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SUBSURFACE DRAINAGE IMPACTS ON CROPPING INTENSITY IN PAKISTAN

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ABSTRACT

Four subsurface tile drainage projects namely; Mardan SCARP Project (MSP), Fourth Drainage Project, Faisalabad (FDP), Chashma Command Area Development Project (CCADP) and Mirpurkhas Tile Drainage Project (MKDP) have been assessed in terms of their impacts on improvement of cropping intensity. The investigations revealed that total cropping intensities (CI) have been improved ranging from 19% (MKDP) to 67% (CCADP) as compared to the pre-project conditions. At MSP, the target value of CI (180%) was not only achieved but also showed an extra upward trend up to 230%. Similarly, at CCADP an upward trend of 162% was observed against the target value of 150%. The four study sites in terms of percent improvement in total CI in the order from maximum to minimum were ranked as: CCADP (67%) > FDP (54%) >MSP (40%) >MKDP (19%), indicating how various project sites were benefited from the drainage activity in those areas. The main reasons for slow benefits at study sites were the limited financial resources available with farmers to reclaim/restore the fertility of waste lands, and shortage of irrigation supplies during the post-construction period to leach down the excess salts. This aspect revealed that efforts put to alleviate the problems of waterlogging & salinity through implementation of tile (pipe) drainage systems had not been up to the expectations mainly due to other associated problems. However, the overall quantitative comparison did indicate the positive impact of tile drainage systems in terms of improving the CI at all study sites.

Key words: subsurface drainage, impact, crop intensity, waterlogging, salinity, irrigation.

INTRODUCTION

Pakistan's economy is mainly dependent on agriculture. More than 68% population of Pakistan is directly or indirectly supported through this sector. Almost 80% of the agricultural production comes from irrigated agriculture and the remaining 20% from the uncommanded rain fed areas (Chaudhry *et al*., 2002; Azhar *et al*., 2004a). After the advent of canal irrigation without adequate drainage facilities, agricultural lands of Pakistan have suffered from the twin menace of waterlogging and salinity. In early sixty's when this situation caused threat to crop production and natural environment of country, the GOP put a great emphasis to control this problem. Till the year 2003, the GOP has made tremendous efforts to mitigate the impact of waterlogging and salinity.

The subsurface pipe (tile) drainage technology was introduced in Pakistan about three decades ago to control waterlogging and salinity. As of end of year 2000, eight drainage projects have been completed in various provinces of the Pakistan. However, no systematic effort has been made to analyse the data of these systems in terms of *"improvement evaluation"*. Keeping in view the huge investments incurred and the benefits attached with those projects, there was a great need to evaluate the performance of those systems and to suggest improvements for future drainage systems. As such, a study was conducted by the International Waterlogging & Salinity Research Institute (IWASRI) under National Drainage Programme (NDP). Under this study, four subsurface tile drainage projects namely; Mardan SCARP Project (MSP), Fourth Drainage Project, Faisalabad (FDP), Chashma Command Area Development Project (CCADP) and Mirpurkhas Tile Drainage Project (MKDP) were assessed in terms of their impact on improvement of irrigated agriculture conditions. For this purpose, various performance indicators were investigated. Previous studies (Azhar, 2010; Azhar et. al., 2010 a & b) discussed other performance indicators; however, in this paper the analysis of performance indicator viz. *cropping intensity* has been presented.

Description of Study Area: In Pakistan, as of end of year 2000 eight tile drainage projects have been installed. However, for this study only four sites viz. MSP (NWFP), FDP (Punjab), CCADP (NWFP) and MKDP (Sindh) have been selected. These project sites have been selected based on their wide range of geohydrological and climatic conditions. In addition, these sites cover a range of old as well as most recently installed pipe drainage systems in different provinces of Pakistan. This range of selection would facilitate to evaluate the performance of pipe drainage systems that were designed using old and new technology. The salient features of four selected project sites are shown in Table-1. (For details of these project-sites, see Azhar *et al*., 2004b).

Table- 1 Salient Features of Selected Pipe Drainage Projects

DESCRIPTION	MSP	FDP	CCADP	MKDP
Gross area	50,020 ha	52,609 ha.	63,509 ha	-
Tile drainage area	29,542 ha	30,351 ha.	60,936 ha	24,281 ha
Installation. Period	1983–92	1988–94	1984-94	1994–97
Mean annual rainfall	542 mm	356 mm	250 mm	150 mm
Design WT depth	140 cm	122 cm	140 cm	122 cm
Target Crop. intensity	180%	-	150%	-
Executive agency	WAPDA	WAPDA	WAPDA	WAPDA
Consultancy	Harza NESPAK	USBR	Harza NESPAK	Mott. Macdonald
No. of units/sumps	385	79	65	52
Area per unit/sump	100-300 ac	900-1000 ac	400-900 ac	-
Type of outlet	Gravity	Pumped	Pumped	Pumped
Total costs (PC-I)	Rs 673x10^6 (1981)	Rs 1127x10^6 (1988)	Rs 1127.800 million	Rs 2473 million

(After Azhar et al., 2004b)

METHODOLOGY

As stated earlier, in this study only one impact/performance indicator namely cropping intensity has been analysed. For this analysis, relevant data were collected from various sources such as WAPDA, Provincial Irrigation & Power Department and through farmers' interviews conducted by IWASRI staff. 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 their integrity, and then analysed in various ways to assess the success of drainage projects based on above stated performance indicator. In this study, for quantitative comparison between pre & post-project conditions, the numerical value of above impact indicator (hereafter referred to as *impact parameter*) has been used. Hence, the *impact parameter* used was the targeted value of that impact indicator, if specified/documented for particular site (e.g. targeted cropping intensity). In case, the targeted value was not documented, the pre-project value of that impact indicator was used as the *base value.*

RESULTS AND DISCUSSION

In general, the cropping intensity is expected to increase with the installation of pipe drainage system. With regards to the *cropping intensity parameter*, it is worth mentioning that for quantitative comparison no targeted value of this impact indicator was available for FDP and MKDP study sites. For MSP and CCADP study sites, the post-project targeted value of total cropping intensity parameter was 180% (Smedema *et al*., 1990) and 150% (Harza, 1995). Hence, at FDP & MKDP the quantitative comparison was made based on the change in pre and post-project conditions at respective project site. The impact on cropping intensities of four study sites is discussed as below:

MSP Area: The year-wise cropping intensities of MSP area for the period 1979 to 2003 as available from the Provincial Irrigation & Power Department (PID) are graphically shown in Figure 1. In this figure, following the implementation of drainage system (i.e. 1991-92 year), a progressive increase in overall total cropping intensity is clearly shown as compared with the pre-project (i.e. 1981-82 year) conditions.

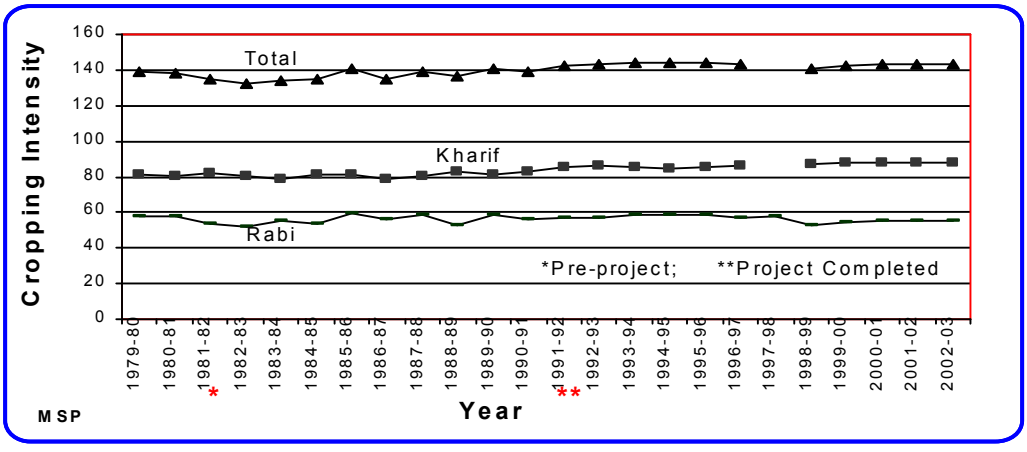


Fig. 1 Cropping intensities during 1979-80 to 2002-03 at MSP

As can be observed, based on PID data the total cropping intensity during pre-project (1981-82) year was 135%, which increased to 143% during the post-project (2002-03) year, showing a net increase of 8%. It is notable that in Figure 1, the increase is not significant; however, the information obtained through farmers' interviews by the IWASRI staff showed a significant increase in the cropping intensity of this area as compared with the pre-project conditions. Based on farmer's interviews pre & post-project cropping intensities at MSP are shown in Fig. 2. An increase of 66% in total cropping intensity (i.e. from 164% to 230%) is clearly shown in Figure 2. It is important to note that there exists significant difference between the cropping intensity data supplied by PID and that obtained through farmers' interviews. The main reason for this variation can be attributed to the fact that the PID data was basically collected by the *Patwaries* which was generally biased/manipulated by the influential farmers as well as by the *Patwaries* for 'abiana' (water charges) theft leading to underestimated cropping intensity information. Nevertheless, the farmers'-interview based data was more realistic/reliable, and therefore, in present study was given more importance than PID data values.

For quantitative comparison of total cropping intensity at MSP area, the post-project targeted value of 180% was documented (Smedema *et al*., 1990). Hence, at this site the quantitative comparison was made based on the change in pre & post-project conditions as well as against the target value of 180%. Based on the above analysis of data, the comparison of pre & post project conditions revealed that there was a simple increase of 66% (i.e. 230-164) in total cropping intensity of this area. Also, the achieved post-project value of 230% was greater than the target value of 180%. This showed the positive impact of drainage system installation in terms of cropping intensity improvement at MSP area.

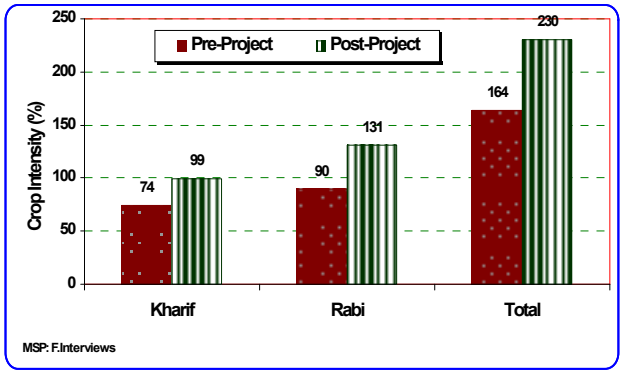


Figure 2Pre and Post-Project Cropping Intensities at MSP

FDP Area: The year-wise cropping intensities of FDP area as available from PID for the period of 1986 to 2000 are graphically shown in Figure 3. As can be observed, during pre-project (1986-87) year, annual cropping intensity was 144% (Kharif 59%, Rabi 85%). For this area, the overall cropping intensity was envisaged not likely to decrease (WAPDA, 2001). Figure 3 revealed that cropping intensities have gone-up to 164% during post-project (1999-00) year (showing a net increase of 20%), despite the fact that water shortage became more acute due to below normal rains during the years 1998-2000 as reported in WAPDA (2001). It was reported that shortage of crop water requirement was made up with the help of pumpage from private tubewells installed in that area.

Based on the farmer's interviews, pre and post-project (i.e. 2003-04 year) cropping intensities at FDP are graphically shown in Figure 4. An increase of 55% in total cropping intensity (i.e. from 102% to 157%) is clearly indicated in Figure 4. Again the variation in PID and farmers'-interview based data (although less influenced) at this site can also be attributed to the same fact as described for the MSP area.

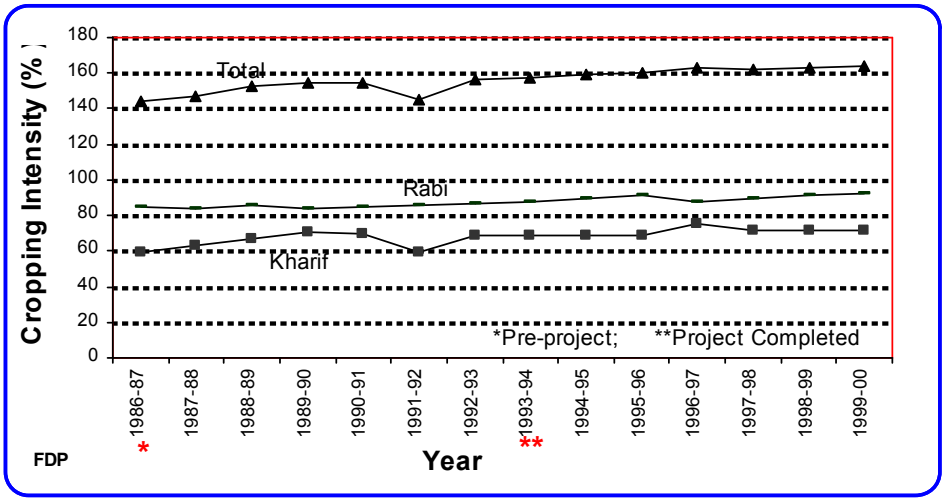


Figure 3Cropping Intensities during 1986-87 to 1999-00 at FDP

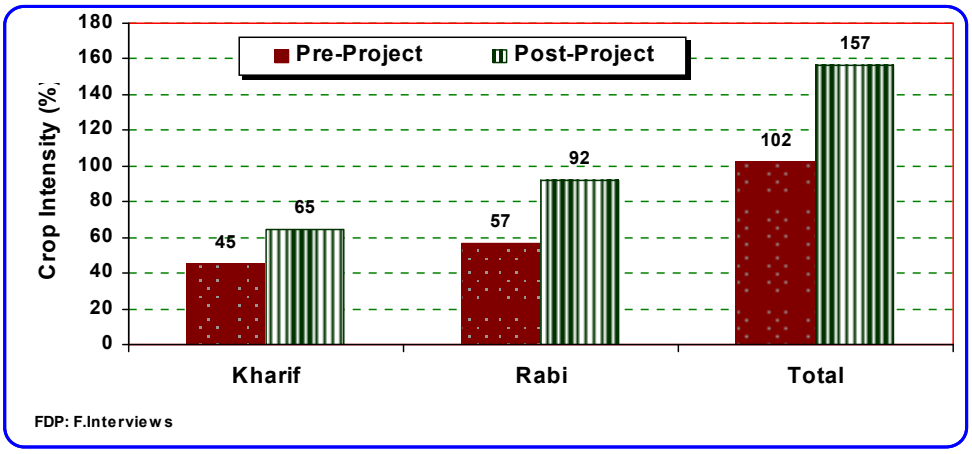


Figure 4Pre and Post-Project Cropping Intensities at FDP

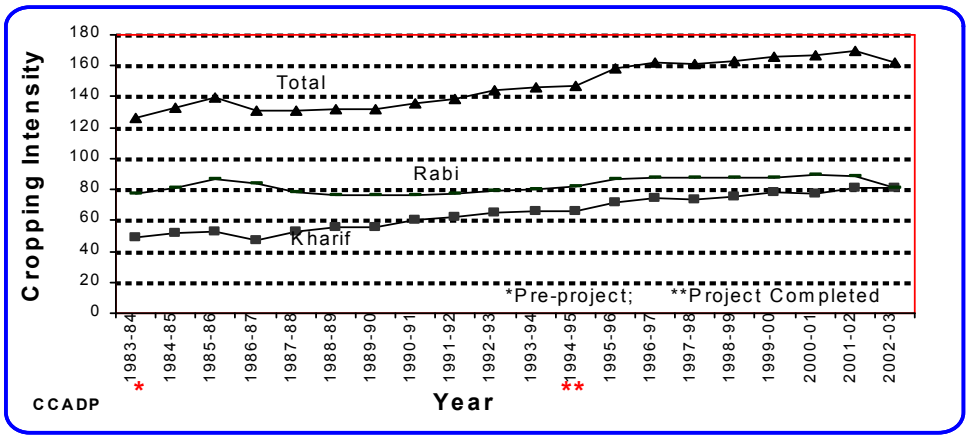


Figure 5Cropping Intensities during 1983-84 to 2002-03 at CCADP

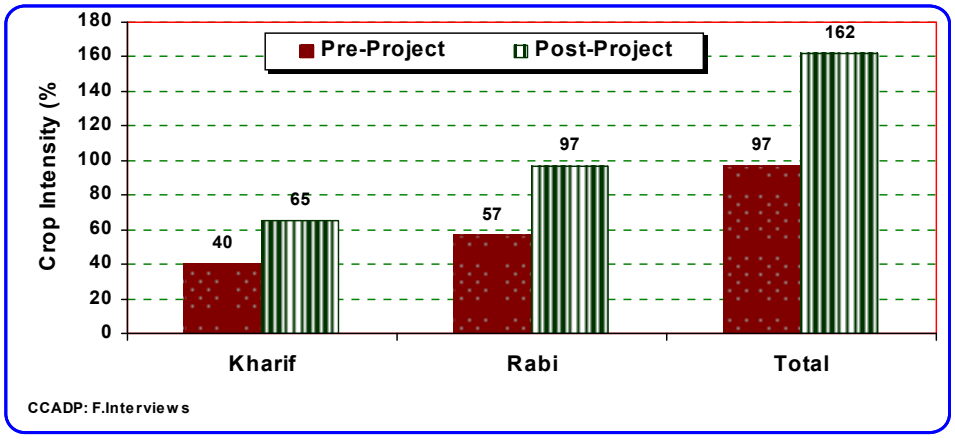


Figure 6Pre and Post-Project Cropping Intensities at CCADP

CCADP Area: The year-wise cropping intensities as available from the provincial Irrigation & Power Department of CCADP area are graphically shown in Figure 5. As stated earlier, the target cro*pping intensity* for CCADP was 150%. In Figure 5, following the implementation of drainage system (i.e. 1994-95 year), a progressive increase in total cropping intensity is clearly shown as compared with the pre-project (i.e. 1983-84 year) conditions. It can be observed, the total cropping intensity during pre-project (1983) year was 126%, which increased to 162% during the post-project (2003) year, showing a net increase of 36%. A slight decrease from

170% (during 2001-02) to 162% (during 2002-03) was mainly due to the shortage of irrigation supplies in the area, as told by the farmers. However, as compared with the targeted cropping intensity value of 150%, the total cropping intensity of 162% during post-project (2003) year, clearly shows that the target was achieved. Based on farmer's interviews pre & post-project cropping intensities at CCADP are shown in Figure 6. An increase of 65% in total cropping intensity (i.e. from 97% to 162%) is clearly shown in Figure 6. The reason for variation in PID and farmers'-interview based data is already explained in previous sections.

MKDP Area: Based on farmer's interview at MKDP, it was revealed that during the pre-project (i.e. 1993-94) year, annual cropping intensity was 128% (Kharif 64%, Rabi 64%). The overall cropping intensity was envisaged to increase, which was achieved (Kharif 76%, Rabi 76%, Total 152%) during the post project (i.e. 2002-03) year despite the fact that water shortage became more acute due to below normal rains during these year due to drought period. The pre and post-project cropping intensities at MKDP are graphically shown in Figure 7. An increase of 23% in total cropping intensity is clearly shown in this figure.

Overall Comparison: For quantitative comparison no target value of this impact indicator was available for FDP & MKDP study sites. For CCADP & MSP sites, the target value was documented as 150% and 180%. Hence, at FDP & MKDP the quantitative comparison was made based on the change in pre and post-project conditions at respective project site. A summary of total cropping intensities at four study sites is given in Table-2. The perusal of Table-2 revealed that at MSP, the target value of total cropping intensity (180%) was not only achieved but it showed an extra upward trend up to 230%. Similarly, at CCADP an upward trend of 162% was observed against the target value of 150%. The quantitative comparison of *simple increase* (i.e. pre & post project difference) in cropping intensities at four study sites (Table-2) is graphically shown in Figure 8-(i). As can be observed, maximum (significant) increase in the total cropping intensity was at MSP (66%) and CCADP (65%) sites, whereas FDP (55%) was second in order. The least increase of 24% was at MKDP area. This shows the positive impact of drainage system installation in terms of cropping intensity improvement in those project areas.

The *percent change/improvement* in cropping intensity (Table-2) based on pre-project conditions for four study sites is shown in Figure 8-(ii). Based on this figure, the four study sites in terms of *percent improvement* in total cropping intensity in the order from maximum to minimum can be ranked/listed as: CCADP (67%) > FDP (54%) >MSP (40%) >MKDP (19%). This order of improvement indicates how various project sites were benefited from the drainage activity in those areas. As investigated, the main reasons for slow benefits at FDP & MKDP study sites were the limited financial resources available with farmers to reclaim/restore the fertility of waste lands, and shortage of irrigation supplies during the post-construction period to leach down the excess salts. Another reason was the poor operation and maintenance (O&M) of the drainage sumps at those study sites. This aspect revealed that efforts put to alleviate the problems of waterlogging & salinity through implementation of pipe (tile) drainage systems had not been up to the expectations mainly due to other associated problems. However, the overall quantitative comparison did indicate the positive impact of tile drainage systems in terms of improving the cropping intensities at all four study areas.

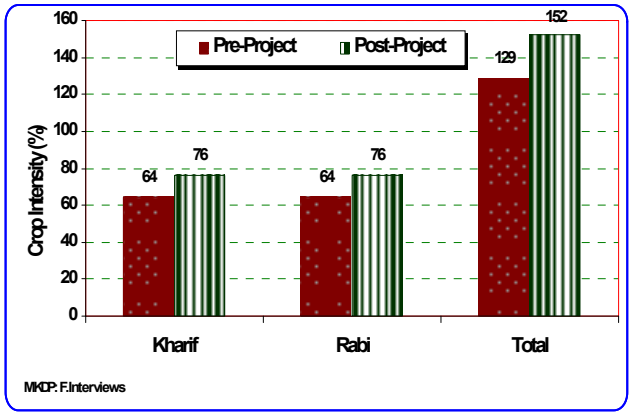


Figure 7Pre and Post-Project Cropping Intensities at MKDP

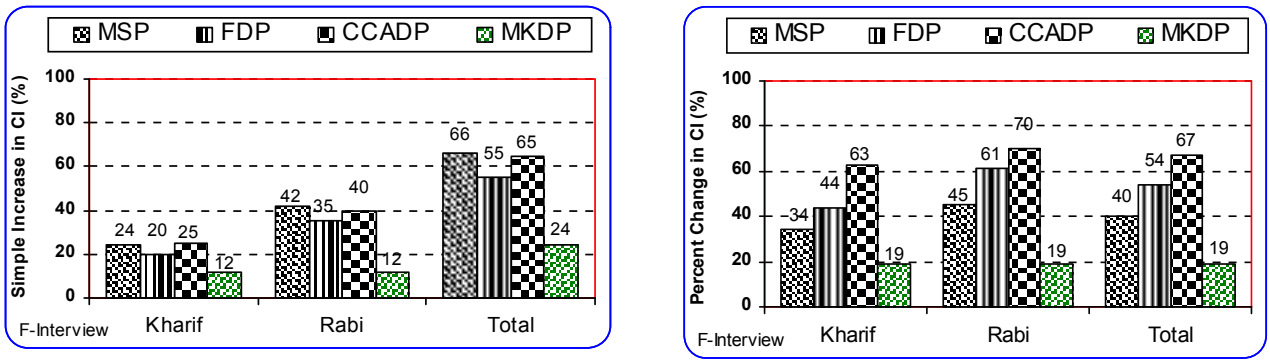
Table-2 Comparison of total cropping intensity at four Study sites

Study Site	Pre-Project (%)	Post-Project (%)	Simple Increase (%)	Percent Change/ Improvement (%)
	(1)	(2)	(3)	(4)
MSP	164	230	66	40
FDP	102	157	55	54
CCADP	97	162	65	67
MKDP	128	152	24	19

Col(3) = {Col (2) - Col (1)}; Col(4) =100{Col (2) - Col (1)}/Col (1)*

A comparison of *simple increase* in cropping intensity obtained from two different sources namely Provincial Irrigation Department (PID) and Farmers' Interviews conducted by IWASRI staff for four project sites is graphically shown in Figure 9. As can be observed, there exists a significant difference in both the values. It shows the ambiguity inherent to data collection from various sources which must be carefully noted

before using a data set for specific purposes. The PID data figures are sometimes socially & politically influenced, hence, in present study the farmer's interviews were given more importance than PID data values. Nevertheless, the historical trends of cropping intensities have been plotted using the PID data sets.



(i). Simple increase *(ii) Percent change*

Figure 8Cropping intensity pattern at four study sites

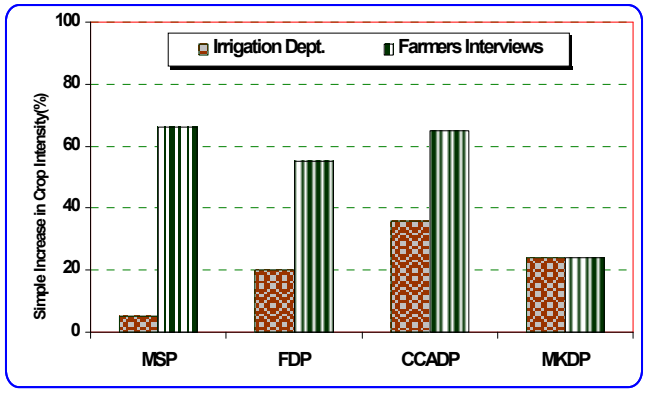


Figure 9 Cropping intensities obtained from PID and through farmer's interview

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

(i). The objectives of drainage systems installation have been achieved in terms of improving the cropping intensities (CI) at all four study sites. At MSP, the target value of annual CI (180%) was not only achieved but also it showed an extra upward trend up to 230%. Similarly at CCADP, an upward trend of 162% was observed against the target value of 150%.

(ii). The quantitative comparison of *simple increase* (i.e. pre & post-project difference) in cropping intensities revealed that maximum (significant) increases were at MSP (66%) and CCADP (65%) sites, whereas FDP (55%) was second in order. The least increase of 24% was at MKDP area.

(iii). The four study sites in terms of *percent change/improvement* in total CI in the order from maximum to minimum were ranked as: CCADP (67%) > FDP (54%) >MSP (40%) >MKDP (19%), indicating how various project sites were benefited from the drainage activity in those areas.

(iv). The main reasons for slow benefits at FDP and MKDP study sites were the limited financial resources available with farmers to reclaim/restore the fertility of waste lands, and the shortage of irrigation supplies during the post-construction period to leach down the excess salts. This aspect revealed that efforts put to alleviate the problems of waterlogging & salinity through implementation of pipe drainage systems had not been up to the expectations mainly due to other associated problems. However, the overall quantitative comparison did indicate the positive impact of tile drainage in terms of improving the CI at all four study sites.

(v). Comparison of CI obtained from two different sources namely Provincial Irrigation Department (PID) and Farmers' Interviews indicated significant difference in both the data values, highlighting the inherent ambiguity in data collection from different sources which must be carefully noted before using a data set for specific purposes.

Recommendations

- In order to get the maximum benefits from installed drainage systems, the capacity building of beneficiaries (farmers) should be carried out through agricultural extension services as well as facilitated with easy credit facilities.
- As a result of drainage system installation, irrigation requirements of crops are significantly increased due to reduced sub-irrigation; hence, the post-construction irrigation supplies should be carefully reviewed and improved accordingly.

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