CROP DIVERSIFICATION IS AN UPHILL TASK: A CASE STUDY OF HIRAKUD COMMAND IN ORISSA, INDIA

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INTRODUCTION

Agroclimate, Soil, and Topography of Orissa

The State of Orissa is located in the eastern part of India. The topography is generally rugged and most of the terrain slopes gradually into the coastal plain along the Bay of Bengal. There is about 300 kilometers (km) of coast line. Agroclimatically it is divided into four zones: northern hilly plateau (23 per cent), central undulating land (23 per cent), eastern ghat region (36 per cent), and coastal plain (18 per cent).

Soils are largely red laterite and shallow in the highlands of the northern hilly plateau, in the central table lands, and in the eastern ghat regions. Soils are deep alluvium in the coastal plains and valley lands of inland areas. Farm holdings average 1.6 hectares (ha). In the coastal region, holdings tend to be smaller, averaging about 1.0 ha, and highly fragmented, sometimes divided into 8-10 separate plots. In the interior areas, holdings average about 2.0 ha.

Orissa has an average annual rainfall varying between 1200-1700 millimeters (mm); 85 per cent falls between June and October. The tropical monsoon climate favors year-round cropping with irrigation. Traditionally two cropping seasons are recognized: June to December (kharif) and January to April (rabi). With the introduction of duration bound rice and non-rice varieties three growing seasons have become apparent: June to November (kharif), mid-October to the end of January (rabi), and the last week of December to the end of April (summer). Discussion in this paper is based on these three growing seasons. At present rice is the most favored crop in kharif and summer. Non-rice crops are grown in limited areas during the rabi and summer seasons, mostly with available moisture after a pre-sowing irrigation, but yields are at subsistence level. Thus the potential for raising productivity in the irrigated area lies in fully diversifying crops in these two seasons to realize higher yields.

Rice's Advantage Over Other Crops

In areas with high rainfall, rice is the predominant crop during kharif People in these areas are used to growing rice and have levelled and bunded their land to suit its needs. When irrigation is introduced in such areas, rice has a natural advantage over non-rice crops. Economic criteria and high yields favor summer rice and farmers readily take to growing it as soon as irrigation is available, while non-rice crops have yet to be established.

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Irrigation authorities find it more difficult to cater to irrigation needs of non-rice crops and thus prefer saving rice growing areas. It appears that irrigation authorities and the few head end beneficiaries connive to irrigate and grow summer rice at the cost of those in the tail ends, who gradually come to believe that their lack of access to water is caused by design. In such areas crop diversification is an uphill task despite strong arguments in its favor. Several issues must be resolved before appropriate system development, operational procedures, and suitable crop technologies are adopted to exploit the potential of diversified cropping.

Problems Affecting Diversified Cropping

No two commands are exactly alike. This individuality warrants a unique solution to each command, and must be taken into consideration when planning developmental change (Naik 1980). Irrigation authorities often find it more convenient and cheaper to transfer responsibilities, which they find onerous, to farmers. However, authorities often fail to realize that the farmers as a group can be incoherent and diverse. They may not respond adequately to new responsibilities, unless their assignments are consistent with and limited to their capacity to stretch themselves beyond individual considerations. Trial and experiment are required to determine the extent to which farmers should be given responsibility for a community irrigation program (Naik 1983).

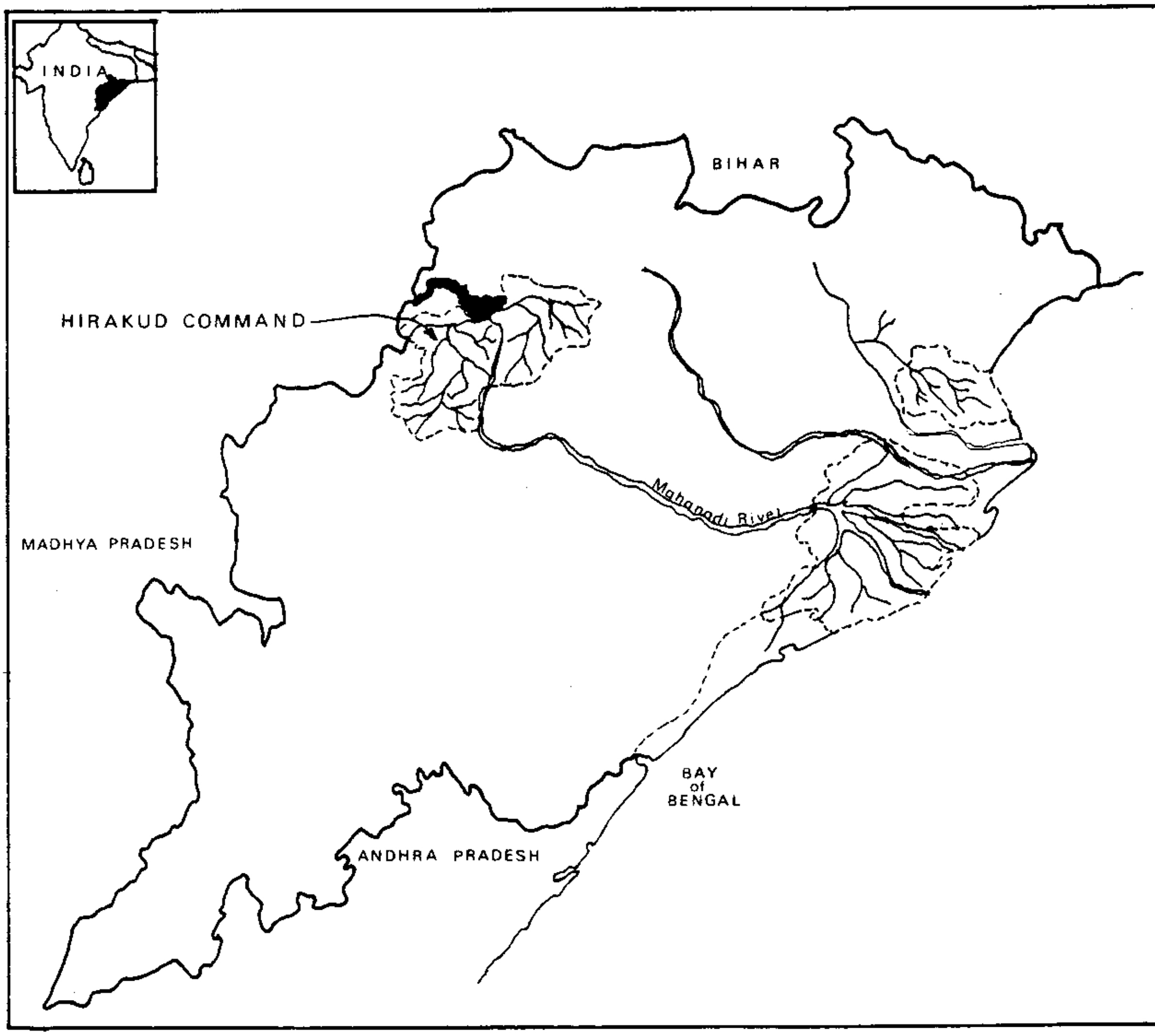
The Agricultural Extension Service, which supports farmers, is incapable of diffusing new irrigation technology and management practices to farmers. Contrary to appearances, they are worried by this. The problem seems to be poor communication between extension and irrigation authorities. Thus, there appears to be a need for developing better understanding of mutual problems so that the farmers' demands can be translated into compatible, practical, and effective solutions. This will require experimenting and working in result-oriented collaborative programs. In most cases one finds substantial deviation between designed and actual crop patterns, yet little effort appears to have gone into correlating the expected and actual performance of the original irrigation infrastructures. This must be resolved before full potential can be realized.

HIRAKUD COMMAND

Description

The Mahanadi is Orissa's major river. Originating in adjoining Madhya Pradesh, it passes through the central table lands, divides the state in half, and empties into the Bay of Bengal (Figure 1). Hirakud Command, created in 1957 following construction of a multipurpose dam on this river, receives water directly from the reservoir. An allocation of 133,000 ha/meters of water with a design stipulation to cover 58 per cent of the cultural command area (CCA) in a composition of 35, 17, and 6 per cent of heavy, medium, and light duty crops, respectively, has been reserved for irrigation. It contains shallow and light soils. The topography is undulating. Water is supplied continuously from 20 June until 30 April with a winter lean supply period (15 November-19 December). Two rice crops are grown during the year.

Figure 1. Orissa and location of Hirakud Command.



Crop Diversification in the Hirakud Command

A particular command is best studied by observing its conspicuous features and then looking for their possible explanation. Such knowledge yields valuable clues for determining appropriate changes. No one visiting Hirakud Command in the rabi/summer seasons could miss the predominance of rice crop and near total absence of non-rice crop. In tail ends, where water is normally scarce and where some non-rice crops would be expected, one sees extensive stretches of fallow lands.

A comparison of the designed provision and actual achievement of water allocation and crop coverage during summer as shown in Table 1 indicates that the crop intensity has risen from 58.0 to 63.9 per cent, and the total rice area has overtaken the land planned for mixed cropping.

Table 1. Comparison between design and actual water allocations (in thousand hectare meters), total planted areas (in thousand hectares) with percentage given to cultural command areas (CCA), and crop intensity (in per cent) for rabi/summer growing seasons.

	Allocation	Crop type	Area	CCA	Crop intensity
Design	133.0	Rice	53.0	35.0	58.0
		Non-rice	35.0	23.0	
		Fallow	64.0	43.0	
Actual	122.0	Rice	93.0	61.2	63.9
		Non-rice	03.1	02.7	
		Fallow	55.9	36.1	

Design and actual data are from government irrigation records. "Actuals" are averages from 1971-79.

By using water planned for medium and light duty crops as well as rice, coverage amounts to about 45.0 per cent[1] of the CCA rather than the present 63.9 per cent. To explain: Naik and Singh established (1983) that this is due to re-use of water which can be represented by the following equation.

$$R \text{ (re-use per cent)} = (X - 45)/45 = (Qh - Q)/Q$$

Where: X = heavy duty crop coverage in rabi as per cent of kharif CCA
Q = Drawal in million acre/feet (MAFT)
Qh = Drawal (MAFT) needed for entire coverage by of heavy duty crops

R has been rising for some time (Figure 2.) At 63.9 per cent crop intensity, R is about 51 per cent. Re-use is an advantage which is a good reason for rice's firm hold in the command. The second conspicuous feature is the large drainage outflow. The natural drainage ways run full during rabi/summer seasons when normally they would be dry. Drainage flows are not mentioned in the project report indicating they are unexpected. Flows have been measured at 25 per cent of the water released into the canals (Table 2; Naik 1979).

Table 2. Results of a study on water balance (in cumec/100 ha) for an irrigated area of 16,000 ha in Hirakud Command.

Description	Measured Values	Inflow (%)
In flow (including seepage)	16.4	100.0
Out flow through drains	4.1	25.0
Consumptive use	5.3	32.3
Direct evaporation	0.6	3.7
Balance (deep percolation)	6.4	39.0

Data provided by the irrigation authorities and the Agricultural Department.

Figure 2. Graphs comparing actual with projected drawal without re-use, area of rice versus non-rice crops, and rise in crop coverage (X) due to rise in re-use (R), Hirakud Command, 1970-79.

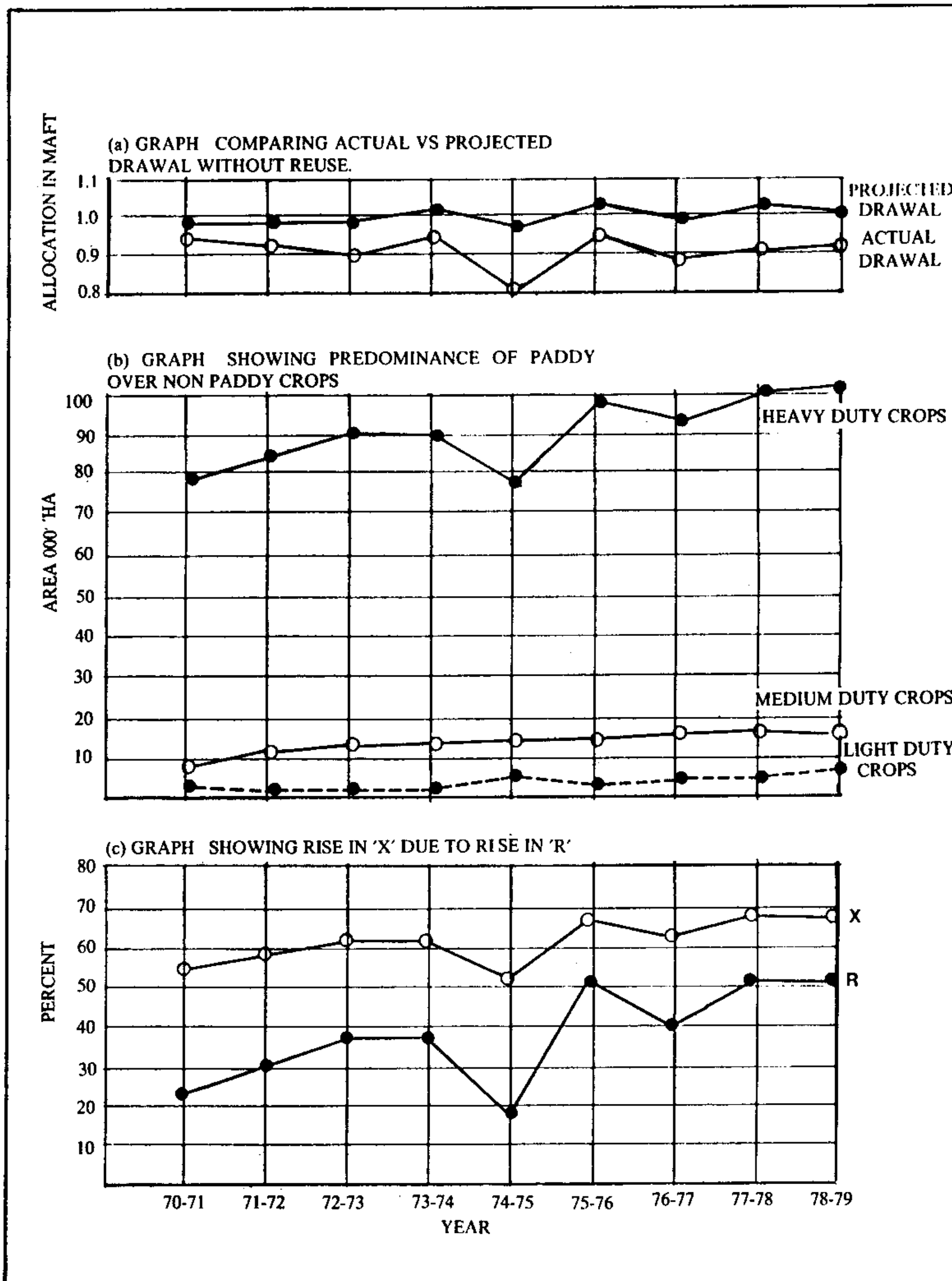
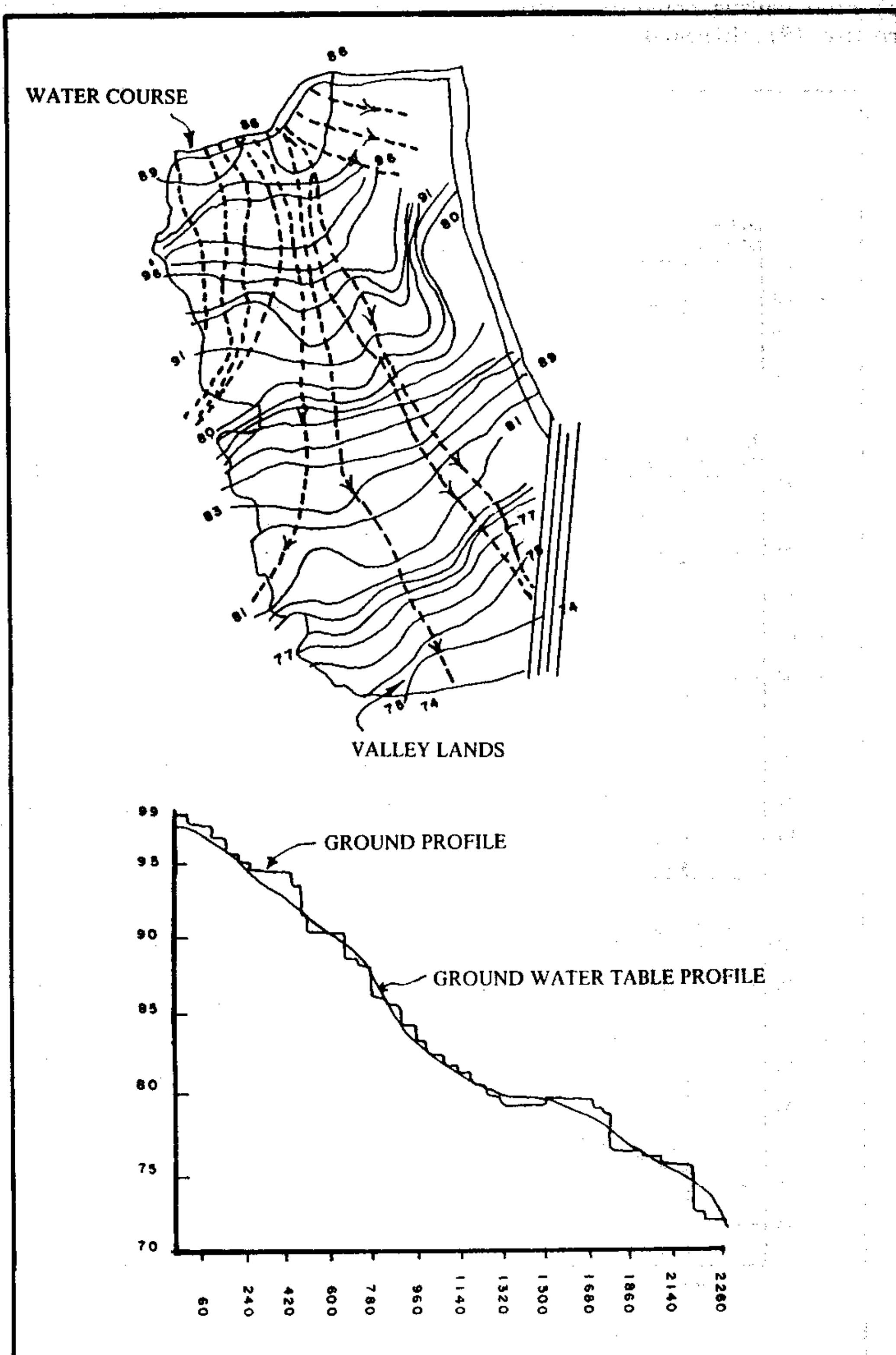
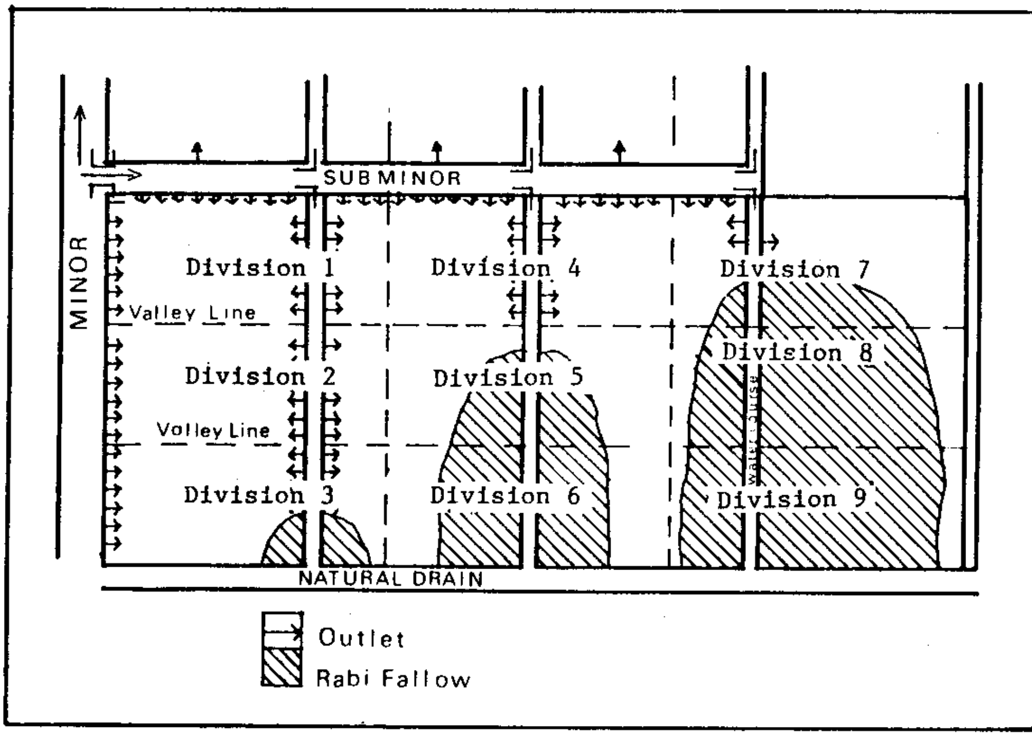


Figure 3. Ground water contours and flow lines, Hirakud Command.



The availability of water for reuse and return flow in natural drainage is explained by the presence of parent rocks at a depth of about one meter, which diverts the percolated water laterally. This water reappears in the valley lands saturating the soil profile irrespective of land types (Figure 3). With such favorable conditions for rice one must consider whether crop diversification is wise in this particular command. If so, the high and medium lands which become wet due to the vertical impediment of percolated water would need to be made suitable for non-rice crops. However, it is logical to consider the rabi fallow for introducing non-rice crops. Learning therefore about the pattern of its occurrence becomes relevant (Figure 4). Land coverage is more or less complete in the head end region irrespective of land types. Fallow lands gradually increase towards the tail of every canal whether it is a distributary/minor/sub-minor or water course (Naik 1980).

Figure 4. Schematic pattern of division adopted for the study of water distribution, Hirakud Command.



Initially, extra water is not needed to cover the fallow areas with non-rice crops. In the normal schedule, a lean period exists during winter due to the low demand of rice. This could be corrected by an intermittent schedule and yet remain within the specified allocation. The number of closure days could be extended to save more water because the kharif demand decreases about a month ahead of the winter cropping period. Then a way must be found to convey water to tail ends. Water scarcity in the tail ends due to higher demand in head end regions must be studied. It should be possible to make water available in the tail ends during low demand period (i.e., toward the end of kharif and before the demand for summer rice has begun; Table 3).

Table 3. Average stream size (in liters/second) at the tail end under normal schedule and as percentage of design flow.

Period	Stream size	Design flow
1 Nov - 14	26.6	92.2
15 Nov - 29	22.4	77.7
30 Nov - 14 Dec	15.7	55.3
15 Dec - 29	15.4	53.4
30 Dec - 13 Jan	12.6	43.7
14 Jan - 28	12.9	44.7
29 Jan - 12 Feb	10.4	35.9

The paradoxical near total availability of water during November and early December in tail ends despite lean supply in the canals creates an incentive to plant long duration rice varieties, and areas where non-rice crops could be grown between November and January remain under rice. After December, lack of water forces farmers to leave these lands fallow. Thus, a strategy is needed for a shorter duration kharif crop to free land by end of October and to schedule a rabi crop when water is available (Tables 4 and 5).

Table 4. Characteristics of rice varieties, including cropping duration (in days) and yield (metric tons/ha) for sowing in last week of June.

Variety	Characteristics	Duration	Yield	
			Broadcasting	Line sowing
CRM 13	very SD, early dry sowing	80-85	1.78	2.81
KAVERI	SD HYV, early dry sowing	100-110	2.45	2.89
PTB 10	SD improved variety, low investment, hard variety	100-110	1.93	2.23

Note: Dry sowing was preferred to avoid possible delay in transplanting.

Table 5. Yield (100 kilograms/ha) for mustard and pulse varieties.

Sowing period		Mustard M-27	Pulse Ratila	Pulse Jhain
Oct	last week	665	408	-
Nov	1st	501	317	-
Nov	2nd	453	-	-
Nov	3rd	415	-	-
Nov	4th	363	-	-
Dec	1st	305	-	-
Dec	2nd	-	-	-
Dec	4th	-	-	450

Note: Data was unavailable for pulses T-44, S-8, HY-12-4, and PB.

A water supply schedule designed to meet this strategy incorporates provisions for intermittent supply from 15 October to 31 December, and a plan for sufficient closure days to save a carry-over supply to advance water releases until 1 June irrespective of the start of monsoon (Table 6).

Table 6. Fitting an irrigation schedule to a selected cropping strategy.

Operating period	Objective	Closing period	Objective
		OLD SCHEDULE	
20 Jun-15 Nov	Supply of Water to kharif rice	-	-
15 Nov-19 Dec	Very low supply in the canals in keeping with very low demand of rice	-	-
20 Dec-30 Apr	Supply to summer rice	1 May-19 June	Annual maintenance 50 closure days
		NEW SCHEDULE	
1 Jun-10 Jun	For nursery raising out of carry over stock	11 Jun-25 Jun	To save water in reservoir
26 Jun-15 Oct	Water for main growing period of rice	16 Oct-31 Oct	To allow high/high medium land to dry; to induce farmers to grow short duration varieties; to allow land preparation for non-rice crops
1 Nov-15 Nov	To give pre-sowing irrigation to those who need it; to give first irriga-to those sowing with old moisture; to give water to needy standing rice	16 Nov-30 Nov	Prevent over irrigation due to seepage; to save water in reservoir
1-15 Dec	To allow another irrigation to those who need it; to enable people to prepare nursery	16-31 Dec	Prevent over irrigation; to save water in reservoir
1 Jan-30 Apr	For growing summer rice	1 May-31 May	For annual maintenance 94 closure days (88% more)

The extension service was informed of the new message and suitable seed varieties were made available. As a result of this effort, the non-rice crop area increased from 3,000 ha to 38,000 ha by the end of 1982 (20 per cent of CCA). Not only does the rabi fallow take up non-rice crop on a large scale but also a large area in the head and mid reaches were converted to a three-crop pattern with a non-rice crop in between two rice crops. The non-rice crop area was expanded where water was easily accessible, and in those lands where farmers could individually plan their crops and manage water delivery. Other areas were left fallow because successful cropping depended on group action to manage and distribute the water equitably. In the absence of organized effort, the available flow was wasted. In order to overcome waste, farmers were informally organized. Authorities learned during that the farmers were highly individualistic: one may join one group and clash with another depending on groups having common or clashing interests.

Organizing Farmers to Establish Discipline in Irrigation

Farmers complain about the general lack of discipline of fellow farmers but avoid taking part in punitive measures against any specific delinquent. In fact every farmer is a potential delinquent when it comes to his own interests. They appear to have a convention of protecting each other against outside actions. The legal provision for punishing canal offenses has never been workable: one can never find a witness. At least two witnesses are necessary for prosecution. On the other hand, unless some discipline is established, expected improvements may not be feasible. Thus it is envisaged that formation and operation of these groups should allow for farmers to discipline their own ranks and that these groups should also be responsible for pre-processing complaints against system operation or deficiencies.

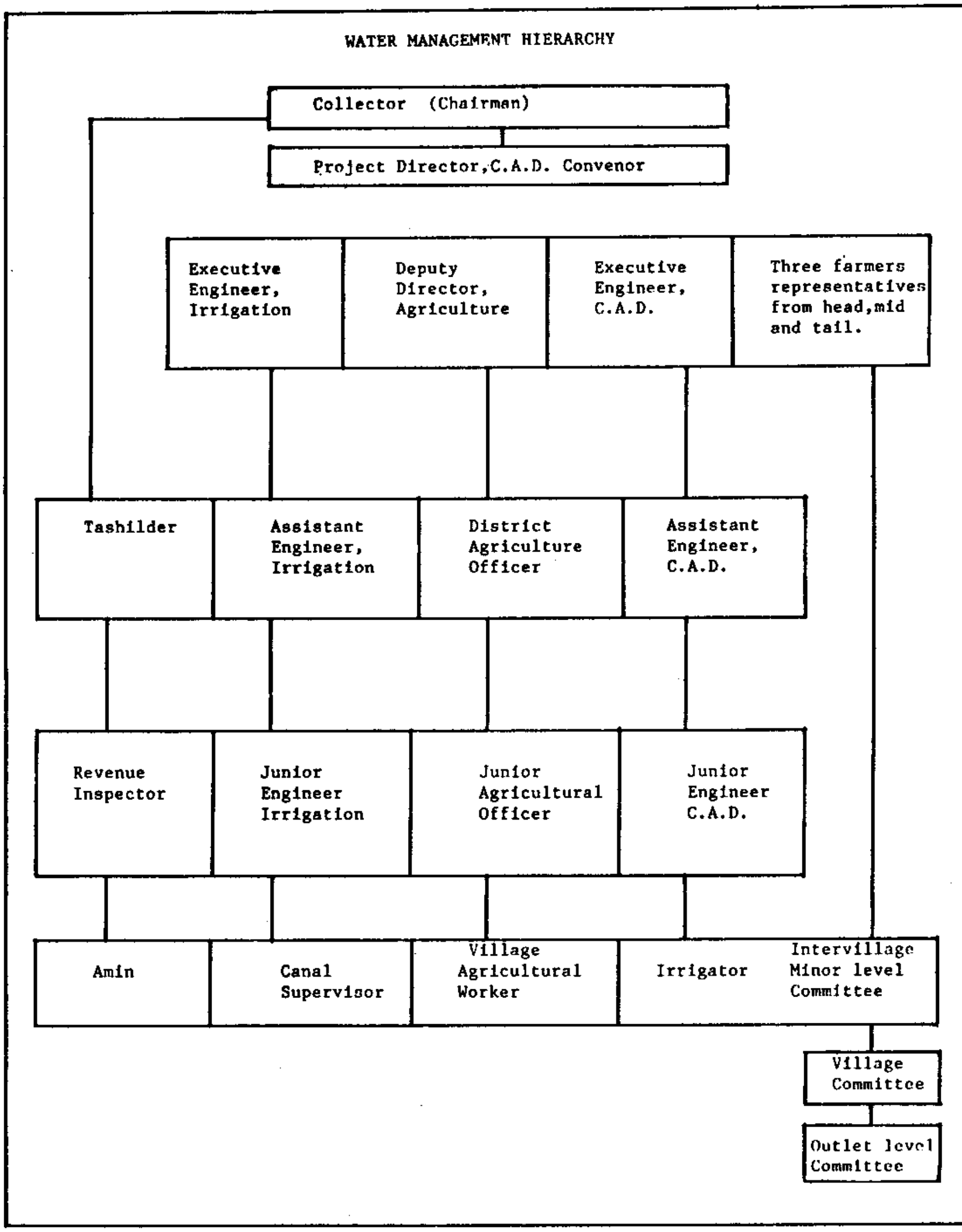
Consistent with this approach were experiments with three tier farmers' committees (Naik 1982). The first tier was at the outlet level. A committee was formed of all farmers at the outlet and a leader and a deputy leader chosen. This committee would look to and seek solutions to problems arising within an outlet command including discharge reaching the outlet.

The second tier was at the village level. This committee was formed by taking two members out of each outlet committee within the village. This committee would solve or seek solutions to problems leading to inter-outlet distribution of water or lack of water into outlets in the village area.

The third tier was organized at the minor/sub-minor/water course level by taking two representatives from each village committee which receives water from the same minor canal. In minor level committees, government officials at grass root level such as village agricultural workers (VAW), irrigators, canal supervisors, were also associated. In this committee the constituent villages would agree on how to share available water, lodge written complaints, and determine whatever infrastructural remedy would be necessary to improve various situations.

Associating government officials at this level with the farmers enabled them to learn about local problems and carry them along the water management hierarchy which was formed to solve farmers' problems (Figure 5).

Figure 5. Schematic of water management hierarchy.



The water management hierarchy formed a Water Management Committee with at least three farmers' representatives. A procedure to form three tier farmer committees has already been created at each project level. The objective is to listen to peoples' complaints, process and classify them, identify solutions, and provide remedies accordingly. It would also, if needed, recommend policy changes for government consideration. Before this, such an agency with statutory powers did not exist nor did a forum for complaints.

One positive result of this experiment was the ability to persuade the head end farmers through committee action to allow tail enders to receive water, at least during the night. A successful application of these results on a large scale has not yet become apparent.

Developing Understanding Between Agricutlure and Irrigation

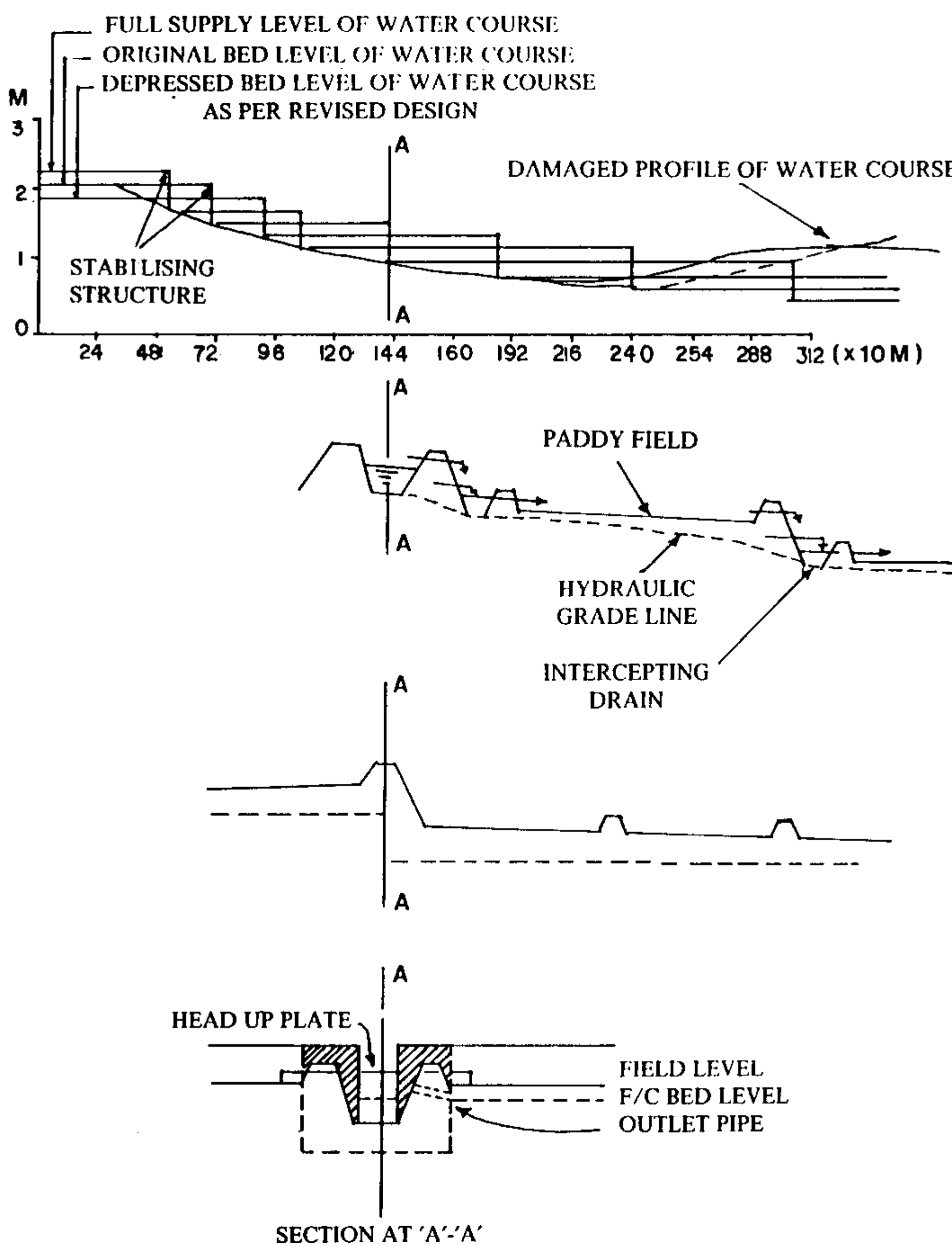
Agricultural scientists speak of crop water requirements on the basis of work conducted on experimental plots. The extension worker, through his own observations and studies, correlates it to agroclimate, depth of water table, application efficiencies, and other factors which might vary within the command, and modifies his recommendations accordingly. There are also socioeconomic factors which motivate the farmers' behavior. The effect of all these reflect a demand pattern which the extension worker poses to the irrigation authorities. They, however, find it difficult to appreciate patterns which vary from the original design assumption. Often local irrigation officers tend to favor operations characterized by minimum regulatory attention and minimum infrastructural developments involving sizeable investment.

At the point of coordination, which is usually at the government level, the irrigation authorities equate changes with large investments, and reject minor management or operation suggestions from the agricultural extension agency. The change in the irrigation schedule discussed earlier was a rare and hard-earned victory in that it represented a concession to a suggestion from the extension agency. The schedule reverted to the old pattern in 1982-83 after the concerned officers changed their positions. The incoming irrigation administration did not accept the views of their predecessors. They saw unnecessary waste in the two intermittent runs as the non-rice crops actually used a small fraction of the water released. This occurred because full discharge was required to convey water flow at full supply levels in absence of cross regulators. It was thought better to save the water for electricity, due to an acute shortage at the time, rather than wastefully supply what was seen as a few hectares of non-rice crop. As a result of this change the area under non-rice crop dwindled to the previous level in two years' time. Thus it is important that mutual understanding be established at all levels between the two organizations.

Infrastructural Development

So far we have discussed cosmetic developments only. No doubt they are forerunners to any major developmental effort. But sooner or later one faces the bare deficiencies of the irrigation system. The shift to rice and consequent concentration of cropping in head and mid-reaches increased requirements in these regions. This was followed by widespread damage to the outlets in an effort to take more water, which led to scarcity in the tail ends. The tail end farmers, reacted to this action by damaging the stabilizing structures particularly on small canals (minor/sub-minor/water courses) thereby making it difficult for the head enders to get appropriate supply head. Damage to stabilizing structures eroded the canal bed warranting cross bunding, which, when broken, carried soil downstream to deposit on flatter slopes. This raised the bed level and rendered the canal permanently inoperative beyond such locations (Figure 6).

Figure 6. Illustration of damage to stabilizing structures which eroded the canal bed and rendered the canal permanently inoperative downstream.



As the matter stands now, unless the original bed slope is restored and the outlet discharges are rationalized according to the newly designed crop pattern, cosmetic improvements will have limited results. This is one reason why an organized effort is needed to guide water to tail ends. Where water courses are damaged as above, alternative paths through the fields are found, probably limiting what can be done.

The possibility of a three crop pattern such as rice-mustard-rice would need some kind of "on farm development" to make all potential land owners adopt such patterns. After adoption of the revised schedule discussed earlier an experiment was taken up to develop an infrastructural development both above and below the outlet to extend the benefit of an additional non-rice crop to as large an area as possible (Figure 7).

The experiment was based on the following (Naik 1981 and 1985):

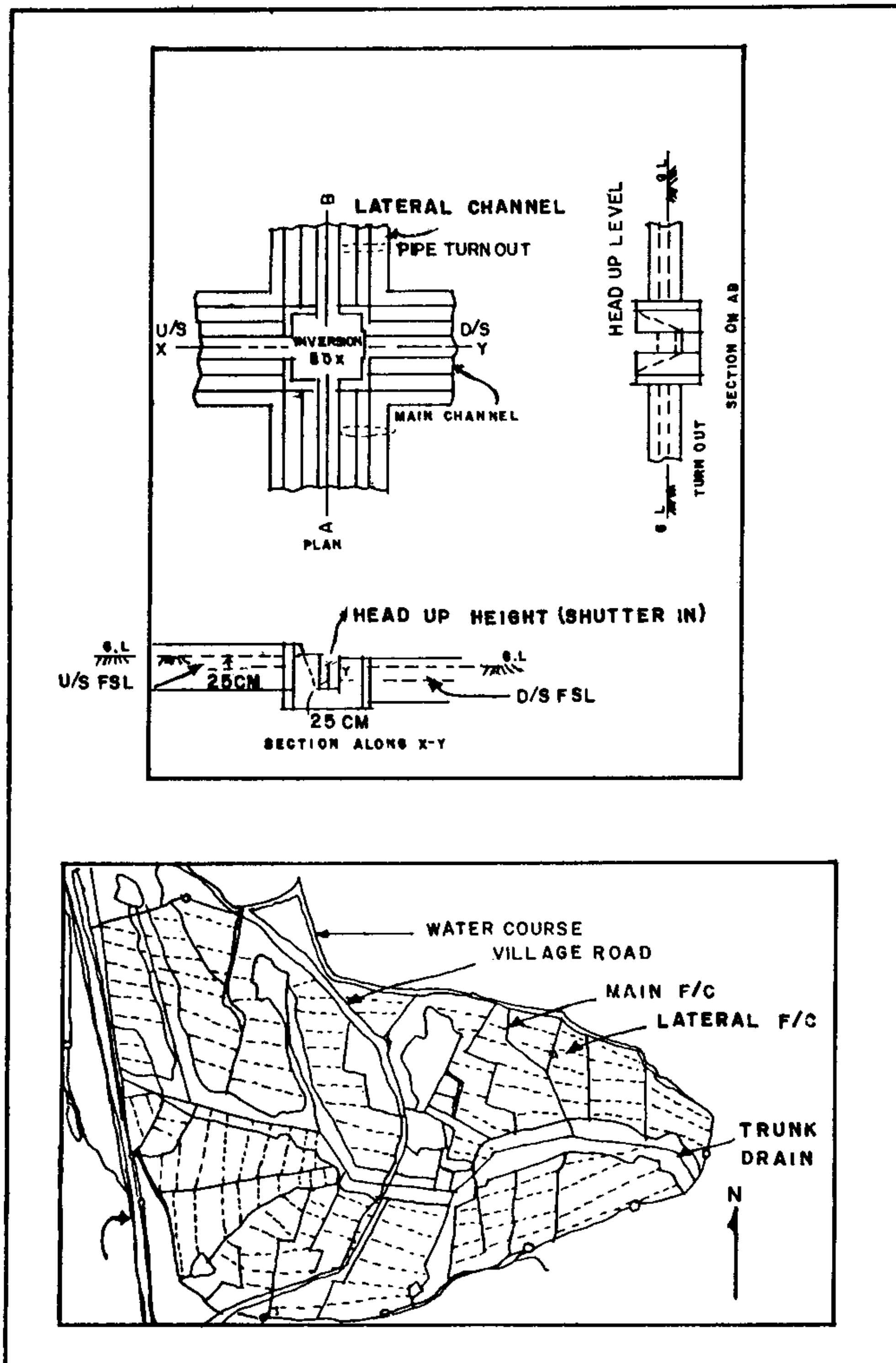
1. All water courses should run below the ground level at a depth equal to full supply depth of the water courses.[2] Irrigation would be by heading up of water through dual purpose structures. This would help the farmers' committees to prescribe an effective plan for sharing water. It would also depress the seepage line originating from water courses.

2. A system of field channels consisting of mains and laterals basically designed as a drainage network would further depress the seepage line (transient water table) and would drain any excess water arising out of over irrigation. Main field channels would be constructed along the principal slope and the lateral would be laid along the secondary slope below each terrace. As a result of such a design, in a village of 150 ha it was possible to convert 75 per cent of the land to a three crop pattern (Table 7).

Table 7. Rise in multi-crop coverage in an area of 150 ha, where water course was improved to new design norms and on farm development was carried out below the outlet.

Year	Multi-crop pattern	Coverage in per cent
1978-79	Rice-rice	100
1979-80	Rice-rice	80
	Rice-mustard-rice	20
1980-81	Rice-rice	50
	Rice-mustard-rice	45
	Rice-pulses-rice	5
1981-82	Rice-rice	25
	Rice-mustard-rice	62
	Rice-pulses-rice	6
	Rice-groundnut-rice	3
	Rice-groundnut-pulses	4

Figure 7. Illustration of infrastructural development both above and below the outlet to improve water distribution.



CONCLUSIONS

In most older commands farmers prefer a particular crop. In any development effort this should be taken advantage of, which requires an intimate understanding of the command. Experiments must continue to fill gaps in understanding. Acceptability of any one strategy should be tested with cosmetic improvements. One positive reaction is to identify the infrastructural improvements appropriate to the tested strategy. Like adoption of any new management plans, understanding and belief in the process must begin at levels where decisions are made. Without that, little is likely to happen regardless of the efforts of people at the lower levels. People must be carried along with an idea via their path of interest. If they are opposed to all plans, no matter how well conceived, such plans are rendered ineffective by the interference of the persons concerned.

NOTES

1. Assuming that medium duty crops require 50 per cent and low duty crops 25 per cent as much water as rice, only 35 + 17/2 + 6/4 = 45 per cent coverage with the same quantity of water seems to be theoretically justified.

2. Water courses are the smallest canals of irrigation system on which 75 per cent of outlets are located. They are usually of about five cusecs capacity.

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