwater also dissipated with time. This was mainly coupled with groundwater travelling along natural slope towards south-west, low canal supplies during 1997-2000, and rise in temperature in the district Faisalabad (WAPDA, 2001). Hence, the groundwater level has been observed going down during the three years 1998–2000, and as such the disaster area totally disappeared during the year 2000. The matter of fact is that the system did not operate fully as designed (WAPDA, *2001*). In spite of this fact, the %age of area under disaster limit became zero in year 2000. This is because, as previously reported too (Iqbal *et al,* 1997) that the watertable response to pipe drainage in most of the FDP area had indicated that the capacity of installed drainage system was higher than actual requirements. The above discussion revealed that at FDP the lowering of groundwater table cannot be attributed only to the functioning of drainage system, as it could never operate fully. The maximum pumpage was done during 1995, which was 22% of the total installed capacity of sumps. Afterwards, the withdrawal by sumps went on decreasing every year and reduced to 3.90% during 2000. Since natural forces are at the back of disappearance of waterlogging, as such it is very difficult to evaluate the performance and efficiency of this system.

Groundwater Quality: Generally, the shallow (up to 30m) groundwater quality is classified into three categories namely *usable*, *marginal* and *hazardous* as adopted by WAPDA (Vlotman *et al,* 1994). Based on this categorisation, the analysis summary of water quality status observed at FDP during various years is graphically presented in Fig. 5. The shallow water quality status presented in this figure revealed that there was a clear trend in the data indicating improvement of the water qualities at FDP.

As shown in Fig. 6, the percentage of area under hazardous water quality class reduced from 48% in pre-project (1985) year to 34% during the post-project year (2000). Similarly, the percentage of area under usable water quality class increased from 23% in pre-project year to 35% during the post-project year. This shows an improvement in shallow groundwater quality from hazardous to usable, as compared with the pre-project conditions. Hence, this aspect indicates positive impact of pipe drainage installation in terms of groundwater quality improvements.

SOIL SALINITY

(i) Surface salinity: In order to describe the surface salinity status, four salinity classes namely: Salt Free (S1), Slightly Salt-affected (S2), Moderately Salt-affected (S3), and Strongly Salt-affected (S4) have been recognized (*WAPDA, 2001*). The details of each of these classes are given in Azhar et al., 2004. Based on these salinity classes, the summary of surface salinity status observed at FDP during 1984 (Bench Mark), 1986-87, 1990-91 and 2000-01 survey is given in Table 1.

Table 1. Surface salinity status during various surveys at FDP (% of area)

Survey Period	Salt Free (S1)	Slightly Saline (S2)	Moderately Saline (S3)	Strongly Saline (S4)	Misc. Land Type
1984 (B.M)	56	23	10	9	2
1986-87	53	24	10	10	3
1990-91	69	8	8	9	6
2000-01	73	8	9	5	5

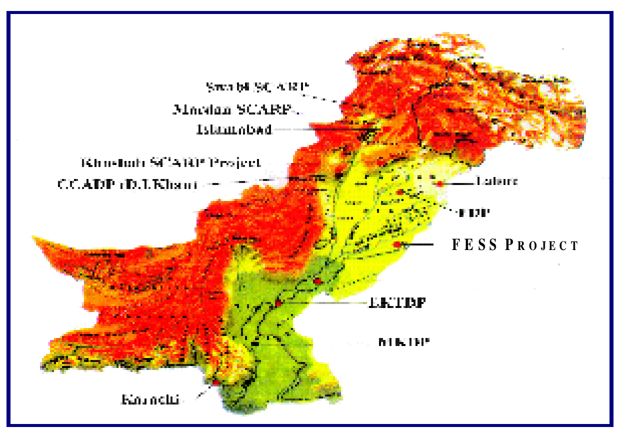
As shown in the latest survey (year 2000), a significant improvement has taken place for salt-free (S1) area over the bench mark (1984) year. It can be observed that during the pre-project year (1984) over to the post-project year 2000, the salt free (S1) area increased from 56% to 73% with a net increase of 17%, whereas the salt affected (S2, S3 & S4) area decreased from 42% to 22% indicating a net decrease of 20%. This improvement can mainly be attributed to the leaching of salts below 180 cm depth due to the lowering of water table resulting from the installation of subsurface drainage system in addition to the application of irrigation water and rains. This aspect also indicates a positive impact of subsurface pipe drainage system installation in the FDP area. A slight decrease of 3% in salt-free (S1) area during 1986-87 year over 1984 pre-project (Bench Mark) year may be attributed to the inherent-complexities associated with the transitional-stage of installation of drainage system at FDP area.

(ii) Profile salinity: The profile salinity survey was carried out to determine the magnitude of hazard in the soil profile. For this purpose, the soil samples were air dried and analysed for Electrical Conductance (ECe), and Sodium Adsorption Ratio (SAR). Under this head, as per the criteria laid down in USDA Hand Book 60, the soils are classified under four classes namely: *Non-Saline Non-Sodic* (NS-NS), *Saline Non-Sodic* (S-NS), *Saline Sodic* (S-S) and *Non-Saline Sodic* (NS-S) The details of each of these classes are given in *Azhar et al.*, 2004. Based on these salinity classes, the summary of profile salinity status at FDP during various surveys is given in Table 2. As can be observed, NS-NS area showed a significant improvement. The area under this class was 50% during the pre-project (1984) year which increased to 64% during post-project (2001) year, thus showing a net increase of 14% over the bench mark (1984) year. Similarly, the improvement in S-S profile was of the order of 8% and in NS-S profile was 5%. Hence, it indicates the positive impact of pipe drainage system in terms of profile salinity control in FDP area.

Table 2. Profile salinity status for various surveys at FDP (% of area)

Survey Period	Non-Saline Non-Sodic (NS-NS)	Saline Non-Sodic (S-NS)	Saline Sodic (S-S)	Non Saline Sodic (NS-S)
1984 (B.M)	50	4	38	8
1986-87	47	9	37	7
1990-91	61	5	30	4
2000-01	64	2	31	3

Cropping Intensity: As reported by *WAPDA* (2001), in the pre-project (1986-87) year, annual cropping intensity was 144% (Kharif 58.3%, Rabi 85.7%). The overall cropping intensity was envisaged not likely to decrease. Cropping intensities have rather gone-up to 164% during post-project (1999-00) year despite the fact that water shortage became more acute due to below normal rains during the years 1998-2000. It was reported that shortage of crop water requirement was made up with the help of pumpage from private tubewells installed in the area. The year-wise cropping intensities of FDP are graphically shown in Fig. 7.

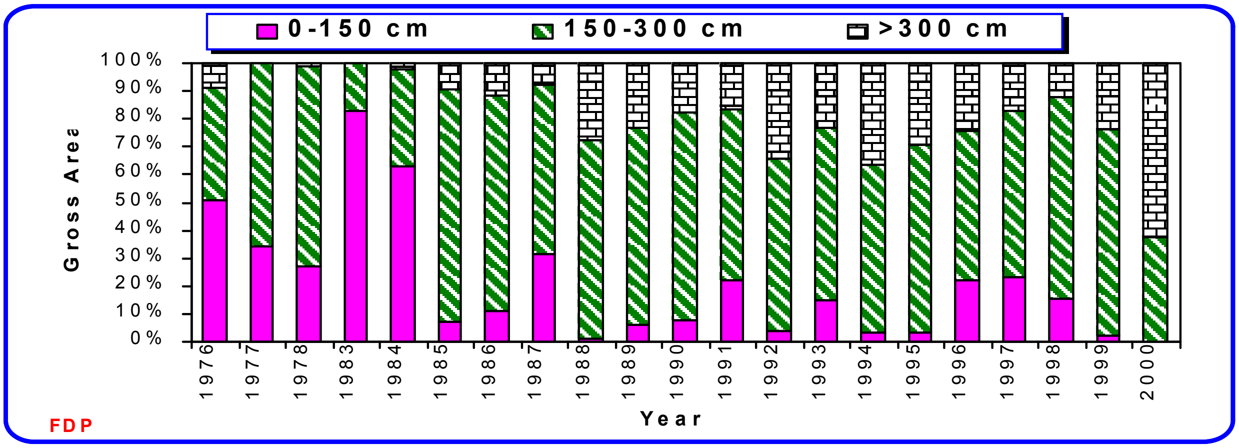


FDP Fourth Drainage Project, Faisalabad
FESS Fordwah Easter Sadiqia South
EKTDP East Khairpur Tile Drainage Project
MKDP Mirpurkhas Tile Drainage Project
CCADP Chashma Command Area Dev. Project

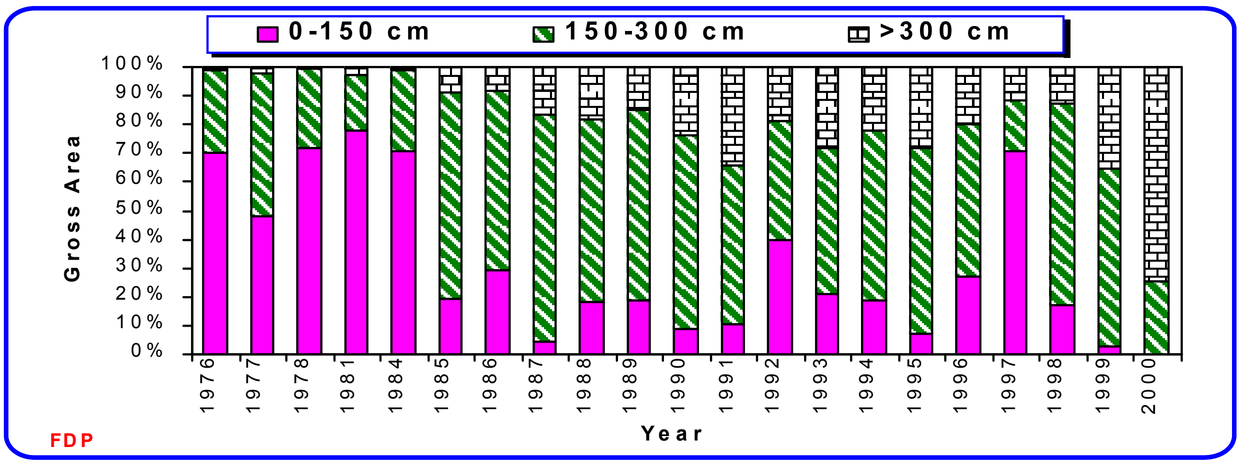
Fig. 1 Location map of drainage projects in Pakistan

Based on the farmer's interviews, pre (1986-87) and post-project (2003-04 year) cropping intensities at

FDP are shown in Fig. 8. An increase of 55% in total cropping intensity is clearly shown in this figure as compared with pre-project conditions. Thus the cropping intensity parameter also signifies the positive impact of pipe drainage installation in FDP area.

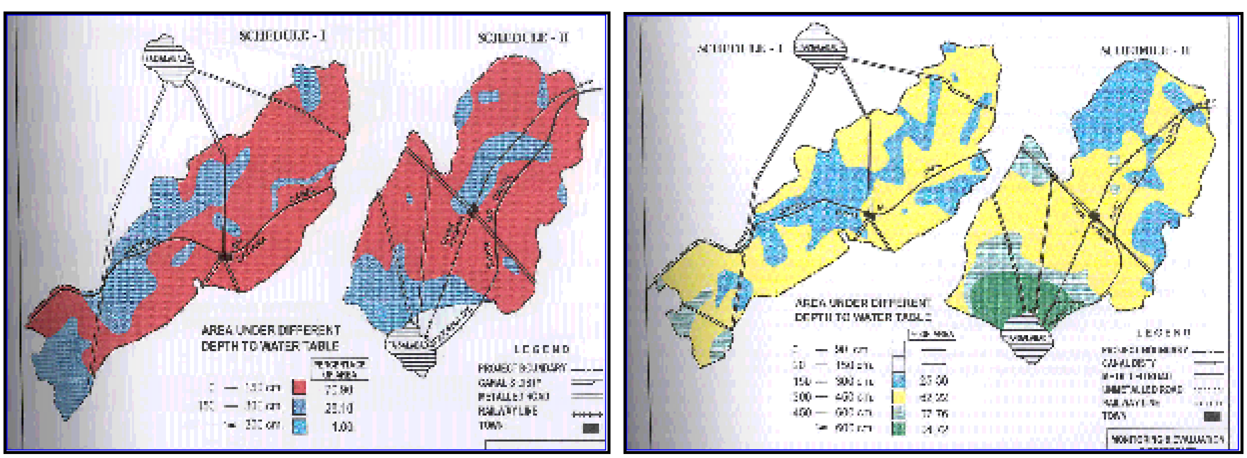


(a) Pre-Monsoon



(b) Post-Monsoon

Fig. 2 Percentage of area under various WT depths at FDP



(a) Pre-project (1984) *(b) Post-project (2000)*

Fig. 3 Watertable depth map of FDP area (WAPDA, 2001)

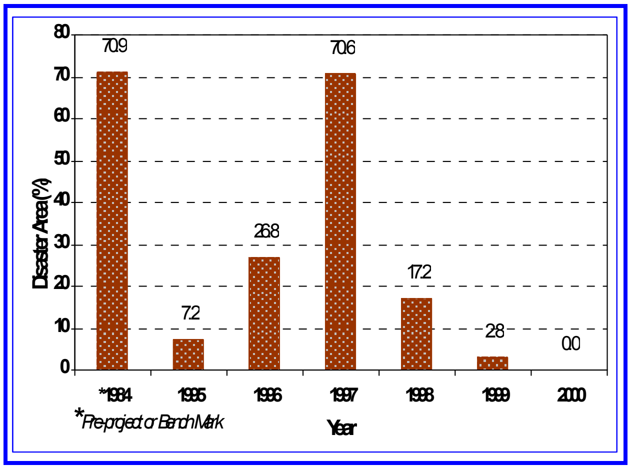


Fig. 4 **Subsurface drainage area within disaster (0-150 cm) limits at FDP**

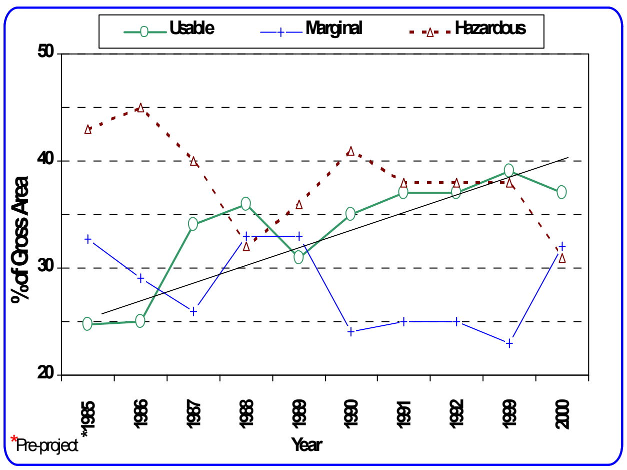
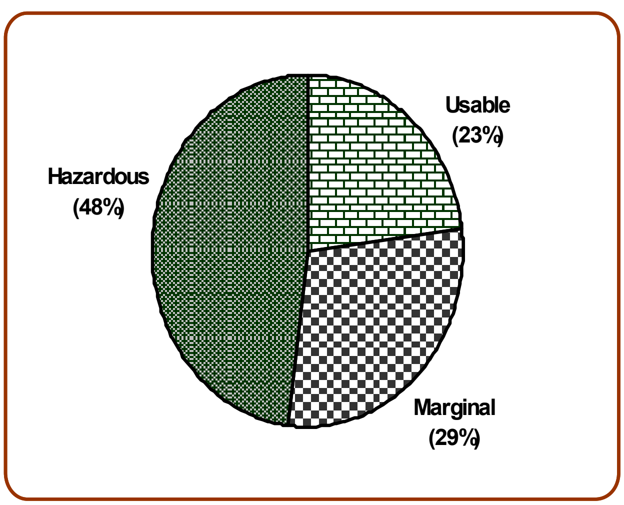
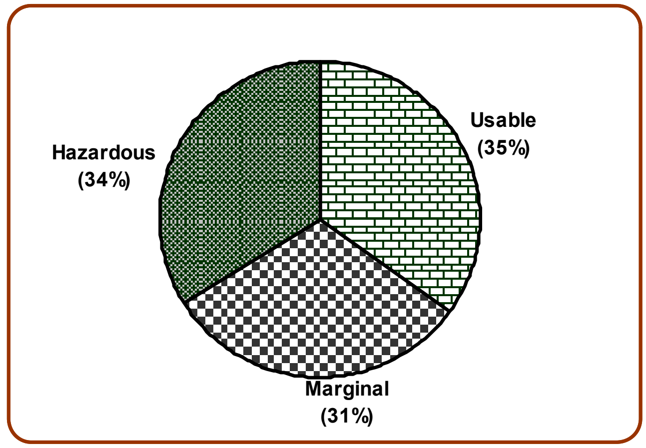


Fig. 5 **Year-wise pattern of shallow water quality at FDP**



(a) Pre-project (1985)



(b) Post-project (2000)

Fig. 6 **Comparison of shallow water quality at FDP**

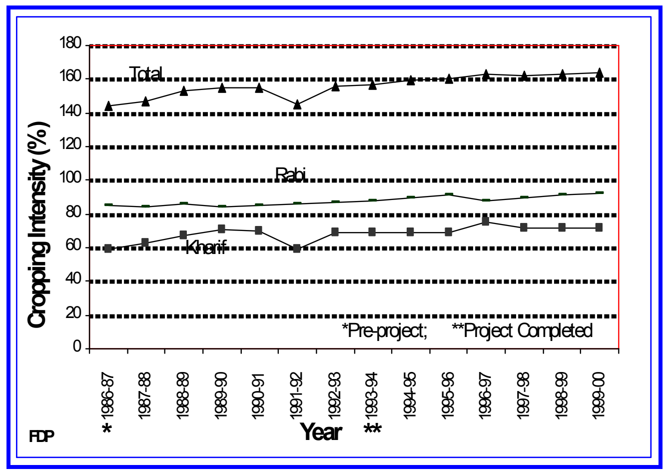


Fig. 7 **Cropping intensities during 1986-87 to 1999-00 at FDP**

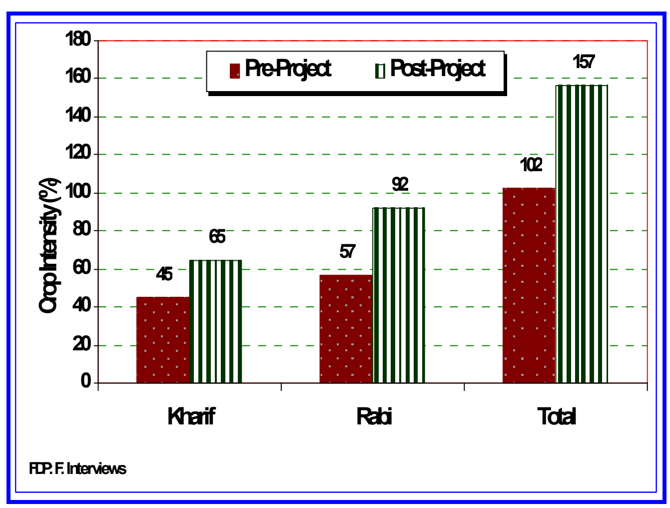


Fig. 8 **Pre & Post-project cropping intensities at FDP**

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- In comparison with the pre-project conditions, the remarkable decrease in the disaster area during post-project (year 2000) signifies that the pipe drainage project at FDP was capable of controlling the watertable in the area.
- The groundwater quality status analysis revealed that there was an improvement in shallow water quality (from hazardous to usable) due to installation of drainage system. The pre-project percentage of area under *useable* class was 23% which increased to 35% during post-project year. Similarly, the pre-project percentage of area under *hazardous* class was 48% which reduced to 34% during post-project year. This shows a positive impact of the project installation in the area.
- The results of surface salinity and profile salinity revealed that both type of salinities were significantly decreased. The decrease in surface and profile salinities was of the order of 17% and 20% respectively when compared with pre-project (year 1984), thus showing improvement in the salinity/sodicity status of the project soils. This indicates positive impact of pipe drainage system installation in the FDP area.
- The analysis of cropping intensity data (collected through farmer's interviews) revealed that project implementation resulted in an increase of annual cropping intensity from 102% during pre-project to 157% during post-project (2003-04) year with a net increase of 55%.

RECOMMENDATIONS

- Operation & maintenance (O&M) of pipe drainage systems demands careful and concrete measures to maintain the efficiency of these systems. Farmers' awareness regarding the need to contribute to the O&M cost of drainage systems should be encouraged. This will help in developing a sense of ownership of drainage systems for long-term sustainability.
- The agriculture extension services should be strengthened in the drainage areas, to educate the farmers regarding their feedback about the installation and operation of pipe drainage systems.

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