Chapter 6
Agricultural practices and extension services

SUMMARY

The high risk of crop failure associated with spate irrigation and consequent risk mitigation strategies adopted by farmers do not leave much space for the classical improvements in agricultural practices that are justified in intensive agriculture. There are, however, some niches of possible production gains that can be obtained through carefully designed changes in cropping practices.

Farmers in spate systems have developed various cropping strategies to cope with the risks inherent in spate irrigation. These include:

- growing local varieties that are adapted to the local agroclimatic conditions and have a high tolerance to drought;
- growing crops that produce some fodder even if the floods fail and grains cannot be grown;
- practising intercropping, so that, in bad years, one of the planted crops can be harvested;
- selecting crops in relation to the timing and volume of the first irrigation and, where possible, of subsequent irrigations; and
- selecting crops in relation to the soil moisture available after irrigation.

Sorghum, millet, wheat, maize and pulses are the main subsistence crops in spate-irrigated areas. Cash crops like cotton or sesame are usually grown only after a staple crop has been harvested and the subsistence needs of farmers have been met. The selection of the crop and varieties that are grown in spate areas depends on a number of factors:

- location of the field within the system;
- timing and volume of irrigation water that is likely to be received;
- resistance to drought, pests and disease;
- alternative use in drought periods when grains cannot be grown, e.g. as fodder;
- suitability for storage;
- possibility of ratooning; and
- market and, where relevant, support prices.

Research for the development of improved varieties in spate irrigation is practically non-existent and when some varieties exist they are difficult to obtain. Local cultivars fare well in terms of drought resistance, labour inputs, market values, food values and storage but these factors are usually not taken into account in plant breeding. Efforts need to be made to develop varieties that are adapted to spate conditions. Exchanges of local varieties between spate systems should be considered more systematically.

The yields of most spate-irrigated crops are highly variable. In bad years, parts of the scheme may not produce any crop, while the crops on other fields may only receive enough irrigation to produce some fodder. The wide ranges in yields observed in spate schemes can be attributed to:

- the unreliability of irrigation;
- the degree of control that farmers can exercise over spate flows;
- the farming skills in soil moisture conservation practices; and
- the priority that farmers give to spate irrigation, considering that many of them work in other sectors because of the low return to labour in spate.

In most spate-irrigated areas, there is minimal use of chemical or organic fertilizers such as manure. While yields could be increased through a combination of greater investment in fertilizers, pest control and labour, it is important to note that the traditional cultivars used in most schemes do not always respond well to increased use of fertilizers. Other factors that contribute to the limited use of chemical fertilizers are the cost and extent of availability of chemical fertilizers, access to credit, the lack of information on the use of fertilizers, and the high level of risk that fertilizers will be washed off by uncontrolled irrigation.

The large difference in cropping practices between areas and countries explain in part the range of observed yields and indicates that there are opportunities to improve crop yields through the adoption of better agricultural practices. Research suggests that there is scope for production increases with relatively simple adjustments to farming practices, such as early planting, mulching and deep ploughing, well-targeted use of fertilizer, etc. Areas for improvement include:

- the introduction of an integrated farming systems approach, including livestock and agroforestry;
- the use of improved seed varieties – for instance, by more exchange of varieties between areas;
- a better understanding of the balance of nutrients, including those brought by spate floods, and better guidance on fertilizer application;
- cultivating more minor crops and wild plants – such as truffle mushrooms or vegetables; and
- a better control of post-harvest losses, which can be reduced by simple improvements in storage.

Although there is considerable scope for crop productivity improvement through extension and research, these services are usually poor and ill-adapted to the specific concerns of spate-irrigated areas, and the bulk of investment in agricultural research usually goes into perennial irrigated agriculture. Spate irrigation is rarely part of the agriculture or engineering curriculum in formal educational institutions. Yet research into a wide range of topics is needed to address specifically the needs of spate irrigation agriculture. Research needs to be systematically carried out in consultation with farmers through farmer-led trials and experiments and through farmer-to-farmer extension activities.

The picture is different in areas where conjunctive use of groundwater and spate irrigation is possible. In such circumstances more intensive agriculture with high-value cash crops is possible under spate irrigation (Chapter 10 provides more details).

INTRODUCTION

Spate irrigation generally supports a low-input, risk-averse type of farming owing to the recurrent uncertainties in the timing, number and size of floods that occur and the potential damage to crops and irrigation infrastructure caused by large floods. At some locations, in any one year, few if any significant floods occur, which makes cropping impossible.

While the risks of crop failure in spate-irrigated agriculture are quite high, the probability of receiving irrigation is not equally distributed throughout the command areas. Within an area served by a wadi or within an area supplied from one offtake, there will be lands that have widely varying probabilities of receiving irrigation. This typically would range from very high for fields close to the wadi and when the wadi has some seasonal base flow, to very low, possibly only once in every five years, at the downstream end of schemes. The crops grown and the agronomic practices adopted reflect these variations.

Drought-resistant crops such as sorghum, millet, wheat, pulses, oilseeds and cotton dominate the cropping patterns. The production of fodder is also a priority in most spate-irrigated areas in order to support livestock. Livestock provide traction for ploughing and bund building, and act as a form of saving, as animals can be sold to generate cash in bad years. In addition, farmyard manure can be an important source of income.

This chapter summarizes the agronomic aspects of spate irrigation, including the choice of crop varieties, cropping pattern, and associated agricultural practices, and explores possibilities for improvement.

CROPS GROWN IN SPATE IRRIGATION

Farmers have developed various cropping strategies to cope with the precarious circumstances that are part of spate irrigation:

- they generally grow local varieties that are adapted to the local agroclimatic conditions and have a high tolerance to drought;
- they grow crops that produce some fodder even if the floods fail and grains cannot be grown;
- they may practise intercropping, whereby two or three different crops with different water requirements and harvesting times are planted in the same field, so that, in bad years, one of the planted crops can be harvested;
- at some locations, their crop choice is determined by the timing and volume of the first irrigation and, where possible, subsequent irrigations. For example, in Pakistan sorghum is grown in fields with early irrigations, oilseeds and pulses are irrigated later and the last summer floods are reserved for the cultivation of wheat during the winter months; and
- at other locations, their selection of crops depends on the soil moisture that is available after irrigation.

Varieties

The selection of the crops and varieties that are grown in spate areas is affected by a number of factors, amongst which are the: (a) location within the system; (b) timing and volume of irrigation water that is likely to be received; (b) resistance to drought, pests and disease; (c) alternative use in drought periods when grains cannot be grown, e.g. as fodder; (e) suitability for storage; (d) possibility of ratooning; and (e) market and, where relevant, support prices *(Pratt, 1977; Atkins and Partners, 1984; Camacho, 1987; Wadud and Ahmad, 1989; Michael, 2000b*; and *van Steenbergen, 1997).*

Rooting depth is an important factor in spate irrigation, where the crops need to be able to exploit all the available moisture stored in the soil profile. Sorghum and millet can root to about 3 m and cotton to over 3.5 m and are therefore well suited to spate irrigation *(Williams, 1979)*. Maize is less suited to spate irrigation when only one irrigation can be applied, as roots rarely grow more than 1 m and cannot reach soil moisture stored deeper in the soil profile.

Sorghum, millet, wheat, maize (Figure 6.1) and pulses are the main subsistence crops. Farmers usually consider growing cash crops, e.g. cotton or sesame, only after a food crop has been harvested and their subsistence needs have been met *(Goldsworthy, 1975; Makin, 1977a*; and *Camacho, 1987)*.

FIGURE 6.1
Spate-irrigated maize, Eritrea

The range of crops grown under spate irrigation in Eritrea, Ethiopia, Yemen, Pakistan and Tunisia are listed in Table 6.1. What is striking is the differences between and within countries. In Pakistan, oilseeds and pulses are very common in spate areas. In the Horn of Africa, they are absent, which indicates that there are more opportunities in this region for trying crop diversification.

There are also many wild herbs, vegetables and shrubs in spate-irrigated areas that have useful local economic values. Spate irrigation by nature collects seeds from a large catchment and deposits them in the moist soil of the common area. In the spate-irrigated areas along the Kohi-Suleiman in Pakistan, drub grass is common (*Desmostychia bipinnata*), serving as an important source of fodder as well as a land stabilizer. The short-lived *blue moola* flower is important for livestock as well, fed to sheep and cattle to improve the quality and fragrance of their milk. The wild *teenda* and *chunga* vegetables are important supplements to human diets. Another common sight is the small *ak* plant (*Calotropis procera*), which has a range of medicinal purposes, including anti-inflammatory treatment. Another interesting plant is the *lana* shrub (*Salsola bariosma*), which is slowly burned and its ashes used as a detergent. Some of

TABLE 6.1
Crops grown in spate areas in Eritrea, Ethiopia, Pakistan Yemen and Tunisia

Country/region	Range of crops grown	Reference
Eritrea		
Eastern lowlands	Sorghum: most preferred and is widely grown in the northern part of the eastern lowlands.	*Ogba-Michael (2004)*
	Maize: ranks second and is widely grown in the southern part of the eastern lowlands.	
	Others: pearl millet, cotton, sesame, groundnut, tomato, pepper, okra, kerkede, and watermelon.	
Sheeb area	Main crops: sorghum (hijera variety) and maize.	*Tesfai (2001)*
	Minor crops: pearl millet, sesame, groundnut and, vegetables.	
Ethiopia	Sorghum, maize, millet, cowpea and horse bean (mainly local varieties that are drought-resistant).	*Michael (2000a)*
Pakistan		
Kachhi District, Balochistan.	Sorghum, mung bean, moth bean, melon, rapeseed.	*MacDonald (1987a)*
Lasbela District, Balochistan.	Sorghum, mung bean, sesame, guar, castor, mustard or rape.	*MacDonald (1987b)*
D.I. Khan, Balochistan	Wheat, gram and mustard (sarsoon) in rabi.	*Khan, A.B. (1990)*
	Sorghum and millet (joiwar and bajra) in kharif.	
Rod-kohi area in D.I. Khan, Balochistan	Sorghum, millet and sweet melon (spring).	*Khan, M. (1990)*
	Sorghum, millet (summer), local mustard (summer).	
	Wheat, gram (chickpea), rape/mustard (winter).	
Piedmont Plains (Sulaiman Range)	Wheat, sorghum, millet.	*Khan and Rafiq (1990)*
D.I. Khan	Gram, wheat, barley (rabi).	*Wadud and Ahmad (1990)*
	Bajra, jowar (cherry), mung bean (kharif).	
Chandia, Balochistan	Basic crops: fodder sorghum and livestock, pulses, oilseed and wheat.	*Halcrow (1993a)*
	Minor crops: coriander, radish and melon.	
Nal Dat, Balochistan	Sorghum, fodder guar, pulses (masoor or mash) (kharif).	*Halcrow (1993b)*
	Wheat, some oilseed (rabi).	
Kharan, Balochistan	Wheat, sorghum, melon.	*BMIADP (1994)*
Toiwar, Balochistan	Wheat, barley (rabi season).	*Halcrow (1998)*
	Mash and maize (kharif season).	
	Maize, melon, sorghum, cumin, pulses (kharif season).	*Rehan (2002)*
Yemen		
Wadi Rima	Sorghum, bulrush millet, lentil, cowpea, beans and watermelon.	*Goldsworthy (1975)*
	Sorghum, bulrush millet, cotton, sesame, maize and cowpea.	*Makin (1977a); Pratt (1977)*
Wadi Mawr	Sorghum, cotton (main crops).	*Tipton and Kalmbach (1978)*
Abyan Delta	Cotton, sesame, sorghum, watermelon, millet, groundnut.	*Atkins and Partners (1984)*
	Bulrush, millet and groundnut are grown unofficially.	
Wadi Ahwar	Long staple cotton, sorghum, millet, vegetables, and melon.	*Girgirah et al. (1987)*
Wadi Rabwa	Sorghum, maize, millet, sesame, pulses, and medium staple cotton.	*Girgirah et al. (1987)*
Tunisia	Wheat, olive, and almond.	*Nouael II Project*

these wild species could have larger market opportunities. The most spectacular crop in this regard is the underground truffle mushroom, which is found in some spate-irrigated areas in Pakistan and Iran, that could fetch very high export prices.

Yields

The yields of most spate-irrigated crops are highly variable. In bad years, parts of the scheme may not produce any crop, while the crops on other fields may only receive enough irrigation to produce some fodder.

The wide ranges in yields observed in spate schemes are variously attributed to the unpredictability of water supply, degree of control that farmers can exercise over spate flows, farming skills and soil moisture practices and the priority that farmers give to spate irrigation, considering that many of them work in other sectors because of the low return to labour in spate *(Goldsworthy, 1975; Makin, 1977a; Tipton and Kalmbach, 1978; Atkins and Partners, 1984; Mu'Allem, 1987; Shah, 1990; Tesfai, 2001;* and *Rehan, 2002).* Figure 6.2 shows a contrast between a poor, under-irrigated sorghum field and a good one in Eritrea. Table 6.2 gives an indication of the range of yields achieved in spate irrigated areas in Eritrea, Iran, Yemen, Tunisia, Morocco and Pakistan.

FIGURE 6.2
Poor, under-irrigated sorghum field and a good one in Eritrea

Yields also vary substantially from one year to another. In the areas of the Shabwah Governorate in Yemen, the average yields are 1 500 to 2 000 kg/ha for sorghum and 1 000 to 1 500 kg/ha for millet. However, the yields of sorghum and millet may rise to 2 500 kg/ha and 2 000 kg/ha respectively in years with good rains and floods or reduce to 800 kg/ha and 600 kg/ha respectively in dry years *(KIT, 2002).* There are, however, large differences in cropping practices between areas and between countries that cause the range of crop yields to fluctuate. This indicates that there are important opportunities to improve crop yields through the adoption of better crop and moisture management practices. The average yields of main crops under spate irrigation in different parts of Yemen are given in Table 6.3.

TABLE 6.2
Crop yield in spate-irrigated areas (kg/ha)

Country	Crops grown under spate irrigation	Yields (kg/ha)
Eritrea	Sorghum	800 – 3 800
	Maize	500 – 2 000
	Pearl millet	200 – 900
	Cotton	200 – 1 000
	Sesame	100 – 800
	Groundnut	700 – 2 500
	Tomato	500 – 2 000
	Pepper	900 – 4 000
	Okra	500 – 1 500
	Watermelon	1 000 – 3 500
Iran	Sorghum	2 000 – 6 500
	Wheat	2 500 – 6 000
	Barley	600 – 2 500
	Watermelon	10 000 – 13 000
	Date Palms	400 – 700
	Mungbeans	800 – 1 100
Morocco	Wheat	1 200 – 1 500
	Barley	1 500
	Maize	900
Pakistan	Sorghum	360 – 550
	Sorghum fodder	1 500 – 4 800
	Oilseeds	150 – 350
	Pulses	200 – 500
	Cotton	360 – 620
	Castor	395 – 988
	Mung bean	270 – 550
	Mustard	760
	Gram (Chickpea)	789
	Wheat	450 – 1 706
	Barley	905
	Millet	564
	Mash	480
	Chickpea	470
Yemen	Sorghum (Grain)	600 – 3 500
	Sorghum (Fodder)	810 – 11 500
	Millet	600 – 1 200
	Maize	1 000 – 1 500
	Sesame	350 – 700
	Melon	5 000 – 14 100
	Cotton	350 – 8 500
	Qaira (for grain)	900 – 1 500
	Groundnuts	1 200

Source: van Steenbergen et al., 2008

Yields also vary reflecting the adequacy of irrigation and the effort made by farmers in moisture conservation and husbandry. Table 6.4 shows yields in the traditional Wadi Rima system (before modernization) for areas with different probabilities of irrigation.

TABLE 6.3
Crop yields in spate-irrigated areas of Yemen (kg/ha)

Crop	Coastal area (Red Sea)	Coastal area (Aden Gulf)	Coastal area (southern Yemen)	Wadi Rima (Tihama)	Wadi Mawr (Tihama)
Sorghum	2 000 – 3 500	700–1 200	900	–	–
White	–	–	–	1 100	1 000
White ratoon	–	–	–	600	–
Red	–	–	–	–	600
Millet	–	700–1 200	900	800	600
Cotton	650–1 350	–	–	1 100	1 000
Extra long staple		850–950	900	–	–
Medium staple		1 000–1 600	1 500	–	–
Sesame	700	350–650	500	700	700
Maize	1 100–1 500	–	–	1 400	1 000
Melon	–	7 900–14 100	10 000	–	5 000–5 500
Groundnut	–	1 200	1 200	–	–

Source: Al-Shaybani (2003), Mu'Allem (1987), DHV (1979), and Shahin (1990)

TABLE 6.4
Crop yields in areas with different probabilities of irrigation in Yemen (kg/ha)

Crop	Perennially spate – irrigated area	Regularly spate – irrigated area	Irregularly spate – irrigated area
Maize	1 200 – 1 300	1 200	–
Sayf Sorghum			
Grain	1 000	800 – 1 000	600
Fodder	3 200	1 900 – 2 300	2 000
Sorghum			
Grain	1 400	400 – 1 100	–
Fodder	3 500	1 000 – 2 800	2 200
Sorghum			
Grain	2 500	1 000 – 2 500	1 100
Ratoon	800	300 – 800	200
Cotton	8 500	850 – 3 500	350
Millet	–	500 – 1 000	500
Sesame	–	200 – 500	200

Source: Makin (1977)

The perennially irrigated area here refers to lands close to the mountain front that were irrigated with reliable seasonal base flows that could be rotated between fields.

As shown in Table 6.2, relatively high yields are also obtained in the eastern lowlands of Eritrea. The water management practice there is to divert as many spate flows as possible to a relatively small area; ideally, farmers hope to achieve two or three irrigations before planting. The result of this approach is that in a good year harvests in Sheeb can be larger than in most spate system elsewhere in the world – up to 3 500 kg of sorghum on the first cutting and half of that again as a ratoon crop *(van Steenbergen, 2003)*.

Compared with the yields of spate-irrigated crops in Yemen and Eritrea, yields in Balochistan (Pakistan) are significantly lower (see Table 6.2). The reason is that most spate-irrigated crops in Balochistan receive one flood irrigation and are then dependent on 'unreliable' rainfall for addition moisture. In Yemen, in contrast, supplementary irrigation from groundwater is common, while in Eritrea there are often two or three floods before seeding, with soil moisture being conserved every time.

Changes in cropping patterns

In several areas, there is a decline in the cultivation of traditional spate-irrigated crops. In Pakistan and Yemen, traditional cereal crops, such as sorghum and millet, cannot compete with imported wheat, which is sold at low subsidized prices in the local markets. With increasing prosperity and urbanization, changing taste may lead to deterioration in the position of the local producer compared with that of the importer. Rising standards of living and changing habits can reduce the market for traditional grains, such as sorghum, allowing imported wheat and other cereals to take their place *(Makin, 1977)*. Consumers in Yemen prefer wheat, as the consumption of traditional food grains indicates a low socio-economic status.

Furthermore, research, extension and credit services have been directed to high-value crops, at the expense of traditional spate-irrigated crops, and promoting the use of groundwater for irrigation. The cropping patterns in Wadi Tuban and Wadi Zabid in Yemen have changed dramatically, owing to the remarkable increase in shallow wells since the 1980s. As a result, the area under banana has increased from 20 ha in 1980 to more than 3 500 ha in 2000 in Wadi Zabid (see Figure 6.3), while about 2 300 ha are under vegetables in Wadi Tuban. This shift in cropping pattern has improved the living standard of farmers, but it has mainly focused on the upstream region of the scheme and has led to reduced spate flows to the downstream area and thus has deprived the tail-end farmers of their livelihood. Examples of the cropping patterns adopted in spate-irrigated areas in Eritrea, Ethiopia, Pakistan and are shown in Table 6.5.

FIGURE 6.3
Bananas irrigated by spate flows and shallow groundwater Wadi Zabid, Yemen

TABLE 6.5
Cropping patterns in spate-irrigated areas in Eritrea, Ethiopia, Pakistan and Yemen

Country/region	Cropping patterns/additional information	Reference
Eritrea	Crops usually sown from mid-September after flooding of fields has subsided, and harvested after 90–120 days.	*Tesfai (2001)*
Ethiopia	Two cropping seasons, locally known as hagaya (September – January) and ketena or sorora (April-August). Normally plots are double-cropped under mixed cropping and ratooning system. Usually up to three types of crops (if not varieties) are intermixed in one cropping season.	*Michael (2000a)*
Pakistan		
Kachhi District, Balochistan.	Mixed crop of sorghum, mung bean and moth bean (sown after summer rains in July, August and September). Spring plantings of sorghum and melon made whenever possible. Rapeseed sown after late summer rains, important in some areas. Melon grown on one February-March flooding. Wheat only sown when there are late floods, particularly in late August and September. Main crop of sorghum sown as soon as possible after first summer floods. Rare for these crops to receive a second watering; farmers prefer to expand acreage with subsequent storm water. Irrigation priorities: sorghum, pulses, mustard, wheat.	*MacDonald (1987a)*
Lasbela District, Balochistan.	Sorghum, mung bean, sesame and sometimes guar sown on early floodwater (July-August). Castor sown on floodwater that arrives August-September. Late water stored to grow rape in December (mustard rarely grown due to insufficient moisture). Spring sowings of mixed mung and sorghum or guar as monocrop made if sufficient water (usually grown as fodders). Irrigation priorities: castor, sorghum + guar, mustard.	*MacDonald (1987b)*
Rod-kohi area in D I Khan, Balochistan	Long planting season (February-August) for spring and summer crops; October-December for winter crops.	*Khan M. (1990)*
Chandia, Balochistan	Basic farm system of area fodder, sorghum and livestock is combined with pulses, oilseed and wheat. Sorghum – high value when grown for fodder, often interplanted with pulses, mainly mung. Sorghum ratooned – high return on investment. Wheat grown on finer-textured land (wheat riskiest crop).	*Halcrow (1993a)*
Nal Dat, Balochistan	Planting time for kharif crop June-early July. Crop harvested September-October. Rabi crop sown in October, harvested in April-May.	*Halcrow (1993b)*
Kharan, Balochistan	Wheat sown October-December; no wheat grown unless there are floods. Wheat harvested April-May. In drier years, wheat and sorghum used for fodder.	*BMIADP (1994)*
Balochistan	Early monsoon floods used to grow sorghum; subsequent floods used for oilseeds. If monsoon arrives late, moisture stored and a wheat crop grown.	*van Steenbergen (1997)*
Toiwar, Balochistan	In the kharif season cropped area is restricted owing to shortage of water.	*Halcrow (1998)*
	Melon and pulses more drought-resistant; maize sensitive to water stress.	*Rehan (2002)*
Yemen		
Wadi Rima	Lentil, cowpea, bean and sometimes watermelon sown in the rows between the millet, if farmer thinks soil moisture sufficient. Sorghum most widespread and profitable crop (75 percent of total value of crop production in an average year). Bulrush millet has superior drought-tolerance. Maize locally important. Cannot be reliably grown under single-spate irrigation, but popular under more regular wadi irrigation. Cowpea undercropped beneath both sorghum and maize. Cotton main cash crop. Usually several floods in March-May, which allows production in most years of early subsistence crop of sorghum or millet. Sesame less important, but is apparently expanding under spate and pump irrigation.	*Makin (1977a); Pratt (1977)*

Country/region	Cropping patterns/additional information	Reference
Coastal areas of the Yemen	Two distinct flood periods – seif (March-May) and kharif (July-September).Seif floods permit the cultivation of a few field crops on a limited area. Crops include melon and sorghum, either as grain-cum-fodder if left till harvest, or green fodder if harvested 50–60 days after planting. Kharif floods permit the cultivation of several field crops on a larger area. These crops include the main cash crop (long and medium staple cotton), sorghum, millet, sesame, melon and, more recently, groundnut (on a limited area).	*Mu'Allem (1987)*

Another trend is that state-organized cultivation is declining and with it the cultivation of cash crops such as cotton and castor. Both in south Yemen and in Sudan, cotton was common in the spate systems until the 1960s and processing and marketing facilities were in place. In the Gash system, government-organized cultivation of castor replaced it but in the end in all areas state monopolies ceased to exist and farmers were given the freedom to choose their own crops.

Cropping patterns in farmer-based, spate-irrigated areas are strongly influenced by the priority given to subsistence crops, the need to grow forage to support livestock and the strategies that farmers adopt if there is insufficient water. In Balochistan, farmers at the head of the system, who normally receive a more reliable supply, can follow a cropping pattern of mixed sorghum, mung beans and wheat. As water becomes less reliable at the middle and tail-end sections of the system, the cropping pattern changes. If the flood season arrives late, moisture is stored in the soil and wheat is grown. If the flood season is early, sorghum is grown and later floods are used for oilseed *(van Steenbergen, 1997).*

OPTIONS TO IMPROVE AGRICULTURAL PRACTICES

The high risk of crop failure associated with spate irrigation does not leave much space for the classical improvements that are justified in intensive agriculture. There is, however, a possibility that production gains can be obtained through carefully designed changes in agricultural practices.

Traditional versus improved varieties

Farmers mainly use local varieties. Local cultivars are well adapted to their environment, having developed over long periods. Where water supply is limited, a local cultivar can produce both grain and fodder and, if additional rainfall or floodwater becomes available, the yield increases *(Williams 1979).*

In Yemen, local varieties of sorghum and millet have less growth above ground than improved varieties and can tolerate extremely dry conditions by regulating their water use through surface area. There is evidence to suggest that local cultivars have slightly faster, deeper-growing root systems than improved cultivars so that they can exploit moisture held deep in the soil profile *(Williams, 1979).*

In traditional systems, seed is normally retained from one year to the next. The practice of using self-produced seed, however, can lead to diseases. Yet there are very few substitutes for the traditional varieties as agricultural research in most countries has been concentrated on improving the yields of perennially irrigated crops. Seed may be purchased in some instances when self-produced seed becomes liable to disease *(Halcrow, 1993a and b; Goldsworthy, 1975;* and *MacDonald 1987a and b)* and the use of improved seed varieties through exchange between spate areas should be considered more systematically.

Practically no improved varieties have been developed for the purpose of spate irrigation, and when some varieties exist they are difficult to obtain *(Halcrow, 1993a).* In Kachhi District in Balochistan, improved varieties have been shown to have no advantage over local cultivars *(MacDonald, 1987a).* In DI Khan in Pakistan and Sheeb, Eritrea, however, some efforts have been made:

- early-maturing sorghum varieties have been made available to farmers and these give higher yields than local varieties;
- higher-yielding varieties of bajra have been developed, which are not damaged by birds and which grow better in hot and dry conditions;
- a gram variety has been developed which is blight-tolerant, *(Khan, 1990)*; and
- tetron sorghum variety, introduced in Eritrea, has shown better resistance to drought and pest infection.

Finally, although the main focus of research is often on improving crop yield per unit area, the availability and sustainability of a variety is also crucial *(Michael, 2000b)*. Local cultivars still fare well in terms of drought resistance, labour inputs, market values, food values and storage, and these factors need to be given more consideration in research.

Cropping intensities

The extent, size and number of floods affect the cropping intensity and these change from one year to the next *(MacDonald, 1987a)*. Cropping intensities vary widely between and within countries and schemes. The range of copping intensities in Eritrea, Pakistan and Yemen is illustrated in Table 6.6. Clearly, as for yields, fertile land situated close to the wadi and receiving a reliable supply of water will have higher cropping intensities than areas where there is a shortage of water.

Planting density

The amount of water that plants use depends on the quantity of soil moisture that is available, the root growth rate and the extent of root development. The farmer can influence the relationship between these factors by adjusting the planting density on the plot of land according to whether or not further rain or floodwater in the growing season is likely to occur *(Williams, 1979).*

A very dense plant population creates a high competition among the plants for moisture, nutrients and light. As a result of this competition, plants, especially sorghum, grow very thin and tall and the yield is low. Young crop stands of high plant density are more affected by drought than equal stands of lower density. *Williams (1979)* suggests that, in order to use water more efficiently, it may be more suitable to grow cultivars that yield more grain per plant and grow them at a lower plant density. In spate irrigation systems, however, as is the case in Eritrea *(Ogba-Michael, 2004)*, planting at high density may be preferred by farmers for the following reasons:

- a densely grown crop can be thinned and used to feed their animals, which do not have any other source of feed;
- Waterlogging and infestations of insects such as locusts and heavy attacks by birds can kill young plants. These problems reduce the plant population as well as the yield. To cope with such problems high-density planting is preferred; and
- Densely grown plants suppress weeds and the majority of the farmers do not practice weeding.

TABLE 6.6
Cropping intensities in spate-irrigated areas of Eritrea, Pakistan, and Yemen

Country/region	Cropping intensity (%)	Notes	Reference
Eritrea			
Sheeb area	165		*Tesfai (2001)*
Pakistan			
Kachhi District,	30–40	Typical overall cropping intensity	*MacDonald (1987a)*
Balochistan	90–120	Cropping intensity for irrigated areas – depending on the small amount of sequential cropping of wheat and April-planted fodder.	
	150–180	On land that is well and regularly watered, when a sorghum-mung-moth crop and an early sorghum crop are grown back to back.	
Lasbela District, Balochistan	30–60	Typical values in sailaba areas can rise to 120 percent overall in exceptional circumstances with very reliable flooding. Individual bundats may have cropping intensities of 200 percent at a time. In rainfed areas, cropping intensity can be as low as 20 percent.	*MacDonald (1987b)*
Yemen			
Wadi Rima	150	Spate irrigation has a high water use efficiency – though land at the end of most canals receives spate on such an irregular basis that it is basically rainfed.	*Makin (1977)*
	230	Areas receiving regular spate irrigation (significant area of sorghum ratoons).	
	130	Areas receiving irregular spate irrigation (11 percent of area lies fallow in any one year) – success in cropping depends to some extent on timely rainfall.	
Wadi Mawr	'High'	Cropping intensities in main spate irrigation areas lying close to wadi are generally good because of the concentration of good arable lands and the more reliable water supply.	*Tipton and Kalmbach (1978)*
Wadi Bana and Abyan Delta	33–143	Reflects uncertainty of water supply – increases from north to south.	*Atkins and Partners (1984)*

Fertilizers

In most spate-irrigated areas, there is minimal use of chemical fertilizers *(Goldsworthy 1975; Tipton and Kalmbach, 1978; Atkins and Partners, 1984; Shah, 1990; Halcrow, 1993b; Michael, 2000a; and Tesfai* and *Stroosnijder, 2001)*, or organic fertilizers such as manure *(MacDonald, 1987a; Halcrow, 1998; Michael, 2000a;* and *Tesfai and Stroosnijder, 2001).* Farmyard manure is used in some areas of Balochistan (Pakistan) where soils are sandy and recognized as being relatively infertile *(MacDonald, 1987b).* Incorporating crop residues in the soil is also generally not practised, as they are often used as fodder.

It is usually taken for granted that yields could be increased with greater investment in fertilizers, combined with improved cultural practices and adequate irrigation *(Tipton and Kalmbach, 1978; Mu'Allem, 1987; Khan, 1990;* and *Shah, 1990).* While this was true in the case of improved high yielding varieties in the coastal plains in Yemen (Table 6.7), the yield of local varieties in the same region did not respond to the input of fertilizers *(Goldsworthy, 1975).*

Most spate farmers believe that their soils are naturally fertilized by the fine sediments that are deposited during flood irrigation. Floods often carry around 10 percent in weight of fine silts that are deposited on the fields. *Gilani (1990)* reported that the floodwater in DI Khan in Pakistan contain up to 35–40 percent silt. Silts are usually rich in plant nutrients and possibly nitrate *(Atkins and Partners, 1984; Shah, 1990; Tesfai, 2001). Mu'Allem (1987)* reported that a 1 m depth of irrigation with heavily silted water spread over 1 ha, contains 0.92 kg nitrogen, 0.01 kg phosphate and 11.02 kg potash. However, the origin of floodwater affects its nutrient value. In the Sheeb area in Eritrea and when spate flows come from nearby hills and mountains, which have little vegetation cover, the sediment is poor in nutrients. Runoff from the highlands, where land is used for agriculture, contains organic matter and plant nutrients. Although soils in Sheeb receive inputs of total N, P and K from spate flows, soils are in fact low in N and organic matter. The application of organic fertilizers would thus increase the organic matter content of the soil and improve the water storage and nutrient retention capacity of the soils *(Tesfai, 2001).* These questions and possible improvement options are discussed in detail in Chapter 5.

TABLE 6.7
Yield responses of spate crops to nitrogen fertilizer and improved cultural practices in the coastal region of Yemen

Crop	Long staple cotton	Medium staple cotton	Sorghum/ millet	Sesame	Melon	Groundnut shelled seed
Treatment			**Yield (kg/ha)**			
Nitrogen at (9.3 kg/ha) and improved agricultural practices	221	339	212	121	2482	263
Control yield	147	226	151	81	1711	202
Increased yield over control	74	113	61	40	770	61
Increased yield over control	50%	50%	40%	49%	45%	30%

Source: Mu'Allem, 1987

In the Sheeb area in Eritrea, farmers believe that mineral fertilizers and manure burn the crops *(Tesfai, 2001)*. However, if manure is applied after irrigation has finished and before the seeds are sown, fertilizers will be retained in the soil, and manure will decompose and dissolve so that germinating seeds do not get burned *(Tesfai, 2001).*

There are, however, other factors that contribute to the limited use of chemical fertilizers. These are:

- the cost, as the use of chemical fertilizers depends on the availability of credit to farmers;
- the lack of experience of farmers in the use of fertilizers and pesticides;
- the availability of chemical fertilizers; and
- the high level of risks that fertilizers will be washed off by uncontrolled irrigation.

It is, however, to be noted that much of the literature on fertilizers comes from the 1970s and 1980s, when large investments in spate irrigation were being made in Yemen and Pakistan and tended to be biased towards the larger spate systems where there was some agricultural extension support to farmers. More site-specific studies, carried out in small farmer systems rather than in the controlled environments found on research farms, are needed to develop clear guidance on cost, benefits and attractiveness to farmers of the use of increased inputs in spate cropping.

Pest and disease control

As the cropping pattern in many spate irrigation systems is dominated by monocultures and large areas are planted at the same time, the impact of pests and diseases can be dramatic. The use of pesticides and insecticides is rare as most farmers lack the financial resources to apply these products. Following a number of insect attacks, which affected the quality and quantity of the crops, several types of crops were not cultivated in the Sheeb area in Eritrea during the 2000–2001 cropping season *(Kahsaye, 2002).* In Eritrea and Ethiopia, crop damage by birds is widespread, especially of sorghum.

The traditional cropping system is designed to be flexible enough to cope to a certain extent with inevitable crop failures induced by pests and diseases. At the beginning of a cropping season, a late-maturing, high-yielding crop is planted. If this crop fails because of over-flooding or shortage of water or pest and insect attack, it is replaced by an early-maturing and drought-, pest-and disease-tolerant variety, which is usually a low-yield variety.

Some adaptive research has been conducted by local agricultural institutions in spate-irrigated areas to introduce crop varieties that are high-yielding and at the same time resistant to drought, pest and bird damage. Examples include Bajar and Hijeri sorghum varieties in Pakistan and Eritrea respectively, which were tested and found to be less affected (as compared to other local varieties) by drought, pest and bird damage *(Khan, 1990* and *Mehari, 2007).* Such adaptive research on crop varieties should be promoted as an integral component of crop productivity improvement projects and endeavours.

Crop rotation

In many areas, crop rotation is not practised and in most cases farmers are not aware of its benefits. In Wadi Rima in Yemen, for example, no crop rotation is practised. As a result of continued monoculture, soil fertility is declining, yields are decreasing and plant pests and diseases are multiplying. In contrast to the situation in Pakistan, there is no leguminous crop in the rotation in Yemen which by nitrogen fixation could build up fertility for the succeeding crop *(Goldsworthy, 1975).* Where practised, crop rotations may be relatively simple. In Chandia in Balochistan, for example, the crop rotation is sorghum, fallow and oilseed. However, in most areas, and with increasing population pressure and the pressing need to grow subsistence crops, improving rotational practice is not seen as a priority by farmers *(Makin, 1977; Halcrow, 1993a;* and *Shah, 1990).*

FIGURE 6.4
Sorghum ratooning

Ratooning

Sorghum ratooning (see Figure 6.4) provides a high return on investment. In the Sheeb area in Eritrea and when there is sufficient floodwater, sorghum can produce a main crop, a first ratoon crop with grain yield and a second ratoon crop of forage only, without the application of any fertilizers *(Tesfai, 2001)*. When the main crop has matured, the remaining moisture in the soil profile is deep and, unlike new seedlings, a ratoon crop is able to extract this moisture. Ratooning also saves on material and labour, as land does not require preparation or sowing and there are no seedlings to tend. The length of time between sprouting and harvesting is always shorter 70–80 days) in a ratoon crop than in a seeded crop *(Halcrow, 1993a;* and *Tesfai, 2001).*

GRAIN STORAGE

In Eritrea traditional grain storage causes 4–14 percent crop loss *(Haile et al., 2003)*. Investigations by an NGO working in the spate-irrigated area of Daraban Zam in Dera Ismail Khan in Pakistan, found that grain storage losses averaged 7 percent for a several reasons: the work of insects and pests; the storing of grains before they were completely dried and the high moisture in storage spaces. Grains were typically stored in 50 kg plastic bags or earthen containers that were usually not tightly closed. Storage spaces were in most cases multi-functional and shared with residential or animal husbandry functions. A number of low-cost changes were introduced that brought down storage losses to less than 1 percent:

- cleaning of grain prior to storage;
- construction of special storage place;
- fumigation of seeds affected by pests and diseases;
- improved storage containers:
  - earthen containers of (150 x 90 x 120) cm, containing 1 200 kg of grain, separated from the walls and floors, containing an opening closed with a wooden plug;
  - large polyethylene bags (binda), containing 2 000 kg of grain, placed on an elevated platform and tightly closed with plastic sheeting on top;

THE ROLE OF LIVESTOCK

Because livestock is an integral and important component of the livelihoods of households in most spate-irrigated areas, livestock support programmes – ranging from restocking after drought and providing para-veterinary services to improvement of fodder availability within the irrigation command area – can make substantial contributions to livestock production (see Table 6.8).

TABLE 6.8
Examples of improvements in livestock production

Improvement	Description	Likely impact	Remarks
Livestock restocking	Making draught animals available after drought or other services on credit or on rotational system	Availability of draught animals will contribute to land preparation	
Veterinary or para-veterinary services	Training of local animal health workers	Most appropriate basic animal health care, especially for transhumant groups or livestock owners	In some cultures it may be best to train women health workers especially for care of small ruminants
Rangeland improvement	Selective closure and floodwater spreading	Rangeland regeneration can be remarkably fast	In many areas there are informal rules for insider and outsider groups, including monetary compensation for using local rangelands

The main source of animal feed is usually crop residues and rainfed grazing lands. A second source is the cultivation of spate-irrigated fodder crops, such as (green) sorghum (see Figure 6.5). In Eritrea and Sudan, ratooning sorghum is an important feed for livestock as well. The cutting of weeds in the fields and along the canals is another source of forage and leaves from trees in and around the spate-irrigated fields are also used to feed animals. For instance, households in the Sheeb area in Eritrea practise 'zero-grazing' from October to May, whereby the animals are fed with cut grass from the fields, to prevent livestock from causing damage to standing crops and to economize on the scarce animal feed. Farmers in the northern part of Amhara State in Ethiopia have moreover indicated that spate irrigation has boosted the availability of animal feed through a significant increase in biomass production. The improved availability of animal feed has improved household income generated from livestock products.

FIGURE 6.5
Marketing green sorghum as fodder, Yemen

A less common but potentially important practice is irrigation of grazing land. In the Gash flood plains in Sudan, large areas are covered with a variety of annual and perennial grasses through seasonal flooding with excess floodwater from the Gash River. According to traditional water governance practices, the first flood in the river is diverted to the extremes of the scheme in order to stock drinking-water for livestock and to irrigate the grazing lands, so that animals will be kept away from the planted crops. However, increased mechanized farming activities on traditional grazing lands, as well as the migration of additional livestock herds from other areas, have increased the pressure on the remaining rangelands, which are gradually deteriorating.

Under the Artificial Groundwater Recharge Project on the Gareh Bygone Plain in Iran, the average yield of indigenous vegetation on spate-irrigated rangeland was 11 times higher (445 kg/ha) than for rainfed land (42 kg/ha), whereas the average crown cover was 31 percent for spate-irrigated rangeland against 16 percent for rainfed grazing land. If the yield of the planted quail bush is also added, the overall yield for spate-irrigated rangeland is 23 times higher, which is enough to graze four sheep on one hectare for an entire year *(Kowsar, 1999)*.

Spate irrigation aimed at producing fodder for pastoral communities was tried in Turkana district (Kenya) in the late 1980s. This was done with large temporary brushwood diversion weirs with graded canals to facilitate the overtopping and uniform spread of the water on the land. Although they were quite productive, these structures were not sustainable since they had been constructed through food-for-work programmes with little concern for community ownership.

AGROFORESTRY

An important element in spate agriculture is agroforestry. Spate irrigated trees are often planted on field bunds and in outwash areas. In the Shabwah Governorate in Yemen, each household has between 25 and 50 species of zizyphus trees in and around their spate-irrigated fields for beekeeping, fodder, fruits, timber, fuelwood and medicinal uses, whereas spate-irrigating farmers in the Tihama region earn an additional income from the sale of fuelwood and/or charcoal. In the Konso spate irrigation system in Ethiopia, many trees can be found and many beehives have been installed. In the spate-irrigated areas of Pakistan, trees are also common and are used for many purposes. For instance, trees with large spines, such as the acacia species, are used for constructing fences around fields, in order protect standing crops from roaming animals and to build corrals for safeguarding livestock at night. Women use dwarf palms for the production of mats, ropes and sandals. Trees also provide vital shade for livestock during the hot season.

In DI Khan in Pakistan, tree plantations were laid out in specially designated land with a relatively low probability of irrigation. Fields were prepared in diamond shape in order to concentrate runoff and spate releases on the tree plantations. In the Gash in Sudan, there are trees that depend on the excess flooding of vast areas of the plains outside the Gash spate irrigation scheme.

In the floodwater-spreading areas of the Gareh Bygone Plan in Iran, eucalyptus and acacia species were planted in a sedimentation basin of about 3.6 ha and the average yield after eight years was 60 m^3/ha of stem wood and 18 m^3/ha of fuelwood. In a less flooded area of 6 ha, the average yields for stem wood and fuelwood were 39 m^3/ha and 11.7 m^3/ha respectively. The annual carbon sequestration potential of spate-irrigated eucalyptus is 3 699 t/ha, and 3 392 t/ha for acacia. It is estimated that the annual income from stem wood, fuelwood and fresh leaves could be US$290, which is substantial, considering the low risk and very low capital investment. Other noticeable incomes could also be derived from forest by-products, such as forage, food products, pharmaceuticals, honey and beeswax.

In the Tihama region in Yemen, tree coverage has increased with many important multifunctional indigenous trees. The most important ones are *Zizyphus spina-christi*, for high-quality honey, forage, timber wood, fruit, detergent (from the dry leaves) and camel fodder; *Salvadora persica*, used to produce toothbrushes (from the roots) and food condiments (fruits) and also used to stabilize sand dunes; *Balanites aegyptiaca* for shelter, camel feed and fruits; and *Acacia ehrenbergiana*, providing prime-quality honey, forage, goat fodder and charcoal wood. The moisture captured from the acacia charcoal (*keteran*) is used for skin treatment of livestock *(Haile and Al-Jeffri, 2007).*

Agroforestry offers multiple advantages and trees are well adapted to the uncertainty associated with spate irrigation. In particular, growing nitrogen-fixing trees like acacia species can help to improve soil fertility. The wood can be used as fuel as there is a high demand for fuelwood in the area to replace cow dung, that can then be used as a fertilizer, leading to better yields. Trees can be used as a source of fodder and provide crops with some shelter. *Iqbal (1990)* and *Kowsar (2005)* have proposed an alternative mixed system of raising trees, agricultural crops and livestock simultaneously in spate-irrigated areas in Pakistan and *Tesfai (2001)* refers to the potential for growing trees along field bunds. Box 6.1 shows the value of trees for bee-keeping in Yemen, Ethiopia and Pakistan and Table 6.9 gives examples of possible improvements in agroforestry practices.

AGRICULTURAL EXTENSION, TRAINING AND RESEARCH

Although there is considerable scope for crop productivity improvement through extension and research, these services are usually poor and ill-adapted to the specific concern of spate-irrigated areas. Many regions lack a resident extension service supporting spate irrigators, and when this is available, agricultural research and extension services do not meet spate farmers' development needs *(Khan A B, 1990; DHV, 1988)*. In Pakistan, the spate-irrigated areas lie in the most marginalized and socially low-ranking districts *(Van Steenbergen, 2003)*. This is reflected in the decision making and resource allocation for the irrigation sector at the national level. The bulk of investment in agricultural research and physical development has gone into perennial-canal-irrigated agriculture. Spate irrigation is not part of the agriculture or engineering curriculum in any formal educational institution of the country. The lack of academic knowledge and the lack of empathy among decision makers for the marginalized communities that practice spate irrigation have negatively affected state support for extension, training and research. Yet, the spate-irrigated sector accounts for more than 1.5 million ha and has potential to reconcile food security with natural resource management in a very fragile environment *(ICARDA, 1998).*

BOX 6.1

Use of trees by spate farmers in Yemen, Ethiopia and Pakistan

In Yemen, the honey from *Ziziphus spina-christi* and *Acacia ehrenbergiana* is fetching the highest prices for honey anywhere in the world. Each household in Shabwah Governorate has between 25 to 50 ziziphus trees in and around their spate-irrigated fields for beekeeping, fodder, fruits, timber, fuelwood and medicinal uses. In the Tihama area in Yemen, trees are cut and sold directly as fuel or used to produce charcoal for sale. The smouldering wood of *Acacia ehrenbergiana (ketaran)* is carefully collected and used to treat skin diseases of goats, donkeys and camels. In Ethiopia, a large number of trees, such as acacia, are found in the command areas of spate irrigation systems in Konso, where many beehives have been placed. In Pakistan, trees such as tamarisk are common in the spate-irrigated areas in Balochistan and Dera Ghazi Khan and Punjab. They are used for many purposes, including their use and sale as fuel, either as wood or charcoal. Women use the dwarf palm for making mats, ropes and sandals. Trees with large spines, such as the acacia, are used to construct fences to protect crops from animals and to corral livestock.

Source: Verheijen (2003)

TABLE 6.9

Examples of improvements in agroforestry practices

Improvement	Description	Likely impact	Remarks
Spate-irrigated trees	Combination of local water harvesting and planting high-value (grafted) tree crops.	High-value use of 'outwash areas' – that may otherwise have little value.	
Uprooting of invasive species	Uprooting of mesquite manually or mechanically; processing into charcoal	If not controlled, mesquite will invade spate fields and channels.	Mesquite is a problem in spate areas in Sudan and Yemen (Tihama).
Improved marketing of non-wood forestry products	Improvement of marketing of high-value, non-wood products, such as honey and medicinal products.	Can add significant farm incomes.	Range of products such as detergents, traditional medicines and fodder. Zizyphus and acacia honey fetch US$30/kg in Yemen.
Local tree cutting bans	Bans on using trees for external sales of charcoal production.	Will protect trees in common lands.	Effectively enforced in Sheeb in Eritrea.

Research into a wide range of topics is needed to increase yields and the returns from spate irrigated agriculture. These topics are listed in Table 6.10 *(Goldsworthy, 1975; Makin, 1977a; Williams, 1979; Atkins and Partners, 1984; MacDonald, 1987a and b; DHV, 1988; Khan A B, 1990; Michael, 2000b; Rehan, 2002).* Furthermore, it is important to improve the link between research and extension *(Michael, 2000b)*. Research needs to be systematically carried out in consultation with farmers, in farmer-led trials and experiments on working spate systems and through farmer-to-farmer demonstration activities and get away from the 'research farm' approach. Of particular relevance to research in spate irrigation is the integration of indigenous technical knowledge with scientific knowledge to increase productivity and ensure sustainability *(Tesfai, 2001)*.

Of these research topics, possibly the most important is the development or the dissemination of higher-yielding but drought-resistant varieties and of improved water management and soil moisture conservation practices.

TABLE 6.10
Research topics needed in spate irrigation

Seeds and cropping pattern
Drought-resistant crops
Propagation of seedlings
Establishment of seed banks
Potential for high-value crops (e.g. mushrooms, wild vegetables)
Improvement of existing mixed/intercropping systems
Land preparation
Land preparation before flooding
Land levelling
Farm tools and mechanization
Time of sowing
Crop spacing and plant density
Crop management
On-farm water management (including depth of water retained)
Moisture conservation through mulching or deep tillage
Soil conservation
Fertilizer applications
Weed and pest control (including documentation of indigenous pest management practices)
Harvesting and crop storage
Harvesting methods
Post-harvest methods
Improvement of crop storage
Other
Use of tree crops
Improving animal nutrition
Improvement of sharecropping arrangements
Land distribution practices

Chapter 7
Water rights and water distribution rules

SUMMARY

Water distribution rules and rights have evolved over time in traditional systems to help mitigate the unpredictability that is inherent in spate irrigation and reduce the risk of conflict by regulating relations between land users that have access to floodwaters. The way rights are defined in spate systems is different from the way they are defined in perennial systems. In spate irrigation, water rights describe acceptable practices in a given situation, rather than quantifiable entitlements to a resource. Water distribution rules make it easier to predict which land will be irrigated. They define the likelihood of irrigation for different areas and hence serve as the key to the collective maintenance and rebuilding of diversion infrastructure. The rules and rights are therefore also at the core of the arrangements for maintenance, the landowners who contribute to the labour-intensive maintenance being rewarded with access to the inherently unpredictable spate flows.

A clear understanding of existing water rights and rules in a given spate irrigation system and a good comprehension of the possible impact of external interventions on existing water distribution and system maintenance rules and practices are essential. They will help set up water distribution rules in new systems, identify opportunities for improvement in enforcement and modification of water rights, take into account new circumstances and the way they affect distribution rules and avoid unintended drawbacks of the proposed changes.

Demarcation rules define the area entitled to irrigation. They often protect the prior rights of downstream landowners, by prohibiting new land development upstream, which could result in the diversion of floodwater to new lands. Closely related to the demarcation rules are those concerning the **breaking of diversion** structures, or the timing of a water right. The rules on breaking bunds are usually in place in areas where the entire wadi bed is blocked by earthen bunds, as in the lowland systems in Pakistan. The **rules on flow division** between irrigation channels arrange the distribution of water between the different flood channels. A fourth category of rules is the **pre-arranged sequence** in which fields are irrigated within the irrigation system. A fifth type of rules concerns the **depth of irrigation** and is expressed in agreements on the height of the field bunds, which determines the amount of floodwater that can be stored in the fields. A sixth category of rules is the **right to a second water turn**. In many systems, floods come and go and a season may bring a series of spates, posing the problem of distribution of a sequence of floods. Two options are possible, either the option of upstream landowners to take a second turn, or the obligation to restart irrigation from the place where it stopped the previous time. Finally, there are rules that take into account the possible changes in the wadi bed and in land elevation inherent in arid land hydrology and concern the location of diversion and other structures and compensation for lost land.

All the above rules impose a certain predictability and equity while ensuring efficiency in the use of the resource. The first three rules prevent the water from being monopolized in the head reaches of the flood irrigation system. The sequence rules, in turn, identify priority areas, and equity issues are significant in the fifth and seventh rules. The sixth rule shows how spate systems attempt to balance efficiency with equity in water distribution.

Maintenance is as important as water distribution in spate irrigation, and water distribution rules dictate the way maintenance is organized. In many systems, the right to irrigation by spate flows is in proportion to one's contribution to repairs to the headwork or flood channels. If one abstains from public duty, one is simply not allowed to open the intake to one's field. Water distribution rules often serve to create a reasonably coherent group of land users who are dependent on the spate system and jointly undertake the maintenance of the structures.

Of crucial importance to maintenance is the critical mass required in undertaking repairs. This is particularly relevant when repairs depend on human labour and draught animals and a large force is required to rebuild structures and make repairs. When tail-end users are systematically deprived of flood water supplies, they may no longer want to contribute to the maintenance. The critical mass factor hence works as a way of avoiding too large inequity in water distribution. However, the importance of critical mass may be expected to diminish when maintenance becomes mechanized or directly undertaken by government organizations.

An important requirement of the maintenance rules in place is their robustness, i.e. the degree to which they will ensure the constant rebuilding of the common works. This is particularly challenging when there is substantial work to be done and it is highly probable that years will pass without irrigation for much of the command area. In these circumstances, contributions based on land shares usually have a greater resilience than those based on benefit, capacity or contract (see details in the text).

The extent to which water rights and rules in spate irrigation are enforced depends mainly on the social structure within the community and the level of the overall governance in the area. Spate systems need a far greater degree of discipline than other resource management systems and the rules must be observed by the majority of the farmers. This can be achieved only when there are local organizations that are accountable to most farmers and that apply well accepted enforcement approaches that take into account the social structure of the communities concerned.

Enforcement of water rights and rules in spate irrigation is closely related to the authority of local organizations and government institutions and to the level of codification of water distribution rules. Traditional spate systems usually have well established local governance. In larger systems enforcement of rules is usually done through a mixture of user organization and local government. The role of local government is in such cases to regulate local water distribution arrangements, organize maintenance by water users and solve disputes. In some spate systems, the rules are codified. Codifying water distribution rules clarifies and completes local water management arrangements and introduces a neutral factor in resolving disputes.

Water rights in spate systems are not static. They change in accordance with new situations created by various factors. Amongst those factors are the increase in population and the pressure for new land development, changes in cropping patterns and new market opportunities, the introduction of more permanent spate diversion structures, the shift in power relations, and the changing levels of enforcement. One of the main challenges faced by users of spate irrigation is the decline in the authority of the organizations charged with spate governance. It is particularly striking – as one might expect the opposite – that enforcement has declined as water has become scarcer. There are different reasons for this:

- competition with more labour-rewarding opportunities;
- increased use of groundwater in the spate command areas, leading to reduced need for collective action;
- confusion of responsibilities following public intervention and investment in the system; and
- reduced importance of collective action with the introduction of mechanized power.

Structural improvements in spate systems have implications for distribution and maintenance rules, which need to be considered carefully in the design phase. The construction of new permanent and more robust headworks often result in better upstream control, integration of previously independent systems, more controlled flow and changes in the maintenance requirements. Usually systems are integrated to obtain economies of scale that can justify the large investment required in civil works. Such changes bring together in one single system communities of farmers that may have little interaction between them. If not considered carefully at the outset, such a situation can lead to intractable social problems or even prevent improvement projects from materializing.

Interpretation of rules and their implication for the design and operation of new infrastructure is best done directly by farmers, with discussions facilitated to help them understand the proposed arrangements and the actions to be taken to respond to changes in the system. For existing spate irrigation systems, water rights and actual practices need to be investigated, shared, agreed and, where possible, even codified. For new schemes, a basic set of water distribution rules needs to be agreed with farmers when the schemes are designed. They should be widely shared and arrangements for supervision and enforcement agreed upon. It is desirable that any water distribution arrangements have a high level of flexibility to adjust to unforeseen circumstances. Robust arrangements on management and agreement are more important than detailed specifications on how water is distributed.

Changes in spate irrigation systems usually affect existing rules and local organizations. They are often accompanied by changes in the legislation. This legislation is vital for providing farmers' organizations with the legal recognition and the authority they need to collect and manage water fees, run independent bank accounts, make direct contacts with funding agencies and own or hire machinery and other necessary assets for water management. Ensuring financial and organizational autonomy, however, requires more than legislation. It calls for support of the organizations through capacity-building programmes that include financial accountability, and a technical package with clear operation and maintenance guidelines.

MANAGING UNPREDICTABILITY

Water distribution rules and rights help to mitigate the unpredictability inherent in spate irrigation. Rules and rights impose a pattern and reduce the risk of conflict, by regulating relations between land users that have access to floodwaters. Rights are defined in a different way in spate systems from the way they are defined in perennial systems. In essence water rights in spate systems are reactive. They deal with agreed claims in a changing and variable environment. They describe acceptable practices in a given situation, rather than quantifiable entitlements to a resource, as in perennial systems.

Water rights and water distribution rules in spate irrigation regulate access to water and hence minimize conflict. Water distribution rules make it easier to predict which land will be irrigated. As such, they encourage land preparation by pre-flooding, which is important for adequate water storage and moisture conservation (see also Chapter 5). Water rights and water distribution rules also define the likelihood of irrigation for different areas and hence serve as the key to the collective maintenance and rebuilding of diversion infrastructure. In particular, where floodwater users depend on one another for maintaining flood canals and reconstructing diversion structures and if this work is substantial, agreement on how water is distributed is a precondition for cooperation. However, water distribution rules are not necessarily finely detailed. *Serjeant (1980)* makes this point for instance for Wadi Rima, Yemen, noting that "many of the disputes seem to lie dormant, though not forgotten, … they can spring to vigorous life with some new turn of circumstances". *Al-Maktari (1983)* makes a similar observation for the unwritten customary rules in Wadi Surdud.

Water distribution rules also have to be placed in the context of medium- and long-term changes in flood irrigation systems. Increases in land levels and changes in wadi courses and flood canals are almost unavoidable. Spate irrigation systems are morphologically far more dynamic than perennial irrigation systems. Water distribution rules deal both with reducing and mitigating the risk of such dramatic long-term changes, as well as coping with them when they come along. In the end water distribution rules tend to be packages describing the distribution of floodwater, the way maintenance is organized, the practices for avoiding breaches and changes to the command areas and the arrangements and penalties associated with operating the rules. Table 7.1 summarizes one such set of rules for the Kanwah spate river (Rod-e-Kanwah) in Dera Ghazi Khan District in Pakistan. The rules were recorded during a land settlement of 1918/1919 and are still used.

The remainder of this chapter describes the most common types of water distribution rules, including the rules on protecting command area boundaries and on maintenance. It describes how the rules are enforced. There is a strong relation between the overall governance in an area and the local organization for spate irrigation and the codification of the water distribution rules in particular. The final section describes how changes in water distribution are caused and how they take effect. Several recent engineered interventions in large spate schemes have unwittingly altered water distribution rules by creating new opportunities for different players. The reactive nature of water distribution rules in spate systems has often led to a gradual accommodation of these new opportunities. The purpose of this chapter is to increase awareness and understanding of water rights and the changes therein, so as to:

- support the development of water distribution rules in new systems;
- understand the process of codifying and enforcing water rules and rights and identify opportunities for improvement in enforcement and modification of water rights; and
- understand the impact of interventions on existing water distribution rules and practices and avoid the worst pitfalls.

TABLE 7.1
Water management rules in Rod-e-Kanwah (Kot Qaisrani, DG Khan, Pakistan)

Water distribution	Command area protection
• Water distribution starts from the head and goes to the tail. • When, after a first irrigation the upstream fields are watered but the downstream fields are not irrigated sufficiently, then the upstream field can still take precedence in using the second flow. • There is no limit on depth of irrigation of an upstream field (though this rule exists, it is not always practised and is conditioned by the crop sowing, maturity time, etc.) • Nobody can sell or donate his share of water. In land transactions, water is transferred as well. • A field cannot be supplied by more than one diversion structure. • If a bund in a flood channel irrigates two fields, water will first be applied to the higher land. • When a diversion structure has been washed away during irrigation, it is permitted to construct a new diversion even if water is already reaching other fields.	• Even if fields remain barren for long periods, the right to irrigation remains valid. • The location of a diversion structure, channel intake or division structure can be changed with the mutual consent of landowners. • If, after filling his own field, a landowner delays breaching his diversion structure and a nearby field is destroyed, then the losses will be met by the person who did not breach the diversion structure in time. • No person has a right to construct a new branch/flood canal that deviates from the prevailing situation. However, when the channel has changed naturally, then a new flood canal can be constructed, provided the earlier flood canal is completely damaged. • When a person intentionally destroys the water course/diversion, then loss is recovered both for the loss of water and the destruction of the adjacent field(s). • On the reappearance of eroded land, (through siltation), the rights are vested with the original owner.
Maintenance	**Others**
• Common maintenance work is performed on the basis of area of land. • To maintain the flood embankments close to a main bund is the responsibility of all users of the *ghannda* (diversion bund). • Strengthening the banks of flood canals is the responsibility of the owner of the land facing the wadi bank. • Landowners whose fields are irrigated through overflow *(chal)* and not through bunds and embankments do not take part in the common maintenance work.	• Ownership of the flood channel – including trees within the channel – is based on ownership of the adjacent fields. • A diversion structure can be constructed on one's own land as well as on others' land, wherever it is most suitable. • Nobody can expand his land by encroaching upon the river bed. • When a shareholder does not contribute his labour during the specific period, he will not have a right to water in the current year. If he wants to contribute in future, then he will have to compensate for the previous year's costs of common labour and provide eight days' labour as a fine.

RULES AND RIGHTS

There are several types of rules that regulate the distribution of the varying quantities of floodwater. Not all rules apply in every system, but it is usual to find that several rules are used simultaneously. The most common and widely applied rights and rules relate to the following:

- demarcation of land entitled to irrigation;
- breaking diversion bunds;
- proportion of the flow going to different flood channels;
- sequence in which the different fields along a flood channel are irrigated;
- depth of irrigation that each field is entitled to receive;
- access to second and third water turns; and
- distribution of large and small floods.

In addition there are rules that regulate changes in the command area and system morphology. These are related to:

- maintenance of bunds and boundaries;
- adjusting the location of intakes and other structures;
- manipulating wadi bed and flood canal scour and siltation processes; and
- compensation for lost land.

WATER DISTRIBUTION RULES

Rules on land demarcation

Demarcation rules define the area entitled to irrigation. As such, these rules precede all other water distribution rules. They define the command area and within it the land users who have access to the spate flows. Demarcation rules often protect the prior rights of downstream landowners, by prohibiting new land development upstream which could result in the diversion of floodwater to new lands, formation of a new group of stakeholders and the loss of farming systems and other established water uses downstream. This can result in violent conflicts, particularly in areas where irrigation development is relatively new. There is a long history of disputes on water rights in Wadi Rima, Yemen, related to the construction of 'illegal' upstream canals. In some cases, expansion into new areas is possible within the rules, though they do not explicitly include such a use in origin. Usually this is possible in downstream areas but examples have occurred in upstream regions too. Thus land demarcation may sometimes not be a strict rule in such situations. In some other cases, common lands can also be brought under irrigation, although the original rules do not give them a clear entitlement to irrigation.

The demarcation of the outer boundaries of a spate irrigation scheme also ensures that overspill from breaches in flood channels does not develop into an established practice *(van Steenbergen, 1997).* The consequences of such demarcation rules are the penalties for negligence in the maintenance of bunds and channels. In the spate systems of the Suleiman range in Pakistan, explicit agreements exist, obliging landowners to plug gullies that have developed after severe floods. This is to prevent new drainage patterns developing in these soft alluvial plains. Similarly, in Eritrea and South Yemen farmers are penalized for not maintaining field bunds, which could cause water to escape to new areas. Such rules, however, are not in force everywhere.

In some systems, there are 'sanctioned' overspill areas. Though they do not have a recognized claim to the spate flows, the custom is that these areas receive water during unusually high floods. Water is then allowed to escape at certain prearranged points to avoid damaging the canal network downstream.

Like most of the other distribution procedures, demarcation rules are in place when water is scarce. They are more common in lowland systems, where land is abundant, than in highland systems.

Rules on the breaking of bunds and timing of water rights

A category of rules closely related to the rules on the boundary of the spate area concerns the breaking of diversion structures, or the timing of a water right. The rules on breaking bunds are usually in place in areas where the entire wadi bed is blocked by earthen bunds, as in the lowland systems in Pakistan. The earthen bunds are generally made in such a way that they scour out in high floods. This works as a safety valve (see also Chapter 10). It avoids substantial damage to the canal network, as very large floods flow down the river rather than damaging canals and fields. In several systems, there are also rules on when farmers can break bunds, for example once the designated area served by an upstream bund has been irrigated or when a certain time slot of the flood season has elapsed. An example of such time slots are the rules for breaking *ganndas* (a local term in Pakistan for an earthern bund that diverts spate flow from a wadi to a main canal) in the Nari spate system in Kachhi, Pakistan and is outlined in Box 7.1. The rules were formalized in 1917 and are still observed, although there is considerable tension concerning the actual breaking of bunds.

BOX 7.1
Rules on Nari system in Balochistan, Pakistan

- From 10 May to 15 August the landowners of the Upper Nari are allowed to make *ganndas* in the Nari River.
- When the land served by one *gannda* in Upper Nari is fully irrigated, the landowners in that *gannda* must allow landowners of the next *gannda* to break it.
- After 15 August the landowners of Lower Nari are allowed to make *ganndas* in the Nari River course.
- Landowners in Upper Nari are not allowed to irrigate their land during this period or let the water go to waste.
- Water is not allowed to go to waste to the low-lying areas east and west of the Nari River. Guide bunds will prevent water flowing to these areas – all landowners will contribute towards these bunds with farmers in Lower Nari paying twice the amount per hectare in case bunds on the Upper Nari are broken.
- If any dispute arises, judges appointed by Kalat State will inspect the area and are authorized to decide whether a downstream party should be allowed to break the *gannda* at an appropriate time or whether a guide bund should be repaired within 5–10 days. If repairs to guide bunds are not made, the main bund of the area concerned may be broken.
- In case a landowner refuses to contribute *gham* (the contribution for maintenance), his land may be confiscated.

The reluctance of upstream land users to have their bund broken is not only because it allows more water to be diverted to the upstream area, but also because it saves the effort of rebuilding the bund in a subsequent year. An example of such a case in the Chakkar River in Balochistan (Pakistan) is given in Box 7.2. Rules based on the time slots when water diversion is allowed in different parts of the system are also found in Yemen. An example from Wadi Zabid is shown in Box 7.3.

Rules on flow division between irrigation channels

This category of rules arranges the distribution of water between the different flood channels (Figure 7.1). Where an area is served by several flood channels, there may be an agreement on the proportion of floodwater going into the different channels. In the Tafilalet Plain in Morocco, for instance, the distribution of spate water between different areas is based on proportions of the flow from Oued Ziz *(Oudra, 2008).* All diversion structures have been designed on the basis of this agreement and a consensus exists to avoid any new construction or change of the existing structures.

In practice, flow division is often achieved by using rather crude hydraulic structures, for example the head sections of flood canals may be of different widths and obstructions may be placed in front of some of the channels to achieve the required division. Flow division may also be practised along a flood channel, with the width of the field intakes determining the proportion of flow that each field receives.

BOX 7.2

Disputes over bund breaking in the Chakkar River in Balochistan, Pakistan

This is a fairly typical example of a dispute on the breaking of a soil bund and concerns the Chakkar Bund on the Chakkar River in Balochistan. In the past, this earthen bund – spanning some 50 m across the river – was constructed using bullocks and tractors. It collapsed every year, as the water seeping through its base undermined the structure. In 1990, the landowners of Chakkar were given a generous allocation of bulldozer time by the government. They used this by making a very strong bund and the bund did not fail that year. It irrigated all the demarcated land of Chakkar and then the Chakkar landowners allowed the water to escape through a breach in their flood channel to an area that was not entitled to floodwater. The same pattern repeated itself in the subsequent year. The Chakkar landowners were not keen on breaking their bund, as they wanted to spare themselves the effort of rebuilding it. This led to fierce protest from downstream landowners, who approached the head of the district administration and argued that he should break the controversial soil bund. However, the verdict of the head of the district administration was only partly a success for the complainants. He reasoned that he could not break the bund since there was no earlier agreement on breaking bunds in the Chakkar River. However, he did maintain the demarcation rules and ordered the Chakkar farmers to repair the breach in the flood channel to prevent water from going to unauthorized channels

FIGURE 7.1

Flow division in a flood canal, Yanda-Faro, Konso, Ethiopia

BOX 7.3

Water distribution in Wadi Zabid

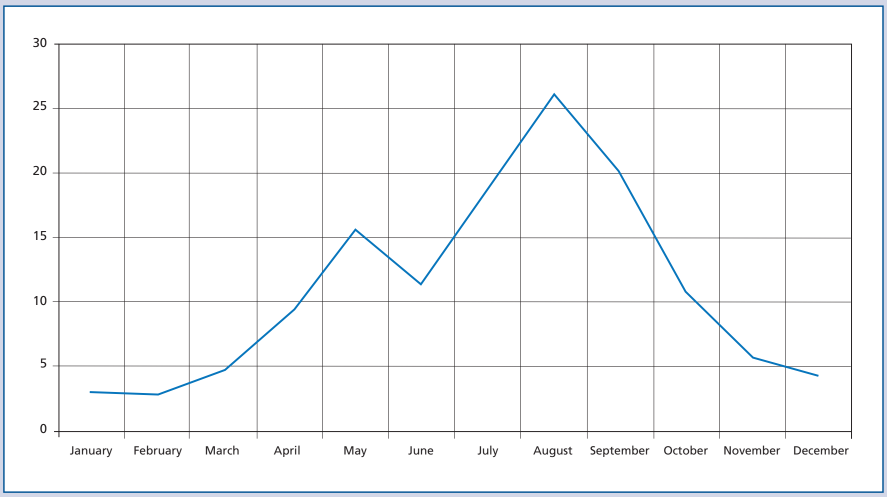
The traditional canals in the Wadi Zabid system are split into three groups, with water rights at different times of the year. These rules were retained when the system was modernized in the 1980s. The canal groups and the periods when they have water rights are:

Group	Nominal command area (ha)	Dates
Group 1 (upstream canals)	4 325	29 March–2 August
Group 2 (middle canals)	9 165	3 August–13 September
Group 3 (downstream canals)	1 305	14 September–18 October
Canals within the groups also have water rights at different periods within the group turns.		

This allocation gives the upstream canals access to base flows and the first part of the main flood season. The middle reach canals (group 2) have about six weeks during the period when the main flood season occurs to irrigate the largest area. The downstream canals have a shorter period at the end of the main flood season.

Mean monthly flows measured upstream some distance from the first canal offtake are shown below. Some water is lost in minor abstractions and bed seepage between the measuring location and the first canal offtake and little flow reaches the first diversion structure outside the period of the water rights.

Mean monthly flows at Wadi Zabid (million m³)



Flow divisions within the flood channels may be fixed, but it is more common that there is a large degree of flexibility to adjust to changing bed levels of river and flood canals and to variations in the flow. An example of a flexible flow division is the traditional main division in the flood canal of Wadi Laba in Eritrea, which used to be adjusted by moving brushwood around. During a spate, the water masters of the five main flood channels stood on top of the structure and adjusted it to ensure that the flows to each area were fair, taking into account earlier irrigation. In the same system, a series of gabion command area flow division structures were constructed to distribute water between major command area channels and to stabilize the canal beds. The first designs were conventional, but later, a more flexible structure was developed at the instigation of farmer leaders.

In Balochistan (Pakistan), flow divisions are affected by the canal bed and water levels and slopes and it is unusual to find rules in this area. Conflicts due to changing canal-bed levels, after fertile fine sediment deposits were taken from the channels, are reported in *Ahmad et al. (1998).*

Farmers have also worked out automatic flow division systems: when the quantity of water is small it is diverted to one part of the command area only and the other canals are blocked, usually with a small earthen bund. When flood flows are larger, water breaks the small bunds and flows to several channels simultaneously.

Rules on sequence of irrigation

A fourth category of rules is the prearranged sequence in which fields are irrigated. Where it applies, the route water follows within the area entitled to irrigation is described in detail, in terms of the branch channel that will receive water first and the priorities of the different fields near the branch channels. Irrigation in many cases moves from the head of the channel to the tail *(Maktari, 1971).* In Yemen, the fundamental rule governing the use of spate water for irrigation grants upstream users priority rights to irrigate their fields but downstream users may not be denied the right to surplus water after the upstream users have exercised their rights to divert a quantity of water sufficient to satisfy their needs. Sequence rules are called *numberwar* or *saroba paina* in Pakistan or *ala ala fala ala* or *rada ah* in Yemen.

The sequence is adjusted according to the level the flood reaches. If the flood is low, water will only flow in one or two of the priority branch channels and the sequence rules will apply to those channels only. But, if the flood brings large quantities of water, it will find its way through a large number of channels simultaneously. Moreover, during high floods the force of the water is greater and, instead of being controlled and regulated, it will flow into a large number of fields at the same time.

In some cases, the ‘head reach first’ principles do not apply. One example is the Chandia system in Balochistan (Pakistan), where the upstream area is only supplied at high water levels or after the downstream area has been irrigated. In other systems there are rules to send larger floods downstream on a priority basis.

Rules on depth of irrigation

All the four rules discussed above impose a certain predictability and equity, while ensuring efficiency in the use of the resource. The demarcation of command areas, the rules on breaking of bunds and timing of water rights and the rules on flow division, with the limitations on the width of field intakes, prevent the water from being monopolized in the head reaches of the flood irrigation system. The sequence rules, in turn, identify priority areas. Equity issues are also significant in the fifth type of the water distribution rules, which concerns the depth of irrigation and is expressed in agreements on the height of the field bunds. These field bunds are usually built up from the sediments deposited within the fields. The height of the bunds determines the amount of floodwater that can be stored in the fields.

Rules on the height of the bunds, and hence irrigation depth, are standard practice in Yemen and appear to be based on a ruling of the Prophet Muhammad. The amount of flood flow to be applied to a field with palm trees shall be the depth of two ankles or an amount sufficient to reach the tree trunk. According to the eleventh-century Islamic jurist Al-Mawardi, the underlying principle of this ruling is that the amount of water applied shall be sufficient to water the crop and that it is easy to measure *(Varisco, 1983).* The prevalence of irrigation depth rules in Yemen is probably related to the practice of field-to-field irrigation. In this system, a farmer gets his turn as soon as his neighbour has completed irrigating his land. This is done by cutting the bund surrounding the field of the upstream farmer. Competition between neighbours can be fierce and rules on water depth may have evolved to mitigate this. Moreover, if the bund in the neighbouring field is very high and too much water is impounded, uncontrolled breaching could cause severe damage to the neighbouring fields. These rules, however, are not common in spate areas in Pakistan. It is only in some of the small mountain systems in Balochistan that they are in place, prescribing that the soil for repairing these field boundaries shall be taken from the lower plot (Ahmad *et al.*, 1998).

In contrast, when each field is fed by its own separate intake, as is usual in the spate irrigation systems in Pakistan, such conflicts are rare and rules on the depth of inundation are unusual. The amount of water applied depends on the height of the field bund and the levelling (or the lack of it). Yet in most systems there is no limitation in this respect. Field bunds are seen as a way of disposing of the excess silt that accumulates with the floodwater and can reach any height.

In general, it appears that the height of the field bunds is influenced by two factors: the size of the field and the number of irrigations that are expected. When fields are only approximately levelled, a large field needs high field bunds to ensure that all parts of the fields impound a reasonable depth of water. Fields of 1–2 ha in area with field bunds higher than 1 m are found in Yemen and fields of up to 4–5 ha in area with very high field bunds are found in Pakistan. The field bunds need to be high enough for sufficient water to infiltrate the soil for the intended crop if only one irrigation is likely to occur. When two or more irrigations are probable then less water needs to be impounded and lower bunds are used.

The probability of receiving irrigation is also a factor that influences the height of the field bunds. In the Wadi Rima traditional system in Yemen, low bunds are found near the mountain front where two or more irrigations are almost assured, and the largest bunds, over 1 m in height, are found at the downstream margins of the system where only one large irrigation is possible in years when large floods reach the downstream sections of the wadi or the flood canals *(Makin, 1977).* Figure 7.2 shows high field bunds in Wadi Tuban in Yemen.

Figure 7.3 shows small bunded plots in a spate system at Yanda-Faro in Konso, Ethiopia. The Yandefero system is characterized by a large number of relatively mild floods, allowing a distribution of water not very different from a perennial system, with secondary canals and fields with low bunds.

Rules on second turns

A final category of rules is the right to a second water turn. Several crops, though they may survive on one water application, give significantly higher returns when they are irrigated more than once. Sorghum, wheat and cotton are examples. Sorghum, in fact, is often grown as a ratoon crop to catch an off-season flood. For other crops, like pulses, one watering is sufficient.

FIGURE 7.2
Spate-irrigated fields in Wadi Tuban, Yemen

FIGURE 7.3
Small bunded plots in a spate system at Yanda-Faro, Konso, Ethiopia

In many systems, floods come and go and a season may bring a series of spates. This poses a dilemma: is the water that comes with a second flood to be applied on the land that is already under cultivation? Or, is priority given to those cultivators whose lands are still dry? Both variations exist, either the option of upstream landowners taking a second turn, or the obligation to restart irrigation from the place where it stopped the previous time and irrigate all downstream land before upstream owners can use the water again. Where restrictions are imposed on upstream owners, they usually apply in the planting season. In Morocco it is common that within the same *seguia* the priority of the upstream part is paramount, yet with some exceptions: during the sowing period the irrigation turns will restart from where they were interrupted during the last flood. After this period, generally lasting three months, the rule is to irrigate only those lands that have already been sown *(Oudra, 2008)*. There are exceptional, inter-seasonal cases of downstream water rights, such as those regarding the Jama Bund in Kharan, Balochistan, or Wadi Laba in Eritrea. Here irrigation in the next season starts where it stopped the previous season.

Closely related to the rules on second turns is the size of the command area. Having a relatively small command area makes it possible to irrigate a field more than once – which can have a considerable impact on crop yields, as the second irrigation often 'lifts' the crop out of the stress zone. In Morocco, for instance, the traditional water management system aimed to secure on average two irrigation turns at the earliest time of the flood/irrigation season *(Oudra, 2008).* The farmers believed that a two-irrigation turn was sufficient to secure cereal production (mainly barley); whereas three irrigation turns would cause a bumper harvest.

Rules on large and small floods

Finally, the water distribution may differ according to the size of the floods. One example discussed above is the automatic flow division when floods are large and able to break the bunds in the various flood channels. In other systems there are explicit rules on how to accommodate small and larger floods. Small floods tend to be diverted to the upper sections of the command area, if only because small floods are not likely to travel that far. A rare example of explicit rules dealing with floods of different sizes concerns the Irrigation Plan for Wadi Tuban in Yemen (see Box 7.4).

BOX 7.4

Water allocation rules for Wadi Tuban, Yemen

The principle of *rada'ah* (upstream land first) is applied in Wadi Tuban. It gives precedence to upstream users, who have the right to a single full irrigation of their fields before their downstream neighbours, both between and along the main canal systems. Furthermore, the rule has been established that spate water will not be diverted into fields that have already received either base flow or earlier spates. To ensure the efficient use of spate water, the allocation is based on the following Irrigation Plan:

- When the spate flow is small (5–15 m^3/s), priority is given to the canals in the upper reach of the wadi.
- When the spate flow is of medium size (15–25 m^3/s), priority is given to canals in the middle reach of the wadi.
- When the spate flow is large (25–40 m^3/s), the flow is directed either to Wadi Kabir or Wadi Saghir in the lower reach of the delta, depending on which one has the right to receive the spate water.
- When the spate flow exceeds 40 m^3/s, the flow is divided equally between Wadi Kabir and Wadi Saghir.

RULES ON MAINTENANCE

Maintenance rules are as important as water distribution rules in spate irrigation and, in turn, water distribution rules dictate the way maintenance is organized. Because the area of irrigated land fluctuates widely from year to another, it is difficult to match farmers' contribution to maintenance to actual irrigation, as is the case in perennial irrigation. In maintenance of spate irrigation systems, there is often an inevitable degree of unfairness, summarized in the Yemeni saying that "he who pays is the laughing-stock of the man who has the right to water first". Box 7.5 describes the maintenance rules of the Korakan Spate Irrigation Systems in Balochistan (Pakistan).

There are several types of contribution to maintenance work by farmers. Amongst these are: a contribution according to land shares, graded contributions, a contribution according to capacity, a contribution according to benefits and a contribution by contract.

- A typical example of a contribution according to shares is the *jorra* system practised in many spate irrigation systems in Pakistan. A *jorra* stands for a pair of bullocks – the unit of work in the repair programmes. Agricultural fields are also measured in terms of *jorra*; the amount of land that can be cultivated with one pair of oxen. The shareholder has to participate with his oxen in accordance with his land share, irrespective of whether it was irrigated or not.
- Graded contributions are particularly common in the larger spate systems of the Kachhi Plains of Balochistan or in some of the now disused spate systems in Saudi Arabia *(Wildenhahn, 1985).* Different villages have to contribute different maintenance levies – with areas in less privileged places contributing proportionally less to the collective effort.
- Contribution according to capacity is a variation on the two systems above. In accordance with their land shares, farmers are expected to bring bullocks to the common maintenance work. Farmers who do not own draught animals, however, are expected to contribute their own labour. As ownership of draught animals is a fair reflection of the returns from spate irrigation in the previous years, this system is largely fair.
- An example of contribution according to benefit comes from Dameer Bakar in Tareem District in Hadramawt in Yemen. One-fifth of the crop is set aside to pay for the maintenance. This type of rule works well in systems where the benefits are guaranteed. It would, however, be ineffective in systems where there is a genuine risk that a number of years go by without irrigation.
- With contribution by contract, only those who want to be entitled to water contribute, while others are expected to close their field inlets. The rules can only be practical in relatively small systems, where it is easy to check on earlier contributions, and cannot be used in field-to-field systems, where opting out is not an option. An example of this practice is in the Toi War system in Balochistan.

An important requirement of the maintenance rules in place is their robustness, i.e. the degree to which they will ensure the constant rebuilding of the common works. This is particularly challenging when the work that needs to be done is substantial and there is a good probability that there will be years without irrigation for a large part of the command area. Contributions based on land shares often work better in these situations than those based on benefit, capacity or contract. Mitigating rules that spread spate water in a relatively egalitarian way include the demarcation of the command area and restrictions on the depth of irrigation and second water turns. The scale of the flood irrigation system is an important factor in applying mitigating rules. Mitigating rules are more feasible in small systems than in large systems.

BOX 7.5

Maintenance rules in Korakan spate irrigation systems in Balochistan, Pakistan

The different soil bunds along the deeply incised Korakan River in Kharan, Balochistan, are fully farmer-managed. The existing operation and maintenance practices for a number of larger bunds illustrate the capacity of farming communities to manage their spate irrigation systems without substantial government support.

The *Jama Bund,* with a command area of more than 2 000 ha, is normally breached four to five times during the flood season. Farmers are able to rebuild the bund within five days with the help of tractors, whereas it took one month to undertake this work with the help of bullocks in the past. Each farmer has to contribute labour and cash in accordance with the size of his irrigated land. If a farmer does not contribute his share, he loses automatically his right to use spate water for irrigation purposes. In 1992, the farmers spent PKR 15 000 for renting tractors. The operation and maintenance of the entire spate irrigation system is carried out without the employment of a canal master.

The *Shah Bund*, which is made of sand, is breached partially with every flood and 20–25 farmers are able to rebuild the breached portion within one to two days with the help of their own oxen. Each farmer has to contribute labour for the repair of the bund according to the size of his irrigated fields, even if he has already irrigated his land. The reconstruction of the bund and the distribution of spate water are undertaken without the supervision of a canal master.

The *Nothani Bund* is normally breached once every 3 to 4 years. If the bund is breached, the community of about 100 farmers is able to reconstruct the bund within a few days with the help of their bullocks. A canal master (*miriaab*) is in charge to organize the reconstruction work and to mobilize the farmers, who are supposed to contribute labour in accordance with the size of their irrigated lands. If a farmer does not contribute his labour share, he is fined PKR 50 for each missed working day.

The *Madagan Bund* is breached by every large flood as it is made of sand. Until 1992, about 80 farmers rebuilt the breached bund with their bullocks within a couple of days. If the damage to the bund was very large and the farmers were not able to undertake the reconstruction works before the next expected flood, they could call on the help of other farmers from other areas on the basis of mutual assistance (*asher*). In 1993, the bund was rebuilt with bulldozers, when 200 bulldozer hours were provided by a local politician and an additional 100 hours were paid by the farmers.

The *Karkhi Bund* commands an area of more than 1 200 ha and farmers from 12 different communities have to contribute labour and cash for the maintenance of the bund and the canal system according to their respective land shares. In case the bund has been washed away by a large flood, bulldozers are rented and the necessary cash contributions are collected by the village leaders in each community.

As seen above, there is a strong link between the rules on distributing spate water and the organization of maintenance. In principle, it is a two-way link. In many systems the right to irrigation by spate flows is proportionate to one's contribution to repairs to the headwork or flood channels. If a farmer stops contributing labour to the public good, he will not be allowed to open the intake to his field (especially where the field network is supplied by individual intakes). The link works the other way around; water distribution rules often serve to create a coherent group of land users who are dependent on the spate system and will jointly undertake the maintenance of the structures. In particular, the demarcation of the irrigated perimeter is important as this defines who has an entitlement to the floodwater. Without this, it is difficult to form a group of partners and the organization of the recurrent repair work becomes problematic, as well as the formulation of rules on cost sharing. A second issue is the critical mass required in undertaking repairs. This is particularly relevant when repair is dependent on human labour and draught animals and a large force is required to rebuild structures and make repairs. When tail-end users are systematically deprived of floodwater supplies, they may no longer want to contribute to the maintenance. The critical mass factor hence works as a check on too large an inequity in water distribution. However, the importance of critical mass may be expected to diminish when maintenance is mechanized or undertaken by government organizations instead.

RULES ON ADAPTATION TO CHANGES IN WADI MORPHOLOGY

The nature of flood systems implies changes in land elevation and in the form and elevation of the wadi bed. In many instances, there are special sets of rules to account for these morphological changes. These rules concern the location of diversion and other structures; the alteration of the ephemeral river bed level and the direction of flood canals through scour and siltation processes; and compensation for lost land.

An example is the Sheikh Hyder Zam system in DI Khan (Pakistan). A number of local rules are in place to accommodate these constant changes to the system. First, major diversion bunds may have to be reallocated. As bad-quality soil (cracking clays or saline layers) gets deposited in an ephemeral river or intake sections silt up, the location of an earthen bund may have to be changed every now and then. The common practice is for all land owners to go to the site and identify the location from which water can feed all or most of the land. Arguments that some land may now no longer be commanded are usually not given weight. The new location of the diversion bund should however not interfere with the benefits accruing to riparians lower down.

In case a suitable location is not available for the construction of new diversion bund in the village territory then, with the permission of the local District Officer, a new bund can be constructed in the land of another village. In case a particular bund is heavily damaged and there is no time to reconstruct it or make a new bund in another location, then downstream people may join upstream landowners to work on the upstream bund and get water from the upstream bund. The upstream landowners cannot stop the downstream landowners from participating in earthwork on their bund and are bound to release water to them.

In Sheikh Hyder Zam in Pakistan, there are also rules on the reallocation of flood channels. For instance, if a section of a flood channel becomes too deep and needs to be changed, it can be changed provided the next diversion structure in the flood channel is not damaged. To test this, a modest amount of water may be released from the new section to the downstream structure by making a small hole in the upper *wakra* (an earthen bund that diverts spate flow from a secondary canal to a field) to find out if it can stand the pressure. If a flood channel become unserviceable for irrigation through erosion or gullying, all the stakeholders, with mutual consultation, can construct a new flood channel that can easily and conveniently feed all the fields in the area. The landowners are not paid compensation for the land that comes under the new flood channel.

ENFORCEMENT

The extent to which water rights and rules in spate irrigation are enforced depends mainly on the social structure within the community and the level of the overall governance in the area. In the spate irrigation systems in the eastern lowlands of Eritrea, farmers have comparable access to land and there is no great contrast between large and small landowners. Local government is active and there is a well established organization of farmer leaders. As a corollary, disputes on water distribution are unusual. This may be contrasted to frequent disputes in Tihama systems in Yemen, where powerful parties stand accused of using their power to their own advantage and tail-end areas are increasingly marginalized.

Spate systems need a far greater degree of discipline than other resource management systems, yet the returns are sometimes small. Enforcement of water rights and rules in spate irrigation is related to three factors:

- local water users' organizations;
- actions of government organizations; and
- codification of water distribution rules.

Social enforcement through user-based organizations

In smaller systems, enforcement of rules is done through self-motivated local organizations. It is important to understand these organizations and the role they play and take them into account in spate improvement strategies.

Local governance is often the prerogative of a small group of well respected members of the community. The system in Belilo scheme in East Harrarghe in Ethiopia is quite typical. The allocation of water is supervised by a water master, called a *malaaka*. Water distribution rules are established by consensus among the members of the community. The *malaaka* supervises water distribution and ensures that basic maintenance tasks are performed. There is no honorarium but the appointment as *malaaka* is considered an honour and a service to the community. The appointment is for an indefinite period, as long as the performance is satisfactory. In Belilo there was a change of guard when the system was upgraded and it was felt that a younger and more dynamic water master should take over. The lack of democracy and transparency in the appointment of the leader may, however, lead to inequity in access to water, corruption and overall under-performance of the system.

Often the move to formalize water management is part of external investment in a system. In improved spate systems, the maintenance requirements change – often with a cash component – and organizations need to adjust to this. There are many successful examples of the building of local organizations on traditional organizations. An example of well performing farmers' organizations in managing improved spate irrigation systems is the case of the Sheeb Farmers' Association in Eritrea (see Box 7.6). In Tunisia, the traditional water use groups have been formalized as AICs (associations of collective interest), endowed with a legal personality and formally recognized by the administration. A management contract of 3 years' duration is signed between the administration and every AIC. AIC expenses cover running and maintenance expenses of facilities.

However, externally induced changes in governance may negatively affect the performances of spate systems when they do not take existing local governance into account. In Yemen, until the 1950s, allocation of spate and base flows in Wadi Tuban, as well as water distribution, including the length of diversion structures, was the responsibility of the *Sheikh al-Wadi*, who was appointed by the local Sultan. If upstream users took water without the permission of the Sheikh al-Wadi, the latter had the power to impose a crop ban on the violator's land. Alternatively, downstream farmers had the right to grow crops on the irrigated fields of their upstream neighbours. If crops were already cultivated, the yields had to be given to the immediate downstream farmers after the harvest. With government intervention through the collectivization of agriculture, the responsibility for operation of the spate irrigation systems was taken over by government employees and staff in the agricultural cooperatives. The role of traditional organizations declined, in particular after the reunification of South and North Yemen in 1990, and left a vacuum in terms of local institutions. This situation resulted in increased conflicts between upstream and downstream users, as the traditional rules concerning the distribution of spate and base flows were no longer observed *(Al-Eryani and Haddas, 1998).*

BOX 7.6

Sheeb Farmers' Association, Eritrea

The Sheeb Farmers' Association is an example of a well performing farmers' organization, managing an improved medium-sized spate irrigation system. The Sheeb Farmers' Association is based on the traditional well established local organization of *ternafi* (sub-command leader) and *teshkil* (heads of sub-unit). What has been added is an executive committee (consisting of a chairperson, secretary, treasurer, four members and an invited representative of the local administration) and the tasks of managing the 'modernized' headworks in an efficient way and undertaking fee collection in support of this.

The Association came into force in January 2004, following a general election. It has a formal constitution recognized by the local government and it received training in financial assessment, the use of bulldozers and frontloaders, the design and operation of the system, general organization and computer skills.

Membership is compulsory. In the year 2006, it was expected to raise Nfk1 500 000 (US$100 000), based on annual fee contribution of US$400/ha for all land, irrespective of its irrigation status. Default was generally low (8–11 percent) and late payments were recovered in the subsequent season with a fine. The fee collection is well organized, with all members having individual passbooks in which their payments are recorded.

The Sheeb Farmers' Association had several other achievements to its credit in the period 2004–2007. It coordinated the traditional maintenance of soil bunds and flood channels, with as great a value added as in the work on the modern parts of the system. It was also involved in solving a number of water distribution issues and coordinated successful adjustments to the water distribution system that arose from the new civil works. In general, it is a well recognized and appreciated association.

Enforcement through government organizations

In larger systems, enforcement of rules is usually done through a mixture of user organization and local government. The role of local government is in such cases to regulate local water distribution arrangements, organize maintenance by water users and solve disputes. In many instances, however, the authority with which the government enforces rules has declined. The recent history of the spate systems and the slow institutional erosion in DG Khan and DI Khan in Pakistan is illustrative of this type of problem (see Box 7.7).

BOX 7.7

Evolution of governance in DG Khan and DI Khan systems, Pakistan

Up to 1973, the Government nominated one of the biggest and most well respected landowners of a village as *numberdar*. The *numberdar* had a dual function. First, he was in charge of organizing other landowners and farmers for the construction of the flood diversion works and overseeing the distribution of floodwater in line with the codified practices. In addition he was attesting local applications and documents. The *numberdar* was also responsible for collection of the land tax, based on crop yields, from other landowners and for depositing it with the government treasury and he was allowed to retain an agreed percentage as compensation for his services. Every landowner had to maintain a certain number of bullocks according to the size of his land, and make them available for the construction of diversion bunds. The construction of the main diversion bunds was directly supervised by a government employee (*darogha*), who had the authority to call upon all the landowners to take part in the work. The distance between each diversion structure was fixed to allow floodwater to travel with sufficient velocity to avoid silting of channels and river sections.

In 1973, the Government introduced several changes.The first was the termination of the *numberdari* system. The responsibility for collecting land tax was assigned to the local revenue officials (*patwari*) in the respective villages. Another change was the introduction of free or heavily subsidized bulldozer time. With these changes the institutionalized system of collectively constructing diversion structures ended. The construction of diversion works was undertaken with heavy mechanical equipment, under the supervision of the Assistant Commissioner, Rod-Kohi region in DG Khan. The rule on the distance between the diversion points was no longer observed. With distances often shortened, the velocity of floodwater was reduced and this caused silting of the flood channels.

After 2001, the situation worsened. The general neglect of the system had resulted in siltation in parts of the system and gully formation elsewhere. At this time the Agriculture Engineering Department was abolished and, with it, access to subsidized bulldozer services ended. The legal powers of the revenue staff were removed, making it impossible for them to summon water users to perform collective work.

Of special relevance in the administration of spate irrigation is the interface between hydrological and administrative boundaries. Governance of spate systems has traditionally integrated the interconnectedness between water users in a wadi. With modern administration, such integration is not always preserved, in particular when spate systems have their catchment area in one province and their command area in another province. For instance, in Pakistan, all spate irrigation rivers originate in Balochistan Province and irrigate in Punjab Province. The case may be worst when wadis cross national borders. In 1997, Afghan farmers stopped the Pishin River flowing into Pakistan. As a result, farmers in Pakistan were not getting water any longer. It was the Sharia Laws, under which no one is allowed to block the water permanently in such a situation, that helped to resolve the problem in this case.

Government alone or local organizations alone are sometimes not adequate to enforce these laws. Unfortunately local laws in many cases do not cover such uncommon aspects of resources management.

Codification

In some spate systems, the water rights and water distribution rules are codified. The oldest example is Wadi Zabid in Yemen, where the rules for distributing base and spate flows between the different diversion structures were first recorded 625 years ago by the renowned Islamic scholar Sheikh Bin Ibrahim Al-Gabarty. The scholar is still revered and his grave visited by a large number of followers on the occasion of an annual festival.

Similarly, rules on spate rights in the large systems in the Suleiman range in Pakistan (DI Khan and DG Khan) have been documented in a register, the Kulyat Rodwar, which was prepared by the Revenue Administration during the British colonial period. The register contains a list of all villages responsible for the labour on each bund. A special functionary was responsible for the enforcement of these rules, exhorting farmers to plug gullies and rebuild their bunds. The spate-irrigated areas were an important grain basket at the time and an important source of tax, hence the interest by the Revenue Administration. As they were recorded, the water distribution rules also provided the opportunity to resolve a number of long-standing disputes *(Bolton, 1908)*.

In the main spate-irrigated area of Balochistan, in Pakistan, the long and extensive Nari system in the Kacchi Plains, detailed rules have been written down concerning the breaking of the different bunds in the spate course. These rules were enforced by the *teshildar ghandahat*, an official put in place by the then native ruler of the area, the Khan of Kalat, whose land was located at the tail-end of the system. After Kalat State joined Pakistan in 1948, this functionary became an employee of the new administration.

FIGURE 7.4
Pakistan: Revenue Official using the 1872 record of rights

Codifying water distribution rules clarifies and completes local water management arrangements and introduces a neutral factor in resolving disputes. Testimony of the importance of codifying water distribution rules is the continued use made of water registers, prepared as long ago as 1872, in the spate-irrigated area of DG Khan (see Figure 7.4). Yet, recording water rights as such is not sufficient to mitigate conflict or ensure that water rights are observed. The vehement conflicts on Wadi Rima in Yemen in spite of codified water rights stretching back over the centuries clearly illustrates this point *(Makin, 1977)*.

It is more common for water distribution rules not to be formally registered, even in relatively large systems. In some systems this is because there is little competition for the floods as the distance between the mountains (where the spate flows arise) to the sea or the main river (where they discharge) is short. Even when there are no formal rules, local district officials are often requested to intervene in conflicts in spate systems – particularly where it concerns water rights between different areas.

A related subject is the registration of land titles. In some systems, particularly in Sub-Saharan Africa, there are no individual land titles. This is the case in the Gash system in Sudan. An annual lottery determines who will have access to the land. This system discourages any land improvement, such as field bunding, the key to moisture retention (see Chapter 5). Recent efforts of land titling have been initiated under the ongoing Gash Sustainable Livelihoods Improvement Project, by establishing clear entry and exit rules for the leaseholds, screening and clearing the tenancy registry books, fixing leaseholds in conjunction with increased control of floodwaters and, finally, devolving enforcement of the exit and entry rules to farmers' organizations and water users' associations *(Cleveringa et al., 2006)*.

CHANGING WATER DISTRIBUTION RULES

External factors affecting water rights

Water rights in spate systems are not static. They change in accordance with new situations created by various factors. Among these are the increase in population and the pressure for new land development, changes in cropping patterns and new market opportunities, the introduction of more permanent spate diversion structures, the shift in power relations and the changing levels of enforcement.

One example of such adjustments in rules took place in Wadi Laba in Eritrea, where they occurred in response to the increase in the number of inhabitants. Land under spate irrigation increased from about 1 400 ha in 1999 to nearly 2 600 ha in 1990. As a result, the existing rules increasingly failed to guarantee that all the fields received water at least once a year. In the mid-1980s, to deal with this with new reality, the farmers modified the rules to indicate that fields which did not get a single irrigation in the previous flood season would have priority in the next season.

It is also evident that there is a strong link between enforcement and overall governance. There are several examples where new water rights have been created by power play and intimidation. The development of water rights in Wadi Rima in Yemen during the last few centuries illustrates well the factors operating in the allocation and distribution of base and spate flows (see Box 7.8). The skewed local power distribution, the weak nature of local government and the absence of an effective countervailing power created the setting for the 'capture' of spate water rights by strong players – literally bulldozing their way through. In Wadis Zabid, Siham and Mawr there have been examples of major upstream land development and water diversion by powerful parties in contravention of existing traditional rights or legal injunctions. This has been propelled by the possibilities of highly profitable banana cultivation based on the conjunctive use of groundwater and spate flows. The situation is quite different in Eritrea and South Yemen, where the social structure has been more egalitarian and the role of local government has remained strong.

Changes induced by new infrastructure

The construction of new permanent and more robust headworks has often resulted in better upstream control, integration of previously independent systems, more controlled flow and changes in the maintenance requirements. The impact of these changes is summarized in Table 7.2. They all result in greater control by upstream water users.

Provision of better control of water at the upstream end of a system often disturbs the delicate balance that exists between upstream and downstream diversions – as reported from many places, for instance Morocco *(Oudra, 2008)*. It is not uncommon for new structures to create a new water management situation, which over time changes *de facto* the water distribution rules. An illustration of this is the change in water distribution in Wadi Rima in Yemen after the construction of the headworks. In the past, the tail-end area was served by independent intakes. The common headworks allowed better upstream control of the spate flows, but over time the volumes of water passed on to the tail area were reduced *(Al-Eryani* and *Al-Amrani, 1998).*

In the past, water was diverted by earthen or brushwood diversion structures, that were usually destroyed during high floods, allowing water to go downstream. Now, with a permanent structure, in principle only the peak flow crosses the weir, but the lower flows remain upstream because of the way the system is operated.

BOX 7.8

Changing water rights in Wadi Rima, Yemen

At the end of the seventeenth century, four main canals were irrigating fields in the middle reach of Wadi Rima, which were constructed by the first settlers. During the last three centuries, the allocation and distribution of base and spate flows along Wadi Rima were affected by the following developments:

- In 1703, the right of abstraction was extended to downstream farmers, who were granted the right to take water for 20 days in November, 10 days in June and 10 days in August. The resulting abstraction restrictions were confined to the upper four canals and not to additional canals further upstream, probably because they only took small amounts of water.
- In 1809, the customary water allocation rights were established for six different *shaykhdoms* and they continued to function without any major change for about 100 years. These water allocation rights only apply to low flows, i.e. base and flood recession flows, and not to flood flows.
- Owing to the development of two upstream canals around 1900, farmers from the middle reach felt it necessary to take action through the courts to establish their prior rights to the low flows. They succeeded in obtaining an injunction to block the two new canals until their four canals had taken all the low flows to which they were formally entitled, without any restrictions either on the cropping intensity or the number of irrigations per crop.
- Following a civil war between the Imam and the Zaraniq people in 1928–1929, a tract of land was expropriated by the Imam and the Al Hudayd canal was constructed from the point where the wadi emerged onto a coastal plain to irrigate this tract of land. Although this new upstream canal initially took a small quantity of water, it took water throughout the year, thereby violating the principle that new lands should not be irrigated with low flows. The precedent created was used by landowners on the south bank to abstract the low flow as well. As their canals were much larger, they took the entire low flow at the expense of the downstream users.
- The people who had lost their traditional access to the dry season flow, protested vehemently and they ultimately took the law into their own hands by breaking the main canal on the south bank. However, the influential canal owner succeeded in jailing the culprits and eventually forced them to repair the canal.
- The irrigation expansion continued on the north bank, despite the ruling in 1931 that the Al Hudayd canal, commanding the land of the Imam, should be closed.
- In 1952, major works were authorized by the Imam to enlarge the Al Hudayd canal to expand the irrigated area. Simultaneously, the Government sold water to people without original water rights at the expense of users with traditional rights to use the water of the Wadi Rima.
- Following the revolution in 1962, a committee consisting of the Minister of Justice, local magistrates and the secretary of the former Imam, ultimately decided that the claims of the people of the south bank should be respected and that the Al Hudayd canal, now supplying government land, should be closed. Until the mid-1970s, however, the Governor of Hudeidah did not implement this decision, possibly fearing the reaction of the people on the north bank *(Makin, 1977).*
- The new modernized irrigation system commissioned in the late 1980s recognized at least some of the claims of the water users of the middle reach on the south bank. A division structure was designed to provide one-third of the flow to the north bank and two-thirds to the south However the majority of the water is still being used on the north bank – the powerful north bank water users have vandalized the control gates at the flow division structure and the operating agency does not have the power to impose the water distribution envisaged when the scheme was modernized.

TABLE 7.2
Effect of engineered headworks on water distribution

Larger upstream control	Puts upstream land users in a position to control flows that would have destroyed their intakes in the past. Decreases downstream access to flood flows and larger flood recession flows.
Combining independent intakes	Creates dependency and creates new tail-enders, as water is distributed sequentially, whereas earlier each area diverted part of the floods.
Controlled flows	Reduce the risk of scour and gullying, but the attenuated flows may no longer reach the extreme ends of the command area.
Changed maintenance burden	Generally reduces the dependence of upstream land users on the labour of downstream land users.

In Wadi Laba in Eritrea, the modernization which was completed in 2001 replaced the main earth bund with a permanent weir and many other secondary earthen distribution structures with gabions. The modern structures required a different type of maintenance, replacing labour and the collection of brushwood with earth-moving machinery such as loaders, bulldozers and trucks which, in turn, called for new technical and financial arrangements. In the past, the critical mass of labour needed for collective maintenance was the key to the enforcement of water rules. The new maintenance requirements have changed the way that water distribution is organized. Instances were witnessed where upstream farmers used large floods and irrigated their fields two to three times before downstream fields got a single turn, which caused many conflicts. The rule of sequential water distribution was not applied any more, partly also because the new infrastructure effectively reduced the number of the largest floods which in the past were serving the tail-end fields.

Another example of the inevitable impact of larger upstream control on water distribution is the Rehanzai Bund in Pakistan (Box 7.9). The Rehanzai Bund case shows that it is hard to make enforceable agreements in the absence of an effective authority and in a situation where people have considerable differences in power. Ultimately this technically successful change in diversion bund increased inequity in the system. In other cases, the change in water distribution creates severe conflict. One of the most spectacular examples is the flood diversion weir, built on the Anambar Plains in Balochistan (Pakistan). The weir was meant to divert spate flows to the upstream land but also cut off the base flow to the downstream area. Tensions ran high between both communities and were ultimately resolved when by mutual consent part of the weir was blown up (see Figure 7.5).

Another change sometimes brought about by engineering interventions is the integration of previously independent systems, extensively discussed in Chapter 4. A variation of this occurs when a system with a free intake is replaced by a common controlled diversion. Usually systems are integrated to obtain economies of scale that can justify the large investment required in civil works. Such changes bring people (sometimes entire communities) together in one single system. In the past such communities may have had little affinity with one another and there may have been little interaction between them, but they are forced to work together to distribute scarce water. In some cases this has led to intractable social problems and in others it has prevented integrated systems from materializing.

BOX 7.9
The Rehanzai Bund, Balochistan, Pakistan

The massive earthen Rehanzai Bund – stretching over 2 km – was constructed at the confluence of the Bolan Rover and an offshoot of the Nari River on the Kacchi Plains of Balochistan. The construction of the bund allowed the control of spate flows in the Bagh area, where previously the spate flow had been too fast to capture. After the Rehanzai Bund was completed, a number of well-placed landlords constructed a series of permanent diversion bunds immediately downstream of the new bund. This obstructed the water rights of the tail-end Choor-Nasirabad area. The district administration supported the case of the downstream farmers and instructed the upstream landlords to break the bund after their area had been served. The landlords, who had considerable power and influence, refused to do so. As time passed, more and more people had to leave the Choor Nasirabad area for lack of farm income. The remaining group was too weak to exert any influence and the upstream landlords prevailed

FIGURE 7.5
Diversion weir blown up by farmers as it interfered with the base flows, Pakistan

Implications for spate governance

Interpretation of rules and their implication for the design and operation of new infrastructure is best done directly by farmers, with discussions facilitated to help them understand the proposed arrangements and the actions to be taken to respond to changes in the system. For existing spate irrigation systems, water rights and actual practices need to be investigated, shared, agreed and where possible, codified. For new schemes, a basic set of water distribution rules needs to be agreed with farmers in the design phase. They should be widely shared and arrangements for supervision and enforcement agreed upon. When possible, it is desirable that any water distribution arrangements have a high level of flexibility to adjust to unforeseen circumstances. Robust arrangements on management and agreement are more important than detailed specifications on how water is distributed.

The water rights and rules need to be drafted and implemented in a way that meets the floodwater management needs in a given situation. They should be adjusted to, and tested in, new situations that arise, for instance, when traditional systems are modernized and permanent concrete weirs replace earthen diversion spurs. If the water rights and rules are not compatible with the new situations, they can end up being frequently violated and become a source of inequity in water distribution and of conflict, which may in turn contribute to:

- paving the way for disintegration of the long established local farmers' organizations; and causing the creation of a gap between the poor and the rich in what were rather homogenous societies as regards wealth;

- accelerating the downfall of downstream farmers, leaving them unprotected against the excessive capture of the floodwater by the upstream farmers; and
- deliberate destruction of investments.

When structural changes affect water distribution and scheme maintenance to the extent that traditional rules become obsolete, a new set of rules is needed that must be consistent with national legislation. Modern laws and legislation are vital to providing farmers' organizations with the legal recognition and authority they need to collect and manage water fees, run independent bank accounts, make direct contacts with funding agencies and own or hire machinery and other necessary assets for water management. These activities contribute to making the farmers' organizations financially and organizationally autonomous and provide farmers with the security they need to operate and invest in their scheme. Of particular importance to farmers are the following questions:

- What kind of land and water user rights do spate irrigation communities and individual farmers have?
- What decision-making power do these user rights confer on the farmers' organization regarding the cropping system, the water rights and rules, and other important land and water utilization activities? and
- What obligations, if any, do the farmers' organization and the communities as a whole need to fulfil to retain the said rights?

However, ensuring financial and organizational autonomy requires more than legislation. It also needs sincere efforts to graft farmers' organizations on earlier local organizations and avoid creating dual structures (traditional and formal). It further calls for supporting the organizations through capacity building programmes that, among other things, entail financial accountability as well as through a technical package with clear guidelines on how to operate and maintain the different components of the new scheme. Such activities are needed to guarantee an active participation of the farmers and their organization in the development and management of the spate irrigation system.

Chapter 8
Management arrangements

SUMMARY

The viability of spate systems is mostly determined by the strength of the organizations involved in their operation and maintenance. Large, integrated systems can require relatively elaborate organizations, whereas small runoff diversions can be operated more simply. The larger the system, the more difficult it becomes to organize common maintenance activities, not least because some areas will always have a larger likelihood of receiving otherwise unpredictable flood supplies.

While farmer management exists at some level in all spate systems, there are essentially three types of management arrangement:

- predominantly farmer-managed;
- farmer-managed with involvement from local government or other external support; and
- managed by a specialized irrigation agency, in which case farmers may become passive recipients of water delivered.

For farmer-managed schemes, development projects should not attempt to formalize agreements for water distribution and scheme maintenance unnecessarily. These agreements have to be made by, and left to, farmers on the basis of prevailing practices, unless they themselves request assistance from a higher-level authority. Projects should, however, ensure that:

- there is clear leadership by locally appointed caretakers and/or by committees accountable to a wide constituency of land users and not to a limited interest group;
- there are clear and specific arrangements for maintenance. Maintenance arrangements must be able to cater for prolonged periods of crop failure;
- overhead and transaction costs are kept low – effectiveness, simplicity and ability to react quickly are most important; and
- larger schemes are divided into sub-groups that can effectively mobilize contributions to maintenance and enforce rules on water management at a local level.

Large, agency-managed schemes in general struggle to reach financial sustainability and are vulnerable if long-term routines can no longer be guaranteed. A series of criteria need to be fulfilled to ensure successful agency-managed spate irrigation schemes. They include the principles of transparency, accountability and subsidiarity, the acknowledgement and integration of existing traditional arrangements, effective communication and guarantees of financial sustainability.

Of particular relevance is the introduction of bulldozers to assist farmers in maintaining diversion weirs. While bulldozers respond to a real need, and provide much required assistance, in reducing the burden of maintenance work on farmers, they should be managed in a way that does not modify unduly the balance of power between users.

INTRODUCTION

Most spate irrigation systems have a long history of farmer management – some of the world's largest farmer-managed irrigation systems are spate schemes. The reconstruction of diversion structures across spate watercourses and the operation and maintenance of a network of flood canals requires strong and effective organizations. The viability of spate systems is often determined by the strength of the organizations involved in their construction and maintenance. A historic example is the ancient Ma'rib dam in Yemen, which is believed to be built around the third millennium BC and was intended to divert water from spate floods rather than to store water over long periods. The dam was sustained by a strong state organization, so that its eventual failure has been linked to the diminishing capacity of the state to manage the system (Chapter 1 provides more details).

There are essentially three types of management arrangement:

- predominantly farmer-managed;
- combination of management by local government and farmer management; and
- combination of specialized agency management and farmer management.

There is a link between the management arrangement and the scale of the systems, as shown in the rather simplified overview given in Table 8.1. Full farmer management is common in smaller systems, on tributaries and small streams. Such systems are often relatively simple to operate. There may be no diversion structures and a simple, almost automatic system of water distribution may be in place. Some small schemes obtain limited support from NGOs. In larger systems, the role of the local government becomes more important to mediate in disputes and oversee operation and maintenance (O&M). Agency management has often followed in the wake of public investment in very large systems.

TABLE 8.1
Overview of management arrangements

Mode of management	Farmer management	Farmer management with support of local government	Management by local government in partnership with farmers' agency management
Typical size	*Less than 1 000 ha*	*1 000-5 000 ha*	*More than 5 000 ha*
Examples	Upland systems, Balochistan	Rod Kohi systems, DI Khan and DG Khan (Pakistan)	Tihama and South Yemen Systems
	Hadramawt systems	Kacchi and Las Bela systems (Pakistan)	Gash System (Sudan)
	Eastern and western lowlands system, Eritrea	South Yemen systems in the past	
	Spate systems, Ethiopia		

Management arrangements of spate irrigation systems evolve with time. The past 20 years has witnessed a clear movement in development policy towards strengthening the role of farmers in management and their increased participation in operation and maintenance. In some cases, the operation and management responsibility of medium to large systems has been handed over to farmers' organizations. At the same time, many countries have seen a drastic reduction in the role of government in the operation of spate irrigation schemes. Pakistan is a case in point.

FARMER MANAGEMENT

Farmer management is common in all spate irrigation systems, but the level of involvement of farmers varies from one scheme to another. It may range from the management of an entire system to management of secondary flood canals or to on-farm water management only. Maintenance in spate systems includes the reconstruction of soil bunds or brushwood diversion structures in mobile wadi beds, or the repeated restoration of field bunds and canal banks. The local organizations operating these labour-intensive and unpredictable systems are often intricate.

Although there are many examples of long-lasting, traditional, farmer-managed systems, farmer management is not without problems. Rules are rarely codified and not always comprehensive. Leadership may be contested. Powerful landowners may take advantage of the weakness of local farmer and government organizations and divert water upstream of the schemes and create new *de facto* water entitlements for themselves. Existing arrangements may not be able to adapt to changes or unpredicted situations, such as the introduction of heavy machinery or new infrastructure, changes in the spate course or the introduction of groundwater-based agriculture.

In describing the arrangements for farmer management, there are three main factors:

- internal organization;
- external support mechanisms; and
- activities beyond spate management.

Internal organization

In most traditional farmer-managed systems, transaction costs are kept to a minimum. It is common to have a committee of experienced farmers supervising the works on an honorary basis. The committee may meet regularly and invite all farmers, depending on the strength of the local organization (Box 8.1). Other committees come together less frequently and invite office holders only.

BOX 8.1

Committee meetings in Bada, Eritrea

The first meeting of the committee and group leaders is usually held after the harvest to discuss the reconstruction of the diversion structure (*agim*). The second meeting takes place after the reconstruction to evaluate the work on the *agim*. The third meeting is held before the start of the planting season to discuss whether diversion structures require additional maintenance and whether measures to avoid crop damage by pests and livestock are necessary. During this meeting the committee usually decides on the fields to be irrigated with the water from late floods. The fourth meeting takes place after the planting period to organize crop protection, and to discuss measures to control damage by floods, especially in the field-to-field system. Meetings should be attended by at least two-thirds of all farmers. Farmers absent during a meeting have to accept the decisions made.

Source: Haile and Van Steenbergen (2006)

Maintenance is usually organized as common labour. It is usual for a series of days to be planned, during which all farmers take their earth-moving equipment and draught animals and provide free labour for the execution of the maintenance works. This simplifies work arrangements and makes it easy for all to see who is present to make his contribution and who is not. In some of the larger spate irrigation systems in the Kacchi Plains in Pakistan, a water tax, called *gham*, is still collected through a network of local leaders.

The number of paid functionaries is usually small and seasonal. Remuneration is, in most cases, in kind (dispensation from maintenance labour, share in the crop). This contrasts with government staff working on spate systems who are usually paid in cash and on a full-time basis. Many small systems are run with little formal organization. In some of the small systems in Hadramawt in Yemen, for instance, spate water follows a set route through the canal system and excess water is channelled back to the wadi. Farmers divert water when needed and no one supervises the water distribution.

Larger farmer–managed systems may have paid employees. In the Kacchi Plains and Rod Kohi areas of DI Khan and DG Khan, local engineers (*raakha*) are appointed to supervise the construction of the large earthen bunds and to check the safety of the bunds during the flood season. In a few spate irrigation systems in the Las Bela region in Balochistan (Pakistan), *sepoys* are engaged. Their main role is to mobilize farmers to contribute to the reconstruction of the diversion structures. This position was established at a time when native rulers organized the construction of the diversion structures with forced labour. After the dissolution of the princely state and the formation of the State of Pakistan, farmers continued with the employment of the *sepoys*, as they valued their role. The most common function however is that of water master, called *rais* or *arbab* in various areas in Pakistan, *sheikh-al-obar* or *sheikh-al-shareej* in Yemen, *ternafi* or *tashkil* in Eritrea and *malaaka* in Ethiopia. The water master coordinates the water supply to the flood channel and sees that water is distributed along the channel or sections as per established rules, assesses the repair works and mobilizes the contributions for maintenance. An overview of typical farmer-employed functionaries and their scope of work is described in Box 8.2.

Not all functions are remunerated. In the Wadi Laba system in Sheeb in Eritrea (see Figure 8.1) there is a well articulated system in place of unpaid water masters both at the level of main groups, served by primary flood canals, and at the level of sub-groups or blocks. All in all, there are five main group leaders and 77 sub-group leaders *(Haile et al., 2003)*, some of the latter being women. The area served is 2 800 ha and so the management responsibility of the five group leaders is extensive. The group and sub-group leaders also take on board other tasks, particularly distributing agricultural inputs. The main group leaders are part of an Irrigation Committee that decides on the water distribution in the main command areas.

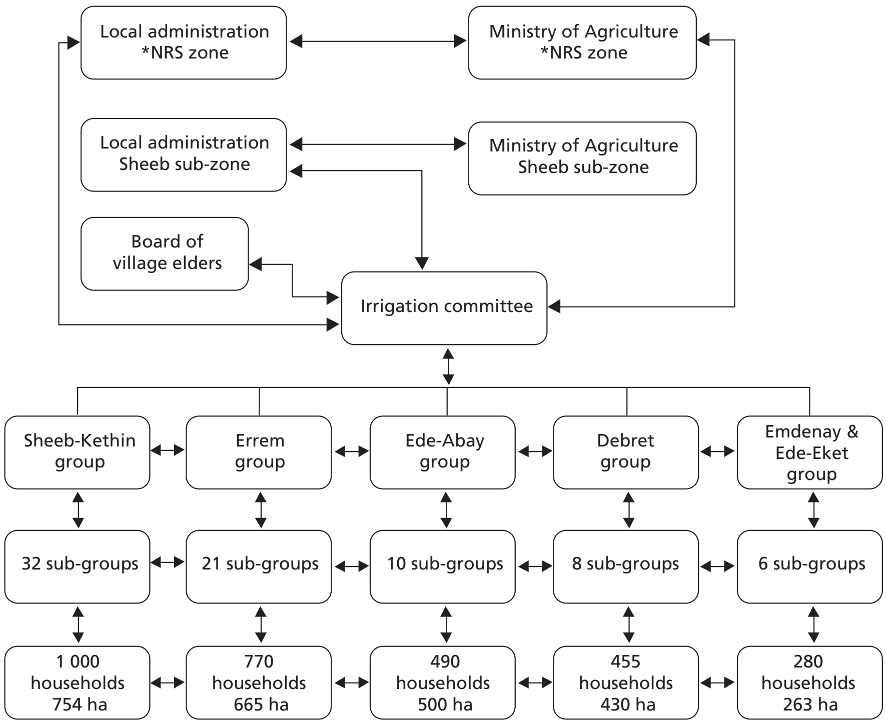
The existence of sub-groups makes it easy to mobilize labour for maintenance at the level of the block and group/flood channel. It also facilitates the implementation of rules on the maintenance of field bunds, etc. The sub-group leader (called *tashkil*) ensures linkage between individual farmers and the water master. He conveys the instructions of the group leader to the individual farmers and submits messages and requests of individual farmers to the group leader. Traditionally, the sub-group leaders have been elected directly by the individual farmers of each farmers' sub-group; although the Ministry of Agriculture is sometimes involved. In order to be elected as a sub-group leader, a candidate should be physically fit, having authority to mobilize the farmers for collective labour, and preferably be literate. It is also crucial that a sub-group leader does not move from the area. The sub-group leaders are not remunerated for their efforts.

BOX 8.2

Examples of traditional water management functions

Main system (main diversion)	
Sheikh al-wadeyen (master of two wadis) *Wadi Tuban, Yemen*	*Raakha (engineer/guard on earthen bund)* *DI Khan, Pakistan*
• Determines the water share of each main canal following consultation with each *Sheikh al-obar* (canal leader) • Decides the number of days that water is allocated to each main canal. • Decides the works required to divert spate water into the main canals.	• Supervises the layout and position of the earthen bund, when it is constructed. • Before the rainy season, inspects the structure and points out the weaker sections. • Keeps watch during the spate season and communicates with individual field owners, water users' associations, downstream farmers and the revenue department. • Witnesses the breaching of the *sad/ghandi.* • Keeps in contact with the *raakha* of the next downstream structure(s)
Sub-system (flood canal)	
Ternafi (sub-command leader), *Sheeb, Eritrea*	*Sheikh al-shareej, Wadi Zabid, Yemen* *Sheikh al-obar, Wadi Tuban, Yemen*
• Assesses the amount of labour required to carry out specific works. • Mobilizes labour for maintenance of irrigation structures. • Supervises the works undertaken by farmers of his group. • Checks if all fields in his group receive irrigation water • Conveys information and directives from the local administration/Ministry of Agriculture to the sub-group leaders. • Investigates reasons when a farmer has not contributed labour during collective works. • Transfers messages and requests from to the local administration. • Prepares written reports about the works undertaken by his group.	• Assesses the quantity of water going into the primary flood canal so as to avoid erosion. • Enforces water distribution rules and supervises water distribution. • Decides which particular plot of land has the first right to receive water when the next flood comes. • Calculates the operation and maintenance costs and charges each farmer in proportion to his irrigated area. • Mobilizes farmers for the reconstruction of the diversion and control structures and the cleaning of the canals. • Settles any dispute among water users and reports violations.
Block (part of flood canal or branch channel)	
Tashkil (block leader), Sheeb, Eritrea	
• Monitors the progress of field bunding. • Organizes and supervises large teams of farmers to work on the main structures. • Implements community rules for the management of floodwater. • Ensures water delivery to the branch canal where his sub-group is located. • Imposes fines on those who waste or steal water from adjacent fields. • Collects land tax among the individual farmers in his sub-group.	

FIGURE 8.1.
Farmers' organizational structure in Wadi Laba, Eritrea



**NRS refers to the Northern Red Sea: an average household has 7 members*

Source: Haile et al., 2003.

External support – the use of bulldozers

In addition to the resources mobilized internally, farmer organizations often benefit from external support. Particularly since the 1970s, bulldozers have become popular for rebuilding soil bunds, plugging gullies in the command area and making field bunds (see Figure 8.2). In many spate areas, the availability of bulldozers has revitalized farmer-managed spate irrigation.

Balochistan Province in Pakistan has probably had the largest infusion of mechanical equipment. In 1948, the Department of Mechanized Cultivation was created, equipped with seven bulldozers. These bulldozers were used to develop agricultural lands and raise earthen field embankments to retain more soil moisture. From the 1960s onwards, the fleet of earth-moving machines expanded rapidly, much of it tied to aid programmes from Russia, Italy and Japan. By 1975, the Department possessed 231 bulldozers, and this number further increased to 321 in 2002. There has, however, been a large fallout, because of heavy use and insufficient maintenance, and it is estimated that only 70 percent of them were still operational in 2005.

Bulldozers are often made available to farmers at substantially subsidized rates. In Balochistan, Pakistan, rental prices to farmers have been as low as US$1–5/hour,

FIGURE 8.2
Bulldozer repairing a traditional diversion spur during a flood recession. Wadi Rima, Yemen.

covering less than 10 percent of the operational cost, and have been widely used for political purposes. The usual practice has been for farmers to take care of the bulldozer operator and encourage him to work effectively by providing a gratuity, paying for assistants and, at times, paying for fuel and small repair costs. From 1985, political office holders were privileged to distribute 'bulldozer hours' to farmers. Testimony of the importance of bulldozers in spate management, this programme turned into one of the most popular programmes of political patronage in the Province. Common practice was to give the bulldozer hour allocation to a village leader who was instrumental in collecting votes. During the 1990s, the bulldozer time allotment was more than the working capacity of the bulldozer fleet in the province. Bulldozers are used for a variety of purposes, but in spate irrigation areas they have been particularly popular because they allow the timely reconstruction of the massive earthen diversion bunds.

It can be argued that if it had not been for the availability of bulldozers, spate irrigation would have been in decline in Balochistan. The social organization required to mobilize human and animal power for construction of diversion structures and flood channels has been difficult to sustain in places. The same applies to other areas. In the Sheeb systems in Eritrea, bulldozers were employed to plug gullies, created throughout the irrigated areas after uncontrolled flooding, thus vastly improving local soil moisture retention.

The intensive use of bulldozers can have drawbacks. Research in DG Khan in Pakistan has pointed out the inexperience of some of the bulldozer operators, resulting in inappropriate structures. Training of bulldozer operators, and making them work under the guidance of local farmer leaders, was recommended. Another drawback is in the use of bulldozers to construct higher and stronger soil bunds that do not break and jeopardize downstream water allocations. Long-term sustainability is also at risk. This can be witnessed in several areas in Pakistan, where bulldozers and frontloaders are far beyond farmers' economic standard. The largest drawback of the bulldozer programmes is their success – and the vacuum that is created when they gradually go out of service and are not replaced.

COMBINED MANAGEMENT OF USER ORGANIZATIONS AND LOCAL GOVERNMENT

Where systems become larger, the role of local government in management becomes more important and complements that of local farmer organizations. There are several examples where local government has played a constructive and supplementary role in supervising water distribution and organizing maintenance. Particularly because of the 'reactive' nature of water rights in spate systems, a strong and legitimized authority is crucial in the management of large spate systems. In the Sheeb system in

Eritrea, different rules and regulations were formulated and applied by farmers to fine individual farmers who did not contribute labour as required, or who were breaching a main canal, field bunds or a field gate without permission. Livestock owners could also be fined if their animals caused damage to standing crops in the fields. As many groups in the eastern lowlands had problems with the enforcement of these rules and regulations, they had to request the local administration to use its power to collect the fines. In 1995, the three local irrigation committees were requested to draft uniform rules and regulations in consultation with the local administration. Subsequently, the newly drafted rules and regulations were issued by the local administration as its official rules for its entire area of jurisdiction.

Another example of the constructive role of local government in spate irrigation comes from DI Khan and DG Khan in Pakistan. From 1872, the colonial Revenue Administration recorded the rights and rules in the spate irrigation systems, after endorsement by local leaders. To date these documents remain an important reference for any arbitration and conflict resolution. Apart from the settlement of rights, revenue staff oversaw on a day-to-day basis the distribution of spate water, urging repairs and the plugging of breaches. Traditionally, local user associations took care of the maintenance, providing labour, traction animals and material. The role of the colonial administration was to 'organize' these activities during peak periods and emergencies. Farmers who did not take part in the *kamara* (collective maintenance activities) were fined. In addition, labour was at times brought in from neighbouring areas. This engagement had a number of positive side-effects. Grain production increased, bringing stability and creating goodwill among the local tribal populations. New areas were brought under cultivation and this resulted in settlement and an increase in land revenues. Within the revenue department of the local administration, Rod Kohi departments were established and continued to exist after independence. They come under the Deputy District Officer, who until recently had the powers of a magistrate and could fine, penalize and have defaulters or violators arrested. The Rod Kohi departments are made up mainly of regulatory staff, engaged in conflict resolution and safeguarding the application of floodwater rights. The local engineering was left to the farmers.

Given the magnitude of the area under spate irrigation, the staffing levels are very modest (see Table 8.2 for the staff composition of Rod Kohi departments in Pakistan). The explanation is that a strategy of encouraging governance at the community level is in force. Contrary to the practice in perennial canal systems, the policy has been to follow local decisions for disputes occurring in spate-related issues. Local elders and community members are expected to reach consensus on sensitive issues. The administration facilitates the process and intervenes only when necessary. One of the most important points has been to avoid bringing cases related to spate irrigation to courts of law, but instead to give the final authority on arbitration and adjudication to the deputy commissioner at the district level.

These arrangements changed with the decentralization of 2001. Before 2001, the District Government had the authority to check on illegal actions of farmers under the Minor Canals Act. The Naib Tehsildar could punish and fine accordingly in cases of violation of the indigenous rules agreed upon by all members of water users' associations/ sharecroppers/farmers. It was very common for the Naib Teshildars to issue no-bail warrants to farmers failing to contribute to the collective labour. After the devolution of administration in Pakistan, these powers and authorities of Naib Teshildars have been withdrawn from the Revenue Department and direct involvement of officials is, in theory, not possible any more. More recently, the Government has been working to make the new local government more compatible with local situations. Under the new system, the political, elected person called the district Nazim is head of administration.

TABLE 8.2

Staff composition, Rod Kohi departments, Pakistan

	NWFP		Punjab		
Staff Position	**DI Khan and Kulachi Teshils**	**Tank District**	**DG Khan Districts**	**Rajanpur District**	**Remarks**
Spate Command Area	*224 000 ha*	*118 000 ha*			
Deputy District Officer, Revenue/Rod Kohi	1	1	1	1	General administration of district; general supervision; power of magistrate; final authority in conflict resolution.
Tehsildar	1	1	1	1	Daily supervision; power of magistrate; contact with farmers.
Naib Tehsildar	2	1	2	2	Assistant teshildar
Qanoongo/ Darowgha	2	5	7	2	Supervision, daily contact with farmers.
Patwari/ Naib Qasid	8	6	10	2	Maintains records of rights.
Muhafiz (reader)	1	3	2	2	Watchman/reader of flood measurement.
Temporary Muhafiz		8			
Auxiliary staff	8		33		
Facilities	Office facilities, jeep,telephone for DDO	Office facilities, no jeep, no wireless	Office facilities, no jeep, no wireless	Office facilities, no jeep, no wireless	

A third example of joint management by farmer groups and local government – with local government in a steering and facilitating role – comes from south Yemen. Until 1950, the Sheikh al-Wadi (Master of the Wadi) was responsible for the management of the entire Wadi Tuban on behalf of the Sultan of Lahej. The main responsibilities of the Sheikh al-Wadi were to monitor the allocation and distribution of spate water in accordance with existing rules and regulations; to decide on the length of each *uqma* (traditional diversion spur); to decide on the allocation of small and medium spate flows that cannot reach the tail of the spate river; and to impose and enforce sanctions for taking water without prior permission.

From 1950 to 1967, the role of the Sheikh al-Wadi was taken over by the Agricultural Council that was established following the issue of a decree by the Sultan. The Agricultural Council reported to the Sultan and the Director of the Agriculture Department acted as Chairperson and 17–25 representatives of landowners and sharecroppers were selected as members on the basis of their experience and knowledge. In 1954, the Agricultural Development Board was established to introduce the cultivation of cotton in the spate irrigation systems of Wadi Tuban. The Board took over the O&M services, whose costs were covered through the collection of irrigation fees based on irrigated area.

The basis for the management of the system was an elaborate set of rules, including the governance arrangements (composition, function and meeting) of the Council and rules for water distribution. These covered compensatory water allocations, cost contributions, the funds managed by the Council, arbitration procedures through the Agricultural Court, agricultural transactions, standard lease and tenancy arrangements, penalties for unauthorized use of floodwater or base flow, penalties for negligence of canal banks (causing water to escape to another area), penalties for failing to contribute to maintenance and penalties for failing to pay fines. The governance arrangements linked to these rules, explaining the scope of activities of the Agricultural Council, are given in Box 8.3.

This system ended with the creation of an independent South Yemen in 1967. The Agricultural Council was replaced by an Irrigation Council. Members of the Irrigation Council were directors of state farms and farmer representatives from state farms and cooperatives, as well as political leaders and representatives from the Agricultural Cooperative Union. The Agricultural Development Board was replaced by the Public Corporation for Agricultural Development for Tuban Delta, which became responsible for the O&M services but without the authority to recover any costs from the farmers or their cooperatives. From the early 1980s, the responsibility for the O&M of the spate irrigation systems was transferred to the irrigation section of the Ministry of Agriculture. After the unification of South and North Yemen in 1990, the Regional Irrigation Department of the Ministry of Agriculture and Irrigation (MAI) also made no attempt to recover the O&M expenditures on the modernized spate irrigation systems. In 1996, the Governor of Lahej and the MAI issued Resolution 14/1996 and Decree 7/1996, which reestablished the Irrigation Council, which has a consultative and advisory role only. The role of the Irrigation Council is to discuss and approve the irrigation plan as proposed by the Director of the Regional Agricultural Office; decide on how floods can best be used; and assist in the management and maintenance of the irrigation structures. Management of the spate system irrigation in Wadi Tuban has, however, become confused, as it is no longer clear who is in charge. As a result the Local Council, the Irrigation Council and the Irrigation Department of the MAI all order instructions on the distribution of water. Figure 8.3 shows farmers attempting to control water flows in Wadi Tuban.

FIGURE 8.3
Farmers using brushwood to head up the flow in a canal. Wadi Tuban, Yemen

BOX 8.3

Governance arrangements in the Agricultural Council in Tuban, Yemen

Composition

- Director of Agriculture (Chairperson), Permanent Secretary of the Department of Agriculture (Deputy Chairperson) and 17–25 members, representing the landlords and cultivators.
- *Mashayikh al-A'bar* (supervisors of channels) from the two wadis may be invited to attend meetings but their opinions shall be advisory in nature.
- The Director of Agriculture shall submit to the Sultan a list of the names of those whom he nominates for the membership of the Agricultural Council. The Sultan shall select from among them the required number.
- The term of membership of the Council shall be two years as from the date of appointment.

Functions

- Rationalization of the irrigation problems.
- Protection of the aqna (the right proportions of water established by custom for the irrigation of individual parcels of land) and the *raddyi'* (the sequence of allotting irrigation water to channels and parcels of land established by custom) and the allotting to each channel, barrage, sub-channel and 'marginal' channel the amount of water to which it is entitled according to the established system, i.e. the custom.
- Rationalizing [the rules of] *ijdrah* (tenancy) and *sharak/shirk* (sharecropping).
- Distribution of land among small and large cultivators.
- Division of water between the wadis.
- Maintenance of channels and barrages.
- Devising a system for dealing with the irrigation of lands which are forced to pay *furuq* (contributions for the maintenance of channels) and *masarih*, (contributions for the building of barrages in the *wadi*) each year notwithstanding the fact that they remained unwatered.
- Regulation of maintenance charges on channels and wadis and assigning a special fund for them.
- Introduction of a special system for the irrigation of land, which is planted with red sorghum and provision for its second watering so that the local food security is ensured.
- Scrutinizing agricultural land sales and purchases.
- Review of penalties applied to offenders and transgressors.
- Issuance of an annual report of revenues and expenditure, submitting to the Sultan and then have it published for the information of the public.
- Issuance of bye-laws and putting them into execution after obtaining the assent of the Sultan.

Conduct of Transactions

- The Council shall be convened twice each month and during the spate season at least twice weekly or at any time desired by the Sultan.
- If a member fails to attend four consecutive sessions, without permission or adequate excuse, such a member shall be regarded as having resigned.
- The Chairperson shall preside over the meetings and the Permanent Secretary shall act as deputy in his absence. If both are absent a Chairperson shall be elected for the Council from among those present.
- All decisions of the Council shall be taken by simple majority vote but, when the votes are equal, the Chairperson shall have a casting vote; and a quorum shall be considered to be established only when more than half the number of Council members are assembled.

Source: Maktari, 1971

AGENCY MANAGEMENT

Experience from existing large spate systems

Where specialized agencies have taken responsibility for the management of spate systems, it has usually been as a result of massive public investment in spate irrigation. Not all government investments have, however, translated into the creation of agencies for spate management. For example, the role of the Irrigation and Power Department in the management of the government-constructed spate irrigation systems in Balochistan has been limited to the appointment of O&M staff and guards and the execution of repair works on an ad hoc basis. The Irrigation and Power Departments did not have a routine maintenance programme and the already inadequate budgets for maintenance were further curtailed during the 1990s. In other areas also – DG Khan, DI Khan (Pakistan), Hadramawt (Yemen) or Eritrea, for instance – public investments in spate systems have not resulted in agency management, though in some cases government has assumed responsibility for larger repairs.

The two main examples of agency management to date are the modernized systems in the Tihama (Yemen), managed by the Tihama Development Authority and the Gash System in Sudan. Agency management has suffered from:

- an inability to ensure basic maintenance as a result of under-funding;
- an inability to manage and distribute water in a moderately fair manner because of poor links to farmer organizations or local government; and
- high expectations on continuous support from the agency

The first example of agency management is the Tihama Development Authority (TDA) in Yemen. From the 1970s onwards, the TDA became responsible for the operation and maintenance of the large spate irrigation systems, modernized under a large externally funded programme. TDA's responsibility formally extended down to the level of field turnouts. In the modernized scheme, farmers' responsibility was formally reduced from managing large complex traditional systems to diverting water through field ditches to their fields. Farmers in the Tihama were required to pay two percent of their agricultural production from spate- irrigated fields as an irrigation fee but this system was never implemented. As a result, the TDA often lacked the funds to undertake the O&M necessary in modernized spate irrigation systems.

Data on the O&M budgets for four agency-managed schemes in the Tihama are presented in Chapter 9 and illustrate this trend. The O&M budget received for Wadi Zabid and Wadi Rima, both managed by TDA, cover only a fraction of the costs. The same applies for Wadi Tuban and Wadi Bana in south Yemen. These systems had the additional problem of an inflated payroll, a legacy of past governments.

Earlier, the O&M of the spate irrigation systems in the Tihama were organized by traditional water masters. In the past, the Sultans charged certain families with the responsibility of canal masters, a position that was inherited. The strong control also prevented farmers from violating traditional rules regarding the distribution of spate water, despite the tradition of resolving disputes through conflict. When TDA first asserted its authority, it was able to resolve a large number of disputes.

However, the enforcement of these traditional rules has weakened with time, as the TDA staff were not adequately supported by the authorities concerned to prevent large landowners operating gates without permission. TDA tried to engage the local council to induce farmers but with little success. From the mid-1980s, the number of water conflicts between upstream and downstream farmers increased significantly.

These were intensified by the rapid expansion of banana cultivation, causing many upstream farmers to divert as much water as possible to their banana fields. In several of the main wadis in the area (Zabid, Mawr and Siham), powerful farmers have literally bulldozed new upstream offtakes through. Owing to its growing inability to ensure equitable water distribution in accordance with the existing rules, the TDA gradually abandoned its supervisory role in this field. At the same time, an increasing number of canal masters saw their power eroding due to influence exerted on them by large landowners in the upstream areas (See Box 8.4).

BOX 8.4

Irrigation committees without power – the example of Wadi Zabid, Yemen

In 1988, the Ministry of Agriculture and Irrigation issued Decree No.361/1988, establishing Irrigation Committees consisting of seven members, of which only two are selected farmers' representatives. The main tasks of the Irrigation Committee were defined as:

- to document traditional water rights and customs, as well as land having irrigation rights from base and spate flows;
- to resolve conflicts regarding water allocation and distribution;
- to define the relationship with farmers and outline their duties and responsibilities with regard to the distribution of water;
- to make proposals concerning the role of farmers in the O&M of the spate irrigation systems; and
- to provide advice regarding the optimal use of water and assist in the implementation of irrigation plans.

In 1990, the Tihama Development Authority (TDA) issued Decree No.6/1990 to facilitate the formation of the Irrigation Committee for Wadi Zabid, with five government members and two farmers' representatives. According to the decree, the Irrigation Committee only had the right to formulate recommendations, which needed the approval of the TDA Chairperson and the Governor. The newly formed Irrigation Committee never became effective. Farmers were insufficiently represented, the mandate was too narrow to generate interest and neither decree was fully implemented.

In response to the limited role of the agencies and the limited number of active canal masters, farmers have increasingly taken the initiative to organize the O&M of their irrigation systems themselves without waiting for assistance from outside. To organize and coordinate the O&M, farmers have formed informal groups at village level. Due to the spontaneous, autonomous organization of farmers, who are taking action to ensure that the canal system and diversion weirs are operational, the utilization of base and spate flows are still effective. Most of the maintenance works are executed with the help of their own oxen, while machinery is hired when needed. According to a baseline survey conducted in 2001, farmers receiving water from modernized systems paid an average amount of YR4 000-7 000 (about US$25-47) per year for the O&M, whereas farmers in traditional spate irrigation systems paid about YR20 000 (US$135) per year, as they have to reconstruct their traditional diversion structures every year *(World Bank 1999, 2000a, 2000b).*

A similar experience was seen in the Gash System in Sudan, where the Farmers' Union is supposed to be elected by the farmers. Given that the constituency was not clearly defined in the scheme, and many farmers do not have ready access to irrigated areas, they lost interest in its administration. The Farmers' Union thus tended to represent the interests of the local tribal hierarchy, tribal sheikhs and elites in the project area.

Under-funding was an important obstacle for the now abolished Gash Development Authority (1992–2002). Lacking financial and technical resources, the scheme's irrigation infrastructure deteriorated seriously and the Gash system experienced a decline in income – from a cotton export zone it became a marginal subsistence crop area. In 2002, the Gash Agricultural Scheme (GAS) was incorporated by decree to undertake the management of the Gash irrigation scheme. It has a board of directors chaired by the Federal Minister of Agriculture and co-chaired by the State Governor, to whom the Chairperson delegated his powers. GAS activities are focused on the repair and maintenance of canal offtakes. However, it is still constrained in its ability to plan for development because of inadequate funding, lack of revenues and lack of technical capacity.

Conditions for successful agency-based management

Based on these and other experiences, the following principles need to be respected to improve the likelihood of success and ensure the sustainability of large, agency-managed spate irrigation systems:

- Clarifying and strengthening the roles of both farmers and local government and reducing the role of specialized agencies will be appropriate in most cases.
- Local government can be the repository of agreements on water distribution and maintenance arrangements and make use of its normal powers to solve conflicts between farmer groups. Its authority will be acknowledged by farmers if it operates on a basis of transparency, accountability and fairness.
- Maintenance has to remain a specialized activity. It should be done primarily by farmers, whenever possible. Contracting private companies is also an option and, in any case, the employment of a large full-time staff in the agency for maintenance should be avoided. This will avoid a situation when everyone is responsible, but no one does the hard work of maintenance.
- Public financial support is better directed at recovery from unusual damage and investment in extension and farmer support rather than routine maintenance, which should be transferred, or left, to farmers.
- Effective communication mechanisms are important to avoid a gap in perception between agency staff and farmers.
- Farmer representatives elected from a wide constituency should play an important role in the management of agency schemes. Marginalizing farmer representatives or undue influence by powerful interest groups has to be resisted. Councils of user representatives, local government representatives and service organizations may be the most appropriate method of management.