

4.1 SOIL MOISTURE CONSERVATION AND FIELD WATER MANAGEMENT

Vital to land and water productivity



META
META



Why is soil moisture conservation and management vital in spate irrigation?

- ▶ Unpredictable floods store in the soil profile
- ▶ Major flood season precedes crop production period – pre-irrigation practice!
- ▶ Crops grow under extended dry spells
- ▶ Large reliance on stored soil moisture
- ▶ High evapotranspiration rate > 2000 mm, low rainfall < 400 mm
- ▶ Large single irrigation gifts (200 to 1000 mm)

Important parameters

- 1. Irrigation turns and gifts**
- 2. Water rights and rules**
- 3. Field water distribution systems**
- 4. Field bund height and maintenance**
- 5. Maintaining or enhancing soil water holding capacity and infiltration rate of the soil**

Irrigation turns and gifts

- ▶ Single gift ranges from 200 to 1000 mm
- ▶ Turns are unpredictable
- ▶ No well defined and orderly irrigation turn/schedule
- ▶ *It is not totally unplanned system*
 - ▶ *Rule on size of fields*
 - ▶ *Rule on irrigation turns*

Water rights and rules

- ▶ Medium floods to upstream fields, moderately-large to midstream fields, large to tail-end fields
- ▶ Second, third & fourth turn only after all fields receive one, two & three turns
- ▶ In a new year dry fields first

Irrigation turns and gifts



- “Critical mass” to work together
- Cohesive community
- Strong belief in fairness
- Securing two or more turns for optimum yield



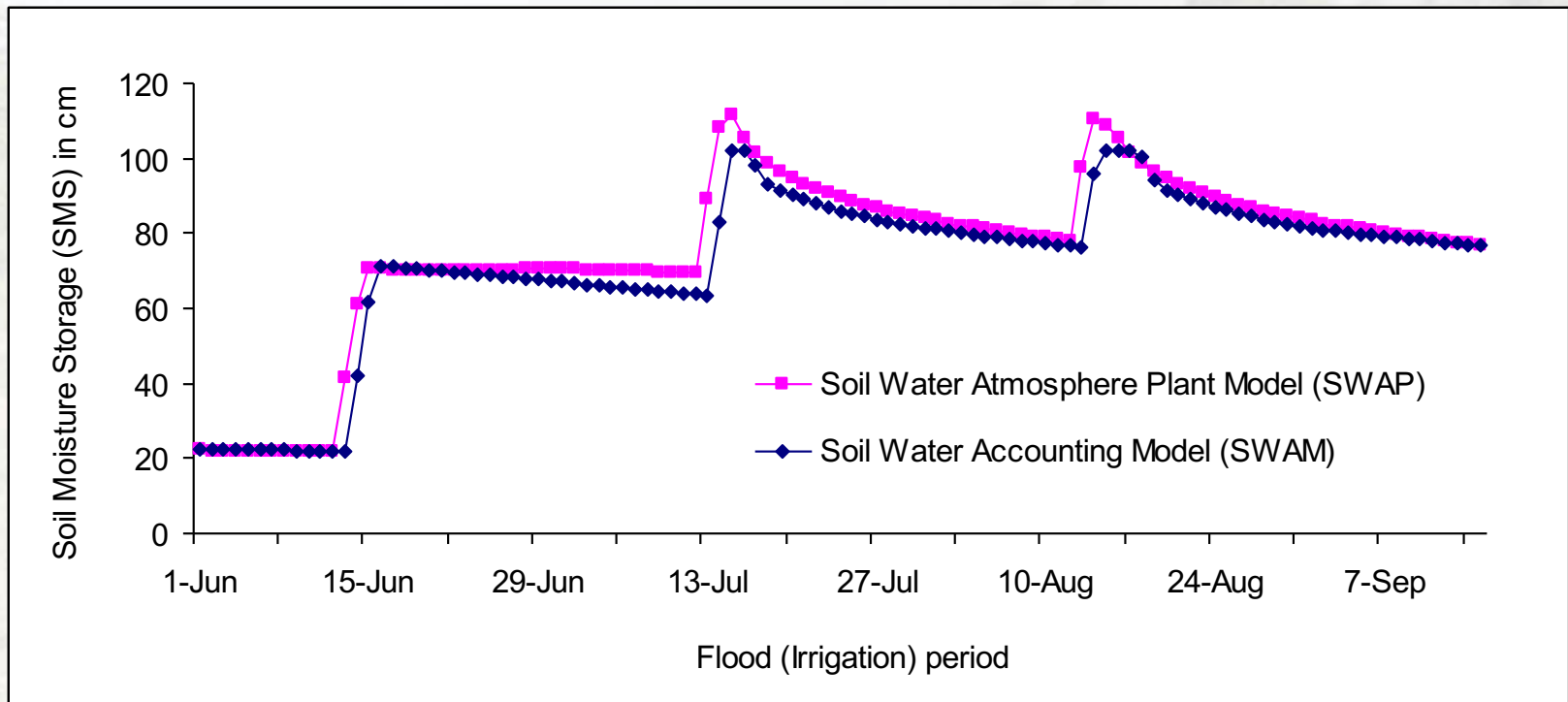
Irrigation turns and gifts

- ▶ ***Highly likely scenario***: two turns in July, a third in June or August; two week interval
- ▶ ***Less likely scenario***: two turns in June or August, one in July, a two week interval
- ▶ ***Unlikely, yet possible scenario***: two or three turns in June or August at a weekly interval
 - ▶ *15 June to 15 August is the effective flood season*
 - ▶ *July is the month when at least 50% of floods occurs; very rarely does a field get a second turn before a two week interval*

Soil moisture storage results

Irrigation schedule scenarios	Day last irrigation turn received	SMS_f within the 2 m deep rootzone of sorghum and maize in cm	
		SWAM model	SWAP model
<i>Likely scenario</i>			
Three turns	15 July	67	69
	30 July/1 August	72	73
	15 August	77.5	77
Two turns	15 July	66	69
	30 July/1 August	71	72
	15 August	77	77
<i>Less likely scenario</i>			
Three turns	15 July	67	69
	30 July/1 August	72	72
	15 August	77.5	77
Two turns	30 June	62	66
	15 August	77	77

Irrigation gift and turns



Simulated Soil Moisture Storage (*SMS*) for an irrigation schedule with gifts of 50 cm at 15 June, 15 July and 15 August using the Soil Water Accounting model (SWAM) and the Soil Water Atmosphere Plant model (SWAP).

Modification and enforcement of water rights

- ▶ *Rule on flood sizes:* Regardless of the size of the flood, if a field gets 2 turns, the subsequent floods should be supplied to downstream
 - ▶ *Small and medium floods are more frequent - 50% of the total number of floods that occur annually*
 - ▶ *Small and medium floods are non-saline, while large floods were found to be moderately saline*
 - ▶ *20 to 50% yield reduction in sorghum and maize production due to salinity*

Rules on water distribution (continued)



Keep command area
small and concentrated

In Pakistan, it is quite common to have large areas that are only irrigated in exceptional years: this creates social tension and discourages land preparation

Keeping the command area concentrated

As far as water
distribution rules
allow

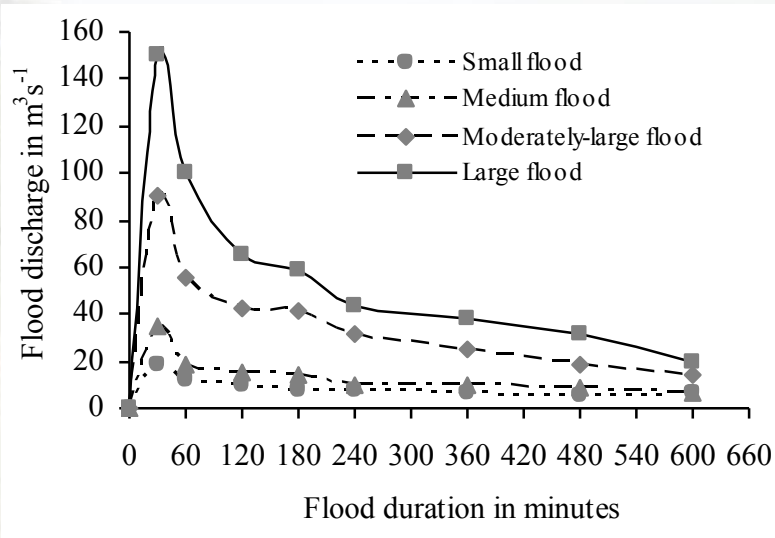
By concentrating the
command area that has reliable
Irrigation and even 2-3 irrigations
increases and one avoids
large marginal 'outwash' areas
with very low productivity



Additional advantages

- If likelihood of irrigation is high – farmers will do pre-seasonal ploughing – which will help the infiltration of flood water
- If the likelihood of irrigation is high – there will be less conflict between 'haves' and 'have-nots' and cooperation among water users will be better

Field water distribution



- Field-to-field water distribution system? OR
- Individual controlled system?

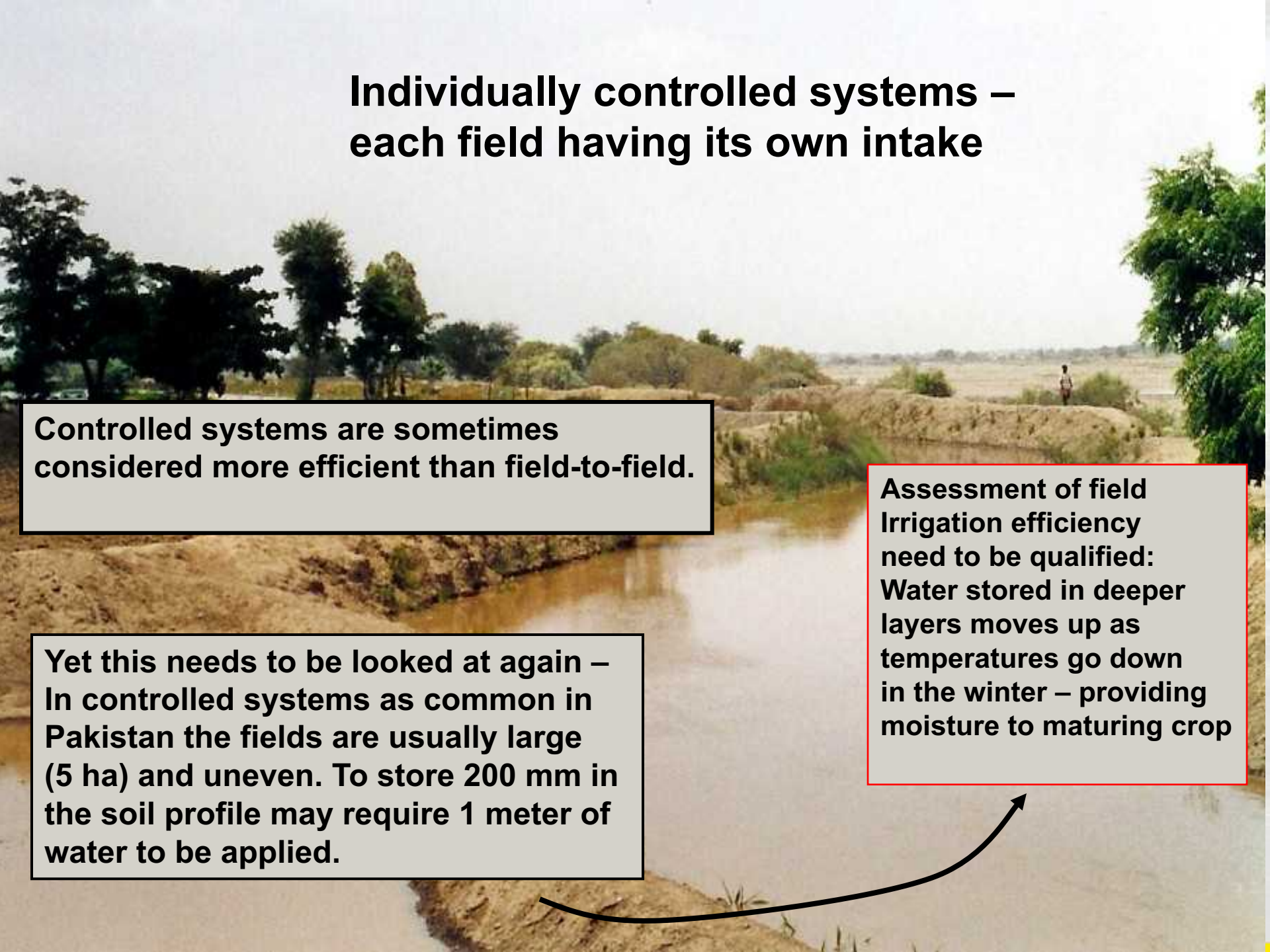


Individually controlled systems – each field having its own intake

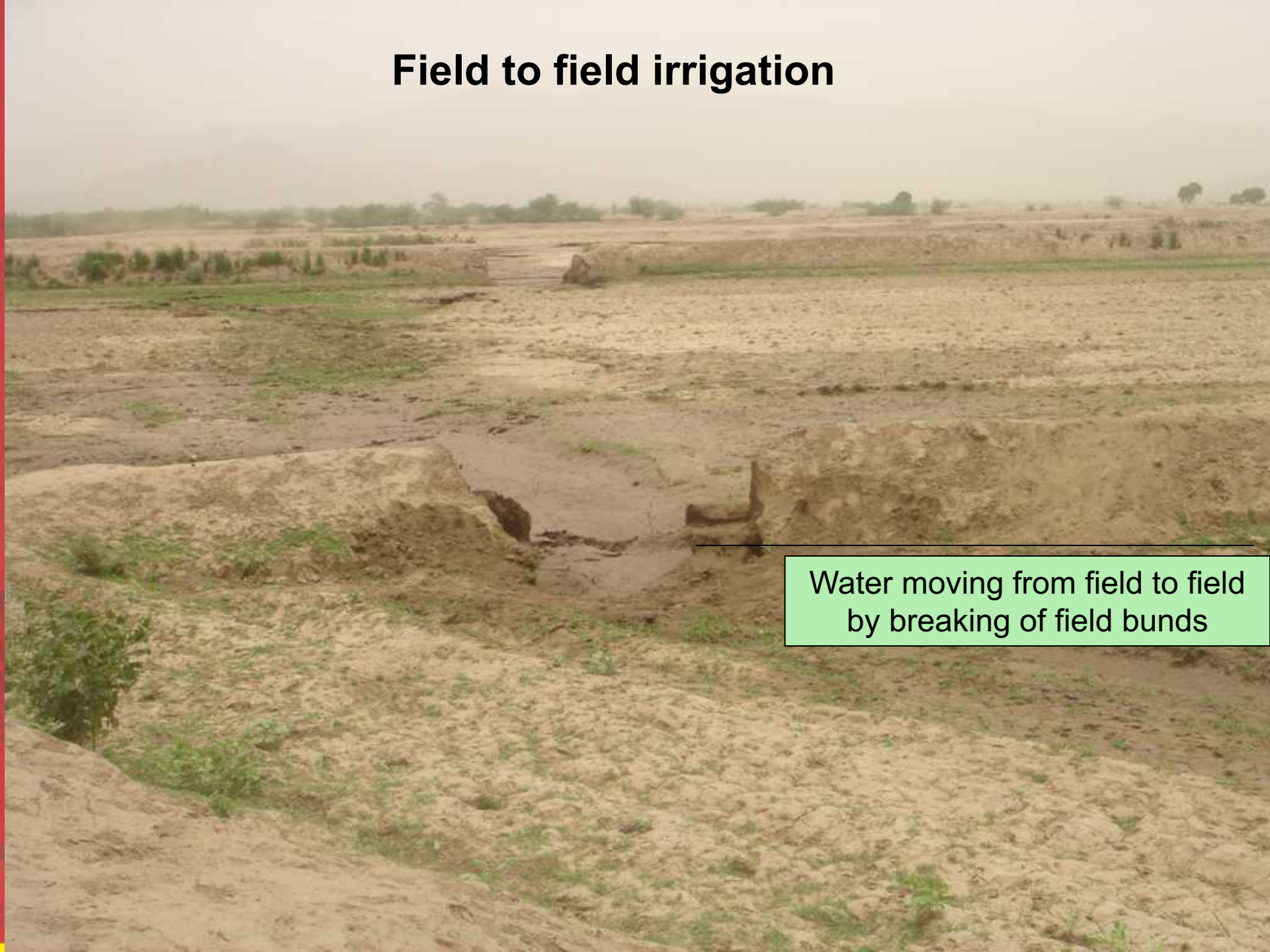
Controlled systems are sometimes considered more efficient than field-to-field.

Yet this needs to be looked at again – In controlled systems as common in Pakistan the fields are usually large (5 ha) and uneven. To store 200 mm in the soil profile may require 1 meter of water to be applied.

Assessment of field Irrigation efficiency need to be qualified: Water stored in deeper layers moves up as temperatures go down in the winter – providing moisture to maturing crop



Field to field irrigation



Water moving from field to field
by breaking of field bunds

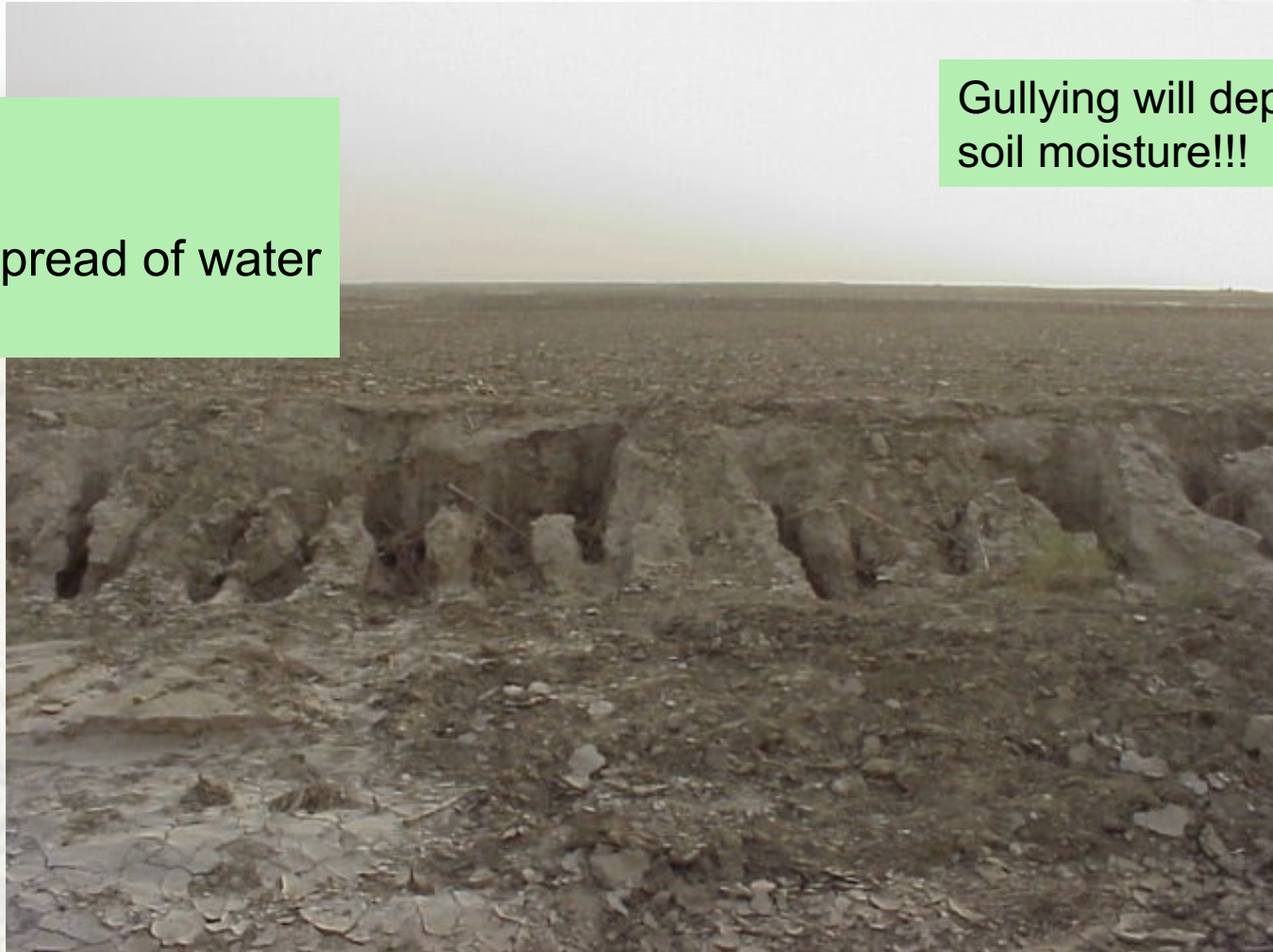
Field-to-field distribution: possible risks

RISKS

Gullying

Uneven spread of water

Gullying will deplete soil moisture!!!



Field-to-field distribution: Overflow control



Gated field intake (500 to 800 USD)

Stone pitch

(50 to 150 USD)



Field-to-field distribution: Overflow control



Orifice: Front side

USD: 300 to 600

Back side: settling basin



Field bund maintenance



- Individual responsibility
- Collective impact
- Single fabric that suffers when damaged

- **Explicit penalties:**
 - Compensation for crop lost
 - *Lethband*: hereditary tenant – one who maintains the field bund

Field bunds determine the amount of water that can be received in the field in a single event and also should prevent uncontrolled breaching to the neighbouring fields

Water holding capacity & infiltration rate



Ploughing before irrigation



Timely ploughing after irrigation

Since spate irrigation usually is based on pre-sowing irrigation moisture conservation is essential



Soil mulching - *Mekemet*

Water holding capacity & infiltration rate



Traditional Soil mulching

Timely ploughing and mulching improve the capacity to maintain soil moisture



Improved Soil mulching

Water holding capacity and infiltration rate: insects and crustaceans



Figure 5 Sowbug (*Hemilepistus shirazi* Schuttz), aquifer manager's best friend! This crustacean drills burrows as deep as 180 cm.

Insects and crustaceans may loosen the soil and improve the infiltration rate of the first floods significantly

Some guiding remarks

- ▶ Effective water diversion does not necessarily lead to higher water productivity
 - ▶ If there is no effective field water distribution based: coherence among water rights and rules, distribution systems and structures and flood characteristics
 - ▶ If there are no soil moisture conservation measures in place
- ▶ Field-to-field system may be effective:
 - ▶ If we limit command area per canal to 100 to 150 ha: In Eritrea a command area per canal is 300 to 400 ha
 - ▶ If separate off-takes to mid and downstream areas
- ▶ Keep the command area small and concentrated

Some guiding remarks

- ▶ Discharge determination of spate flows is not difficult
 - ▶ Ask the farmers to record the number of flood occurrence: small, medium, large
 - ▶ Ask them to for some water level indications at both banks of the river/wadi for the different floods
 - ▶ Use tracing method: slope area or velocity area method (Boiten, 2000: Hydrology)
 - ▶ Discharge measuring gates and divers have limited success
- ▶ Two irrigation turns can provide some 70 to 77 cm water depth, sufficient for optimum crop growth:
 - ▶ If you maintain the silt loam, sandy loam texture of the soil
 - ▶ Maintain higher capillary rise (50 to 100 mm), making water available for the crop from deeper sections of the soil

Some guiding remarks

- ▶ “Irrigation scheduling” is possible in spate irrigation – systems of storing maximum soil moisture
 - ▶ Ask farmers what is the effective flood period
 - ▶ Ask farmers how many floods occur in the different months
 - ▶ Ask them how frequent they pre-irrigate their fields
- ▶ Field bunds are important for soil moisture regulation
 - ▶ Maintaining small level difference between fields: < 25 cm
 - ▶ Adopt over flow control structures that require the minimum operation possible: stone pitch
 - ▶ Avoiding bund heights of above 1 m: In Pakistan, 2 m depth of water took several days to infiltrate (especially with clayey soils) delaying tillage and other land preparation

Exercise: comparing field to field and controlled system

Field to field systems	Controlled systems

Exercise: comparing field to field and controlled system

Field to field systems	Controlled systems
With field to field system a lot of soil/ sediment is removed as bunds are breached – this mitigates rise of land levels	Excess soil is used to make higher and higher field bunds
No land for canals, but possible damage to crops in 2 nd irrigation	Land required for canals – but these may be cultivated
Smaller floods later in season not diverted because of u/s cultivation	Smaller floods may no irrigate entire field, if plots are big
In-field scour due to breaching, though this will also remove sediment from command area	Gated structures will give full control over water diversion
Smaller floods not reaching tails	In large plots irrigation may be uneven
Time of breaching can be source of conflicts	No such a problem
Damage to upstream field bunds will jeopardize new irrigation to lower areas	Sedimentation in canals may affect command