

Flood Based Farming – Spate Irrigation System

Presentation Sub-Title:



- Introduction to Spate Irrigation and Flood Recession Farming
- Spate Irrigation Infrastructures
- Group Exercise

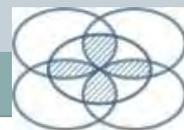
By:

Abebe Demissie Chukalla

abebe@metameta.nl/abedeme@yahoo.com

Arba Minch University

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Spate Irrigation
Network



Spate Irrigation
Network Ethiopia

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2 SPATE IRRIGATION SCHEMES INFRASTRUCTURE

2.1. Traditional Spate Irrigation Scheme

2.2. Modernization of Spate Irrigation Scheme

(Considerations for modernizing; Design considerations for diversion Structures (INTAKES), canals and water control structures and Wadi bed retrogression and wadi training)

- Case study: Boru Dodota Spate Irrigation Scheme
- Group exercise:

Introduction to flood based farming

Flood which is known for its distractive image, can be beneficial

- Spate/flood/ irrigation
- Flood recession farming
- Other benefits, such as
 - Groundwater recharging
 - Ecosystem Conservation
 - Fish farming
 - Leaching saline soils



Fig. Flood from micro catchment flowing to Boru Dodota Spate Irrigation Scheme (Yohannes G.)



Fig. Flood recession farming on the riverbeds in Gambela. (Dr Frank)

... Introduction to flood based farming

Flood for Groundwater recharging

When floods occur, wetlands and floodplains can store water. Slowing down the runoff allows additional time for the water to infiltrate and recharge available groundwater aquifers.

LOW RECHARGE WEIR
TO SLOW DOWN AND SPREAD
FLOODS



... Introduction to flood based farming



Ecosystem Conservation



... Introduction to flood based farming



Fish farming



Artificial pond for fishing in upper Awash Basin (Fig Abebe M., 2011)



1. Which of the listed flood benefits are familiar with you?
2. What other benefit of flood do you know at your locality?

Definition and Concepts

Flood recession agriculture is linked to areas that are prone to annual flooding, making use of the moisture left behind after the floods and sometimes even using the water of the rising floods as well.

In Africa alone, flood recession agriculture may amount to over 20 M ha.

Fig: Farming immediately after recession in illu district (Becho plain)
(Abebe M, 2011)



.... Definition and Concepts



Rice production under flooded conditions using small bunds in the Fogera plains near Lake Tana

... Definition and Concepts

Flood recession agriculture at *Baro-Akobo*



Flood recession farming on the riverbeds in Gambela. Adjacent to the river are marshes that can be partly cultivated later in the dry season (*Dr Frank*)

... Definition and Concepts



Different stages of flood recession agriculture in the Becho plains (*Abebe M. 2011*)

... Definition and Concepts



Omo River Valley

- Flood recession in this valley is mentioned to occur in narrow bands along the banks of the Lower Omo
- In this area, the total area under flood recession is set at 11037 ha, but this includes riverine woodlands, open bushland and bare soil as well

... Definition and Concepts



- Maize, sorghum and finger millet are the main crops. They are planted on the banks of the Omo River as the annual flood retreats.
- A common cropping practice is for sorghum to be planted in groups of ten seeds together to make sure that one in these groups will grow fully mature

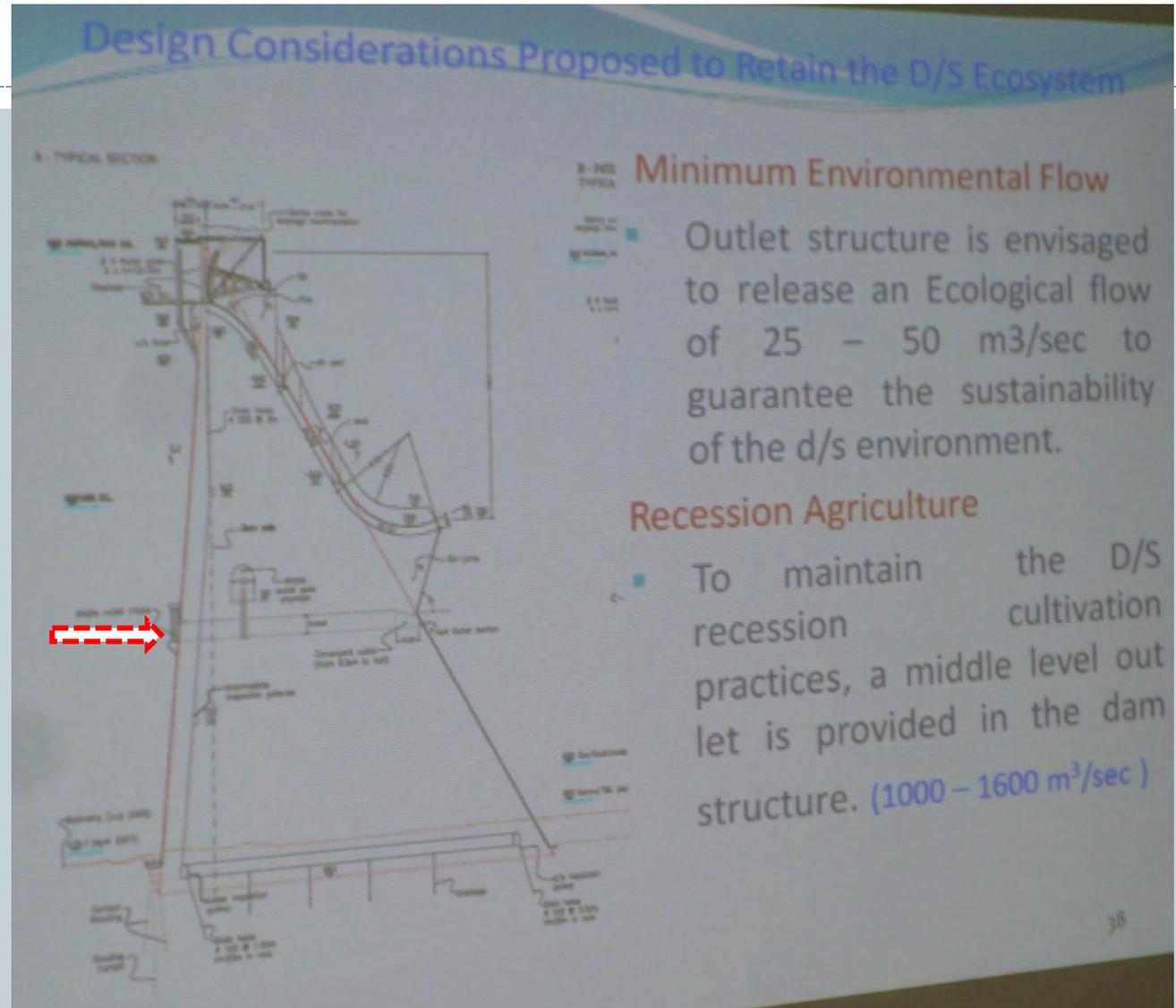
.... Definition and Concepts



Groups of sorghum that are planted on temporarily inundated land in the southern Omo River valley (*Abebe M. 2011*)

... Definition and Concepts

In the section of Gibe-III Dam; To maintain the d/s recession cultivation practice, a **middle level outlet** is provided in the Dam.



Discussion



Have you seen any flood recession agriculture before?

- What are the crops on such agriculture
- What are the difficulties in such method of agriculture and how farmers could be supported?



Spate Migration

Definition and Concepts: Spate Irrigation

Flood (Spate) irrigation makes use of occasional, unpredictable and often destructive floods in ephemeral rivers to irrigate farm land, rangeland and forestry, recharge groundwater, fill drinking water reservoirs and mitigate climate change and variability



(Dr. Abraham M., 2011)

... Definition and Concepts



Fig. Farmers working on flood for farm to farm water distribution

... Definition and Concepts



- **Spate irrigation** is a resource system, whereby flood water is emitted through normally dry wadis and conveyed to irrigable **fields**". Definition by Mehari et al. (2007)
- Spate irrigation development requires high **levels of cooperation** between farmers to divert and distribute flood flows.



.... Definition and Concepts

Spate In Ethiopia

- Ethiopia has three agro-climatic zones:
 - the highlands (above 1,700 m+MSL),
 - the midlands (1,000 – 1,700 m+MSL)
 - lowlands (below 1,000 m+MSL)

Size of the flood,
catchment size,
suitability for
single/multiple intake
and diversion at the

Midland vs low lands!!



.... Definition and Concepts



In the context of Ethiopia, spate irrigation could be defined as a method of applying flood water as;

Supplementary irrigation to the **midlands** and **complementary** irrigation to the **low-lying** lands by diverting floods that are caused by the rainfall on the subsequent upper-lands (Abebe D., 2010).

... Definition and Concepts



1.3. Extent and distribution of Spate Irrigation

- Spate irrigation is the main source of livelihoods for large numbers of economically marginal people and it is found:
 - West Asia, Central Asia, the Near East, North Africa, the Horn of Africa and Latin America. The country with the largest areas under spate irrigation is Pakistan.
- In Ethiopia spate irrigation is being developed by Oromia, Tigray, SNNPR etc. regions

.... Definition and Concepts: Spate irrigation types



Spate irrigation category:

- based on Size of the scheme (Small, Medium and Large),
- Based on the infrastructures (Traditional intake and canal, improved traditional system, modernized and new system),

.... Definition and Concepts: Spate irrigation types



... Spate irrigation category:

- Based on who maintain and operate it (Traditionally managed, managed by farmers and with support from agency, Agency managed)
- Based on source of water for the scheme (Schemes that have access *only to spate flows*, scheme that have access to *significant base flow*, Conjunctive use of spate and shallow groundwater).



Spate Hydrology

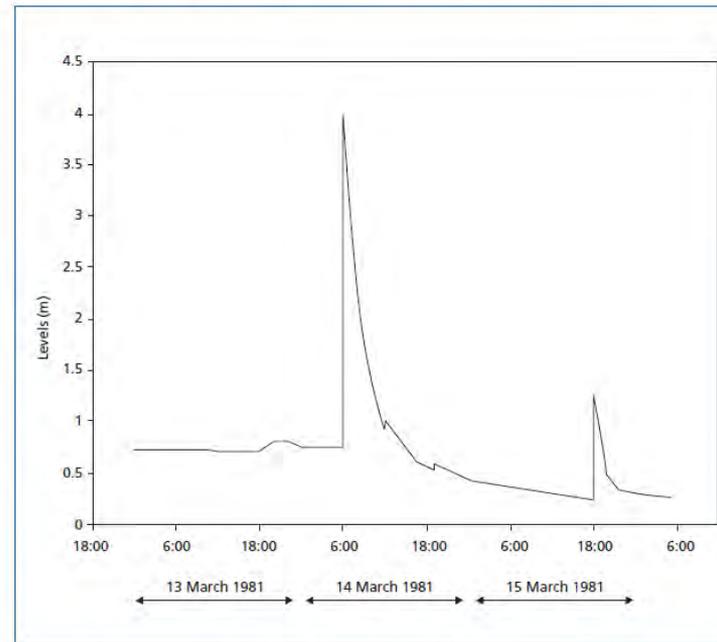
1.5 Hydrology of Spate Irrigation



- Spate hydrology is characterized by a great variation in the size and frequency of floods
- Flood hydrographs are characterized by an extremely rapid rise in time, followed by a short recession

(Dr Abraham M.)

FIGURE 3.1
Spate flood hydrograph from Mishrafah, Wadi Rima, Yemen, 1981



... Hydrology of Spate Irrigation

Most of the Wadis' are un-gaged



Figure: “Kaske River” Sand River, about 60-70 m wide, and trunk transported with the flow

... Hydrology of spate Irrigation

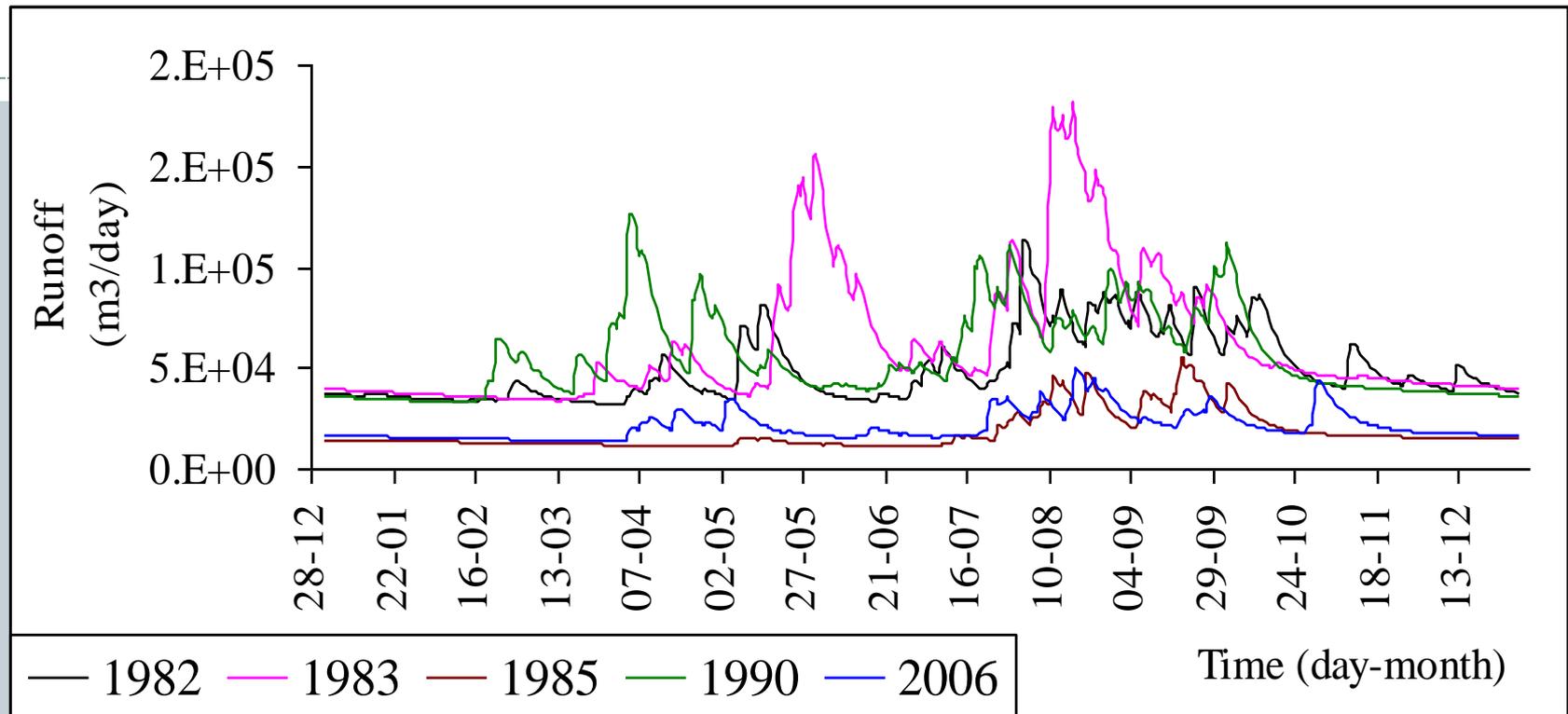


Figure: Rainfall- runoff NAM model Result, Boru Dodota Dodota. (Abebe D., 2011))
Flood from Boru Wadi, varying in the magnitude and time of its occurrence.

How these resources could be diverted ?

How farmers divert it traditionally ?



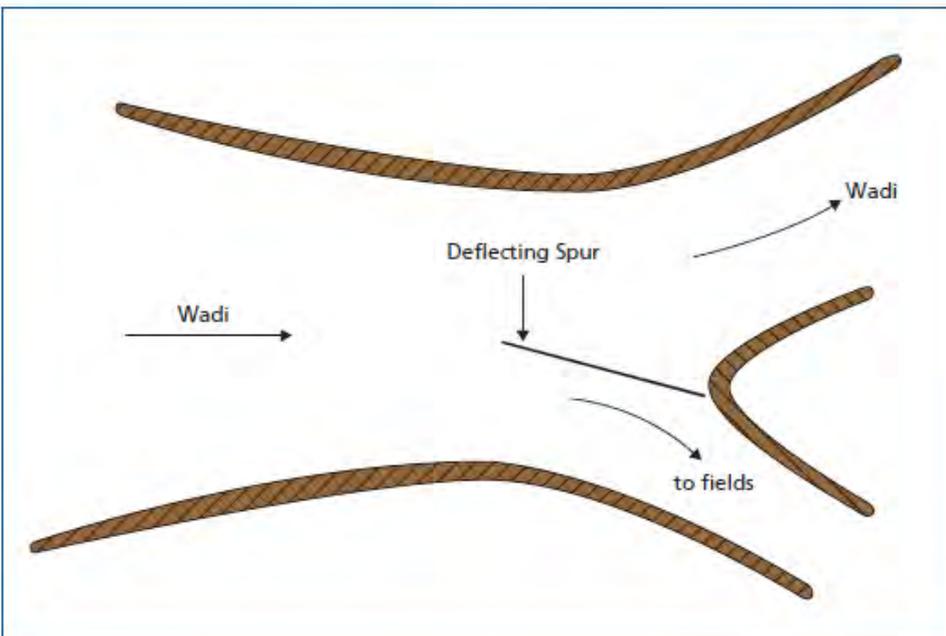
2. Spate Irrigation Schemes Infrastructure

2. Spate Irrigation Schemes Infrastructure

2.1 Traditional Spate Irrigation Scheme

- divert **part of large** and varying levels of flood flows
- deliver water to canals at a sufficiently **high level** to ensure command over the irrigated fields
- one of two forms. These are the spur-type deflector(left) and the bund-type diversion (Right).

FIGURE 4.1
Deflecting spur-type traditional intake



Diversion bund intake

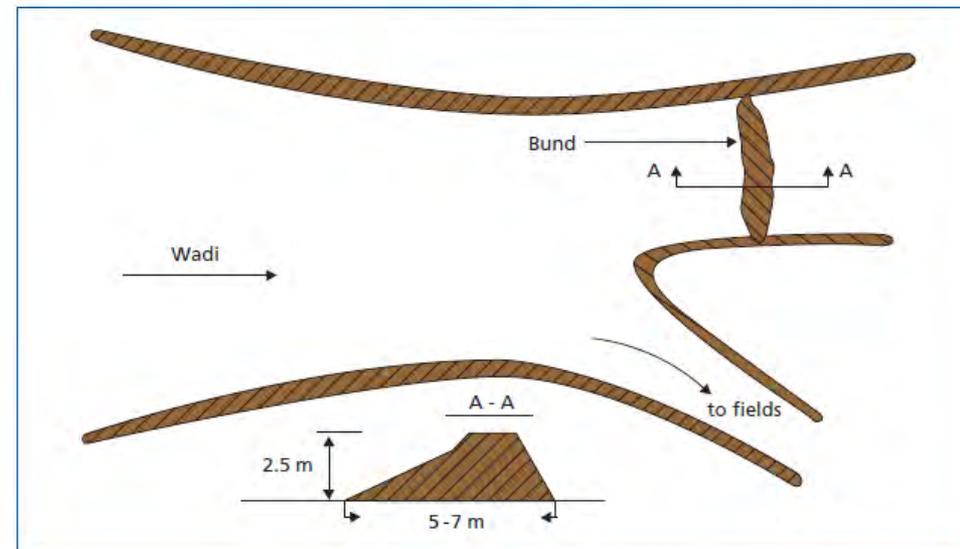




Figure: Traditional flood diversion: spur-type deflector



What is the traditional practice of flood diversion in your respective area

?



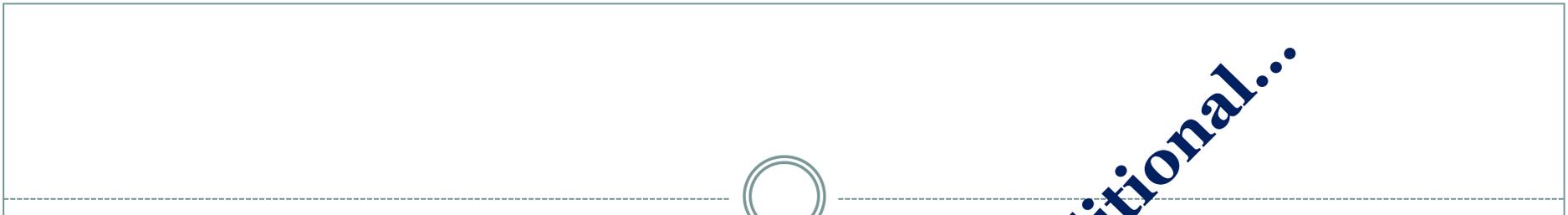
Figure : Lowering of the bed of branch channel, by farmers, to irrigate the field at head that was lost due to sedimentation, Luka Kebele – South Omo , Ethiopia



Figure: Multiple diversion of road side flood for Maize cultivation, Luka Kebele, South Omo - Ethiopia



Channel parallel to Asphalt road for passing flood to the maize field, Luka Kebele



Advantages and disadvantages of Traditional...

Advantages and disadvantages of Traditional Spate Irrigation ...



Advantages

- Located at outside of relatively mild Wadi bends (lower flows are channelled)
- Can be maintained by farmers (local material)
- Designed to be breached during high flood

FIGURE 4.4
Traditional spate irrigation intake in Pakistan



... Advantages and disadvantages of Traditional Spate Structures



- Advantages:
 - **Flexible** (the intake can easily be adjusted to suit the changing bed conditions)
 - **Low cost**; based on local technology (material)
 - High **overall diversion efficiency** (cascades of intakes)
 - **limit** diversion of **high flood** and **high sediment load** (Breaching bunds)



... Advantages and disadvantages of Traditional Spate Structures



Disadvantages of traditional intakes:

- **Enormous input of labour and resources** to maintain and reconstruct intakes
- After the large flood destroys upstream intake, following **flood can't be diverted until repairs**





Is improving the diversion system required?



Improvement need to be done depending on Site conditions, available resources, and farmers' preferences:

With an objectives:

- 1- reduce labour required to maintain intakes
- 2- reduce additional maintenance due to damage and siltation within the system
- 3- retain the traditional water diversion and management practices in line with established rule and right
- 4- avoid unintentional alteration of water distribution within watershed (U/s and D/s)
- 5- cope with frequent and sometimes large changes in wadi bed

Short coming of the so far modernized structures



- ✓ Area in front of weir silts up: >> diversion in the end by traditional structures
- ✓ Gate operation often problematic: >> no operator at the right time or gates getting stuck
- ✓ Sedimentation ponds not operated and not maintained: >> sedimentation problem
- ✓ Large investment in single off-take – often with long conveyance channel: >> creating conflicts and depriving downstream water users



Figure: Short coming of the so far modernized structures: Sedimentation



Figure: Short coming of the so far modernized structures: Trash transport / blockage



What considerations should be taken for the Improvement/modernization?

the Improvement should:



- make it easier and less labour-intensive to operate and maintain;
- minimize the capacity of large and uncontrolled flood flows to damage canals and field systems;
- help maintain the distribution of water within the system in line with established rules and rights;

...the Improvement should:



- avoid unintentional alteration of water distribution (including drinking water and water for animals) within the watershed between upstream and downstream water users;
- avoid excessive sediment load in spate systems and ensure that suspended sediments are deposited on the land and not in the canals;
- cope with frequent and sometimes large changes in wadi bed conditions.



What improvement options do you envisage?



The engineering structures involved when spate schemes are improved can be described under three headings:

- diversion structures (intakes);
- spate canals and water control/dividing structures;
and
- Bank protection and wadi-training structures.



New permanent diversion structures

- A typical diversion structure includes a raised **weir**, with or without **a fuse plug**, a **scour or under-sluice**, a **canal head regulator** and a **guide or divide wall**;
- Single versus multiple intake;
- Location of intake
at the outside of relatively mild wadi bend, just d/s from the point of maximum curvature

...Options for improvement include:



- provision of basic gated intakes;
 - wider intake considering the requirements and the response time for the operation of the gates should be less than the time to flood peak (10 – 30 min)
- provision of rejection spillways
 - The spillway needs to be designed as a lateral-flow weir capable of passing all the flow in excess of the downstream canal capacity.



Discuss Traditional Vs improved structures on spate irrigated scheme for the following lists of hydraulic structures

Canal, water control/ division structures

- Canal,
- check and drop structures,
- flow splitting structures,
- field offtakes,
- infield structures.

Bank Protection

Design considerations



Objectives: Design operable, maintainable and sustainable structures, systems

- Diversion
- Under sluice
- Intakes /single or multiple/
- Rejection spillways,
- Fuse plugs /breaching section/
- Canal
- Drop
- Water divider/ DB/

Design Considerations: Spate flow characteristics



Our design need to consider these spate characteristics

- Sedimentation
- Trash transport / blockage
- Scour
- Changing of river course

Design considerations

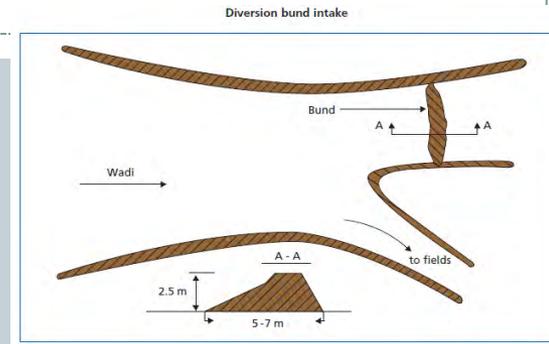


- Best location to be determined by comparison of wadi level, field levels (with allowance for rising) and canal slope
- Intake structure to occupy less than 20% of wadi width
- Orifice head regulator limits maximum flow into the canal
- Side spillway enables rejection of excess flow approaching canal intake
- Managing for the big floods: gravel or soil embankments will breach to enable passing of big floods

Design consideration: Flood Diversions and Control Structures

Intakes in spate systems

- have to divert large and varying levels of flood flows and prevent large uncontrolled flows from entering canals,
- deliver at high level to ensure command over the irrigated field



... Design considerations



Intakes in spate systems

- limit the entry of the very high concentrations of coarse sediments
- function over the longer term with rising irrigation command levels, degradation of wadi bed levels
- canal capacities have to cope with a wide range of discharge

... Design considerations: Intake



- Gates to only be provided if required by the farmers. A large orifice may be sufficient
- Sluiceways are more appropriate in the upstream part of wadis where more water is available for flushing
- Strength / cost of structure will decrease upstream to downstream, but the benefits will also decrease unless a large command is reached (which is often possible in downstream areas)

... Design considerations: Intake capacity



- Need to convey large volumes of water by gravity to fields during the short periods when Wadi flows occur.
- Hydrological information on Wadi flows are in almost all cases very limited,
- The timing, duration and maximum discharge of spate flows are thus unpredictable,
- Areas traditionally irrigated varying significantly from year to year.,
- Water conveyance and distribution systems developed for perennial irrigation are not appropriate for spate systems.

.... Design considerations: Intake capacity



- Much larger capacities are needed (10 to 100 times greater than for perennial systems for a given area)
- Flow velocities will be higher than conventional canals as the water is heavily laden with sediment and generally pass through much coarser material that have been deposited over the years.
- Traditional intakes and their modern replacements can both fulfil these above functions, although by different means and with large differences in capital and maintenance costs and requirements



Case Study:

Modern, large scale - Boru Dodota Spate
Irrigation Scheme

Boru Dodota Spate Irrigation Scheme



Boru Dodota Spate Irrigation Scheme which is located in Arsi zone, Oromia Regional State at 135 km from the capital Addis Ababa of Ethiopia, is established to increase agricultural production through supplementing the existing rainfed agriculture over 5,000 ha with spate irrigation (Aman, 2007).

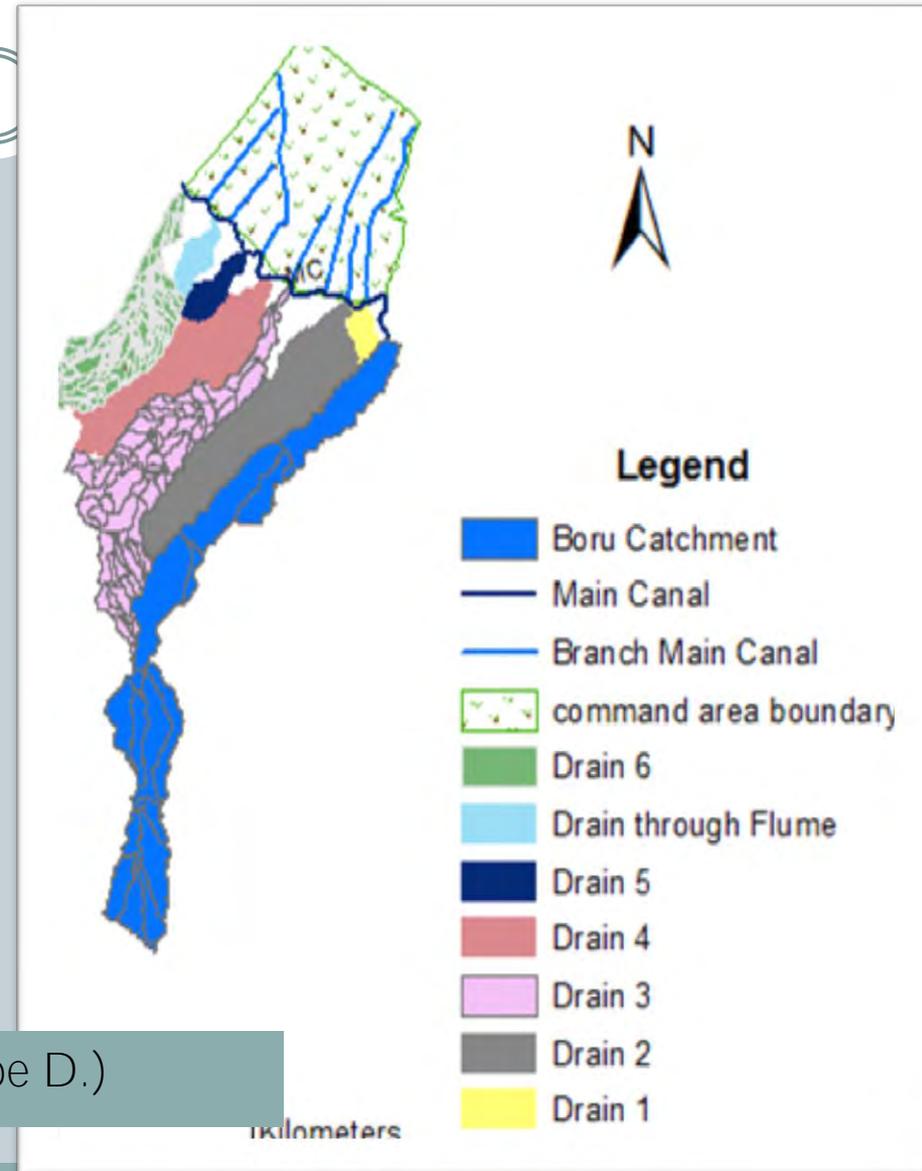
The diverted flood that is used for spate irrigation purposes at Boru Dodota Scheme are originated from Boru sub-basins and the adjacent micro sub-basins.

Case study: Boru Dodota Spate Irrigation Scheme

Diversion headwork (Ogee weir) is built to divert the flood from Boru Wadi.



Fig. (Abebe D.)



Case study: Boru Dodota Spate Irrigation Scheme(BDSIS)



There is enormous room to increase the efficiency of Sediment management, moisture conservation, scheme operation, flood diversion, flood management and scheme operation at BDSIS.



Though the scheme was operated at overall poor efficiency level, in the year 2009 substantial improvement in yield on the spate irrigated field compared with the adjacent rainfed agriculture was observed.

Case study: Boru Dodota Spate Irrigation Scheme(BDSIS)



<i>Crops</i>	<i>*Rainfed (Kg ha⁻¹)</i>	<i>*At Boru Dodota Spate Irrigation (Kg ha⁻¹)</i>	High producing variety (kg ha⁻¹)
Wheat	80	250	4000-6000
Barley	100	270	-
Teff	109	160	2200-2800
Maize	85	60	6000-8000
Haricot Bean	52	60	1500-2500

Table: Actual yield for 2009; on rainfed field versus Boru Dodota Spate Irrigated field (source, Abebe D.)



Questions



SPATE IRRIGATION PRACTICAL EXERCISE

Exercise

The exercise will depict the considerations to be taken while designing, managing and operating improved flood diversion/ intake structures; and ponds. The implementation of such structures is expected to enhance the agricultural, livestock and domestic water supply for the agro-pastoralist community in the low-land areas of Ethiopia.

Two adjacent communities in low-land areas of Ethiopia, community A and community B, have been cultivating crops on their respective command area (refer figure -1) by diverting flood from a wadi that gets flood source from the upper land (micro catchment). The two communities have been sharing the flood almost equally at section S, using traditional structure made of soil bunds. Sometimes, conflicts arise while more flood water is diverted in favor of one of the community at section S due to: I- larger sediment deposition at one of the intakes and less deposition or scouring to the other intake, II- deepening of the canal bed just after the intake by a community to divert more floods to their field. Hence, it is required to modernize the structure at the intake (at section S) thereby to minimizing the conflict and ensuring the sharing of the flood at section S equally.

In the wet season, the flood is let to the outwash - swampy areas that raise pasture for the livestock after irrigating the command area of each community. The flood in the wet season is also a source of domestic and livestock water supply. However, in the dry season the children and women in the community travel long distance (2.5 to 3 hours) to collect water from holes dug in the River bed for domestic and livestock water supply. To improve this situation, ponds are suggested so that extra flood water can be collected during the wet season and to be used later in the dry season.

- Based on the given information, you as expert are asked to advice and discuss the design consideration for the improved diversion/intake and the pond, and present your findings after lunch. Support your presentation with sketch.
- In this particular exercise; give main focus for the structures to be designed as operate-able, maintainable and manageable by the users; these structures also need to consider the hydrology, sediment, institutions and water rights issue.

Group exercise

Exercise

Background of the area

The upper section of the catchment, the source of floodwaters for the low-lying fields is hilly and mountainous with elevations above 2,500 m+MSL (Mean Sea Level). The climate is warm to mild with an average annual temperature of about 22 °C. The annual rainfall at the upper section of the River basin is the source for the flood which is estimated to be sufficient to support the domestic, livestock, agricultural and pasture land requirement of the area.

On average five floods occurs from June to October. Sometimes, heavy rain (one in three years) occurs in March. There is no perennial River at proximity to the community and the groundwater is very deep and for time being fund is unavailable for its exploitation.

At the low-lying land, the average annual rainfall is 450 mm and it is erratic in nature. The potential evapotranspiration at this low-lying land is estimated to be greater than 2,000 mm per year.

Nearby the foot of the mountain the sediment is mainly boulders; however in the lower reach where the flood is diverted for spate system, the sediment deposit is alluvial. The soil type for the command area is Silty loam. The slope in the lower River system is flat (1 to 1.5 in 1 Km), with an average River width and depth of 18m and 0.6m to 1.5 m respectively.



Figure 1: Layout of the micro catchment, village, command area and outwash area.



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Thank You

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