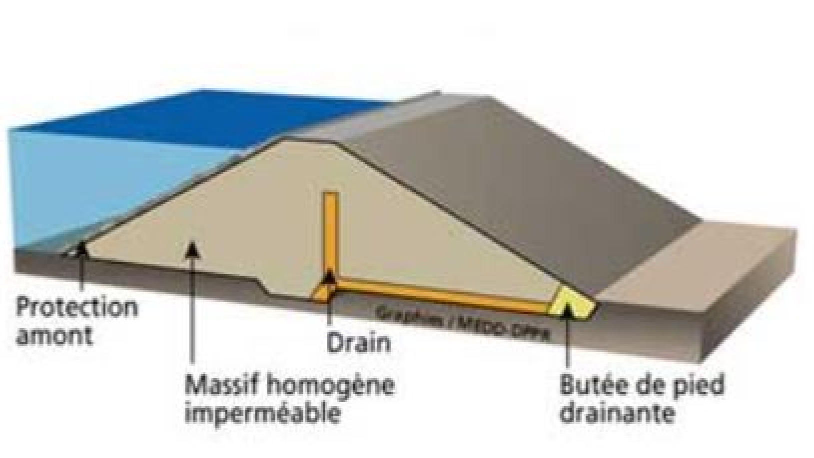
# E7 - Construction of small surface dams

20 March 2012

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# 1) What is involved ?

Dams are structures built in a river valley that retain a certain volume of water by obstructing the natural flow of the river's water. **There are two large families of dam**, those built of **concrete** and those built of **earth or coarse rock. This sheet describes the coarse rock or fill dams only**, as concrete dams are less frequent and above all involve very large capacity impounding reservoirs.

Backfill dams are made up of a loose material, be it very fine (clay) or very coarse (coarse rock). The family does however have **several categories**. The differences come from types of material and the method used for sealing purposes.
- The **homogeneous** dam is a fill dam built with a sufficiently sealing material (clay, silt). This is the oldest technique for fill dams.
- The **clay-core** dam has a central core in clay (which acts as the sealant), shouldered by shells of more permeable materials. This technique has at least two advantages over the homogeneous dam :
the shell materials are stronger than the clay materials ; stiffer banks can therefore be constructed and the flows percolating in the body of the dam are controlled better.
- **Faced** dams are sealed by a "face" on the upstream wall of the dam. This "face" can be in reinforced concrete, bituminous concrete or a thin membrane (usually PVC or bituminous membranes).

## 2) Who use this means and since when ?

This method has been widespread throughout the world **for centuries** as the population has always needed a water reserve available for its domestic and farming needs. Small dams can be built by the villages themselves with the assistance of technical services, NGOs or other bodies such as IOWater and the **Réseau RéFEA**, which has produced for this purpose interesting practical sheets on construction techniques for small earth dams (***access link at the end of the sheet***).
These dams can also have multiple uses and encourage the development of small revenues.
The **Action humanitaire SOS Enfants en Haïti** association has, for example, built a dam for the irrigation and supply to fish-farming basins in a village, not without difficulty, however, and at the third attempt due to a failure to use the most suitable technique, upstream of a channel that only conveyed the water to a brackish pond. The intention was to divert the water from the old channel and convey it via a new channel to the fish-farming basins and fields needing irrigation. (*access link to the relevant report at the end of the sheet*)

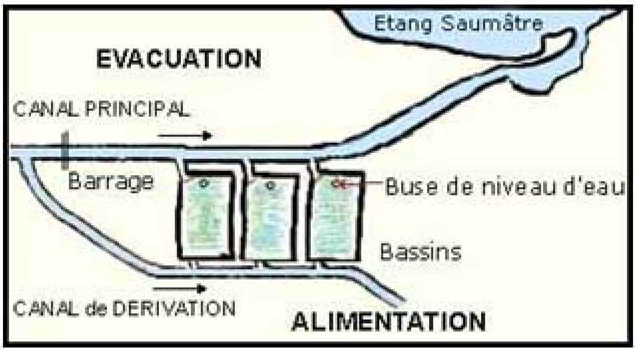



**Diagram of the system**

## 3) Why ?

It is clear from the previous example that building a dam can **create reservoirs of better quality water** than found in retentions that are often brackish and dirty. Water quality is taken into account better and stocks thus formed are monitored better. More generally, dams can store the water brought by the rivers during rainy periods and thus **make a water reserve available during low water**.

## 4) Who is primarily concerned ?

Anybody living near a steep-sided location who needs to build up water reserves for mainly agricultural (irrigated farming, watering animals) as well as domestic use. Large dams can also sometimes supply hydropower plants.

## 5) What does this process involve ? How is it applied ?

### a) Stage 1 : choosing the site and preliminary studies


**Construction of a dam in Mali (photo HSF)**

The **main factors in choosing a site** to construct a dam are as follows :
- the reservoirs must be built on sites which can correspond to a relatively high depth-capture surface to minimise losses through evaporation ;
- the rock surfaces must not have fractures or cracks that could cause the water to leak towards deeper areas or below the dam ;
- the location must suit the groups of users
- no risk of erosion in the capture area

The **best place** is where the valley narrows. The valley must open out with a gentle slope upstream from the narrows to allow the largest volume to be stored. The dyke is therefore smaller and therefore cheaper.
Due to the risk of the dam bursting and the potentially catastrophic consequences, it is mandatory to carry out **reliable preliminary studies** fully and rigorously. These studies cover the topography, geology, geotechnics, hydrology and the environmental impact.
A **few** non-exhaustive **rules** :
- The dams must be built on rocky outcrops
- The rock above the depression must be preferably large and form a funnel going towards the depression so that the water can drain into it.
- Simple stone and mortar troughs can be extended from the ends of the dam, rising above and across the rock to channel the flow from a wider area and bring it down towards the dam.
- The dam site and the bottom of the reservoir must have cracks or rocky fractures that risk draining the water far from the site.
- The dams must be located along the edges of depressions or directly in the lowest parts of large plains, in the rock.

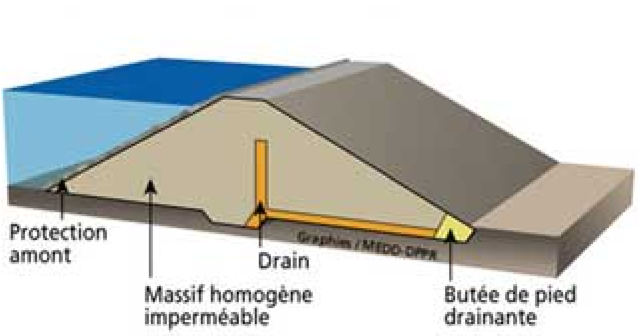
## b) Stage 2 : Calculating the storage volume

The volume of the impounding reservoir must be equal to the sum of water needs and losses. The needs to be satisfied must therefore be assessed (domestic, agricultural and other), along with the inputs (volume of water flowing in the water course) and the losses.
The **inputs** depend on several factors :
- the catchment area : its surface, shape, the vegetation and soil type
- the rainfall : annual amount, frequency, intensity and duration of rains

The **losses** are due to :
- surface evaporation of the body of water : this can be up to 2 to 2.5 m in arid areas
- infiltration through the dam foundation : it can be significant in permeable soils
- infiltration through the dyke, along side walls and underground engineered structures : in can be ignored if the dam is well built
- the silting up of the impounding reservoir by sediments brought by the waters : it can be quick and substantial if the catchment area is subject to major erosion

The **impounding reservoir capacity** is determined using level curves plotted from preliminary topographical surveys.

### c) Stage 3 : Construction




**Barrage en terre compactée, homogène**

**1) Installation**.

Having chosen the site, the **centreline is identified with the concrete markers** installed at each end. These markers continue to serve throughout the work and must not be moved. **Stakes are planted** at regular intervals between the aligned markers. This survey is used to determine the height of fill at each point, the width of the dyke at the base and the volume of backfill.

**2) Installing a coffer dam**

The coffer dam is a temporary dam built upstream of the site to protect the work area from flooding. The coffer dam is not necessary if the work is carried out entirely during the dry season. The water stored by the coffer dam can be used for the work (compacting) and possibly for mixing the concrete.

**3) Preparing the foundations**

For the rocky foundations, the contact surface between the rock and the fill must be as impermeable as the rest of the fill. Smooth surfaces and unplugged cracks must be avoided. The topsoil and the spoiled rock must be removed with a shovel, pickaxe or crowbar and removed from the site. For the coarse foundations, the dyke centreline is stripped until a clean surface area free of all plant matter is obtained. If the foundations are permeable, a sealing shield is created as far as the rock (or the impermeable soil).

**4) Constructing engineered structures**

The materials are transported, deposited and spread to achieve the required thickness. If the natural material does not have the necessary water content for good company, it is moistened either at the borrow pit or after spreading using a tank fitted with a sprinkler tube. Compacting machinery completes the process. Layer thicknesses and the number of machinery passes are determined by a test area on the site. The dyke is built 20 to 40 cm wide so that banks can be well compacted ; these are then cut to the required slope.

**5) Other work Settling earthworks** :

When the dyke has been completely backfilled, a fill height is added of about 5% of the height of the dam to cover future settling.

## 6) Special difficulties and remedies and/or precautions that may be necessary

Here are a few **principles to follow** to maintain the dyke and the water quality :

- erosion must be controlled in the capture area
- sludge traps must be used in the water input channel
- bacteriological and chemical contamination must be prevented in the capture area
- the dyke and spillways must be protected by a hedge to keep humans and animals away
- the pipe and valve must be serviced
- the bank and spillway must be inspected regularly for fractures, subsidence and slides

- fractures must be plugged immediately with compacted clay and erosion on the banks can be solved by planting trees and by plugging small streams.

# 7) Main advantages and drawbacks

Dams are essential infrastructures so that populations can **live and not join the rural exodus**.
Once the basin is filled with water, the dam can be used directly to irrigate land thanks to simple partial emptying systems.
Dams can also improve the **infiltration of water into the water tables**.
Their construction often gives rise to many small local development programmes.
These systems require the **introduction of collective** public or community **management** to ensure fair access to water for all and to avoid disputes.
The **major drawback** continues to be the varying degrees of **water lost** through evaporation and infiltration, which in some cases can result in a preference for building underground dams (***see sheet E8***).
**Another** sometimes significant **drawback** : if the preliminary studies are not well done or do not take account sufficiently of **potentially important secondary effects** on the local populations, the environment, the drop in quality of farmland or fishing possibilities **downstream from the dam**, the result can prove disastrous for the local populations, mainly for example in the case of large dams where they gain virtually nothing. All this contributes to inciting lively debates on the advantages of constructing dams.

# 8) Cost

Small earthen dams, where the semi-circular or curved earth dykes are frequently under 3 m high and 60 m long, are normally built by hand and using animal traction. They can normally be serviced and repaired by the community that uses them. The cost is therefore low but obviously depends on the configuration and the type of position, dimensions and the cost of materials.
Large earthen dams usually need powerful earthwork machinery and huge investment.

# 9) Achievement examples : Tagant Dam in Mauritania

The **Tagant** in the south of Mauritania is an **oasis area** and a transition area between the Sahara and the Sahel. The Rainfed Area Development Project (PARP), **financed by European cooperation** to the tune of **6.2 million euros**, was intended to encourage the control of water by building dams that allowed flooded lands to be farmed in order to fight against the drop in living standards of farmers and herders and fix the populations or allow them to return to their region of origin.
These huge sites were supported by a **multitude of actions more targeted towards inhabitants**. Thus were born the improvement programmes for farm production in bowls, distribution of butane to replace heating wood and coal, support for marketing gardening cooperatives through extension of techniques or installing irrigation infrastructures, developing cereal banks, installing solar panels for water pumping, constructing mills, wells, classrooms, etc.
The **combined effects** of dams and the many microprojects that have seen the light of day have gradually **revitalised life in the country’s rural areas**. The opening up of these regions nevertheless continues to slow down their development substantially. The inhabitants are now patiently waiting for the roads and tracks which already have financing in place.

# 10) Where to obtain further information

## a) Websites

**- IOWater (International Office for Water)**. This site gives access to the **Réseau RéFEA *(Centre télématique francophone sur l’eau)*** site where you will find several small, interesting and practical sheets :

For surface dams, click the link below :
http://www.oieau.org/ReFEA/module3....
then in each of seven corresponding sheets, listed under the headingCapturing surface water
- **SOS Enfants en Haïti**, humanitarian association : Interesting illustrated report on the construction by the population of Haiti *(quoted at the beginning of this sheet)* of small dams - and the difficulties encountered - to increase the revenues of villagers through the boom in fish farming. Available online at :
http://marc.oberle.pagesperso-orang...

## b) Videos

- **Video ( 2'31) of the construction and works for the dam of Soum in Burkina Faso with the association Terres d'Amitié** : https://youtu.be/gk63mrgdqWk
_Vidéo (26'10) of the show tv "C'est pas Sorcier" which explains what the dams are used for, how they work, how do we build a dam,...: https://youtu.be/kNvmUQc45y8