The River Gash Irrigation Scheme, Eastern Sudan

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1. The River Gash irrigation scheme, Eastern Sudan
Spate irrigation has been practised in the Sudan for many years and can be found in several areas. The Gash project in Kassala province in eastern Sudan is presented to provide an interesting example of some of the typical aspects of spate schemes in the Sudan.

1.1 Hydrology
The River Gash rises from the mountainous catchment area (21 000 km^2) in Eritrea a few miles south of Asmara. It runs generally westwards towards the political frontier between Ethiopia and the Sudan, where it swings northwards to the Gash Delta. There its water is lost through evaporation and percolation, part of which is utilized again for irrigation and other purposes.

In its lower reaches, the Gash is an ephemeral river, usually flowing from early July to late September. Its flow is torrential and highly variable, with a high sediment content of 15 200 ppm in suspension (56.3 kg/s as bed load). Its bed has an average slope of 0.0013. Investigation of floods recorded since 1907 indicated that the average annual yield is 650 million m^3. The annual mean maximum discharge approached 360 m^3/s.

1.2 Area
The total gross area of the Gash Delta is 280 000 hectares, of which 180 000 ha is allotted to the agricultural project. The remaining 100 000 ha is to be irrigated with a network of canals. The annual irrigated area for the annual rotation is about 30 000 ha. Normally about 60 percent of the irrigated area is alloted for cash crops, and 40 percent for sorghum.

1.3 Soils
There are two main types of soil in the Gash Delta known locally as *Lebad* and *Badobe*. The *Lebad* soil is the best, rich in silt and highly permeable. It makes up 50 percent of the total project area. The *Badobe* soil is considered to be an inferior type of heavy clay, prone to swelling and cracking, and rather poor in soil structure and permeability.

1.4 Land distribution
The gross area of the Gash Delta has been divided into large squares of 1 600 ha known as "hods". Each hod is subdivided into 25 "murabbas" of 64 ha. Each murabba is subdivided into 16 squares of 4 ha, and these are the basic units of land distribution. The demarcation system is a great help in both agricultural and engineering operations. It makes mapping easier, and allows it to be done by those who are not trained in survey works. It also facilitates quick reporting of flood movements, and allows canal allotments to be marked out by chainmen with minimum supervision.

2. Spate improvement works
The Gash system can be divided into two main sectors:
1. the river training works and protection; and
2. the land watering operations.

2.1 River training works and protection
The violent flow of the Gash river and its high sediment content creates many problems. There are continuous changes in the bed level and siltation of the water courses, plus the problem of obtaining a reliable off-take in such an unstable river.

A succession of engineers has confronted these problems and considerable success has been achieved, especially the training works in the Kassala area of the upper reaches of the Delta. The training works were built after the great flood of 1929 when the Gash started to widen its bed and to become increasingly unstable. This area, the most upstream zone of the Delta, contains many rich cultivation plots and valuable land on both sides; Kassala town, the capital of the Eastern region, is located here.

The unstable nature of the Gash causes many disasters. Kassala town and its neighbourhood are frequently attacked by floods. In addition there is the great danger of the Gash being diverted out of its course and a large proportion of the water lost before it reaches the Gash Delta canalization.

Therefore training works are important to secure the water for irrigation purposes as well as for the protection of the towns and cultivation plots adjacent to the river.

Real attempts to train the Gash, which started in 1930, indicated the spur and dike system to be the best method. The principle of the system is to direct the river in a permanent straight path about 120 m wide with side flood plaints. Spurs are located in pairs, one on each side of the river, 500 m apart.

The existing system in the Massala area extends for nearly 1 km. The middle sector, which is 3 km, was constructed before 1937; spurs upstream and downstream of this sector were extended after 1978.

The spur body is usually about 300 m in length and the side slope is about 15 m above the foundation sited 3 m below the general bed level. It is built from dry pitching with 15 cm gravel backing on the side slope.

The study of the 9 km stretch adjacent to Kassala town proved that the system of spurs and dikes is the most convenient possible to train the river and protect the town; moreover silt has accumulated between the spurs creating an extensive area of fertile agricultural land with abundant underground water, and most important, the bed of the river within the spurs area has become stable with neither siltation nor erosion over the past 50 years; evaporation has also been reduced due to the reduction in area. The reliability of these spurs was tested by the great floods of 1956, 1975 and 1983 when they were never over-topped. They are easy to construct using local materials and labour.

2.2 The land watering operations

The flush irrigation system was introduced in 1926 when seven canals were built to irrigate the annual rotation of around 32 000 ha. Water is released from the main canals to the sub-canals and then deflected to the prepared plots following the ground slope of about 1/1 000.

Each canal feeds a number of plots known locally as "misgas". Each misga is bounded by banks and varies between 400 and 1 200 ha. Discharge through the opening of the main canals and sub-canals is controlled by wooden stop logs of different sizes which can easily be moved on and off by hand. Durable weirs are constructed to ensure adequate discharge through the regulators downstream from the river.

The effective flood period for irrigation is usually from 60 to 70 days, and the annual rotation is divided into two periods. The watering duration is 28 days for the *lebad* soil and 30 days for the poor *badobe* soil. About 1 m^3/s is required for each 100 ha of *lebad* soil and for each 200 ha of *badobe*.

Table 1: Total irrigated area and cultivated crops for the past 7 years.

Season	Total Area (ha)	Caster Beans (ha)	Sorghum (ha)
1980/81	19 260	11 980	7 280
1981/82	20 120	5 160	14 960
1982/83	12 800	2 270	10 530
1983/84	15 340	2 170	13 170
1984/85	20 610	—	20 610
1985/86	22 210	—	22 210
1986/87	21 830	5 710	15 420

Note: These are the areas calculated within the planned and prepared areas for the annual rotation. However, there are always sizeable irrigated areas outside the programme caused by breaches of the banks and drainage at the tail end of the project; these areas sometimes exceed the above recorded areas.

The actual quantities of the irrigated areas are directly affected by the following factors:

- the annual yield of the river;
- the duration of the high levels during the irrigation period;
- the suitability of the off-takes and other structures;
- the clearance and the strengthening of the canals and the sub-canals banks according to the annual redesign; and
- the preparatory works inside the field such as the inter-misga banks and the spreading banks.

In the Gash Delta the river is the major source of the ground water. Around Kassala the studies indicated an unconfined aquifer 21-32 m deep. The depth of the water level varies but is generally between 5-18 m. It rises from July to September during the period of the flood and is lowest in May or June.

Ground water is not a limiting factor for further cultivations in the Kassala area and the authorities intend to establish a monitoring body to control the digging of wells in the future.

3. Problems and solutions

The Gash scheme is now facing many problems, the most serious being siltation. This problem developed in spite of annual clearance and has the following adverse effects:

- the rise of the river bed causing continuous changes of the river track so that the river frequently misses the off-takes, and damages adjacent areas;
- siltation of the channels which directly affects their capacity;
- the continuous rising of the irrigated land with a resultant reduction of command;
- siltation of sites;
- the accumulation of the silt in the shallow well basins blocking the feeding channels; and
- the flood plains also silt up; the adjacent outer banks have been raised as high as possible and any breach may cause a complete diversion of the river.

The following techniques have been used to deal with the problem of siltation:

- annual removal of the silt from the channels. This is really the greatest part of the annual programme taking most of the budget and tying up machines and labour;
- raising the canals banks;
- raising the off-takes and other structures which are affected by the siltation so as to pass the required discharge;
- desilting the wells and basins;
- elongating the sub-canals to escape the silted area;
- the spur and dikes system has a direct effect on the transport of silt, and so it is considered as a partial

solution for the siltation problem, but not a final solution for the whole problem; and

- studies have been made of the effects of introducing silt-traps, but they have not yet been applied.

In spite of these attempts, siltation is still the biggest problem in the Gash and threatens this valuable scheme. However, one of the advantages of the silt is that it is a very good natural fertilizer and no chemical fertilizers are used in the Gash.

The Gash scheme is now more than 60 years old. It is suffering from deterioration of settlements, equipment and machines, and shortage of financial resources.