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# Status and Potential of Spate Irrigation in Ethiopia

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**Abstract** This article discusses spate irrigation in Ethiopia and aims to take stock of the current status of spate irrigation development. It summarizes experiences so far and formulates a number of recommendations on the development of this upcoming resource management system. It argues that raised weirs are useful mainly in areas where a large head for spate flow diversion is required, but that traditional earthen structures with conical stone/gabion reinforcements are cost-effective and technically adequate for floodwater distribution and management. It contends that the practical successes of sediment settling ponds (gravel traps) are at best mixed. Even where a small basin is justified, it can only ever trap a small proportion of the incoming sediment load. It is better to allow large floods with excessive sediment load (>100,000 ppm) to by-pass upstream intakes to be diverted lower down the system, and provide additional livelihood opportunities in downstream areas in the form of rangeland and agro-forestry development. This is particularly useful in the lowlands of Ethiopia with large pastoral community where spate irrigation is yet to make in-roads. The article further explains that water rights in spate are different from the sharing and allocation of perennial flows—they are dynamic and respond to a situation that differs from year to year as well as within a year and that a certain degree of inequity among users is inevitable. Keeping the command area compact can ensure two or more irrigation turns and this can highly increase productivity as

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crops are no longer in the 'stress zone'. To transform spate irrigation in Ethiopia from subsistence to a business-oriented production system, the article proposes the promotion of cash crops including pulses and oil seeds as well as encouraging investors to go for bio-fuel development and agro-forestry in the lowland areas where huge potential exist. To avoid vehement conflicts that may arise among the settled agricultural and pastoral communities due to the implementation of the business-oriented production system, the traditional rights of the pastoral communities must be respected and their rangeland and water resources be safeguarded. For maximum yield, soil moisture conservation measures such as pre-irrigation land preparation, deep ploughing and mulching are essential as is the conjunctive use of spate flow and groundwater. Last, but most important, the article emphasizes that farmers need to be placed at the heart of any spate irrigation development programme as primary beneficiaries, managers and operators as well as part of the decision making institution.

**Keywords** Spate irrigation · Ethiopia · Soil moisture conservation · Water rights · Traditional and improved structures · Tillage practices

## 1 Introduction

Spate irrigation is a form of water management that is unique to semi-arid environments—particularly where mountain catchments border lowlands. It is found in the Middle East, North Africa, West Asia, East Africa and parts of Latin America. Short duration floods are diverted from river beds and spread over land—to cultivate crops, feed drinking water ponds, or irrigate pasture areas or forest land.

Spate systems are risk-prone and are categorically different from perennial systems. The floods may be abundant or minimal and production varies from year to year. The fluctuation also brings along an unavoidable degree of inequity, with some lands always better served than others. Spate systems, moreover, have to deal with occasional high floods that—unless properly controlled—can cause damage to river beds and command areas. Another feature that sets spate systems apart from perennial irrigation is the high sediment load of the water. This sediment is a blessing as well as a curse: it brings fertility and makes it possible to build up well-structured soils. On the other hand, it can also cause rapid rise of the command area and the sedimentation of canals. Finally, in many spate systems floods come ahead of the cultivation season and storing moisture in the soil profile is as important for crop production as the diversion of water.

In Ethiopia spate irrigation is—as elsewhere in Sub Saharan Africa—on the increase. Its popularity is part of a larger movement towards higher productivity farm systems—not exclusively rain-dependent. Spate irrigation is also linked to the increasing settlement of the lowland areas. These lowland areas for a long time were sparsely populated, and mainly due to the mounting population pressure in the highlands and progress in controlling tryposonamis and malaria, lowlands are getting more settled. In some areas spate irrigation is also a response to a trend of perennial rivers no longer being perennial, the result of catchment degradation,—but moving to a semi-perennial state with more flashy floods.

The development of spate irrigation in Ethiopia is driven by both public investment as well as farmer's initiative. Almost all spate irrigation development in Ethiopia is very recent—unlike the history of spate irrigation in Yemen, Iran or Pakistan—which stretches over millennia. The area currently under spate irrigation is estimated at 140,000 ha, but the potential particularly in the lowland plains is much higher (Alemehayu 2008). This is important in Ethiopia as sufficient food has to be produced to meet the requirements of a growing population that still substantially relies on food aid. The recent food crisis and the spiralling prices that came with underlined the situational vulnerability of this. Spate irrigation may also have a role to play to generate surpluses of marketable crops, such as pulses and oilseeds—crops that are quite compatible with spate production systems.

The annual renewable fresh water resources of Ethiopia amount to 122 billion $m^3/y$ contained in 12 river basins, which is only 1,525 $m^3/y$ per capita share and only 3% remains in the country (UN World Water Assessment Programme 2006). At this stage the country withdraws less than 5% of its fresh water resources for consumptive uses. In Ethiopia there is hardly any perennial flow in areas below 1,500 m + Mean Sea Level (MSL) and perennial streams and springs exist only in the vicinity of mountains with an annual rainfall of more than 1,000 mm or from the outflow of lakes. For a long time small scale irrigation development, however, concentrated exclusively on these small and sometimes already overcommitted perennial streams—making little use of the potential imbedded in semi-perennial flows and spate irrigation systems. In recent years this has changed. This article gives an overview of spate irrigation development in Ethiopia, an assessment of experiences so far and ends with suggestions and recommendations.

## 2 Spate Irrigation Development in Ethiopia

Some spate irrigation systems in Ethiopia have been in use for several generations, but in almost all areas spate irrigation has developed recently. Spate irrigation is on the increase in the arid parts of the country: in East Tigray (Raja, Waja), Oromia (Bale, Arsi, West and East Haraghe), Dire Dawa Administrative Region, in SNNP, Southern Nations, Nationalities and Peoples Region (Konso), Afar and in Amhara (Kobe) region (Fig. 1). In southeast Ethiopia the word '*gelcha*' is used—translating as channelling the flood to the farm. In the northern parts the word '*telefa*, meaning 'diversion', is common.

Spate irrigation systems are practiced both in the midlands and lowlands in Ethiopia. Three broad agro-climatic zones are identified in the country—highlands, midlands and lowlands, which are further classified into 5 distinct zones (Hurni 2003). Q3 The highlands are categorized into *Wurch* (cold Highlands) and *Dega* (cool, humid highlands). *Wurch* covers areas above 2,500 m+MSL where annual rainfall usually exceeds 2,000 mm. Barley is the dominate crop and light frost often forms at night. *Dega* areas lie at 2,000 to 2,500 m+MSL with annual rainfall ranging from 1,000 to 2,000 mm. Barley and wheat are the major crops. The midlands, locally named as *Weina Dega*, are situated between 1,000 to 2,000 m+MSL, annual rainfall ranges from 600–800 mm, but is highly erratic and unreliable. This is where most of the population lives and all major cereal crops are grown, especially Teff, the main stable

All boundaries are approximate and unofficial
Graphic produced by UN Emergencies Unit for Ethiopia: March 2000

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**Fig. 1** Detailed map of administrative regions of Ethiopia showing the Zones where spate irrigation is being practiced (UNDP 2002)

food crop in Ethiopia. The lowlands are divided into *Kolla* and *Bereha*. The *Kolla* (warm, semi-arid lowlands) are areas below 1,000 m+MSL receiving annual rainfall that range from 200–600 mm. Sorghum and maize are grown, with teff grown in the better areas. The *kolla* is warm year round and temperatures vary from 27 to 50°C. *Bereha* (hot and hyper-arid)—general term that refers to the extreme form of *kolla*, where annual rainfall is less than 200 mm and irrigation is the only feasible agriculture production system. These five distinct agro-climatic zones (belts) are presented in Fig. 2.

At present most spate systems are in the midlands and some in the lowlands. There are distinct differences between midland and lowland systems (Table 1). First is that in the midlands rainfall is higher and the spate flows complement and are complemented by rainfall. Command areas in the midlands are relatively small, defined by hill topography. Lowland systems on the other hand are larger, receiving water from a large mountain watershed. Lowland soils are alluvial and rivers are less stable. They may degrade, silt up or change course. In long established spate area—such as the western bank of the Indus in Pakistan or the Tihama plains in Yemen, farmers have developed traditional techniques (long guide bunds, brushwood deflectors) to manage these systems and come to productive resource management systems—integrating crop production and livestock-based livelihood systems. In Ethiopia at this moment spate irrigation development in lowland plains is still modest—and often limited to the piedmont areas, where gradients are relatively steep and flood are sometime more difficult to control than they are further down the ephemeral river.

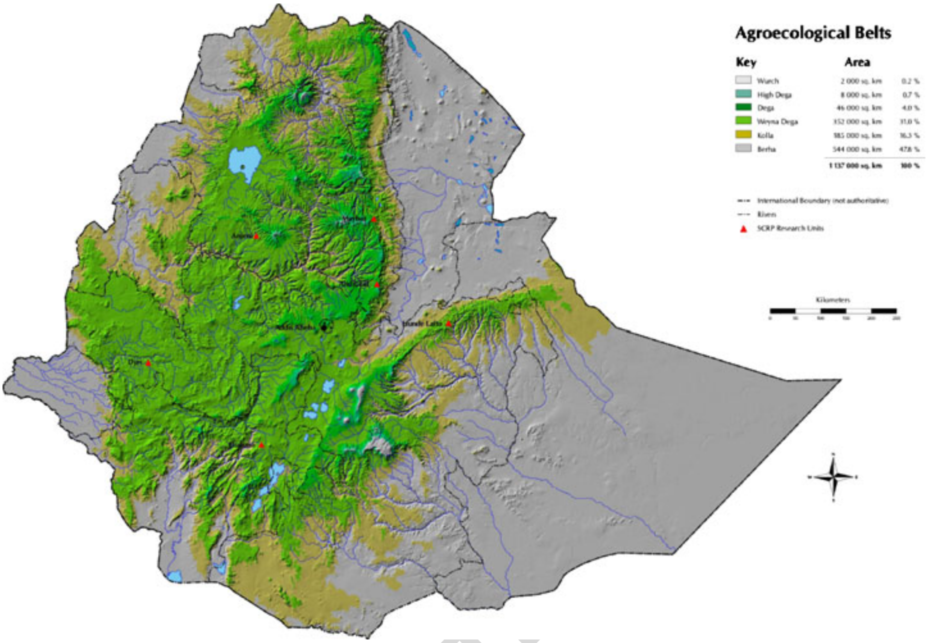

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**Fig. 2** Agro-ecological zones (belts) of Ethiopia (Centre for Development and Environment, CDE, Hans 2003)

Table 2 summaries the area under different spate irrigation systems in Ethiopia. According to various recent estimates, spate irrigation in the country varies from 100,000 to 200,000 ha. During the Expert Consultation Meeting in Cairo in 2008, the best estimate agreed upon was 140,000 ha (Table 1.1 in van Steenbergen et al. 2010). Areas under improved or modernized spate irrigation stand at 20,000 ha and considerable investment is lined up: spate projects under design and construction exceed 50,000 ha (Alemehayu 2008). Most systems are relatively small—with a few systems (Kobe, Yandefero, Dodota) touching the 4,000 ha mark.

The traditional systems typically consist of free intakes incorporating a short diversion spur—in many cases in a series. In Kobo in Amhara Region floods are diverted from a seasonal river (*Gobu*) and directed it to the cultivated fields to

**Table 1** Spate irrigation systems characteristics in midland and lowland of Ethiopia

| Spate system | Midland (1,000 to 1,700 m) | Lowland (below 1,000 m) |
|---|---|---|
| Rainfall | Supplementary | Less important |
| Catchment area | Limited | Large |
| River bed material | Coarse—cobbles, gravel and sand | Mostly sandy |
| Gradients | Steep | Gentle |
| Flow | Flash floods and semi-perennial flows | Short-duration spate flows |
| Command area | Small | Can be large |
| Water diversion and distribution | Change of flood channel | Siltation or degrading of river, change of flood channels |

**Table 2** Spate irrigated areas in Ethiopia

| Total spate irrigated area | Traditional spate irrigated area that need improvement | Improved spate irrigated area | Spate irrigated area under design and construction |
|---|---|---|---|
| 140,000 ha | 70,000 ha | 20,000 ha | 50,000 ha |

supplement the rainfall. The main diversion canal is called ‘*enat mellée*’ (i.e. mother *mellée*). The mother *mellée* starts as a small earthen embankment protruding into the flood course at an acute angle with a gradually curving and thickening build up that guides the flow to the cultivated fields. These main diversions are constructed at a convenient angle across the riverbed slope to divert the flood runoff and convey it to the command area. The longitudinal slope of the riverbed ranges from 1–3%. The system is further divided into ‘*awraj mellée* (secondary canals) and *‘tinishua mellée’* (tertiary/field canals). Once the water reaches the field canals, it is spread with the help of bunds and *‘shilshalo’* (contour/graded furrows). A special feature in Kobo is the excavated ponds that serve for livestock watering and are located downstream from the cultivated land. The ponds are fed from the main canal as well as the excess drainage from the cropped area.

Similarly in Aba’ ala in Tigray there are many waterways that run into farms. In total there are 27 primary channels diverted from the three rivers. The diversion channels are made by digging an open channel both at the left and right banks of the rivers and strengthened by stone, boulders, shrubs and logs of trees (Fig. 3). When there is flood almost all farms get water. Within the farms there are narrow furrows covering the entire field. These furrows distribute and can carry water for some time. The furrows are made in intimate succession to one another and slightly against the contour. Under a Norwegian Aid project some of these traditional intakes have been replaced with masonry walls.

Also the Yandefero system in Konso (SNNPR) consists of a multitude of short flood intakes. At present there are 29 flood intakes—made of soil and brushwoord.

**Fig. 3** Traditional diversion structures in Hara, Tigray, Ethiopia (Haile 2009)

The entire area that can in principle be irrigated is close to 4,000 ha. Eleven of the flood-intakes date back 30 years or more. Most of the remaining ones were developed in the last few years under various food-for-work arrangements. Recently, the Yanda river has started to degrade dramatically—going down one to 2 m in large stretches. This degradation most likely was caused by the cutting of a stretch of downstream riverain forest which caused the Yanda river to shift its outlet to a lower section. The degrading of the river bed has forced farmers to extend the flood channels higher up in the river bed—sometime curving around bends. This has left the intake structures more exposed to the force of floods, and several of them are no longer used. The remaining intakes sustain a mixed cropping system of small-holder maize, sorghum and cotton. Farmers do not reside in the lowland area for fear of malaria and tryposomasis. Instead they live in the midlands and travel 15–25 km and stay in Yandafero for a number of days and nights at a time (preferring to sleep in trees or on hill tops) to cultivate land.

Free intakes are the rule in the traditional systems, even in lowland areas. In West Harrarghe the lowland Weltane system is fed from the Koran Gogoga river through a short guide bund of stones and brushwood. In Hasaliso in Dire Dawa there are a series of free intakes taking—some improved under relief projects and some entirely farmer-built, all located immediately downstream of the gorge. The river on this soft alluvial lowland plain is incised and the flood channels are relatively long. Some of the intakes have suffered from changes in the river morphology. In comparable lowlands systems in Yemen, Pakistan and Eritrea one would find soil bunds that dam up the flow and irrigate both up and downstream area, but such structures are not common in Ethiopian lowland systems.

Initially much of the investment in improved spate irrigation systems was done by non-government organization, but in recent years Water Resources Bureaus in several regions have taken over and sometimes invested substantially in spate irrigation development. The front runner is Oromia State. In Oromia Regional State there are 30 projects at reconnaissance stage, 58 projects under study and design and 38 spate irrigation projects under construction (Alemehayu 2008). The investment program started in 1998 in East and West Hararge Zone, with first systems such as Ija Galma Waqo (Fedis, East Hararge); Ija Malabe (Fedis, East Hararge); Bililo (Mi'eso, West Harargee) and Hargetii (Mi'eso, West Harargee). These systems concern both semi-perennial and spate irrigation systems. One of the largest systems is Dodota, situated in a rain-shadow area in Arsi. Dodota takes its water from the semi-perennial Boru river. The stream has no other off-takes upstream and is not used by other upstream or downstream users. The total net potential area for spate irrigation was estimated at 5,000 ha. The main objective of the design was to supplement the rainfall in the area. Based on the requirements, permanent structures made with concrete and masonry were constructed—diversion weir (Fig. 4) to create head, flood channel with escape for high flows, and network of irrigation canal spanning the command area. 19 earthen small ponds with an average capacity of 60,000 m$^3$ were also introduced to temporary store flood water and distribute it during the dry spell periods in a regulated manner. A striking feature of the design process was "parallel implementation", as the design process was continuing parallel to the construction. A digital evaluation model was used and designs were prepared and adjusted as the project was implemented. These modernization interventions (see Section 3 below)

Q3 **Fig. 4** Modern diversion weir in Boru Dodota, Oromia, Ethiopia (Chukalla 2010)

have significantly contributed to improvement in crop yield, but the successes are being tempered by continuous sedimentation problems and lack of effective pond operational plan (Chukalla et al. 2010).

Other states have also launched spate irrigation systems. In Tigray, the regional government in the last 10 years has made efforts to improve the traditional spate irrigation systems particularly in the Raya Valley. It has implemented more than 13 modern spate irrigation schemes sized between 250 and 500 ha, but sedimentation has been and is still a major problem (Fig. 5). Similarly in Afar spate irrigation development is on-going. For instance the Tali and Alena irrigation projects were built in 2008/2009 to utilize the ephemeral flow from the Tali and Gulina respectively.

The cost for development of spate irrigation projects obviously varies from place to place. In remote area labour cost are low and locally available material may be used, but the cost of mobilization and demobilization of machinery make the projects expensive. The scale of projects also affects the cost. In modernized structures with civil works the community maintenance input is very low at not more than 10% and as a result the project cost is high. On the other hand, the local contribution

Q5 **Fig. 5** Sedimentation problem in Fokisa, Tigray, Ethiopia (Gebreegziabher Embaye et al. 2008) in improved traditional spate irrigation systems is very high and this reduces public investments. As estimated from ongoing spate projects, the current construction cost of spate irrigation systems ranges from USD 170 to 220 per ha for non permanent headwork, including soil bunds, gabion structures and diversion canals and up to USD 450 for permanent headwork for small systems including diversion weirs and bunds. The costs of permanent headwork for large systems including diversion weirs, breaching bunds and siphons as estimated from one of the ongoing project (Koloba Spate Project) ranges from USD 330 to 450 per hectare (Alemehayu 2008). These costs are very reasonable and at par with ‘sensible’ investments in spate irrigation elsewhere (Mehari et al. 2010).

## 3 Experiences

Data on crop yields and other benefits are still sporadic in Ethiopia, but the modest evidence that exists suggests that yields are a big leap up from rainfed farming. The most comprehensive assessment was done in Dodota, comparing yield in the irrigated and non-irrigated area. This shows that for all major crops the increase in yields was substantial. Wheat yield went up from 4 to 13 ton/ha; barley from 7 to 12 ton/ha; teff from 3 to 6 ton/ha and haricot bean from 6 to 15 ton/ha and maize from 3 to 10 ton/ha (van den Ham 2008).

One feature in many of the midlands systems is the large variety of crops. In Eja Gelma Wako in Fedis in East Harrarghe, the cropping pattern included sorghum, maize, groundnut, sweet potato, pepper, onion, garlic, local spices and medicinal plants, but also mango and chat (*chat cadulis*). The chat is entirely spate irrigated—springing to a new harvest of fresh leaves after spate irrigation. To survive the dry period leaves are removed by hand from the chat so as to reduce evapotranspiration from the plants.

The variety of crops in lowland systems is less—with more reliance on annual staple crops such as sorghum, maize and sweet potato. It appears that some of the lowland cash crops common in lowland spate irrigation systems elsewhere in the world, such as pulses (mung, chickpeas, clusterbeans) and oilseeds (castor, mustard, sesame, rapeseed), have not made inroads in lowland systems in Ethiopia, even though they would fit in well with the often remote locations of the spate irrigation areas.

There has been and still is considerable investment in ‘modernized’ spate irrigation systems, as described above. At the same time in the improved systems there are operational problems galore. Many of the modernized system use designs that are akin to perennial irrigation systems—diversion weir, under-sluice and gated intake (Fig. 4). While many systems still need to come on-stream many of the problems with such conventional approach in other countries are also prevalent in Ethiopia (Lawrence and van Steenbergen 2004). In a review of the spate irrigation systems in Aba’ala in Tigray, Haile and Diress (2002) list the following problems:

- Upstream and downstream users do not share the flood flowing through the river equitably;
- Technical faults in developing local diversion canals trigger changes in the river course;

- Improper secondary and tertiary canals leading to in-field scour and creation of gullies in the fields—which reduces available soil moisture;
- Large amount of sand deposition in the canals and even in the cropped fields;
- The large maintenance burden of traditional spate irrigation systems.

In Aba'ala the traditional intakes were in several instances replaced with a stone masonry wall. This wall was not able withstand the floods and in several cases were toppled over. This also led for instance on the Murga River, to the abandoning of previously cultivated land.

An evaluation of a number of other improved systems in Tigray came with comparable points (Teka et al. 2004). The Tirke irrigation system for instance suffered from the blockage of under sluices/off-takes by boulders, sediments and trash and erosion of downstream protection works as inequities in water delivery between land owners in the command area. In the Fokissa system similarly sedimentation was an important issue—manifest in the silting up and blockage of pipe inlets and sluice piers, which catch trash and boulders during floods. In the Tali system in Afar sedimentation was also main problem as well as the lack of preparation of field plots. Sedimentation problems were also abundant in some of the East Harrarghe system, such as Belilo. The trash accumulation problem was at its most spectacular in Ondoloko in SSNPR. At this site, a substantial gabion weir and gated offtake channel have been constructed on a small steep sand bed river. The diversion is badly sited on a very sharp river bend, so virtually all the river flow is directed towards the canal intake. The structure collected an enormous amount of flotsam and is not operational.

There are a number of common issues related to these operational problems. First is that spate irrigation is categorically different from conventional irrigation. To start with the high sediment and trash loads of the rivers in floods, experiences all around the world is that the successes of conventionally designed gravel traps and sediment sluices is at best mixed. Gravel traps, particularly when flushed, and scour sluices can be designed to work well in spate systems. For example in the large spate systems the scour sluice at Wadi Laba (Mehari et al. 2007) works very well in excluding boulders and cobbles from the main canal, as does the flushed gravel trap in Wadi Rima (Lawrence et al. 2004). However, the enormous amount of sediment to be removed from gravel traps requires sophisticated sediment management options involving frequent gate operations. These are only feasible in schemes that are large enough to justify the large investment required and require that appropriate levels of technical expertise are available to design the infrastructure to function in spate flow conditions, and the level of management and maintenance expertise is sufficient to enable the systems to be operated and maintained as intended. The resources and organization to effectively carryout such a sophisticated management task are generally absent in small scale farmer managed spate irrigation schemes—flushing excess sediment from sedimentation ponds is in many cases not feasible as no water is dedicated for it. For these reasons, intakes incorporating gravel traps and scour sluices at the mostly small low cost farmer managed spate schemes in Ethiopia will often not be appropriate.

If desilting of gravel traps is to be minimized attention must be focused on the (limited) measures available to reduce the intake of coarse sediments, and to maximize the transport of fine sediments through the canal system. These include intake location, control over the flows allowed to enter a canal, and providing canals with a high sediment transporting capacity.

It has to be noted that even the effective gravel traps in large scale spate systems can only ever trap a small proportion of the incoming large sediment load. It is better to allow very large floods with excessive sediment load (>100,000 ppm) to by-pass upstream intakes to be diverted at lower sections of the system where they can be vital for developing rangelands and agro-forestry and hence provide additional livelihood opportunities. In many spate irrigation systems, farmers use mainly earthen, stone and brushwood diversion points allowing flows bypassing upstream intake to be diverted lower down the system.

To reinforce these traditional diversion structures and avoid they are washed too quickly and the subsequent difficulty to rebuild, it is useful to consider: (1) conical stone abutments that are anchored in the river bed and provide some degree of protection to the canal head; and (2) a throttling structure and a rejection spillway to prevent very high discharges being admitted to a canal and damaging the command area. Often it makes more sense in spate systems not to have gated intakes: they are difficult to operate with high floods coming at odd hours. Wide open intakes—as for instance were introduced in Tigray—following the evaluation may be more appropriate.

The second problem is organizational. Spate irrigation being new in many areas—the same applies to perennial irrigation; conflicts are bound to arise in the absence of agreement on water rights. Sometimes the results are dramatic. Testimonies to this are the conflicts on the Weida river in Konso where more than 200 persons were killed over a water dispute between investors and pastoralists. It is important to understand that such water rights are different from the sharing and allocation of perennial flows. The water rules in spate rivers are more reactive—responding to a situation that differs from year to year as well as within a year. The water rules concerns more 'agreed principles' on water use: the area entitled to irrigation; the location of the diversion structures; rules on breaking them to allow water to pass on downstream; rules on protecting river banks and not allowing floods to escape to another area. As spate irrigation develops in Ethiopia, the need to work on such water rules increases. It is also particularly important to respect and incorporate the rights and established practices of pastoralist groups. Also in spate irrigation a certain degree of inequity between upstream and downstream users—between and within systems—is inevitable. Some measures can mitigate this. One is to make sure that the command area is not too overstretched. A smaller command area will make it more likely for farmers to have two or more floods, which can highly increase productivity as crops are no longer in the 'stress zone'.

Apart from water rights, the capacity to operate and maintain is very important and not to be taken for granted. Spate irrigation systems are different and in some respect require more effort to make them work. From Kobo there are anecdotes of farmers blocking floods with their bodies to divert the water to their fields. Spate irrigation requires vigilance to catch floods and substantial work in keeping the system intact and remove the sediment. For this reason it is important that farmers are involved in all steps of the development of new systems and also that where traditional systems exist that these are respected and made integral part of the design process.

This raises a final main issue, which is the attention to field water management. There are substantial gains to be made here. As floods often arrive before the growth season, storing moisture is as important as diverting floods. Particularly in many of the newly developed systems there is much to be gained. In Gulina for instance field bunds were not well prepared and water was not properly retained. Also in Dodota the increases in crop yield could have been even larger—with better field water management. At present pre-irrigation land preparation (allowing better infiltration of the flood water), deep ploughing and mulching (to conserve moisture) are not practiced in Dodota. A main reason is the shortage of draught animals and the general weakness of them. Investments in infrastructure may be complemented by programmes to ensure a better stock of draught animals.

## 4 Conclusions and Recommendations

1. Potential in low land areas, Afar/Somali
    - Because of shortage of rain to fully grow crops irrigation is a must in general and the presence of many seasonal rivers flowing in the region in particular makes flood utilization ideal from Logia, Yalo Gulina, Tali and many other descending from the mountains of Amhara and Tigray.
    - Land use planning studies in association with spate irrigation potentials is underway in south-eastern parts of Ethiopia. This helps to address the acute problems of these food insecure areas.
    - Spate irrigation development should be based on a good understanding of the living styles of the large pastoral communities, their traditional land and water rights and their livestock fodder needs. A viable spate irrigation development approach would be one that integrates rangeland and forest as a washout area for large floods. This has the added value of ionizing sedimentation problems in the canal network and structures.
    - As floods are larger and more destructive than in midlands, traditional earthen structures should be reinforced with some better engineered diversion options to relieve farmers from very substantial ongoing maintenance burden. These options include: (1) a bed stabilizer (bed bar) or a raised permanent weir, to control and fix the bed and hence the water levels at the division point; (2) a fuse plug, in earth or wadi bed material, to be used in conjunction with a weir spanning only part of the wadi width, to increase the return period of the design and thereby reduce costs but still protect the intake and weir from exceptional floods; (3) a scour or under-sluice, to exclude very coarse sediment material from the canal during periods of high flows; (4) a canal head regulator or intake, controlled by gates or orifice flow, to regulate the flows entering the canal and share water among several intakes; and (5) a guide or divide wall. These options should in particular be considered when introducing spate irrigation at new locations, where farmers do not have the skills and experience gained from many years of spate irrigation development and management.
    - Field bunds need be compact and stronger and water should be conveyed from field to field using simple, but effective over flow control structures such as stone pitch.

2. Designs should be appropriate for specifics of spate irrigation

   - In lowland areas of Ethiopia where there are large nomadic communities, a low cost technology, earthen or stone bunds supplemented by properly organized drought animal and when possible bulldozer programmes for timely maintenance may be more feasible.
   - In places of the lowland where large head is required for spate flow diversion, the earthen and stone diversion bunds may be completed with weirs at the headwork for the sole purpose of head creation and bank and bed stabilization.
   - In midlands where floods are mild, gabion structures may be adequate for head creation and bed and bank stabilization. Since floods are more frequent than in the lowlands, it may suffice to have about 20 to 30 cm high field bands—at least 50 cm field bund height are necessary in lowlands.
   - The nature and type of spate flows and sediment concentration also affects, among other things, the design of off takes and type of gates. In the Fokissa irrigation systems for example, where the spate flows have very high sediment concentrations (>100,000 ppm), technical improvements included a relatively wider ungated offtake (3 m by 1.0 m) that was aligned at 60° to the flow to minimize blockage of the offtake with sediment.

3. Combine with groundwater

Conjunctive use of spate systems as means of soil and water conservation are adding more value to spate irrigation practices. Water stored in the sub-surface will be utilized in absence of the floods and the alluvial deposit helps to minimize the cost encored for the continuously increasing prices of fertilizer. Soil moisture conservation can be improved by pre-irrigation land preparation, deep ploughing and mulching.

4. Make agronomy and agricultural extension integral components of spate irrigation development to, among other things:

   - Successfully introduce cash and short duration food crops. The cash crops include pulses (mung, chickpeas, clusterbeans) and oilseeds (castor, mustard, sesame, rapeseed) that have performed well in spate irrigation systems in Pakistan, Yemen and Eritrea with agro-climatic conditions similar to that of the Ethiopian Lowlands. There are short duration (2 to 3 month growth period) varieties of maize, sorghum, wheat and barley, and these are stable crops in Ethiopia, that have been found to provide the same yield as their counterpart that mature in 4 to 5 months (Jones 2003).
   - Increasing interest by investors to go bio-fuel development and agro-forestry in most lowland areas using their spate irrigation potentials. This will benefit farmers if they are made out growers and paid good prices for their produce.

5. Farmers involvement and further measures for dissemination and sustainable development of spate irrigation:

   - The increasing need for spate irrigation development by farmers should be supported by all stakeholders in designing and implementing sustainable projects and provision of extension services supported by research. Past development efforts have note adequately benefited from farmers' knowledge regarding their preferences on the scope and type of works, changes in layout, location of diversion structure, type, alignment and size of off-takes.

- The regional and federal governments and other development institutions should ensure that there is proper coordination and a joint programme between trans-boundary regions which share the same wadi to avoid conflicts and realize maximum benefits.
- Provide regular training for professionals and practitioners as well as farmers on technical (engineering, agronomy), soil and water management, institutional and environmental aspects of spate irrigation.
- Technical and operational manuals and guidelines of spate irrigation systems should be prepared in local languages and distributed among the extension workers and farming community and all involved in spate irrigation development.
- Spate irrigation courses should be part of the formal higher education curriculum of the country.

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