# Transition from Traditional to Modern Spate Irrigation: The Case in Kobo – Girana Valley, Amhara Region

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## Abstract

In Ethiopia spate irrigation is on the increase due to public interest as well as farmer's initiative. Though there are newly introduced areas, there are some spate irrigation practices that have been in use for several generations. The technology is in increasing the arid parts of the country. Kobo-Girana Valley is one of the historically practiced areas, having ample potential for spate irrigation. A potential assessment made by Amhara Design and Supervision Works Enterprise showed that an area of 51,668 ha has been identified as a potential for spate irrigation in the Kobo-Girana Valley. In order to reduce the challenges in the traditional system the newly introduced modern spate irrigation also has some limitations that require further research and design considerations. The main problem in the traditional system is frequent damage of structures and labor-intensive mismanagement of silt and water. In similar ways, the modern schemes are also underutilized due to mismanagement of the schemes and absence of proper openings for removing silt and excess water.

**Key words:** *Spate, Kobo Girana Valley, traditional, modern spate*

## 1. Introduction

Spate irrigation is a form of water management that is unique to semiarid environments, particularly where mountain catchments border lowlands (Steenbergen et al. 2011). In Ethiopia spate irrigation is on the increase in the arid parts of the country. The development of spate irrigation in Ethiopia is driven by both public interest and farmers' initiatives. Some spate irrigation systems have been in use for several generations, but in almost all areas spate irrigation has developed recently. One of the potential areas and historically beneficiary area of spate irrigation in Ethiopia is the Raya-Kobo-Girana Valley. In the Raya Valley alone traditional spate irrigation extends to 21,000 ha (Kidane 2009). Traditional spate irrigation practice in the valley is done in plain areas following intermittent rivers found around the Kobo area starting from the Gobu River flows bordering Amhara (Figure 8.1) and Tigray regions to Amid Wuha found between Robit and Gobiye with small rural towns crossing the Tigray Woldya asphalt road (ADSWE 2012).

The traditional system consists of short free intakes. Floods are diverted from the seasonal rivers and directed to the cultivated fields to supplement the rainfall. The river water can be diverted before and after sowing. Before sowing, the farmers diverted the river water to their farms to enable the soil to hold the required moisture. The main diversion canal is called “Enat Melle” (Mother Melle) which starts as a small earthen embankment protruding into the flood course at an acute angle with gradually curving and thickening buildup that guides the flow to the cultivated fields. These main diversions are constructed at a convenient angle across the slope of the riverbed to divert the flood runoff and convey it into the command area.

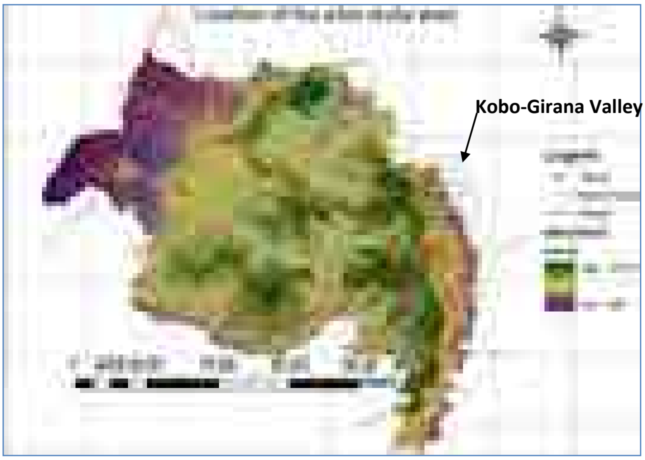
Even if the traditional spate irrigation in the area paved the way for other areas to practice the systems, the traditional spate irrigation system practiced in the Kobo-Girana Valley faces many challenges. The main challenges to utilize the floodwater under the traditional systems include labor-intensive nature; frequent requirement of maintenance; underutilizing of floods as the farmers divert only part of the flood to protect the canal systems and command area from erosion; wrong position of intake; no full control of floods at the headwork resulting in the creation of overtopping; absence of structures to control unwanted materials; poor management of floodwater and riverbank; and erosion of river bank. In this circumstance, improving existing traditional spate irrigation systems and developing new spate irrigation areas in the valley are attractive development options. A potential assessment made by Amhara Design and Supervision Works Enterprise (ADSWE) showed that an area of altogether 51,668 ha has been identified as a potential for spate irrigation in the Kobo-Girana Valley and some Ambassel woredas (ADSWE 2012).

Existing traditional spate systems still need to be improved to reduce the excessive labor input required to keep them operating and there are also identified areas in the valley where spate irrigation could be introduced to improve crop yields in marginally rain-fed areas. Improved flood diversion structures can contribute a lot to the stabilization of river banks and rehabilitating gullies. Even the adoption of simple and cheap technologies for flood diversion structures (gabions) rather than using traditional practices is preferable, as they are adapted to the local soil and climate. Demonstration of improved successful flood diversion structures may convince farmers to cooperate and contribute to the construction and development of plans to implement the technology.

Lack of sufficient skill and experience to study, design and implement spate irrigation technology in the region, difficulty of justifying investments in civil engineering works on systems dominated by low-value subsistence farming, underestimation of potential areas and absence of sufficient flood data in designing complex irrigation structures can be taken as future challenges for the development of modern spate irrigation in the study area.

This study aims to assess spate irrigation potential, traditional and modern spate irrigation practices and identify challenges in transition from traditional to modern community spate irrigation. The study area covers floodplain areas of the Kobo-Girana Valley in Kobo and Habru woredas, and some parts of Ambassel woreda. Modern schemes have just been introduced in the Kobo woreda at Gobu and Golina rivers. The following map shows the location of the valley area covered in the study.

Figure 8.1. Map of the Amhara region and location of the study area.




## 2. Material and Methods

The potential assessment and evaluation of modern schemes were done in May 2012 and September 2013, respectively. The assessment and identification of the potential of spate irrigation resources make use of GPS, digital photography, topographic maps produced at 1:50,000 scales, digital elevation models (30 mx30 m resolutions) of full coverage of the region, and different existing maps. Pertinent River Basin Master Plan study reports, site-specific water resources study outputs, policy papers, etc., were among others extensively consulted throughout the study and in report writing.

The study used mainly secondary data and information from different sources, properly reviewed, accordingly. Moreover, the study consulted responsible experts at the woreda level, individual farmers, and community groups about the advantages, constraints and challenges of spate irrigation and outputs obtained from it. In addition, it used data on farming practices and requirements, flood volume and the field survey.

Field visits were made on the existing spate irrigation sites to collect data on practices, opportunities, constraints and challenges in sufficient detail. Visualization and physical observation were also made about the flood condition and ways to divert it. Along with the land loss, widening and riverbank erosion problems were observed at field level, and reference pictures were captured to show evidence about problems, potentials and challenges.

Potential rivers and streams were identified, and proposed diversion sites were selected during the field visit and possible command areas were delineated using DEM and topographic maps in the midst of the ArcGIS environment. Runoff volume of selected rivers was collected from the Kobo Girana Valley development hydrology report and compared with the potential irrigable areas by spate irrigation technology. In this analysis, the limiting factor was found to be water resource as much of the potential flood goes away during peak flood time.

Introduction of modern spate irrigation in the valley has been planned by starting from upgrading the traditional spate irrigation system practiced by farmers, upgrading the existing river diversion and intake structures which were intended to provide baseflow water for irrigation to serve for flood irrigation and finally introducing spate irrigation to new sites where it has not been practiced as yet.

Evaluation of the modern spate irrigation schemes was started by evaluating the study and design documents and checking design considerations. The agronomical study considered climatic data at the meteorological station close to the command area, suitability of the topographic feature for spate irrigation, cropping pattern and cropping calendar based on farmers' traditions and climatic conditions.

Spate irrigation is entirely different from perennial flows, which rise very quickly and then recede within a period of hours or days. Spate systems need to be able to divert short-duration flood flows into gravity canal systems to ensure that sufficient amounts are abstracted in the time available to meet water demands and that the canal systems ensure command over the fields to be irrigated. The catchment yield is largely influenced by the highland rainfall of the watershed areas (Gidan and Lasta woredas). Hence, maximum rainfall events observed in the dry season (from February to April) of the highland area are considered for analyzing the potential runoff for spate irrigation, and hydraulic structures and scouring effects are designed by considering annual maximum daily rainfall data of the watershed area. Estimation of both spate flood and summer maximum flood has been done by using SCS-CN. In addition to the rainfall-runoff models, designers have considered flood mark levels in summers and dry-season period floods. Spate flood duration is estimated from local people's information and dry-season floods from hydrographs.

River sections are wide (example, Gobu-1 has 89 m of channel width at the intake site) and consists of a prematured and undefined channel. The cross section of the river is composed of thick unconsolidated and coarse alluvial deposits. Intake with bed bar aligned at 30-degree inclination across the main river channel has been designed in all schemes. This bed bar is below the riverbed that stabilizes the intake area and guarantees from possible lowering of riverbed elevation and serves also as a cut off for abstracting more water to the intake. In selecting the position of the intake sites, designers consider farmers' traditional experience, river morphology and availability of sufficient driving head. Side spillway and scouring sluice openings are provided as part of the offtake canal. Scouring sluices are made to have a similar bed level to the canal bed level and the spillway openings attained an elevated sill level than the canal bed level based on their purpose. Both openings are designed to be regulated with a spindle mounted gate with easy operation. The irrigation infrastructure contains drop, division box, turnout and crossing structures like any conventional surface irrigation system to meet requirements of the topographic map and the water distribution system. The flow capacity of the intake is fixed by considering the total available water (TAW) required for 1 m root depth, project efficiency and flood recession time (Steenbergen et al. 2010).

$$Q^i = 2.77 \frac{AxW}{\delta xt} \tag{2.1}$$

where, Qi is the theoretical discharge ($m^3/s^{-1}$), A is the irrigable area (ha), W is the depth of application (assume 0.35 m), δ is the application efficiency (assume 40%) and t is the time of application (take 7 hours).

Gobu-1 River is an ephemeral river; during the rainy season the coming flood has a longer time of recession. For a command area of 380 ha and time of recession taken to be 7 days, depth of application is 0.35 m with an application efficiency of 40%, and the intake diversion capacity has been fixed at 5.5 $m^3s^{-1}$. Diversion capacity of other projects is treated in a similar fashion.

# 1. Results and Discussion

## *a. Traditional Spate Irrigation Practice in the Kobo-Girana Valley*

The traditional spate irrigation systems are very flexible, as the location and layout can be easily adjusted to suit the changing wadi conditions. As the level of the command area rises, they can be easily moved upstream. In addition they are appropriate and of low cost. Furthermore, they are relatively efficient in water use and sharing between users (Embaye 2009). Spate irrigation in Kobo-Girana Valley was traditionally practiced in plain areas following intermittent and perennial rivers found around the Kobo area starting from Gobu to Amid Wuha rivers. The survey addressed about 19 streams and rivers found in Kobo, Habru and Ambassel woredas, and floods from six rivers are presently used for spate irrigation at different levels to supplement rain-fed crop production.

These six rivers are the Gobu, Legaharo (Figure 8.2), Abarego, Hormat, Amidwuha and Shele intermittent rivers, which have huge flood irrigation potential capable of supplementing rain-fed crops in Meher season (June, July, August, September and October) and to start cultivating land and cropping in Belg season (February, March, April and May). Farmers are not utilizing the flood properly, because they have limited capacity to manage the flood and sediment load. The nature of river morphology and bank formation is also challenging to guide floodwater to their farmland properly. Out of these traditional schemes, upgrading to modernized spate irrigation has been started in the Gobu River (Gobu-I and-II).

Golina and Alwha rivers are among the perennial rivers at present and used for irrigation cropping using modernized diversion weirs. However, the rivers have also huge flood potentials for spate irrigation and to supplement both rain-fed and irrigation cropping in the study area. Based on the estimates of the Kobo Girana Valley Development Hydrology Report, Golina and Alwuha rivers annually produce 61.80 and 66.47 $Mm^3$, respectively, of floodwater. Hence wide thinking is required to exploit the base and flood flow downstream of the existing irrigated land. A modernized spate irrigation scheme has also been under construction in the Golina River.

At the time of the field survey there was a flood from the upstream, while at one point there was no rain, and the study team was very much excited by the flood and spate irrigation practices of farmers. One big problem obtained from the observation was the inability of farmers to use the peak flood time because it was very dangerous to manage. In addition, small canal size, land grading and leveling problems were observed.

Figure 8.2. Progress of flooding from the dry Legaharo stream.

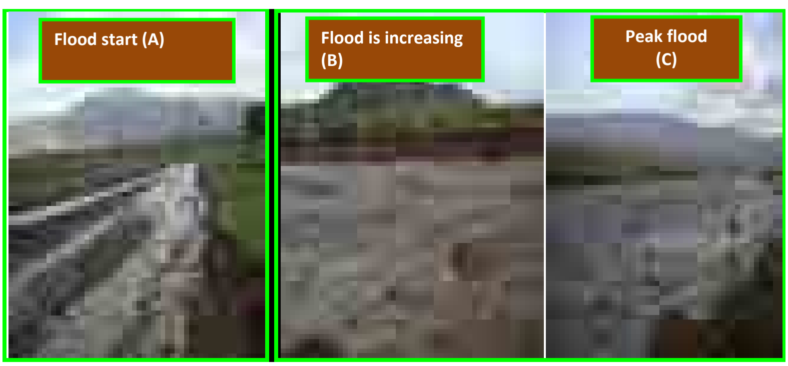
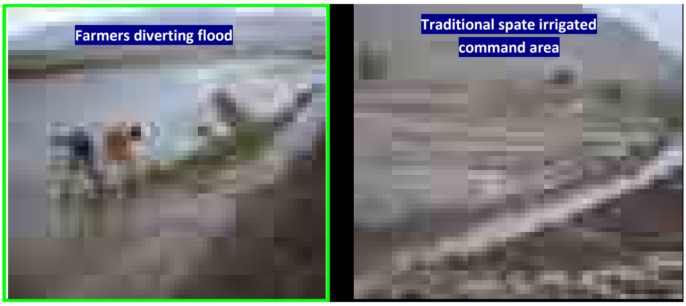


Figure 8.3. Farmers exercise flood diversion for spate irrigation.




## Major constraints of the traditional spate irrigation system are:

- Construction of intake structures after every flooding.
- Small capacity of canals to accommodate high volume and velocity floodwater.
- Requirement of frequent maintenance, which necessitates a large labor force.
- Wrong position of intake and no canals to the end point of the command; only a small area of land close to the intake received floodwater.
- Lack of control over flood at the headwork, unnecessary over-flooding in cultivated lands.
- Inability to divert and use floods from flowing rivers with a deep riverbed. Hard to divert during peak flood time, so flood is not fully harvested.
- Lack of filtering structures to filter out unwanted materials.
- No more secondary and tertiary canals and structures to distribute the floodwater; inundation of the whole farm by a single flood intake favors some fields at lower micro-topography which receive more flood and ponding than the higher part.
- Lacks proper land grading and leveling.
- Unlined canals constructed near and following the river bank weaken the riverbank through seepage and cause erosion of the river bank and damage canals.
- No riverbank management and river training practices.
- No community integration or institution that mobilizes existing manpower resources or is beyond the capacity of the community.
- There is no flood information system to inform farmers about the arrival of heavy floods to the area without raining at the site.
- Lack of capital and skill to design and construct cross-drainage structures.
- Erosion of riverbank and widening of river channels.
- Inundations of the command area by boulders, sand and gravel.
- No experience in integrating groundwater and surface water (flood) irrigation and in recharge of groundwater aquifers. Poor floodwater management and control.
- Poor agronomic practices and crop selection as compared to the labor invested.

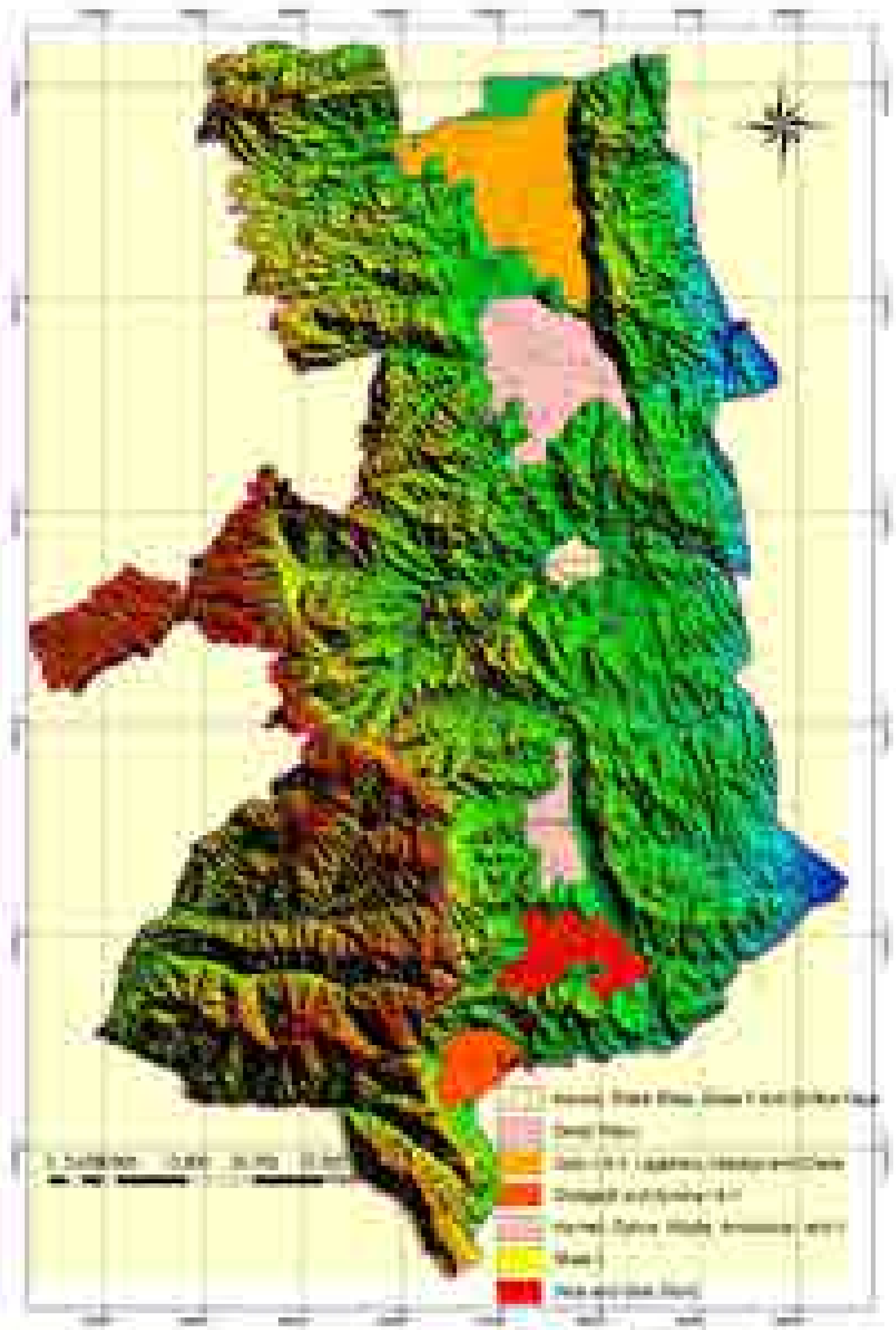
### *b. Spate Irrigation Potential in the Valley*

The survey mainly included three woredas, Kobo, Habru and Ambassel at the eastern extensive plain area found east of the mountain chain of Gidan, Gubalafto and Ambassel. According to the survey in Kobo Girana Valley and Ambassel, spate irrigation is required to supplement rain-fed and irrigated crop production, and recharge groundwater aquifers. In general, the proposal includes the selection of 21 intake (headwork) sites and delineation of 51,668 ha of gross command area.

Table 8.1. Details of proposed sites (** & * describe irrigation structure and spate upgrading).

| No. | Name of river | Woreda | Headwork site | | | Command area (ha) | Status | Development phase |
|---|---|---|---|---|---|---|---|---|
| | | | Easting | Northing | Elevation | | | |
| Golina Denkil Subbasin | | | | | | | | |
| 1 | Gobu-I | Kobo | 559,561 | 1,352,400 | 1589.43 | 18,627 | Upgrading** | Phase II |
| | Gobu-II | Kobo | 561,408 | 1,354,474 | 1531.37 | | Upgrading** | Phase II |
| 2 | Legaharo | Kobo | 566,859 | 1,351,204 | | | Upgrading* | Phase I |
| 3 | Abaerego | Kobo | 567,160 | 1,349,339 | | | Upgrading* | Phase I |
| 4 | Dikala | Kobo | 568,882 | 1,344,424 | | | Upgrading* | Phase I |
| 5 | Hormat | Kobo | 568,580 | 1,339,265 | | 14,267 | Upgrading* | Phase I |
| 6 | Golina | Kobo | 567,848 | 1,333,790 | | | Upgrading* | Phase II |
| 7 | Woylet | Kobo | 568,283 | 1,328,661 | | | Introduction | Phase I |
| 8 | Amid Wuha, R | Kobo | 571,100 | 1,325,090 | | | Upgrading* | Phase I |
| | Amid Wuha, L | Kobo | 570,047 | 1,324,712 | | | Upgrading* | Phase I |
| Alwuha Subbasin | | | | | | | | |
| 9 | Alwuha | Kobo | 574,067 | 1,315,446 | | 2,411 | Upgrading** | Phase II |
| 10 | Shele I, Intake | Gubalafto | 571,023 | 1,310,251 | | | Upgrading** | Phase I |
| 11 | Shele Sihalu, R | Habru | 574,840 | 1,312,918 | | | Introduction | Phase I |
| 12 | Shele, L | Gubalafto | 574,891 | 1,313,087 | | | Introduction | Phase I |
| 13 | Chifra Keya | Habru | 579,952 | 1,313,295 | | | Introduction | Phase I |
| Millie Subbasin | | | | | | | | |
| 14 | Derek Wonz | Habru | 571,931 | 1,290,469 | | 4,735 | Introduction | Phase I |
| 15 | Wula Wonz | Habru | 569,819 | 1,275,870 | | 4,183 | Introduction | Phase I |
| 16 | Gola Wonz | Habru | 569,890 | 1,274,993 | | | Introduction | Phase I |
| 17 | Godigadit | Ambassel | 566,560 | 1,271,279 | | 4,445 | Introduction | Phase I |
| 18 | Ajwuha River I | Ambassel | 567,533 | 1,267,734 | | | Introduction | Phase I |
| | Ajwuha River II | Ambassel | 564,346 | 1,268,257 | | | Introduction | Phase I |
| Total | | | | | | 51,668 | | |

Figure 8.4. Headwork and command area of proposed spate irrigation development sites.



### *c. Status of Modern Spate Irrigation Projects*

In order to maximize the agricultural productivity of the valley area, modernization of the existing traditional system is needed based on scientific approaches, in addition to the traditional knowledge. This includes upgrading the traditional irrigation schemes so as to increase the water utilization efficiency and reducing the labor required every time the flood passed to construct temporary diversion bunds and canal structures by designing permanent structures and improving water and sediment management systems. The modern system, with permanent canals (primary and secondary) and branches, delivers water to the fields without entailing field-to-field irrigation and serves uniformly, whereas the traditional irrigation using earth dikes and canal intakes serves mainly the lower area (Bahamish 2004).

Out of the potential spate irrigation areas identified in the assessment of potential in the valley, the Regional Water Resources Development Bureau studied three schemes in 2011 and started implementation in 2012 with financing secured from the International Fund for Agriculture Development (IFAD). These schemes are Gobu-I, Gobu-II and Golina Spate Irrigation Projects. The consultancy service (study and design) work of the projects is done by Amhara Design and Supervision Works Enterprise (ADSWE) and is being constructed by the Organization for Rehabilitation and Development in Amhara (ORDA). Both of the schemes are under construction and simultaneously operating beside the constructed structures. In addition to the above-stated schemes, three additional projects (Weylet, Legeharo and Shele) are under detailed design stage with plans for implementation by 2014.

Though the above-stated projects are found under the construction stage, farmers started to utilize the schemes as most of the headwork structures were already finalized. During implementation time, the efficiency of modernized schemes has been tested both by farmers and experts. Both schemes have no construction quality problems. According to the farmers, the main advantage of the modernized system is having a stable headwork structure and ability to divert more water than the traditional one. Based on their performance, Golina (Figure 8.5) is best, Gobu-I (Figure 8.6) is next and Gobu-II (Figure 8.7) is the lowest-performing scheme. The main problem of the projects is silt management.

### *d. Golina Spate Irrigation Project*

Golina River is among the perennial rivers with a limited baseflow. The proposed spate irrigation is planned to use both the baseflow and the floodwater. The headwork part of the scheme contains an intake mounted with trash rack, escaping canal opening, scouring sluice opening and intake head regulator. The trash rack is provided at the very entry of the intake to filter out unnecessary suspended and bed load into the canal system. The escape canal opening is provided next to the intake entrance point at a higher elevation compared to the canal bed level and is used to spill out excess water from the canal demand. Scouring sluice is provided just in front of the head regulator with equal sill level to the canal bed to erode the unwanted sediment load.

Figure 8.5. Golina spate irrigation project, headwork and canal structures.


Golina spate irrigation project is doing very well and can be taken as an exemplary scheme. Structures are stable, water is flowing into the system freely, gates are operating well and there is not much sediment accumulating in the canal system that might hinder operation. The possible reasons for the success of the scheme are: efficiency of the escaping canal and scouring sluices and proper management by farmers. The silt-escaping canal provided after the head regulator along the main canal has a significant effect in controlling sediment deposition. The Groyeens provided at the intake guide wall shifted the current flood direction away from the intake mouse and reduced the entrance of much sediment with the current flood.

## *e. Gobu-I Spate Irrigation Project*

Even though Gobu-I spate irrigation is designed on no perennial river, the scheme is using both spate during “Belg” time and supplementary irrigation until the river flow ends after the main rainy season. The headwork part contains similar structures as in the Golina irrigation scheme. However, the system is less efficient than Golina and better than Gobu-II. The intake and main canal after the head regulator are entirely filled up with sediment. The canal is still conveying water into the field, because the canal is deep. Hereafter, it will be challenging to bear additional floodwater as it has been silted up to the top. As it is shown in the following picture, the opening at the head regulator has been closed fully by silt. Farmers are diverting water behind the retaining wall. Unless the system is managed well, the overtopping water along the canal route will saturate the riverbank and loosening it to create flood scouring and add surcharge pressure against the masonry structures.

Figure 8.6. Gobu-I spate irrigation project, headwork structures.

### *f. Gobu-II Spate Irrigation Project*

Gobu-II spate irrigation is located 3.0 km downstream of Gobu-I. Both Gobu-I and-II do have traditional practices on the same river and the modernization is done by upgrading the traditional system. As in the above-mentioned projects, Gobu-II has got similar headwork structures but the main difference is that, both escaping and scouring sluices are located around the head regulator. In addition to this, escaping canal gate of the above schemes has not been installed as yet but the Gobu-II escaping canal is closed by gate. The intake and main canal after the head regulator are entirely filled up with sediment and no more water is getting into the field by using the provided structures. It needs serious attention.

Figure 8.7. Gobu-II spate irrigation project, headwork and canal structures.

## The main problems in Gobu-I and-II:

a. *Scheme management:* Farmers are not well organized by water user associations; they are still trying to use irrigation water through individual effort. During excess flood time, the head regulator should be closed by opening escaping and scouring sluices. There must be someone responsible for closing and opening gates based on the flood situation and irrigation water demand. Since the Gobu-I escaping canal gate was not installed, it was open for the whole summer. As a result, Gobu-I has relatively low sediment deposited compared to Gobu-II. The head regulator and the sluice gates of the two schemes were closed for the whole summer season. That is why both intakes and head regulator openings are filled with silt, and farmers are forced to route water behind the retaining wall of Gobu-I. Hence, a lot of work is expected to enable the community to manage their scheme properly.

b. *Silt type:* Besides the amount of sediment, the particle size of Gobu-I and-II is courser than that of Golina. This makes the silt excluding mechanism challenging because sediment settles easily in the canal. Hence, proper escaping canals and silt excluder openings should be designed and provided.

c. *Missing of additional silt-excluding openings in the main canal:* From the three schemes, Golina has a good quality because of the additional escaping canals provided behind the head regulator. Both Gobu-I and-II do not have this and as a result of this, farmers find it difficult to manage silt in the main canal. If there are sufficient additional escape openings, it will be possible to use dredging when there is sufficient water in the canal. Otherwise, excavation will be the only solution to evacuate deposited silt. Even farmers confidentially recommend the importance of additional canal escapes.

## 2. Conclusion and Recommendations

The survey on identification of spate irrigation potential and assessment of farmers' experiences were made on representative sites from Kobo to Ambassel plain areas; this was meant to provide input data for decision makers to think about the detailed study and design of spate irrigation projects based on upgrading the existing traditional schemes and the introduction and extrapolation of lessons and experiences to other potential sites.

As per the field survey, the highlands provide substantial floodwater, sediment, gravel and boulders to lowlands while the lowlands are highly affected by severe flood hazards, riverbank erosion, and wastage of large cultivated land areas by boulders and gravel from river overtopping.

Altogether 21 potential flood diversion sites suitable for spate irrigation have been identified in the valley. Integrated spate irrigation through upgrading traditional spate and groundwater-based irrigation and introduction to new sites to support rain-fed and irrigated cropping in the area and further extrapolation are highly recommended.

The transition from traditional to modern systems is good, but needs great attention, as there are still unresolved problems, especially in design considerations and scheme management. The following ideas should be addressed by researchers:

a. *Soil moisture retention extent and depletion period:* The best moisture retention techniques and actual moisture depletion period for different soil and topographic conditions should be estimated through research rather than adopting from literature.

b. *Hydrology:* Since most spate areas connected to rivers are not gauged, designers of modern spate irrigation projects are managing spate hydrology based on farmers' information. The application of commonly adopted rainfall-runoff models should be checked for such kind of rivers which pass through deep alluvial formation on a wide and gentle river morphology aggravating excess percolation along the river channel. In the lower reaches of the rivers (Afar area), even peak floods disappear on a wide delta.

c. *The flood contributing area:* This has to be identified rather than just delineating the watershed area above the drainage outlet because the rainfall distribution in the lowland and highland areas is not similar; there is no smooth transition between the highland and lowland watershed elevation. Flood frequency, certainty, sufficiency, distribution, cropping patterns, land use and hydrological impacts of climate change need research.

d. *Silt screening mechanism:* Possibilities to screen courser sediment and take fine sediment with floodwater into the farm will be envisaged based on scientific approaches.
e. *Scheme management:* Community-based irrigation projects are supposed to be managed by the community using an institutional framework. Does the conventional irrigation water management procedure work on these kinds of schemes? The difference between traditional and advanced scheme administrative techniques needs to be evaluated and addressed to the communities.

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