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# Conveyance and Drainage System in Spate Irrigation
## -A case of Boro Dodota Spate Irrigation-

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**Abstract:** Total area of Oromia State of Ethiopia is 36 million ha, out of which 1.7 million ha the potential area for surface irrigation, while only 0.2 million ha had been developed. Previously, the irrigation development was mainly focusing on diversion from perennial river flow. However, it is required to promote agricultural development utilizing seasonal wadi floods for supplemental irrigation (called spate irrigation) in regions where rainfall is insufficient for crop production. The Boro Dodota spate irrigation project is the first case of the modern medium scale spate irrigation in the State initiated in 2004 having 5,000 ha of the command area. The current report discusses contexts, constraint, and prospects of the project, in particular focusing on designing and function of the system. Currently assessment conducted by the Irrigation Farming Improvement (IFI) indicates that the project had positive impact on crop production, while several challenges remained concerning conveyance and drainage. The results obtained in the current study indicate that establishment of the silt elimination and the drainage system is strongly recommended to enhance the benefit of the project.

**Keywords:** Central Ethiopia, Flood, silt sedimentation, Spate irrigation, Watershed analysis

## 1. Introduction

Total area of Oromia State of Ethiopia is 36 million ha, out of which 1.7 million ha is suggested to be suitable for surface irrigation with a slope ranging 0 to 8%, while only 0.2 million ha has been developed (Oromia Irrigation Development Authority, 2006). Previously, the irrigation development was mainly focusing on diversion from perennial river flow. However, it is required to promote agricultural development utilizing seasonal wadi floods for supplemental irrigation in regions where rainfall is insufficient for crop production. This is called spate irrigation. Currently, many spate irrigation development schemes are underway particularly in eastern part of the Oromia State where there are limited perennial river flows. The Boro Dodota spate irrigation project located at 8˚11'N and 39˚22'E, is the first case of the modern medium scale spate irrigation in the State initiated in 2004 having 5,000 ha of the command area.

The paper discusses the context, constraint, and prospects of the project, in particular focusing on designing and function of the system in limited scope.

## 2. Material and Method

The Boro Dodota spate irrigation was projected to intake floods maximum up to 6 $m^3/s$ from the seasonal flow of Boro river into the command area for supplemental irrigation (Oromia Water Resources Bureau, 2008). The watershed consists of arable land (70 %), high land covered by bushes and trees (20 %), and grazing land (10 %). The flood taken is due to be distributed to each command field through 17.4 km of the main canal (out of which 14.7 km is earthen canal), 7 branch canals (total length is 61 km with trapezoid section), secondary and tertiary canals. Mean slope of the earthen main canal is 2/1,000 and the maximum fluid velocity is 1.2 m/s. Further, 11 super passages and level crossings are provided to the main canal in order to drain the excess runoff from the upper command area.

## 3. Results and Discussion
### 3.1. Positive Impact of Spate at Boro

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In order to investigate the impact of the project on crop production, the Irrigation Farming Improvement (IFI) organized by Japan International Cooperation Agency (JICA) and Oromia Water Resource Bureau (OWRB) undertook field visit and data collection in 2007. Out of the command area 280 ha of the land was subjected to the analysis. It is revealed that the production with spate irrigation was significantly higher than that with non-irrigated condition, and it was comparable to the yield record in 2006 which had sufficient rain (**Fig. 1**, Kebebew *et al*., 2008).

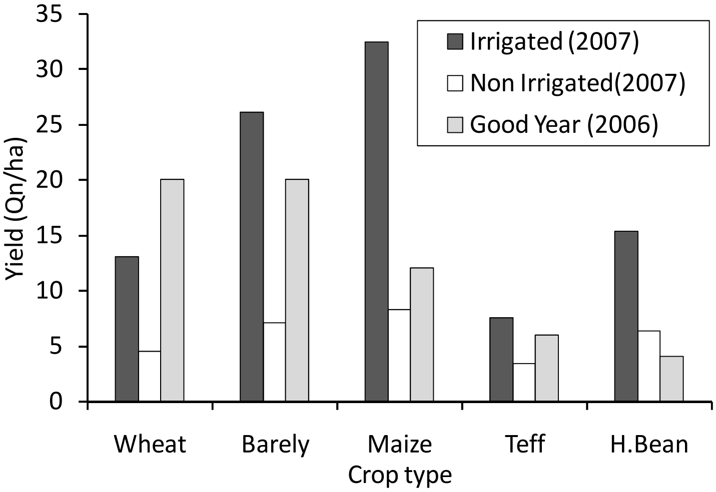


**Fig. 1. The effect of spate irrigation on crop production. (After Kebebew *et al*., 2008)**

### 3.2. Watershed and Flood

To scale up the previous verification result to all over the project command area, constraints were also observed. The project encounters eleven natural drainages which collect flood from the sub and micro watershed, out of which five of them had severe impact on the main canal, the command area, and the drainage system. The micro catchment area of these eleven natural drainages covers 163 $km^2$ area which is greater than that of Boro watershed, 69.3 $km^2$ retrieved by Arc GIS (**Fig. 2**). Assuming the same land use and rainfall for the main river catchment and sub and micro watershed of the command area, one would judge that the flood yield from sub and micro watershed could have not only positive impact but also considerable negative impact when treated inadequately. During the past two years, flood from these micro catchments brought significant damage on farming areas and some residences (**Fig. 3**).

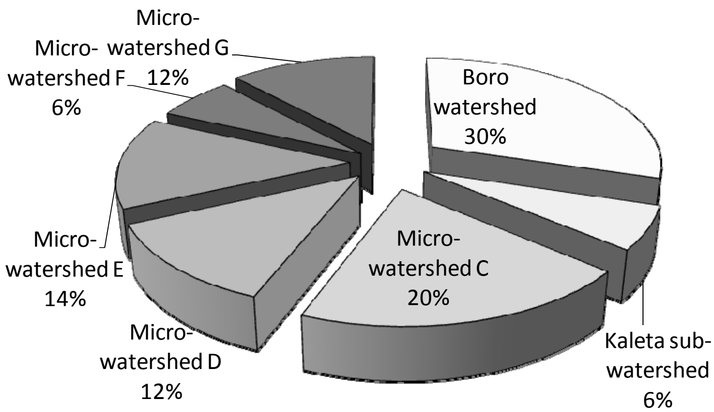


**Fig. 2. Component of watershed of the Boro dodota spate irrigation.**

**Fig. 3. Flood over the hydraulically regulated structure.**

### 3.3. Drainage System

Initially, the project did not include drainage systems, especially cutting drain to protect the main canal from flood of the micro watershed. Flood from the watershed was allowed to pass through the command area across canals, and the flood was not led to the main natural drain. The interference on the natural drain system during construction resulted disturbance on the previous natural drain and created further inundation in other areas.

### 3.4. Silt

The main canal was designed and constructed to take 6 $m^3$/sec of flood from the wadi or the micro catchments and to spill the excess water at 6 different hydraulically regulated crossing structures to the natural drain. However, due to high silt content of the flood, especially from the watershed, the capacity of the canal decreased resulting in overtopping from the main canal at different places. Further, structures were filled with silt (**Fig. 4**).

Silt sediment was observed for the lined main canal and division box structures ranging from 20 to 40% and from 30 to 45%, respectively (**Fig. 5**). The earthen main canal had also silt sediment up to 60% of their capacity with single rainy season flood event (**Fig. 6**).

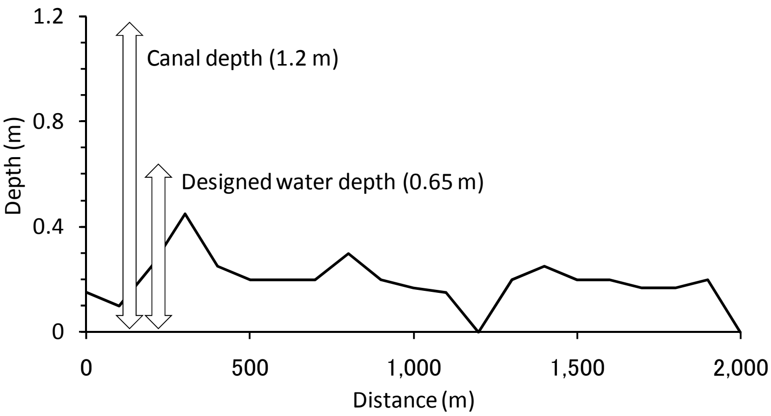


**Fig. 4. Silt sedimentation in the main canal.**

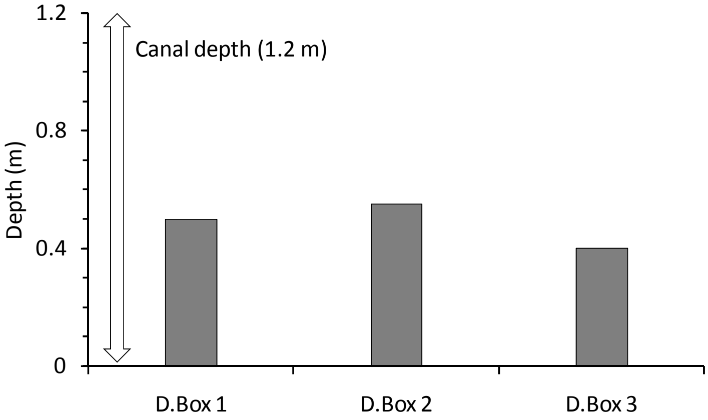


**Fig. 5. Silt sedimentation in the division boxes.**

### 3.5 Discussion

Meteorology, watershed and soil data are essential for sustainable and efficient project. The project was designed using FAO retrieved data at Asella meteorological station, 30 km apart from the head work to the south. The head work and the command area are located between 1,500 and 1,800 m in altitude, while the station is at 2,450m of altitude. Additional three stations are found around the project area at 20, 28, and 34 km apart from the head work of the project. Recently, one station was established by Tokyo University for Agriculture (TUA) at 6 km apart from the head work. The observation, particularly rain fall, of the newly established station and FAO retrieved data for important months of spate irrigation (June, July, and August) ensured adequate, relevant, and reliable data (**Fig. 7**).

Although silt load analysis was not conducted, considerable amount of silt accumulated in the canal resulting in severe negative impact in the system. Particle size of the sedimentation in the main canal were sand (0.06 mm< d< 2 mm) and silt (0.004 mm< d < 0.06 mm). Since the slope in the main canal designed was 1/2,000, the designed system is in part responsible for the sedimentation as it generated insufficient velocity to spill out silt.

The floods overtopped the super passage also caused eroding the downstream part of the structure.

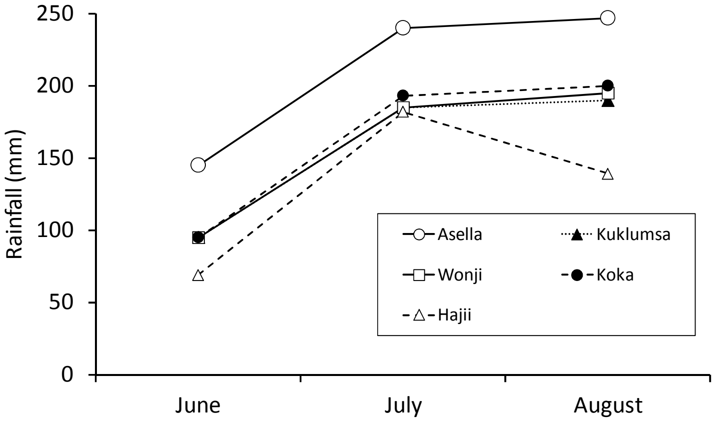


**Fig. 7. Rainfall data observed at a meteorological station and FAO retrieved data.**

**Fig. 6. Soil sedimentation in main canal (above) and division box (below).**

## 4. Conclusion

By its natural characteristics of spate irrigation, it is true that it is a high risk development. But when the development is not done with reliable and relevant data and proper design approach the risk will be exponential. Especially, the flood and the silt can hinder the scale up of positive impacts of the project as intended. Without proper hydrological analysis for the micro watershed and wadi Boro, silt load estimation, overall drainage system design and implementation the project, strong water user association and better water and facility management the blessing can be reversed to curse.

Establishment of meteorological stations and silt measurement in selected areas of the watershed would make planning and design more effective if combined with recent satellite images for land use analysis with GIS and remote sensing.

Certain conservation measures in the watershed are required to minimize sedimentation. Designing and constructing water storage facilities like ponds in the command area and the watershed are also very useful against severe draught, and the facilities would also function as silt reservoirs to protect the main canal (Oromia Water Works and Supervision Enterprise, 2008). Effective drainage system design and implementation are also essential measures to enhance the benefit of the spate irrigation and to mitigate inundation. Design of main canal and hydraulic structure, and improvement of construction are recommended to be conduct in the future to maximize the positive result of the project. The results and recommendation obtained from the current project can be useful for other existing and new spate irrigation projects in the country, Ethiopia.

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