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ASPECTS OF DEVELOPMENT

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APPROPRIATE TECHNOLOGY FOR THE DEVELOPMENT OF WATER RESOURCES IN SOMALIA

Introduction

Somalia is mostly an arid country with rainfall ranging from less than 50 mm/year along the northern coast to about 600 mm in the Bay Region. Rainfall is unevenly distributed and scanty in the central and northern areas. Periodic droughts have occured during the past decades with enormous damages to the agricultural areas and livestock. The rainy season occur from April to June and from September to November. There are two perennial rivers, the Shabelle and the Juba, the main part of their catchments is in Ethiopia; numerous small, medium and large size temporary streams, called 'toggas',flow only in occasion of storms; the most sizeable toggas however maintain an underground flow all year-round.

In the past 30 years, several studies have been carried out for the development of the water resources in Somalia. During this period about 700 wells have been drilled by the public and private sectors in the various parts of the country. A rather comprehensive, country-wide hydrogeological study has been carried out by the United Nations' "Mineral and Ground Water Survey Project". The results of the U.N. survey are presented in the report "Ground Water in the Somali Democratic Republic", in which the country is subdivided in I6 hydrogeological provinces. The report gives information on 274 drilled wells, I230 hand-dug wells, 26I springs, including 773 chemical analyses from these water sources. This information, together with the results of other ground water investigations carried out during the past 30 years in various areas of Somalia, is surely a valid basis for starting a water resources

development process in the framework of the Water Decade Planning. Additional studies are however needed, both on regional and local scale, for the implementation of specific projects.

The population of Somalia has been estimated at about 5.32 millions; people living in rural areas amount to 78%, about 50% of the urban population lives in Mogadishu, and the remaining urban population lives in 69 towns each having more than 5000 people.

Somalia is considered one of the least developed countries in Africa: income is less than $ 300 per capita per annum, and it has one of the highest rates of infant mortality. Water-related diseases are recurrent and account mainly for the high rate of mortality and morbidity. There is therefore an urgent need to improve the water supply situation of the country.

For the future development of the water resources it will be necessary to select those technologies which should be as simple as possible and, whenever possible, implemented with the participation and help of the local population. The scope of this paper is to describe briefly some of the technologies suitable in certain areas of Somalia which require minimum external help for maintenance and which can easily be replicated.

Financial Requirements for Developing the Water Resources

The development of water resources in a country like Somalia, where population is scattered and where distances are enormous, requires a large financial investment which nowadays can only be afforded by some of the oil-exporting countries. For the Water Decade Planning it has been estimated that the investment cost for 100% coverage of the whole Somali population with water supply and sanitation facilities by the year 1990, would amount to $ 1400 millions. The adopted alternative for

1990 with partial coverage, amounts to $ 500 millions; the recurrent costs for the sector total to about $ 100 millions. With this large financial effort it would be possible to have a good distribution of water points to meet the needs of the population and to create indispensable conditions for the implementation of programmes and projects which may lead towards improved health conditions for people and livestock and towards economical self-sufficiency.

Almost all the required amount for achieving the decade target is expected to be provided by external aid. The recurrent costs would be funded directly by the government and through the community's participation; which should gradually be responsible for the maintenance of the water system.

Appropriate Technology for the Water Supply of the Rural Population

With a view to alleviate the pressing water needs of men and livestock, great importance has been given to ground water use in the past 30 years by drilling water wells. However, this has solved the problem only in certain areas, while for other areas it will be necessary to consider other solutions, more appropriate to local conditions.

The main reasons preventing the drilling of successful wells in large areas of Somalia are:

- the excessive salinity of ground water, which is often unsuitable for humans and livestock;
- water table, in many places, is very deep; in some cases the first water struck has between 250 and 350 meters;
- high cost of drilling and pumps;
- difficulty to maintain and operate deep wells;
- high cost of fuel consumption and for covering large distances from the centers of supply; even higher costs are required for wells drilled in areas where grazing lasts only

a few months, mainly during and soon after the rainy season;
- shortage of skilled workers to carry out minor repairs directly at the well sites.

In spite of these considerations, however, drilling activities are necessary in some areas for both rural and urban populations and surely will continue to constitute one of the major burdens on the budget allocated by the Somali government in its efforts to develop the water resources of the country. For the rural water sector, deep drilling should be restricted to those areas with favourable hydrogeological conditions, with large agricultural and grazing potential and mainly where other less expensive technologies cannot be implemented. There are 5300 registered villages with a population of less than 5000 people, for 2040 villages the population ranges from 500 to 3000 people, for the remaining 3260 villages the population varies from a few people to a maximum of 500 persons; nomadic people are attached to these villages. For these rural villages the technology has to be, wherever possible, simple, low cost and replicable to new areas with the participation of the rural communities in the maintenance of their water supply. In the following pages a short description of the main appropriate technologies for the development of the water resources of the rural areas of Somalia is given.

Rain Harvesting

I. Ballehs and Wars: Two major rain water harvesting methods are practised in the rural areas using ground catchments for collecting run-off water. The first impounds water in open reservoirs called 'ballehs' and 'wars' and the second stores water in underground reservoirs called 'barkads'. Ballehs are generally natural depressions which receive run-off water from nearby land drainage; they vary in size according to topographic conditions. Ballehs are used in

Somalia from ancient times.
Traditional wars are artificial reservoirs created mainly in featureless plains to collect rain water by means of ditches. Their shape varies from square to round. The old wars were dug using primitive tools and they are, in most cases, very small in size and used for small communities. Maintenance of wars is generally done by women and children. Because of the high rate of evaporation most of these wars get dry towards the end of the dry season and the people are compelled to move close to a permanent water point or collect water from long distances using camels.

2. Barkads: Barkads are small underground reservoirs generally lined with water-proof masonry walls; each barkad impounds only the water requirement for a family or a few families. In most cases they are covered by brances and other shading devices which reduce the evaporation. A small settling basin is generally constructed close to the inlet of the barkad. A large number of barkads have been constructed by private initiative in the north-eastern regions, in areas where soil is rather porous or in places where rocks are close to the surface.
3. Modern large size water reservoirs: There are only a few available permanent usable ground water resources in many areas of the southern part of Somalia, where, to a large extent, ground water is of a poor quality, often unsuitable for people and stock. Run-off water in many of these areas is the only solution, especially in the large featureless alluvial plains of the Bay Region, the Middle Juba and the Lower Shabelle Region. In these areas some of the unreliable traditional wars have been replaced by reservoirs constructed with modern technology in the past decade. The project was financed by EEC in the early 1970s and has brought enormous benefits to the nomadic and settled people residing in an area of approximately 80.000 km^2. Fourty

reservoirs were constructed at an approximate distance of 25 km from each other. This was considered a good distance for the grazing potential of the number of animals living in the area. The storage capacity of the reservoirs is 30.000 m^3.

This large scale project, which required high investment costs, however, did not give the expected results as a series of faults appeared since its early stage of completion. Some of the major faults are reported below:

- some reservoirs were escavated not in low spots, thus resulting in insufficient inflow;
- the PVC membrane to prevent leakages was destroyed by the temperature and by the animals when they got into the reservoirs because the pumps were not working. In some cases the membranes were removed to cover huts;
- the pumps and engines were not operating in many cases;
- the hand pumps to supply through ceased to function after a relative short time;
- the embankments and ditches became in many cases silted up;
- the spillways were, in most cases, inadequate with consequent floodings of the areas surrounding the reservoirs;
- nearly 45% of the reservoirs had silting problems.

Some of the problems could have been corrected in due time if strong and well-organized maintenance units, capable to intervene with regular repairs, would have been created for this purpose. As a consequence of the damages the reservoirs suffered in less than IO years since their construction. A "Reservoir Rehabilitation Project" is presently in progress with the financial assistance of the UN and from bilateral aids. The cost of the rehabilitation programme is estimated at $ 3.5 millions.

The users pay for watering their stock according to the following tariff: one SoSh per camel, 0.20 SoSh per goat or sheep, 2 SoSh for a 200 liter drum, 0.20 SoSh for a 5 liter container.

There is no participation of the users on decisions and responsibilities regarding the use and maintenance of the reservoirs.

Advantages and disadvantages of water harvesting systems

I. Advantages: The arid rangeland of Somalia is in large areas, limited more by the lack of drinking water than by lack of feed. By constructing water reservoirs in these areas it will be possible to:
   - reduce the movement of livestock and consequently increase their weight;
   - provide water without requiring fuel or power;
   - involve the users in the maintenance of the reservoirs;
   - rainharvesting reservoirs can be constructed in areas with rainfall as low as 80 - I00 mm/year if soil and topographic conditions are favourable.

2. Disadvantages:
   The limiting factors of storing water in open reservoirs are the following:
   - high evaporation rate between 2000 and 3000 mm/year;
   - high infiltration in some areas;
   - low and scattered rainfall in large areas;
   - growth of algae and breeding places for insects and frogs;
   - high amount of silt;
   - lack of suitable natural catchments;
   - unsuitable slope and soil conditions for rain harvesting.

   There are however remedies for most of the disadvantages indicated above by introducing appropriate techniques such as reducing the permeability of the catchment area by spreading granular wax, which would be melted by the sun and thus seal off the granular interspaces; the use of PVC

membranes, possibly protected by gravel from radiation and wind damages. Asphalt has proved to be a good soil sealant and can be easily applied by spraying; there are also other sealants, the selection of the most appropriate ones will however depend on local conditions and economic factors. For the reduction of the evaporation and the pollution other remedies are available and could be introduced; they are described in various technical papers.

Size of rain-harvesting reservoirs suitable for Somalia

The size or type of the reservoirs will depend upon several factors including rainfall rate, land slope, grazing potential, soil conditions and evaporation. As these conditions may vary from place to place, it will be necessary to consider more than one standard size of reservoir which would fit with the local conditions.

Reservoirs, however, should not be less than 5 - 6 m deep as evaporation and infiltration loss may account for about 50%. The volume may vary from 5000 to 20.000 m^3 and in exceptional cases, in areas with high rainfall and good natural drainages, higher volumes could be considered if grazing potential would justify.

Priority areas for the construction of water reservoirs have to be defined based on the water requirement of these areas as well as on the unavailability of cheaper and more suitable water sources.

However, before construction starts an investigation is required aiming to define: soil and slope conditions, form and size of the reservoir, grazing potential and other required elements. The future programme should also include an overview of existing wars, in view of possible improvements by increasing the depth and extending the drainage system. The users, whenever possible, should be involved in the regular maintenance.

Development of Surface Water Resources by means of Underground Dams or other Water Holding Structures

Of the two rivers of Somalia, one, the Juba, is considered to be perennial while the Shabelle is usually dry 2 - 3 months a year.

Besides these two major watercourses, Somalia could exploit a good number of temporary streams which are dry almost all the time, except in flood periods. During the floods, considerable volumes of water flow down their beds, which, if retained, could constitute a very important and cheap source of water for many areas which presently suffer an acute shortage of water.

At some depth below their bed, sometimes even at the end of the dry period, one can find water, which, however, is scarcely and inefficiently used by the local populations. Among the streams which appear worthy of consideration we may mention Uadi Giael in the Daror Valley, Uadi Nogal and its tributaries in the Nogal Valley, the tributaries of Shabelle in Hiran, the major uadis in the Bur Zone (particularly the uadi traversing Bur Acaba and Uadi Matagoi, which has a remarkably long course) and the many tributaries of the Juba in both Upper and Lower Juba. Investigations should be undertaken as to the possibility of constructing barrages.

Suitable Areas for the Construction of Water Reservoirs

The most promising areas for the construction of small, water-holding structures are the Bari Region, the northern regions, the Hiran Region, the Bay Region, and the Gedo Region.

In these regions, due to lack of reliable water supply available all year round, the population is at present scantily distributed during the dry seasons, but increases during the rainy season, when livestock finds good grazing and water conditions.

The selection of the most suitable temporary streams to be dammed should take into account the following factors:
- favourable geological conditions;
- dependable rainfall;
- grazing and/or irrigable land potential.

Numerous dry streams however, present geological and morphological conditions favourable to water storage either in open reservoirs by constructing small earth or concrete dams, or in sand reservoirs by means of sand storage dams or underground dams.

Investigation of Selected Sites for Dam Construction

The development of the areas where dams could be constructed has to be in accordance with the ascertained farming and grazing potential and the identification of the target group capable of carrying out the agricultural or animal husbandry activities in the selected areas.

In general, three types of dams could be considered. Small surface dams could be constructed in the headwater of the 'toggas': they would be used to store water which during the dry season would be released to recharge the downstream sand reservoirs. Sand storage dams could be built in the middle section of the 'toggas' so as to trap sand and gravel during flood waters. The sand storage dams have to be constructed in stages; therefore a study on the amount of materials transported during spate flows is indispensable. Underground dams could be built across the lower reaches of the 'toggas' so as to stop the underground flow and store water during spate flows in the coarse, permeable sand and gravel which fill their beds. Hand-dug wells and infiltration galleries could be constructed to tap the water stored in these 'togga' beds.

The main activities of the investigation programme are as follows:
- to study the characteristics of the selected catchments and

define the rainfall/run-off relation;
- to study the geology of the basins and of the potential dam sections;
- to carry out geophysical works, exploratory drillings and pits in order to check the physical characteristics of the alluvial deposits and of the underlying rocks;
- to carry out topographical surveys and define the storage capacity of the reservoirs;
- to locate building materials and decide on the most economical type of dams;
- to construct small sand storage dams and underground dams for field testing;
- to carry out socio-economic studies of the area and to consider the effects deriving from the water sources;
- to prepare a report on the activities and results of these investigations including all the technical data of the proposed dams. The report should also include the financial and socio-economic aspects.

Dam Construction

The design of type(s) of dams to be constructed, including all the technical details and costs involved, is part of the investigation phase; in this follow-up phase, however, a detailed investigation of the selected sites should be carried out before starting the construction of the dams.

Shallow Aquifer Development

Ground water from shallow aquifers can be exploited by hand-dug wells, infiltration galleries, driven wells and shallow drilled wells.

Hand-dug wells

Experience in many developing countries has demonstrated that, whenever possible, shallow hand-dug wells, probably designed

and constructed, should be preferred to deep drilled wells because

- their cost is much lower;
- they can be constructed in aquifers with lower yield since they have a certain storage capacity and the removed amount of water can be replenished during the night and when the well is not in use;
- maintenance cost is minimal compared to that of deep wells since the water can be drawn by hand-pumps, windmills and other low-cost means;
- the implementation of a shallow well construction programme is justified also by economic reasons deriving from the benefits of the improved health conditions of the population and because the distance from the present distribution of water points would be shortened; this would also consequently benefit the livestock. Local communities could contribute with local materials and labor.

In view of the above, much more importance should be given in Somalia to the construction of new shallow wells, wherever this is possible, and to the improvement of existing ones.

Rehabilitation of old hand-dug wells

No precise statement can be made as to the number of open wells, both seasonable and perennial, existing in Somalia, but there are estimated to be over 2000. Their depth and capacity varies greatly according to climatic and geological conditions.
Many of them were built centuries ago, as is the case in the Baidoa region, and present many shortcomings due to the lack of maintenance; some of them are partially silted up. These open wells have, oftentimes, very large orifices and consequently present a threat to causalities. In most cases they are unlined and unprotected; small animals, insects, dead leaves, and dust have easy access into them. Wells dugs in

depressions are more prone to heavy pollution, because during the rainy season the run-off water brings abundant animal excreta from the surrounding areas into these wells. Pollution is brought into the wells also by wind and skin buckets which are generally used to draw water.
Due to the above conditions, hand-dug wells represent a serious hazard to the health of the people and livestock. If these wells were properly constructed and protected, they could be of great benefit to the country.

Suitable areas for the construction and rehabilitation of hand dug wells

The selection of a hand-dug well location is based on the possibility of finding water of good quality and substantial quantity at shallow depths which can be used by people and livestock.
Compared to the size of the country, the zones offering favourable conditions for the construction of hand-dug wells are rather limited. The most promising are the following:

- Coastal Dune Belt. It follows the contours of the Somali peninsula. The best conditions for manual excavation of wells are from I - 20 m above sea level. Water quality varies from very satisfactory to unsuitable for people and livestock;
- Sand River Beds and Alluvial Belts. Numerous large temporary streams, 'toggas', incide the northern regions, Bari Region, Hiran Region, Bay Region and Gedo Region. Among the major streams are the Wadi Giael in the Daror Valley, the Wadi Nogal and its tributaries in the Nogal Valley, the tributaries of the Shabelle in Hiran, the major Wadis in the Bur zone and the many tributaries of the Juba in its upper and lower parts.
  These streams maintain, all year round, an underground flow

in their sandy beds which is scarcely and inefficiently used by the local population.
In many cases, hand-dug wells in the alluvial belts of these 'toggas' culd increase their yield if connected by infiltration galleries to be constructed across sandy beds;

- Juba and Shabelle Alluvial River Belt. Along the alluvial belt bordering these two rivers for a width averaging on either bank about 5 km the conditions are favourable for the construction of shallow wells. However, the conditions regarding the depth of the aquifer vary greatly from place to place. Water quality varies from good to unsuitable for people and livestock;
- Erigavo Plateau. Numerous hand-dug wells and karstic sink-holes are presently supplying people and livestock in the area.
Conditions are favourable for digging shallow wells in this area. However, a hand-dug well rehabilitation programme should have priority since the existing wells are all heavily polluted by animal dung brought into the wells by wind and run-off surface water. Most of these wells are located in karstic depressions, and water quality varies from fair to bitter in taste due to the sulphates;
- Scattered Areas in Mudugh and Galgudug Region. Some areas of these two regions are covered by limestone formation affected by karstic phenomeny which have created small depressions and cavities. These phenomena are at times limited to the surface because of underlying strata of clay and marl which form perched water bodies. Wells in these zones are mostly perennial and provide water of good quality.
The most extensive zones are: Ghelinsor, Merengur, Sindago, El Dere, El Bur, Dirri, Bud Bud, and the zone from Galcaio to 50 km inland from Obbia. Other zones are also promising but less extensive;

- Area along the Disputed Border between Fer-Fer and Dolo. Shallow aquifers of the perched water type exist along a large belt between Fer-Fer and Dolo. Water has slightly bitter taste due to the presence of sulphates; however, the total salt content is not excessive and the water is accepted by the people and livestock. The hygenic conditions of these shallow water wells are extremely poor because most of these wells are located in karstic depressions and thus are heavily polluted.

Institutional support for the Implementation of a hand-dug well programme

At present no governmental institution is carrying out hand-dug well programmes in the country. In the past, mainly in the late I950s and early I960s, a successful hand-dug well programme was implemented by the public administration.
At the level of private initiative, hand-dug wells are presently constructed in Mogadishu as well as in other parts of the country. The implementation of a nation-wide hand-dug well programme requires technical and financial support from the government.
The Water Development Agency (WDA) is the most qualified organization for carrying out such a programme because, apart of the Drilling Department, it has also the Hydrogeological Department and the Engineering Department which could well be involved in this programme.
Furthermore, the I6 regional WDA offices could help during the construction operation and later on with the maintenance of the works. The hand-dug well programme should be carried out in collaboration with the Ministry of Local Government and the Rangeland Agency which should indicate their priorities of both the rehabilitation and construction of these wells in suitable areas.

Community Participation

Experience has demonstrated in many countries, that the most successful projects are those which have been implemented using simple and low-cost techniques with the help of the local communities.

In Somalia a large number of hand-dug wells have been constructed without external help in most cases, and there are numerous well-diggers who have reached a good skill in this work. The communities' motivation to help and support the programme will be a guarantee for the maintenance of their own water wells once they are aware of the danger of polluted water to health.

The community participation should consist in labour and locally available materials (sand, clay and rock).

Project Implementation

The project should be implemented in various phases. The first phase, of a two years' duration, should be restricted to the selection and rehabilitation of 100 existing hand-dug wells, with the scope of cleaning, lining and protecting them from external pollution; some wells should be equipped with hand pumps or windmills.

One of the main tasks of this phase however, should consist in the organization of the programme which should include the training of personnel, the pruchase of equipment, the collection of materials, the manufacturing of concrete rings, etc. For gaining a comprehensive, country-wide preliminary experience on the various techniques to be used during the first phase and for the preparation of an expanded activity in the follow-up phase, it will be necessary to develop the programme in different geographical and geological conditions.

The choice of the appropriate technology for the rehabilitation well programme, as well as for the construction of new

wells, may depend mainly on economical and technical factors and on the geological conditions. Lining will be made with concrete rings or masonry works or with any other suitable and appropriate material according to local conditions.

The number of people who could benefit from the first phase of the programme may depend on several factors including the depth of the well, the distance from the well to the users, the size of the village and other factors including rainfall occurence, habits of the people in their water needs, etc.

Experience in other African countries shows that a village supply well, equipped with a hand pump, could, in normal conditions, supply between 250 and 300 people with 20 liters of water per day. In case of pressing water need, the number of people per well can be doubled.

From the above, it is estimated that under normal circumstances, between 25.000 and 30.000 people could benefit from having an improved water supply in the first phase of the programme.

Development of Spring Water

More than 250 springs have been inventoried in Somalia, but its number may well be over 300. Most of them are located on the slopes of the northern mountains; some springs have been located also in the Mudugh, Hiran and Bay regions. Their utilization is negligible as most of the water disappears, in many cases, after a few meters from the source in boulders and gravel filling the beds of water courses.

Spring water could be piped to areas with good grazing and agricultural potential. At present only a very minor amount of water from this valuable source is used for agriculture, mainly for date cultivation and for watering stock. A project

aiming to develop this interesting and promising cheap water, which in many cases can be brought to users by gravity, is highly recommended. The first selection of the most interesting springs could be done from the existing inventory carried out by the UN Mineral and Groundwater Project. Additional information however is required on their regime before planning their exploitation.

Conclusions and Recommendations

I. In spite of the fact that Somalia is mostly an arid county, conditions are, in many cases, favourable for the development of its scarce surface and shallow ground water resources by means of appropriate and low-cost technology.
2. Deep drilled wells, which are very costly to construct and to maintain, should be restricted to large villages and urban towns having favourable hydrogeological conditions. For the rural sector, deep drilling is justified only in areas with large agricultural and grazing potential and where conditions are not favourable for cheaper technologies.
3. The traditional small reservoirs, 'wars', are, in most cases, unreliable because they may dry up during prolongated droughts. The rehabilitation of traditional wars by proper deepening and lining to reduce infiltration and evaporation will assure permanent water supply and thus prevent people from abandoning villages and grazing areas during the dry months.
4. Barkads have proven to be valuable small sources of water for many small settlements, especially in some of the northern regions. Most of them have been constructed by the private sector. This method of storing water could be

improved and introduced in other areas of Somalia.
5. Modern large-size reservoirs have proven to be very expensive and require an efficient organization for their construction and maintenance. Reservoirs varying in volume from 5000 to 20.000 m^3 appear to be more appropriate to the conditions of Somalia.
6. Conditions are favourable in large areas for the implementation of a successful hand-dug well rehabilitation and construction programme. The most important areas are the coastal dune belt, the main sand river beds and their alluvial plains, the Erigavo Plateau, some areas in the Mudugh and Galgudug regions, along the disputed border between Fer-Fer and Dolo.
7. Sanitary conditions of wars, ballehs, barkads and hand-dug wells are generally very poor mainly because they are unprotected from pollution. As people are little aware of the dangers of water-related diseases, a strong village health programme is required.
8. Conditions are favourable for developing surface and sand storage water reservoirs by means of surface and underground dams with consequent benefits for large areas which presently suffer from an acute shortage of water. Numerous small dams could be constructed in the Bari Region, the northern regions, the Hiran Region, the Bay Region and the Gedo Region. In many cases, small surface dams for storing water in open reservoirs could be constructed in the headwater of the major toggas, sand storage dams could be built in their middle sections and underground dams could be constructed across their lower reaches. Water stored in sand reservoirs would then be tapped by hand-dug wells and infiltration galleries.

9. It is estimated that there are well over 300 natural springs in Somalia; their utilization is however negligible as in many cases most of the water disappears in boulders and gravel at short distances from the source. In some cases spring water is presently used for the irrigation of small plots and for watering stocks. A better utilization of this cheap, valuable water source could bring considerable benefits to numerous settlements and to nomadic people. The selection and study of the most important springs is highly recommended.

IO. The Water Development Agency is presently engaged in drilling deep water wells for rural areas and urban towns. There is a need to strengthen its technical capability, in order to expand its activity and to satisfy the water needs of the country, developing appropriate, and, wherever possible, low-cost technologies.

II. A Water Resources Development Master Plan for the whole country is required and should be prepared as sonn as possible; effort should be made to obtain financial aid from international organizations and donor agencies for this purpose.