Command Area Improvement and Soil Moisture Conservation in Spate Irrigation

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Practical Notes Spate Irrigation

Spate Irrigation Network pakistan

Introduction

This note discusses two types of water management practices in spate irrigation that are as important as diverting flood water to command area:
(a) command area improvement
(b) moisture conservation
Both command area improvement works and measures to improve moisture conservation can enlarge the productivity of spate irrigation systems considerably - in fact often more than investment in better river diversion.

1. Command area improvement

The challenge in spate irrigation is guiding large and unpredictable quantities of flood water over sometime extensive command areas – made up often of predominantly soft sedimentary material. There is always a risk of flows going out of control and causing erosion and rutting of land – especially in sections with a considerable slope. Farmers describe this effort in managing the flows within the command area as 'killing the flood'. It is achieved by splitting the flood water in manageable proportions, avoiding steep slopes and by stabilizing the flood channel and channel beds.
The common techniques used in command area development in spate irrigation are:

- Flow dividers – parts of the command area. An example of a high impact flow divider is the Machiwal Division in the Daraban Zam in DI Khan – developed by the WRRI[1)] (see box 1).
- Drop structures – to overcome level differences and dissipate energy (figure 1). Without such drop structures floods may accelerate in certain parts of the command area and cause scouring. This can cause canal and field rutting – destroying land and its capacity to retain moisture. It can also flood flows to move in an uncontrolled manner – even moving out of the command area altogether.
- Bed stabilizers – this can be done by buried gabion structures of sufficient length so as to avoid scour. Bed stabilizers prevent that flood channels scour out and change position, making it difficult henceforward to control the flood flows at those points (see figure 2).

In Pakistan such command area works are not implemented at large scale yet, but where they are undertaken they often have a pay-back period of 1-2 years or less. In several cases they are copied by farmers themselves. Development of command area structures is to be undertaken in very close collaboration of farmers – to identify the best locations, to jointly take care of costs and material and to impart skills locally.

Figure 1. Drop structures to overcome level differences and dissipate energy: note the stepped construction

Figure 2. Flow division and channel bed stabilizer: important that apron has sufficient length

Figure 3. Rutting can destroy the land and deplete moisture

1) The innovative work of WRRI in spate command area improvements is highly recommended and deserves more following.

Box 1: Impact of flow divider on the Daraban Zam in Di Khan

Mochiwal Division on the Darabam Zam in Dera Ismael Khan (Pakistan) consists of a three-gated division structure – operated with hoisting gear. The function of the structure is to distribute the flow between two spate irrigation channels – the North and the West Channel. The cost of the structure as well as the short guide bund sections was USD 2,000. Prior to the Mochiwal Structure, the flow of the Darabam could not be controlled. It disappeared in its entirety to the low lying North Channel areas, every time causing considerable damage to this flood channel. The water could not be controlled in the North Channel as the spate flow washed away all earthen diversion structures in its path. At the same time the West Canal was in most years left high and dry.

Figure 4. Solution: Flow division structure

The Mochiwal Structure now controls the inflow into the North Channel and keeps the flood in manageable quantity. At the same it diverts the water from Darabam to the West Canal command area, where there is substantial end. In the end, the investment of US$ 2,000 restored and safeguarded farming to an area, measuring 3500 ha.

2. Moisture conservation

Moisture conservation is equally critical in spate irrigation – especially since in many systems floods arrive well ahead of the sowing season and a large part of the spate irrigation is 'pre-planting'. Moisture conservation is important because crop yields can be severely depressed by moisture deficit: yields may increase with a factor two or more in response to adequate moisture management (van Steenbergen et al, forthcoming).

In spate irrigation, it is generally assumed that irrigation application should result in an average of 400 mm net stored in the soil (Camacho, 1987). It is also reported that the application of 600-1,000 mm of water in a single pre-planting irrigation is sufficient to raise all spate irrigated crops, provided that the moisture holding capacity of the soil is satisfactory (Mu'Allem, 1987) and land management is adequate. There are two types of watering. First is single watering – where a field received one irrigation gift in a season. In other areas several irrigation are given during a season, preferably preparing the land after every irrigation. There are several techniques to conserve soil moisture that can be applied in spate systems (see table 1).

Figure 5. Much of the irrigation is pre-cultivation, hence the need to conserve soil moisture

Table 1. Soil moisture conservation techniques in Spate systems

Improve infiltration and moisture storage	
Ploughing prior to irrigation	This will increase the infiltration of flood water – but the interest in pre-irrigation ploughing is related to the likelihood of the concerned field receiving irrigation.
Encourage burrowing action of insects and crustaceans	Some insects (for instance dung beetles) and crustaceans loosen up the soil. Their presence can be increased as part of the farming system.
Timely ploughing after irrigation	Research that if land is not ploughed within two weeks after irrigation, up to 30 to 40 percent of moisture may be lost – access to bullocks or tractors is essential.
Deep ploughing and soil mulching	Planking is an effective way of reducing moisture loss through soil evaporation. In Pakistan this is done by attaching a beam to tractors.
Intake closure	To prevent water from flowing out from a high bunded field after it is watered is a major effort and can be helped considerably if improved field intakes are used.
Avoid gullying and rutting	
Maintenance of field bunds	This is essential to avoid uncontrolled breaking which would cause field gullying and rutting and water to escape from the command area.
Overflow structures	Controlled overflows from one field to another help prevent field rutting and uncontrolled breaches.
Field depression	Field depressions in the receiving field will quickly spread water over a field and avoid rutting – as the depression will act as a sump.
Plugging gullies and ravines	Particular in soft alluvial soils the risk of gully and ravine formation is large. Timely plugging of such gullies will prevent that moisture is lost over a large area.

Figure 6. Stone reinforced overflow structure

Figure 7. Soil mulching (planking) reduces soil evaporation losses. The plank is used to close the soil pores and reduce evaporation

3. Discussion

In Pakistan there is considerable scope to improve the productivity of spate irrigation. Sorghum stands for instance are poor and yields do not exceed 1 ton/ha, whereas elsewhere they are in excess of 2.5 ton/ha. Part of the explanation is the land and water management practice within the spate irrigated area that leaves much room for improvement.

In Pakistan the predominant system in most of the systems is to do all the irrigation in a single large watering. Fields are very large (can reach 10 ha), surrounded by high bunds – of 1 to 3 meter. The fields are usually supplied by an independent intake canal. A major challenge is not so much to allow water into the bunded field but to prevent that it does not flow out once the field is filled. Traditionally this required considerable effort to close the inlet with brushwood sticks and mud – while the field was full at that time.

Within the fields there may be subdivisions and low bunds and field depressions to guide the water. Water is impounded within these enormous bunded fields and made to infiltrate over a period of time. Particulary where soil are rich in clay, infiltration will be time consuming and incomplete. This may be contrasted to systems where the fields are smaller and water cascades from one field to another – after water has infiltrated the upstream field.

The advantages of this field to field systems are (1) limited evaporation losses – all water not infiltrated drains to the next field (2) automatic sediment removal as field bunds are broken and sediment is transported downstream.

There are many opportunities to improve water productivity in spate irrigation in Pakistan.

- Where possible aim at more compact command areas. This particularly relevant when new systems are developed or older systems are re-arranged (for instance following the development of the Chasma Right Bank Channel. In most spate irrigation systems in Pakistan command areas are very extensive – with large tracts of land only receiving irrigation once in ten years, whereas the remaining fields are at best irrigated once in the season. By keeping the command areas compact, second irrigations become possible. These second irrigation turns often 'lift' field moisture out of the stress zone – and there are indications that in such circumstances the water productivity of the second irrigation turn is higher than the first. Smaller command areas also encourage more investment in pre-irrigation land preparation and bund maintenance, because the predictability of the system is higher. Moreover, co-operation between farmers will be easier as there is no sharp divide between haves and have-nots.
- Invest in better command area water distribution structures by improved flow divisions, drop structures and bed stabilizers. Some such structures have been put in place (see box 1) but they are few and far between. In general there is not much experience on the side of farmers and experts alike to install such permanent structures but the impact will be high.
- Promote better field level water management structures – in particular field intakes and overflow structures. In this field the innovations that have been developed by WRRI are promising (see box 3) and they deserve a much larger uptake. Part of this is already happening spontaneously – particularly with farmer investing in improved field intakes following the examples by WRRI.

Box 2: Soil moisture conservation and land holding practices

The importance of soil moisture conservation in spate irrigation is illustrated in several land holding practices. In Las Bela (Balochistan) very poor land owners (that do not have their own draught animals) give their land in tenancy to bullock owners. The timely ploughing of fields once irrigated is essential to conserve soil moisture – vital to ensure an attractive yield. The ability to conserve soil moisture by the timely deployment of draught animals is as important as land ownership. Without access to bullocks land owners are 'too poor to farm'.

Another widespread practice is hereditary tenancy. The right to cultivate goes from one generation to the next. In fact the tenant is the co-owners of the land – but the condition is that they continue working the land. The hereditary tenants is called 'lathband" – meaning 'he who maintains the field bunds'. Maintaining the bunds is key to the functioning of the spate irrigation areas as it avoids floods escaping in unexpected directions and water infiltrating the bunded fields.

Box 3: Innovations by Water Resources Research Institute

Innovations 1: Improved field overflow, orifice with a stilling basin in Pakistan

Structures such as these (figure 6) were introduced in Vehoa in DG Khan and become very popular. They make it possible for water to travel from one field to another in a controlled manner – without certain breaches or rushes – that can rut the downstream field and make it unusable. Costs: USD 700-900. An alternative is a stone reinforced overflow structure (figure 5).

Figure 8. Improved field overflow structure

Innovation 2: Stop-logs

The intake gate operates with stop-logs. Once a field is filled the stop logs make it possible to rapidly close the field and prevent the water from washing backwards.

Figure 9. Intake gate with stop-logs

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