A BRIEF REVIEW OF THE SURFACE AND GROUNDWATER RESOURCES OF THE NORTH-WEST REGION OF SOMALIA

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A - INTRODUCTION

The Northwest Region of Somalia is mostly montainos toward the northern part and nearly flat grassland toward the southern border. A pediment, followed by a coastal plain, marks the area along the Gulf of Aden. The drainage system is well developed along the northern side; the major ephemeral water courses reach the Gulf of Aden, (Fig. 1). There are no permanent streams in the Northwest Region; however, conditions are favourable for the storage of runoff water in open reservoirs and sandy river beds. Several efforts have been made in the past to develop surface and groundwater for solving local water supply problems.

Information regarding surface and groundwater resources of the Northwest Region is contained mainly in the reports of Hawes (1953), Hendrikson (1965), Humphreys & Sons (1960), Hunt (1951), MacFadyan (1950) and Morgan (1971).

The author, as a member of the FAO/World Bank mission for the preparation of the "Northwest Integrated Agricultural Project", has examined these reports and carried out field observations

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Note: This paper was written in late 1973; since then hydrological and hydrogeological knowledge of the area is better known as a result of the UN Mineral and Groundwater Survey, whose findings are reported in the well known work of Popov, and the investigation programme carried out by the "Integrated Agricultural Project in the Northwest Region". The paper, however, contains a considerable amount of groundwater data and ideas which makes its publication worthwhile.

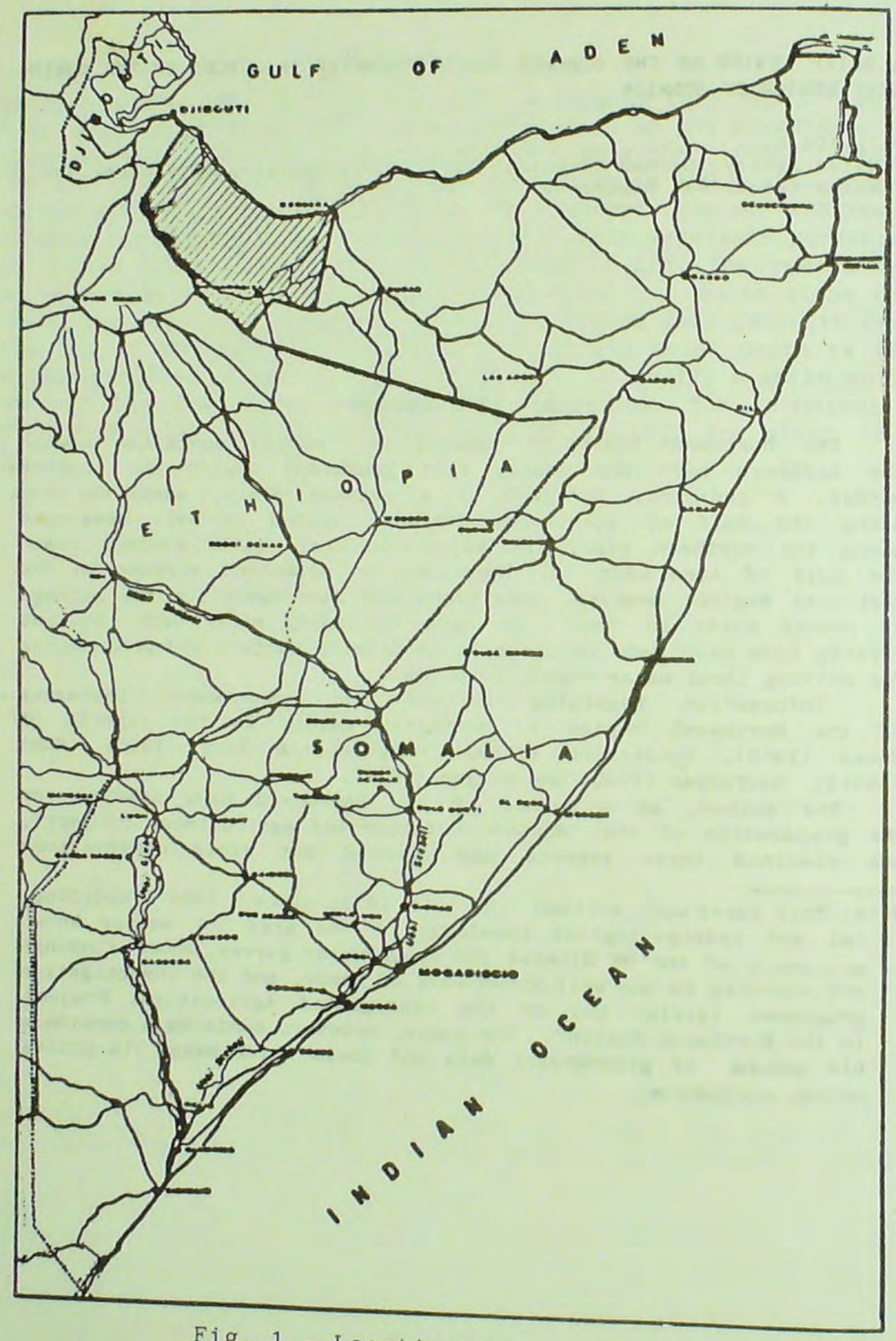


Fig. 1 - Location map.

when he visited the area in September 1973; additional information was obtained from the Water Agency and the UN Mineral and Groundwater Project, which was in its final phase. From these various sources it was possible to compile this paper.

Most of the information here presented is included in volume II, Annexes 6 & 7, of the FAO/World Bank mission's report, However, as only a few copies were distributed to Government institutions in early 1974 (most of which went astray), this report is not readily available.

The scope of this paper is to preserve and disseminate available information on the Northwest Region regarding surface and groundwater resources, and to suggest ideas on water resource develpment of the area for various purposes.

B - HYDROLOGY

The Hydrological Service was established in 1953 with the arrival of a Hydrologist Engineer who set up a number of gauging points in tugs to record water levels during spates, to collect data on discharge, rainfall, evaporation, and to prepare designs for flood control. Eight river gauge stations were set up including Hargeisa, Salil and Kabri Bahar and records were kept from 1954 to 1961.

Rainfall

Rainfall in Hargeisa, on an annual average for 31 years over the period 1929 to 1972 (missing from 1941-1949), is 414 mm. The highest rainfall recorded is 800 mm (1926), the lowest 156.7 mm (1965). At Berbera on the coast, the driest year was 1947 with 1.8 mm, the wettest 1950 with 96.3 mm. The rainfall stations are either on the coast or the plateau area; because in the past there were no settlements in the most important catchement areas and sta - tions could not be established.

The rainfall values in areas between the interior foothills and the edge of the Upper Plateau, considered by Morgan (1971) as the "most effective" catch-ment areas are given in table 1.

Runoff

Humphreys (1960) found that "the runoff expressed as a percentage of rainfall decreases inversely with the size of the catchment area". This is because runoff is related to the variability of

the rainfall, which often occurs as localized showers. High discharge rates occur during intense rainstorms, followed by a rapid recession period. In the lower section of the main water courses, at their outlets to the plain, runoff water arrives in single or combined flows. Table 2 shows the annual flow in the major tugs.

Table 1

Rainfall in the "Most Effective" Catchment Runoff Area (in mm)
(from Morgan's Report, 1971)

Months	Silil	Dur Dur	Biji	Wahen
Jan	-	-	-	-
Feb	-	-	-	-
Mar	25	30	30	25
Apr	18	32	45	45
May	33	37	40	
Jun	40	55	55	55
Jul	27	25	25	22
Aug	40	50	47	50
Sep	40	40	37	35
Oct	15	18	18	12
Nov	-	-	-	-
Dec	-	-	-	-
Total	238	282	294	284

Table 2

Annual Flows in Silil, Kabri Bahar and Hargeisa
(in ha. metres)

	Area km^2	1953	1954	1955	1956	1957	1958	1959	1961	1962	Mean
Silil	3,850	(a)NR	414	NR	NR	770	74	331	NR	NR	397
Kabri Bahar	3,040	(a)BR	1,280	6,550	8,000	1,770	2,070	3,960	NR	NR	3,938
" "	"	(b)NR	1,282	6,535	7,943	1,765	2,060	3,938	357	NR	3,411
HargeisA	300	(a)NR	820	910	1,060	800	332	68	NR	NR	66
		(b)79	824	908	1,054	800	331	69	1,385	149	662

(a) from Morgan's report (Dec. 1971).
(b) from Hydrologist-Irrigation Office in Hargeisa (Nov. 1972).

Evaporation

Using two types of evaporimeter pans, Humphreys (1960) recorded evaporation of 3,100 mm p.a. at Dagahkured. Evaporation records for Hargeisa and Burao for the period 1958 to 1965 indicate that the mean evaporation recorded for Hargeisa was 2,947 mm (7 years' observations) and for Burao 3,601 mm (6 years' observations).

Infiltration

Infiltration is generally considered a minor component of the hydrological balance. Both the Hunt (1951) and Humphreys (1960) reports support this view. In Hargeisa, observations have shown that "even after exceptionally heavy storms in the soil recently contructed bunds seldom exceeds a depth of six inches; in virgin ground the deepest penetration observed did not exceed four inches" (Humphreys, 1960). Hunt (1951) and Hawes (1953) describe similar conditions in the Haud. Groundwater recharge of the water bearing fissures of the basement, therefore, occurs mainly in eroded areas by infiltration through faults, fissure and weathered rock.

C - SURFACE WATER

Open Surface Water Storage

The plateau and escarpment zones are favourable for the construction of dams and reservoirs. The basement complex is considered to be practically impervious and has suitable morphological and static condition for dam construction.

During the rainy seasons from March to May and from September to the beginning of November, reservoirs would be filled. Two small surface water reservoirs of 8 and 3 million gallons, were constructed in 1960 to impound runoff to be used for Hargeisa's water supply. Data on evaporation and silting have been collected for a few years.

Several sites have been indicated by A.J. Warden (1960) as suitable for dam construction. Catchments entirely in the escarpment appear to be more favourable because there is little or no topsoil. Humphreys (1960) considers that among the various dam sites investigated near Hargeisa "the most attractive possibilities are given by the Jikrile and Agamso Valleys. The two sites on the Hikrile and the upper one on the Agamso are all close together, and the favourable topography of the area, particularly in the vicinity of the upper sites on the two rivers, would permit the development of a combined scheme.

The catchment above the upper Jikrile site is approximately 117 square miles and it is estimated that the maintainable yield with a dam of a suitable height is not less than 1.0 million gallons a day".

Sub-surface Water Reservoirs- Storage in Tug Beds

The main problem in the plateau area is the silt content of the spates. This in due to severe erosion in the high catchment areas, overstocking, deforestation, and the high intensity of rain storms. The upper reaches of the main river courses are eroded gulleys which incise backwards from the main water courses.

The problem of the high silt content could be overcome by building silting dams or underground dams. Water could be stored in sand reservoirs which offer the advantage of reducing or eliminating evaporation losses and pollution problems.

The efficiency of sand reservoirs is strictly dependent on the grainsize of the sand accumulated in river beds. Some river beds in the plateau area appear suitable. Sand reservoirs would reduce considerably the fluctuation of water levels in these deposits, and irrigation development along tugs could be extended by pumping water from hand-dug wells or infiltration galleries.

State Flow Water Utilization

Most of the rainwater is at present lost by evaporation, run-off into the Gulf of Aden, and infiltration. Attempts have been made in Ber and El Berdaile to divert tug flow into cultivated areas. Experience from these two areas is available. Spate flow may be strongly recommended when certain conditions such as minimum silt and seaweed content are fulfilled. In Ber several negative factors, including silt and seaweed spreading, resulted in a heavy loss in 1972-73.

D - GROUNDWATER RESOURCES

Groundwater Occurence

Basement complex. This covers extensive areas of the plateau, escarpment and lowland area. It includes schists, gneiss, granite, etc. of pre-Cambrian age. Rocks are often foliated and f lted and crossed by numerous acid dykes. It is believed that most of the metamorphic basement complex is derived from sedimentary rocks and is

impervious. Experience has proved that boreholes drilled in this complex have given very poor results.Some positive results may be expected by drilling boreholes in the bottom of valleys or where better recharge of the joints or fissure system appears possible. Their yield would be, as in other parts of the world in similar conditions, from a few hundred to a few thousand litres per hour.

Jurassic.The basal part of the Jurassic suite consists of an arenaceous layer of the Adigrat formation. The arenaceous beds towards the top of the succession become calcareous and intercalated by thin limestone layers. This section is the passage to the overlying fossiliferous marine stratified limestone. The Jurassic cutcrops extensively in the Borana and Zeila districts in thick stratified sequences. It is mainly preserved in blocks, down-faulted in the high escarpment sector, and step-faulted in the lower areas towards the Gulf of Aden.

The Jurassic sequence appears to be the main aquifer of the Northern Regions, but its groundwater potential has not yet been evaluated

Most of the main springs in the Dur catchment emerge at the contact between the Jurassic and the impervious basement. The Adigrat formation at the base of the Jurassic marine suite is certainly a water bearing horizon where structural conditions are favourable for water storage. In El Berdaile several water wells have been drilled through the lower Jurassic marine sequence and the Adigrat formation. The latter proved to be the main water-bearing horizon in this locality.

In El Berdaile 10 boreholes have been drilled. Their exact locations are not known, but more probably not all of them were drilled in the Jurassic. A partial lithological log of well No. 5, the deepest well in the area, is preserved in the WDA office in Hargeisa. Its total depth is 296 ft, the recorded depth of the water level is 186 ft. The well was abandoned because a pump dropped into it. The partial log, from samples seen in WDP in Hargeisa, in as follows:

0 -100'	white to pinkish limestone
100 -120'	arenaceous limestone
120 -170'	no sample
170 -180'	hard grey limestone
180 -200'	coarse limestone (many secondary crystals of calcite)
200 -230'	fine to medium coarse sand of the Adigrat formation.

Water is reported to have been struck in sand at 234'. Six boreholes are reported to have been abandoned because of hard rock, three more were abandoned because of insufficient water or for "mechanical reasons". At present, only one well is working and is reported to yield little water.

Cretaceous. The basal Cretaceous overlying the Jurassic quite often consists of sand and argillaceous sandy beds, called Nubian Sandstone. In the plateau area the thickness of the Cretaceous suite is 300 - 350 m, but in the lowlands of the coastal area it may reach over 1,000 m. Both the Jurassic and the Cretaceous are largely preserved from erosion in the down-faulted areas with the basement. In the plateau it consists of a succession of sand and sandstone beds overlying the basement complex and is apparently in stratigraphic continuity with the Auradu limestone.

Cretaceous sediments were met in several boreholes drilled in Hargeisa, Gebile and Tug Wajale area. In Tug Wajale, 11 boreholes ranged from 202 to 435 ft, five were abandoned, were reported dry or yielded little water. Six were reported to have struck water, and of these the minimum reported yield was 180 GPH, the maximum 315 GPH. In recent years other boreholes were drilled, but no records exist of the latter. At present, there are only two working wells at Tug Wajale village, located on the bank of the river which marks the de facto boundary between Somalia and Ethiopia.

The lithological sequence in these drilled wells at Tug Wajale consists mainly of fine brown and yellow sandy clay, red sand, sand and pebbles in a clay matrix, and white quartz. In most wells, casing had to be driven down while drilling to stop caving in, and this caused a sealing-off of water-bearing horizons.Similar results were obtained in Hargeisa where, in attempting to solve the serious problem of the water shortage for the towns, the Nubian sandstone was tested. MacFadyan (1950) listed in his report 13 boreholes drilled at Hargeisa, 8 of which produced water. The deepest hole, 445', produced only 280 GPH. The maximum reported yield was 2,00 GPH from a 100' deep hole.

Deep boreholes were drilled in Hargeisa from 1958 to 1961; some of them were sunk to the basement in order to ascertain the total groundwater potential. The results were inconclusive. The maximum yield obtained is reported (Mason) to be 4,000 GPH: two boreholes, 1,100 and 960 ft deep, were dry. The successful boreholes proved to

be brackish (SO_4 600 ppm and Cl 1,200 ppm). Static water level is reported to be deeper than 700 ft.

The poor results obtained in Tug Wajale, Kalabeit and Hargeisa are due to the low permeability of the fine grained sediments of the Nubian sandstone. Furthermore, drilling difficulties, due to the unstable properties of this formation, did not permit normal development of the boreholes.

Tertiary and Quaternary formations. The possibility of extracting water from Tertiary formations is so far not known. Tertiary formations, both sedimentary and volcanic, are distributed mainly on the escarpment and on the lowland facing the Gulf of Aden. A few water wells were drilled in recent years in the Zeila-Bulhar Plain, for which no lithological logs are available.

MacFadyan (1950) reports that two wells were drilled in Silil in 1931 and 1939, in sands, pebble and sandy clay beds, and in coarse sandy clay layers of alluvial origin. The second well was sunk to 325', but "the hole plugged back to 225' and engine and pump installed. A pump test yielded an available supply of 1,200 GPH". Water was struck at 220'. Water quality is reported to be good.

MacFadyan (1950) also reports two wells drilled near Zeila, in 1931 and 1933. Wells Nos 1 and 2, drilled respectively to dephts of 242' and 292', in spite of being less than 100 yards apart, gave surprising results: Well No. 1 was salty and No. 2 was dry. Well No. 2 had Zhyolite at a depth of 292' from the surface.

A water well located at 20 km ESE of Zeila was drilled through volcanic rocks. The area between the lava plateau and the coast is underlain by sediments of Quaternary age varying from fine silty sands to boulder beds. The thickness of these sediments is not known, but it appears to increase towards the coast. These sediments rest on the volcanic formation which extends at least locally as far as the coast (Stock). In areas near the coast, groundwater was struck at approximately sea level, showing a very flat gradient of the water table towards the sea.

Both the lava sheets and Quaternary sediments of the Zeila plain have not yet been fully investigated; furthermore, the hydrogeology of the large adjacent Zeila-Berbera plain is still almost unknown.

Recent alluvial deposits. Alluvial deposits are located and restricted along the river valleys. The physical character of these alluvial deposits, such as grainsize, porosity, permeability, etc.,

TABLE N. 3

EXISTING BOREHOLES

Locality	District	Depth (ft)	Casing (in)	Output (gal/hour)	Water quality	Type of pump	Type of engine	Present condition
1. Warabale	Seylac	350	6	1,500	-	None	None	-
2. Sillil	Seylac	300	6	1,400	sweet	Electric Rotor	Slanzi	Fair
3. Kalloleh	Luchaya	274	6	1,500	"	Edeco	Lister 6/1	Poor
4. Adad	Seylac	470	6	1,500	"	None	None	-
5. Karroreh	Luchaya	350	6	2,200	"	Rotor	Slanzi	Fair
6. Jidi	Seylac	133	6	500	"	Edeco	Lister 6/1	Poor
7. Gebile	Gebile	60	6	1,500	"	Morrison	Lister SR2	Good
8. Tug Wajale	"	274	6	600	"	Edeco	Lister 6/2	Poor
Tug Wajale	"	270	6	400	"	Edeco	Lister 6/2	Poor
9. Eudka	"	427	6	1,000	semi-brackish	Edeco	Lister 6/2	Poor
10. Gedbalad 1	"	450	6	2,500	"	Peerless 52	Slanzi	Good
Gedbalad 2	"	462	6	2,500	"	Peerless 52	Slanzi	Good
Gedbalad 3	"	450	6	2,500	"	None	None	-
11. Kalabait	"	348	6	200 ?	"	None	None	-
12. Alibady	"	648	6	1,200	sweet	Edeco	Lister 5/1	Poor
13. Bebederwanak	Hargeisa	650	6	1,500	-	Edeco	Lister 5/1	Poor
Bebederwanak	"	655	6	1,500	-	None	None	-
14. Wada Makahil	"	820	6	1,100	sweet	None	None	-
15. Gumar	"	1,010	6	1,200	"	None	None	-
16. Salahaleh	"	1,030	6	1,200	-	None	None	-
17. Daragodle	Berbera	110	6	2,200	sweet	None	None	-

TABLE N. 4

SPRINGS YIELDING MORE THAN 1 l/sec

Spring name	Coordinate	Date	Yield l/s	Temp. °C	Specific conductivity µ/cm	Total dissolved soils ppm	pH	HCO_3 ppm	SO_4 ppm	Cl ppm	Ca ppm	Mg ppm	Na + K ppm	Remarks
1. Binendula	10°09'-45°08'		1.4	31	-	-	-	-	-	-	-	-	-	Riverbed
2. Biyo Gura	10°20'-45°15'	1/7/70	37.5	38-58	-	-	-	-	-	-	-	-	-	In valley, from gypsiferous rock
3. Bugada (Ilkore)	10°06'-43°21'	28/6/70	40-50	-	-	-	-	-	-	-	-	-	-	Riverbed
4. Dainal	10°34'-43°23'	2/7/70	13.2	31	2,375	1,616	7.1	586	67	482	128	116	198	Broad valley from cristalline rock
5. Dameryog	10°28'-43°05'	26/6/70	2.6	32	-	-	-	-	-	-	-	-	-	Riverbed
6. Barin	10°02'-45°10'	12/6/70	3.2	31	4,060	2,280	6.8	1024	462	937	96	145	329	Riverbed
7. Dubar	10°20'-45°05'	5/7/70	38.6	38-46	2,800	1,960	7.1	892	1193	710	128	29	1140	Steep slope at the base of sandstone
8. Dur Dur	10°09'-23°26'	29/6/70	5.8	-	-	-	-	-	-	-	-	-	-	Riverbed
9. Hul Xaboba	10°03'-45°06'	12/7/70	5	31	1,240	1,300	6.9	780	207	197	80	68	101	Riverbed
10. Kabri Bahar	10°19'-43°42'	2/7/70	37.5	32	-	1,500	-	-	-	-	-	-	-	Riverbed
11. Lafarug	10°03'-44°48'	5/7/70	1.28	35	2,990	4,760 ?	8.1	874	1172	1530	230	277	1092	Valley, from jointed cristalline rock
12. Lafanc rodi	10°00'-45°11'	12/7/70	6.8	33	920	648	7.1	683	121	71	64	38	213	From cracks of cristalline rock
13. Zaragale	10°09'-43°24'	28/6/70	8-12	-	-	-	-	-	-	-	-	-	-	Riverbed
14. Rural	9°45'-44°21'	22/6/70	2.3-4.5	34	3,850	-	6.6	413	795	195	194	340	1280	From cracks of cristalline rock
Biyodai	9°55'-44°20'	1958	2.25	-	-	2,670	8.1	223	547	840	162	169	-	From vesciculer lava
Dibrawein	-	1958	-	-	630	440	7.4	280	33	40	93	20	-	From limestone at contact with basalt

Source: Water resources inventory book, Office of the "Mineral and groundwater Survey", Mogadiscio.

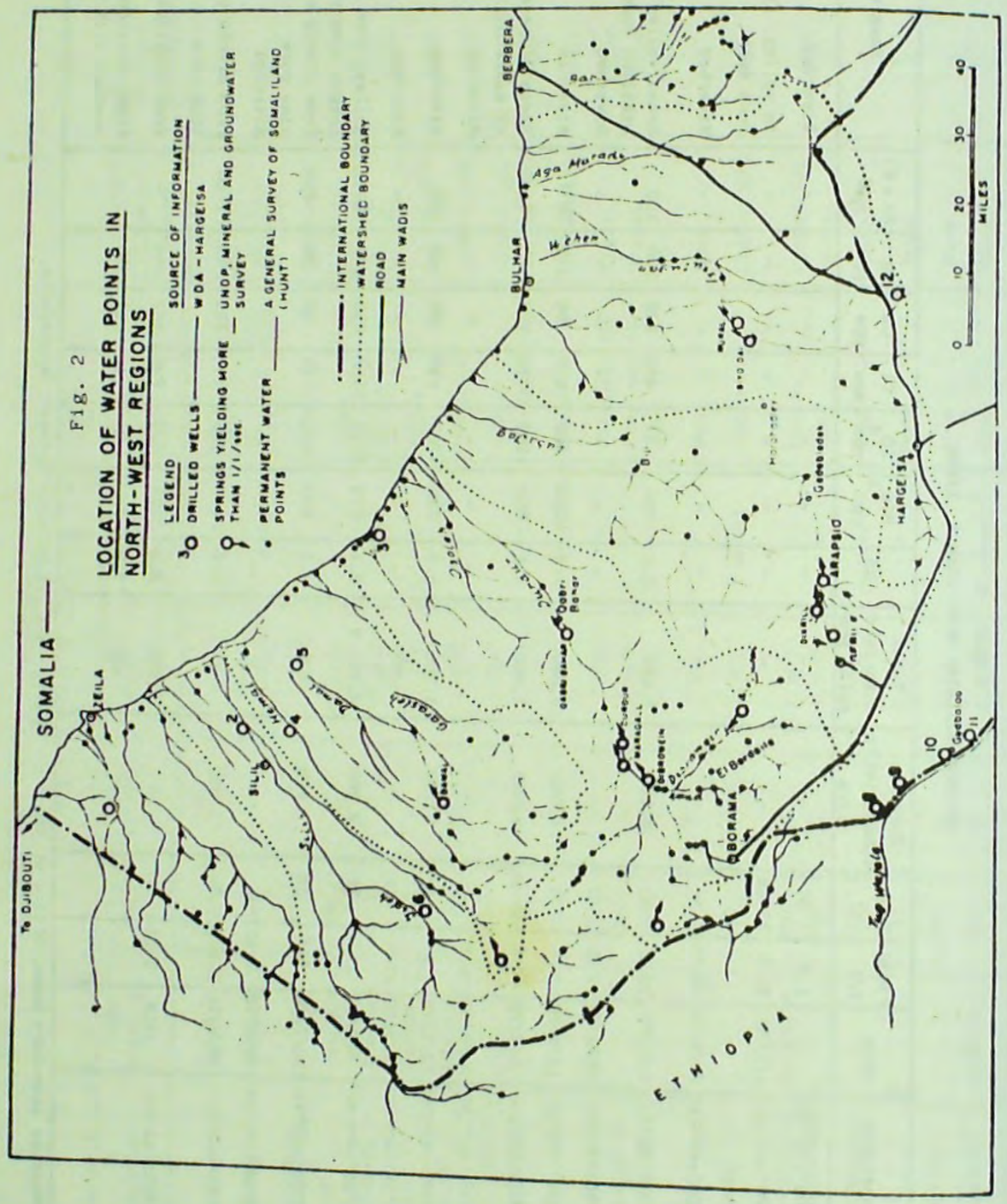


Fig. 2

are quite heterogeneous, both along their longitudinal profile and in depth. The underground flow occurring in these valleys constitutes the most economical exploitable underground water resources of the Northwest Region. Annex I indicates the areas presently irrigated, using underground "tug" flow, and provision is made to extend their exploitation.

D - CONCLUSION

Groundwater potential in the basement complex is very poor. It may occur in single fissures or in a system of fissures, or in sheer, faulted and weathered zones. The amount of water that can be tapped varies greatly over a short distance. Due to these difficulties, proper criteria are needed to site, test and construct successful boreholes. Because of the low yield obtained from the crystalline basement rocks, water wells sunk in them may be used mainly for human consumption and for livestock.

The groundwater potential of the Jurassic limestone seems to be good. Proper studies are required to locate its water-bearing horizons. The study of the geometry of this aquifer is very important as the Jurassic limestone has been crossed by faults which have displaced it in grabens. Dibrawein spring is reported (Warden, 1960) to be emerging "along a faulty plain where Jurassic limestone abuts against impermeable gabbro". The basal Jurassic sandstone acts as the main aquifer drained by this spring.

Boreholes drilled in Cretaceous Nubian sandstone have shown that this formation is unstable; water quality is generally poor and water levels are rather deep. Extraction of water from the Cretaceous appears uncertain and uneconomical.

The small amount of information available on Tertiary and Quaternary sedimentary and volcanic rocks in the coastal area is not sufficient to evaluate their groundwater potential and characteristics. Water quality problems may be encountered in drilling in the coastal area.

The best and easiest groundwater sources to exploit, so far known, appear to be the alluvial areas of the main tugs in their upper and intermediate sections. In these areas the sediments, recharged periodically by tug spates, may store a considerable quantity of fresh groundwater which could be used for irrigation.

The information regarding boreholes is scattered and often unreliable, most of it is contained in the report of MacFadyan(1950);

in past years, considerable borehole data has been lost or has not been collected. The information made available by the Water Agency to the author is reported in table 3. Borehole location is shown in Fig.2.

Numerous springs have been inventoried in the Northwest Region, most of then located in the northwestern part of the region. Their utilization is often negligible as most of the water disappears a few meters from the source, in boulder and gravel filling the beds of river courses. At present only a very minor amount of water from this valuable source is used for agriculture. The location of springs yielding more than 1 l/sec is shown in Fig. 2; their chemical characteristics are reported in table 4.

A programme aiming at developing these interesting and promising cheap water sources 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 a plan for their full exploitation can be implemented.

Annex I

PRESENT IRRIGATION IN THE NORTH-WEST REGION

Background

1. The irrigation of small areas by means of pumps has started only in recent years. The Somali Government's policy is to help farmers by giving technical assistance and, in many cases, pumping equipment.

2. The main areas at present irrigated are in small alluvial valleys, at the headwaters of the main tugs, in the Hargeisa, Gebile, El Berdaile, and Borama areas. Most of the farms grow citrus fruits and vegetables.

Present Irrigation

3. All the currently irrigated areas receive water by pumping either from shallow hand-dug wells, or from springs. A typical well consists of a large excavation, up to 10 m in diameter, in the banks of tugs; water is pumped into the upper end of the main channel and then led by gravity over the farm.

Arapsiyo

4. In Arapsiyo most of the hand-dug wells are square-shaped, with sides from 1.50 m to 3.00 m. Depths range from 4 to 9 m. The top of each well is protected by a rim made by part of the excavated material, and a small stair usually connects the surface with the lower part, where a pump is installed. Only the bottom part of the well has a stone wall for protection.

5. Most of the wells are sunk in red sandy clay alluvial deposits which grade into coarse sands with gravel towards the bottom. Other wells, situated 400 to 500 m from the river bed are dug in the alluvial and weathered part of the Nubian sandstone, and are recharged by alluvial deposits. Well yields vary from place to place. Some 50 "gardens", varying in size from 1 to 2 ha, are reported to exist in Arapsiyo. The most common motor pumps are 2 to 2.5 hp.

Horohadley and Gedeblede

6. Some farms are reported to exist in Horohadley on the Las Dorai tug, growing coffee, oranges, grapefruit, etc. Hand-dug wells are 4

to 5 m deep with diameters varying from 3 to 6 m. Because of the poor yield of these wells, most farmers have two pumps in two separate wells, which are pumped alternately, twice a day for 4 to 5 hours. The farmed areas are near the confluence of two tugs. The Gedeblede citrus multiplication center and the adjoining farms also obtain water for irrigation from the tug bed by means of pumps.

Amhud

7. At Amhud, about 4 miles west of Borama, some 13 gardens are reported to be irrigated by pumps installed in hand-dug wells. These wells, 5 to 6 m deep , are not lined and often need to be cleaned out after heavy rains. They are excavated in sand, gravel and boulders with high permeability. In fact, only a small drawdown occurs while pumping. The two large waterholes in a farm at Amhud are equipped with two big pumps, with a 4" suction pipe and a 5.5 hp motor. They are reported never to dry out despite prolonged pumping and although they are only 10 m apart.

8. In Amhud, groundwater potential is good, but soil conservation works are urgently required, both to protect the existing farming area and to irrigate new areas.

Dibrawein and El Berdaile

9. The Dibrawein spring, reported to yield 100 l/s in the dry season and 1,500 l/s in the wet season, is at present only partly used for irrigation. Kat is the main crop. From the tug, water is diverted by a canal; a pump lifts the water from a lower to a higher canal.

10. The El Berdaile citrus farm is irrigated with perennial water from a minor tug. Water is led into a small pool where a low-capacity pump is installed. The yield of the permanent flow was 1 to 1.5 l/s at the time of the mission's visit. Small hand-dug open wells in the tug bed are also used for irrigation with small pumps.

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