PN-AAP-551

Tunisia

Small scale hydro potential: A fact finding visit

NRECA Small Decentralized Hydropower (SDH) Program

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Small scale hydro potential: A fact finding visit

by David R. Zoellner

December 1981

Sponsored by the United States Agency for International Development under Cooperative Agreement AID/DSAN-CA-0226
9365115

Small Decentralized Hydropower (SDH) Program
International Programs Division

National Rural Electric Cooperative Association (NRECA)
1800 Massachusetts Avenue NW, Washington, DC 20036

Small decentralized hydropower program

This publication is one of a series that fosters the effective use of small decentralized hydroelectric power systems. The series is published by the Small Decentralized Hydropower (SDH) Program, International Programs Division, National Rural Electric Cooperative Association (NRECA). NRECA operates the SDH Program under the terms of Cooperative Agreement AID/DSAN-CA-0226 with the Office of Energy, Science and Technology Bureau, U.S. Agency for International Development.

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Small and mini-hydro potential in Tunisia

Introduction

A meeting between Samuel E. Bunker, Administrator, International Programs Division (IPD) of the National Rural Electric Cooperative Association (NRECA) and USAID/Tunis staff, chiefly the Mission Director, Martin Dagata and Richard Stevenson, Science and Technology Officer took place at Tunis in August 1981. This meeting was a follow-up to a request* from the Mission for information on NRECA capabilities and ways to access that assistance for Tunisia. Mr. Bunker explained the two USAID-funded programs at NRECA and the general capability of NRECA in rural electrification and renewable energy. As a result of this meeting and of continuing interests at the Mission for assistance, a request was cabled to USAID ST/EY for assistance in evaluating the potential in Tunisia for the development of energy from wind, solar ponds and mini-hydropower.

Two teams were sent to Tunisia. In October, Mr. Carl Aspliden, U.S. Dept. of Energy and Mr. John Kadyszewski, Solar Energy Research Institute (SERI) examined wind resources. In December, Dr. David Zoellner, NRECA and Dr. Michael Edesess, Flow Industries (formerly with SERI) examined the resource potential for the development of mini-hydropower and solar ponds, respectively. Dr. Zoellner also determined whether there was any interest in the Government of Tunisia (GOT) for assistance with electric cooperatives or other management aspects of rural electrification. The purpose of these fact finding trips was to determine where the resource potential in Tunisia warrants sending teams to conduct more thorough assessments of these resources.

Generally speaking, there exists some limited small and mini-hydropower resource in Tunisia. The chief source of this potential are existing barrages and others that are either in the planning or construction stage. Other regions of the country may have some small seasonal potential just south of the Dorsal. Another limited region with likely potential is that north of the Oued Medjerda, where flows tend to be year-round. This report documents this potential and suggests a practical approach to more clearly assess this resource.

Funds for Dr. Zoellner's trip and for the preparation of this report were provided by the NRECA Small Decentralized Hydropower (SDH) Program, via a USAID centrally-funded Cooperative Agreement.

*Of particular interest to the author(s) of this communique were the topics of cooperatives, wind energy and mini-hydropower.

Contacts

Discussions were held with both Mission staff and GOT staff.

For USAID--

Mr. Richard Stevenson--Science and Technology Officer who provided general orientation, support assistance and facilitated our efforts where possible. Source of information for the upcoming Energy Planning Project and the electrification of Hamman Biadhaf with photovaltaics (PV), a project underway.

Mr. John Fligenger--Agriculture Development Officer who provided an overview of agriculture--crops, processing, transportation and attendant population distribution as well as a review of surface water resources in Tunisia.

Ms. Saida Zouitem--Assistant Science and Technology Officer who provided extensive assistance with various appointments, arrangements and general information.

Mr. Salah Mahjoub--Assistant Food and Agriculture Officer who provided background on agriculture in Tunisia and on government management of water resources.

For GOT--

Mr. Ali Ben Ahmed--Director, Energy Task Force, Ministry of National Economy (MNE) who accompanied author to sites, discussed energy picture in Tunisia and was generally helpful in providing background regarding Tunisia.

Mr. Horchani--Director, Grands Traveau Hydraulique, Minister de l'Agriculture who provided maps and information on surface water resources, particularly helpful on details of selected barrages in Tunisia, existing and planned.

Reports. A number of reports available at the Mission were reviewed. Unfortunately, none dealt specifically with small or mini-hydropower, although they were helpful in other topic areas. A reading list of these documents is attached (see appendix A).

Sites visited. Attached (see appendix B) is a listing of sites suggested by the staff at Genie Rural as those with some potential for installation of hydro facilities. Those suggested sites already generating power, presumably have potential for uprating.

Two sites were visited. The first was a water supply and irrigation reservoir under construction, to be completed in 1985. The site name is Djoumine, on the Oued Djoumine, 3 to 4 Km from Mateur (Matir on map, see appendix C). Water is to be supplied to both Mateur and Tunis. Supply for irrigation will be on an as-needed basis. The guaranteed flow is 74,000,000 m^3/yr or an estimated 3,807 ft^3/min. and the head is 50 m (162.5 feet). A large conduit will transport the water through a series of "breakers" for dissipating the energy.

The second site was north of Kairouan (Al Qayrawan--see appendix C) at Barrage Nebhana, an existing irrigation reservoir supplying the Sousse area, with many take-offs enroute. The guaranteed flow is 2.3 m^3/sec. or an estimated 3,726 ft^3/min. and the head is 60 m (195 feet). A long conduit transports the water again through a series of "breakers" for dissipating the energy.

Although there was one more candidate site that we would pass on our return to Tunis (Bir M'Cherga), time and the press of other business did not permit us to visit there.

Both sites visited suggested a type of potential which may exist at other sites in Tunisia. Power production should be achieved by installing one or more turbines at one or more "breakers" in the conduit at these sites. At Nebhana, for example, just such a scheme was designed (680 kW) for installation at the first "breaker" but not implemented due to lack of funds. This scheme is detailed in a 4-volume report, Nabhana Usine--Hydroelectrique, which was borrowed from the Operations Manager onsite.

Small hydro contribution. The listed barrages (see appendix E) that exist or are under construction with potential for hydroelectric power generation could produce an estimated average of 500 kW each. If six of these sites are developed, this would result in a total of 3,000 kW or 3 MW additional capacity for Tunisia. It is assumed that several barrage sites are near towns and most are close to the grid. Power developed at these sites could either be grid-connected to enhance system reliability (in Beja, for example, where the author witnessed several outages during an overnight stay) and to help handle the peaking demand--a serious and growing problem in Tunisia. The existing installed capacity of Tunisia is approximately 1,500 MW of which hydropower, at 29 MW comprises less than 2%. Therefore, 3 MW in that context would be small, albeit important, as just stated. Another important use of the power generated from these barrages would be for local productive consumption--agricultural purposes: irrigation pumping, processing, etc. Many of the sites are located in agriculturally active areas. The reader should bear in mind that 3 MW (from developing 6 sites), or 10% of the existing hydropower capacity is only an estimate, consistent with the stated purpose of the trip. Any follow-up team activity would more clearly refine this estimate.

3 Activities

Finally, in subsection--Other factors--the author has attempted to reflect six factors which are important considerations for developing and using power from decentralized hydropower.

Economy

Natural resources in Tunisia are oil, phosphates, iron ore, lead and zinc.

Agricultural products are wheat, olives, citrus fruits, grapes, truck crops, fish and the estimated percentage of GNP is 20.

Types of industry are crude oil, phosphates, olive oil, textiles, construction and the estimated percentage of GNP is 30.

Climate

The Tunisian Dorsal, orientated southwest-northeast, ends in the Cape Bon peninsula. Composed of small low chains separated by broad north-south passes and inland basins, it marks a climatic limit between the northern Mediterranean-type regions of the country and the much drier southern regions with Saharan characteristics.

Maritime Tunisia is warm all year-round, with little difference in temperature and enough rainfall for sedentary agriculture. Inland Tunisia is much more arid, with wide daily and annual temperature extremes, the largest being recorded in the south in Gafsa region.

In the winter, the north is within the temperature zone depressions and receives rain from the north and northwest winds. The often violent Mediterranean rainstorms suddenly make the oueds (wadis) overflow and cause heavy soil erosion, especially on the deforested hillsides. North of the Dorsal, average rainfall is always above 400 millimeters (mm), the highest regions being the wettest. South of the Dorsal, rainfall suddenly drops below 300 mm and the southern regions have a near-desert climate.

On the eastern coast, thanks to maritime influences, the Sahel enjoys a milder climate, with at least 300 mm of rain and heavy dew during most of the year. In general, even in the north rainfall is irregular from year-to-year, the variations increasing as one moves south.

In summer, Tunisia is dry. The 400 mm isohyet, which follows the Tunisian Dorsal, marks the southern limit of cereal cultivation and defines the region where agriculture is the predominant occupation. This is the Tell region, where the marle clay soil is, in general, favorable for crops. Because of the aridity south of the Dorsal, the soil rapidly becomes thin and increasingly sandy as one approaches the desert. This southern area constitutes the steppe, where nomadic herding is predominant,

crops becoming very subordinate and risky. The appearance of palm groves at the 200 mm isohyet marks the northern limit of the desert.

Attached to this report (see appendix D) are isohyets for Tunisia, shown on a map, Normales Pluviometriques Annuelles, 1931-1960. This map shows the concentration of rainfall above the Dorsal. It is of interest to note approximate U.S. equivalencies (in terms of total rainfall) for some Tunisian cities.

Rainfall	Tunisia	U.S.
1500 mm	Ain Drahan	Miami, Florida
1200 mm	Tabarka	Washington, D.C.
700 mm	Bizerte	Corpus Christi, Texas
500 mm	Beja	Spokane, Washington
400 mm	Tunis	Los Angeles, California
200 mm	Gafsa	Phoenix, Arizona

Water resources

A large part of agriculture is sedentary, however efforts to increase the amount of land under irrigation are increasing. Surface water resources are also developed for water supply to cities. By far the largest source of water for mining, industrial processing and domestic supply for small towns is ground water. Ground water is also used for irrigation. Approximately 60,000 shallow (less than 50 m) wells pumped almost 400 million m^3 in 1980.* The distribution of these wells follows the rainfall pattern in Tunisia.

Little of Tunisia's water resources are developed for hydropower. To the author's knowledge and based on an interview with Genie Rural staff, there are two sites--Nebeur (13 MW) and El Aroussia (3 MW) that exist and one--Sidi Salem (25 MW) under construction. The USAID Project Paper (Energy Planning Project) states that there are 29 MW of installed hydro capacity. The latter source prevailed in the author's calculations.

Energy

The following comments are taken from information contained in the Gordian report (see Reading list, appendix A).

Hydropower currently supplies less than 2% of the electricity generated in Tunisia. In 1975 the fossil fuel breakdown for

*Division des Resources en Eau. 1980 Situation de l'exploitation des nappes phreatiques.

electricity generation is 46% petroleum-based and 54% natural gas. In energy consumption the overall trend is a 10% per year increase in demand for petroleum products. Because of anticipated imports from Algeria there is a potential for natural gas, currently under 10% of all primary fuel consumed, to increase to 30% of the primary fuel consumed.

It is interesting to note that in the following table the approximate value for non-commercial fuels (mostly wood and vegetation) is relatively high.

Energy sources	Percentage
Petroleum products	56.3
Natural gas	0.8
Town gas	0.4
Purchased electricity	4.1
Solid fuels	4.6
Non-commercial fuels	33.8

There is already a danger of severe environmental damage to forest areas through indiscriminate removal of increasingly scarce wood for fuel use. In addition, the rural household sector may turn increasingly to commercial fuels such as bottled gas posing problems of fuel supply.

Other energy-related points have to do with the agriculture and industry sectors. Agriculture represents less than 7% of the overall national energy consumption, but as noted above, is a major contributor (approximately 20%) to the GNP. Industry represents 33% of the national energy consumption, consumes half of the electricity generated by the Tunisia Gas and Electricity Co. (STEG) and uses approximately 57% of the total electricity consumption, generating a significant portion itself.

Other factors

There are a number of factors gained through document review, conversation and observation that have some bearing on small and mini-hydropower--

1. Emphasis in the World Bank analysis of the 5th 4-year plan for Tunisia on--

The importance of irrigation

Need for rural power source to provide heat at night for green houses (for winter crops), infirmaries, crop drying

Need in interior Tunisia for the development of more valuable products--beans, tomatoes, melons, peppers and the development of truck garden scale operations

Need to develop power sources for agricultural processing, consistent with GOT wish for value added agricultural products

Need in the government to decentralize (1) management functions, (2) finance, and (3) development programs suggests a trend toward stronger regional and local management.

2. Availability of the Regional Development Fund (allocated to Regional Governors to develop programs designed to decrease the flow of people from rural to urban locations) to help finance the development of small and mini-hydro systems.

3. Besides agriculture, the existence of rural activities of mining and cottage industries with potential for productive use of energy.

4. Potential for seasonal use of power (provided winter farming can be developed) to coincide with seasonal rainfall.

5. Given a past history of waterwheel use (not a widespread practice, however) there is a potential for--

Retrofitting existing sites for mechanical or electrical power

Local fabrication of waterwheels.

6. Given the relative health of the private sector (30% of GNP), and its own generation of a substantial amount of electricity, there is a potential for private development of power (to be purchased by STEG or sold direct to municipalities, farms, etc.) as long as the government provides proper incentives, such as the U.S. example in the Public Utilities Regulatory and Policy Act (PURPA) requiring utilities--public and private--to purchase power, at an avoided cost.

Government management responsibilities

Water

For groundwater, no permit is required for wells up to 50 m. For wells deeper than 50 m, DRES, the Water and Soils Department of the Ministry of Agriculture decides on a case-by-case basis. The Engineering Department of the Ministry of Agriculture carries out studies on hydrology and hydrogeology and also maintains flow stations.

For water supply, SONEDE, the national water supply company provides water to villages with populations over 300. For populations under 300 Genie Rural is responsible for development and distribution of water supplies.

For agricultural use, the Ministry of Agriculture is responsible for irrigation, barrages and wells, hand-dug or drilled.

For industrial use, SONEDE is responsible for water supply in urban areas and Genie Rural in less populated areas.

For hydropower use, surface water development is controlled by the Ministry of Equipment (civil works) and power development by the MNE via STEG. Equipment design, construction, etc. are coordinated between the two ministries.

For large water resource projects, the Ministry of Equipment via the ONAS builds and develops the facilities for such projects as waste treatment and via the Director de Gran Traveaux for projects such as large reservoirs. On these projects coordination with the Ministry of Agriculture is carried out at all levels. Multiple use questions and conflicts of interest, e.g., hydropower vs irrigation vs water supply--who has priority and when is apparently worked out by "Commission."

Power

STEG has the authority to generate, transmit and distribute power in Tunisia. Rural areas receive 220v 50 Hz 1Ø (high cost problem with 3Ø equip.), power distributed at 30 kv and 5.5 kv. Tariffs for rural power are the same as for urban power.

STEG has four regional districts--Tunis, Northwest, Sfax, and South. These districts are autonomous, but make an effort to coordinate with headquarters in Tunis. Each district office has a department head, with a B.S. or M.S. degree in engineering, several engineers with five or six years experience in distribution and one or more survey groups made up of engineers and technicians.

STEG is apparently involved in promoting rural electrification. The office of the governor receives a request (presumably from a village), the office contacts STEG, who makes a feasibility survey and, if feasible, partially subsidizes the hookup at 100 Dinars per customer. The rest is paid for with Rural Development Program funds from the governor's office.

Cooperatives

Tunisia has a relatively recent history of cooperative formation. Following independence in 1956, much of the land held by the "colonists" was turned over to the people. Government-supported cooperatives on much of this land were developed for agriculture. These cooperatives have largely failed. The two reasons most often given were--

Members did not trust management
Tunisians are not "team players;" they are too independent.

There is a belief in some Tunisians interviewed that, after an appropriate "cooling off" period, cooperatives could work, but

without so much government intervention, with better organization and in areas other than agriculture--transportation and credit, for example. Not all cooperatives are the same; rural electric cooperatives are different in many ways from, for instance, agricultural cooperatives. It is felt, however, that STEG would be strongly opposed to electric cooperatives and there does not appear to be any other potential base of support for development of electric cooperatives in Tunisia.

Some agricultural cooperatives still exist in parts of Tunisia. A formal evaluation of the cooperative experience in Tunisia, from the early sixties to date with successes, shortfalls, lessons learned, and appropriate recommendations does not appear to have been done. Such a study would seem to offer substantial insight not only into Tunisia society, but also suggest opportunities for further economic development.

Conclusions

There is limited potential in Tunisia for the development of small (greater than 1 MW) and mini-scale (100 kW to 1 MW) hydropower. For example, retrofitting 6 barrages to generate 500 kW, each would add 3 MW of capacity.

Geographically, the greatest potential exists in the northern portion of the country, the area with the greatest rainfall, north of the Dorsal (400 mm isohyet).

Sites with the greatest potential appear to be barrages developed (or under development) for irrigation and/or water supply.

Potential mini-hydropower sites with year-round flow may exist in the extreme northwest corner of the country, which should be surveyed for same.

Potential end-use of the energy ranges from grid connection to agricultural operations to cottage industries to industrial processing to domestic uses and public facilities. The type and method of use will depend on the location of the user to the grid, to the resource, the use to which the power is put and the financial and technical resources available to the user. Generally, the use would be for agricultural and domestic purposes.

There appears to be a long history of government-supported programs to develop cooperatives, agricultural types, in particular. These cooperatives have had many difficulties. Based on conversation with representatives of MNE and STEG, there does not appear to be any GOT interest in developing rural electric cooperatives at this time.

Recommendations

For USAID/Washington--

Reach a timely decision regarding whether or not to provide ST/EY funds for further small hydro study in Tunisia

Recognize the potential for developing a methodology (retrofitting conduits at "head breakers") for use at many other similar sites in many other developing countries and involve the SDH Program of NRECA in this activity.

For USAID/Tunisia--

Encourage the GOT to go forward with a more detailed study of the limited small hydro potential

Assist the GOT in securing funding for not only a further, more detailed small hydro feasibility study and methodology development, but also for site development.

For GOT--

Go forward with a survey of potential small and mini-hydro sites.

The scope of the follow-on study would be conducted in three parts.

Part 1. Conduct preliminary investigations in U.S.--at NRECA headquarters (if NRECA is chosen to carry out the study)--developing detailed plan for study (schedule, contacts, etc.), outlining methodology to be developed, receiving background briefings from NRECA, USAID and other relevant development agency staff and reviewing relevant maps, documents and reports.

Duration	1 week
Location	Washington, D.C.
Level of effort	2 person-weeks
Products	Draft plan of action, draft methodology

Part II. Meet with mission staff and Tunisian government representatives to discuss plan and methodology, work out local travel, briefing, etc.

Read background material--reports, documents, etc., and pick up necessary maps.

Visit Nebhana. Review hydroelectric report (ref. above). Conduct onsite analysis as per draft methodology resulting in an updated feasibility for retrofitting the Nebhana site. The report will also include appended details on--

Equipment specifications
An end-use plan
Options for system management

Collect information on other barrages in Tunisia and determine those with likely potential for retrofit. Visit one or two of the most likely and--

Determine onsite the extent of the potential

Check the methodology to make certain the approach can be used at other sites

Recommend a plan of action suitable for use by GOT staff to apply the methodology at all other relevant barrages in Tunisia.

Duration	4 to 5 weeks
Location	Tunis and field sites (Nebhana and 2 others)
Level of effort	8 to 10 man-weeks
Products	Feasibility report on Nebhana, refined methodology, plan of action (to apply methodology at other sites in Tunisia)

Part III. Visit areas with seasonal potential for power generation (due to stream flow resulting from seasonal rainfall). Consider sites with potential for new site development and productive end-use associated with winter crops--irrigation, heated greenhouses, processing, etc. Give particular attention to appropriate agricultural areas in the 400 mm isohyet zone. The potential may be mechanical or electrical and the scale is under 1 MW.

Duration	1 to 2 weeks
Location	Field sites in Tunisia
Level of effort	2 to 4 man-weeks
Products	List of sites with brief descriptions of potential for development

Naturally, all products of this survey would be in draft form and would be finalized back in the U.S. before forwarding to the GOT.

Assumptions, costs and candidate barrages for examination are all contained in appendix E.

Gordon, Morton, Wm. Schaffer and James D. Westfield, 1979.
"Tunisia renewable energy project final report
(Contract AID/DSAN-C-0059)"

N. Saad, 1980
"TUNISIA - renewable energy"

Abed, Bassam, et al. 1980
"Background document for the rural extension and outreach project for Central Tunisia," Country Report No. 3
Contract No. AID/DSAN-C-0060.

World Bank, 1977
"Tunisia: Economic position and prospect of Tunisia; Review of the fifth development plan, 1977-1981." Special economic report.

La Macchia, Linda, et al. 1967
"Rural life in Tunisia: Summer observations," International report 1. Harvard University research project in North Africa.

USAID, 1981.
"Project paper: energy planning project," pp. 664-0326.

H. Zebidi, 1980
"Bilan des Resources eu Eau," Rep. Tun., Min. de Agriculture, Dir. de Res. en Eau et en Sol, Div. des Res. en Eau.

B.G. Tunnah, 1980.
"An Assessment of the Current Energy Situation in Tunisia."
Gordian Consulting Services, Ltd., London.

Sites (from Genie Rural)

Nebhana

Status = exists
Purpose = irrigation
Q = 2 m^3/sec. (est. 3,240 ft^3/min.)
H = "breakers" for dissip. energy = 60 m head long conduit

Jourmine

Status = under const. (com. in 1985)
Purpose = water supply and irrigation
Q = 74,000,000 m^3/yr (est. 4,121 ft^3/min.)
H = 50 m

Sejnane

Status = soon to be under const. (com. in 1988)
Purpose = flood control and irrigation
Q = Phase I - 85 x 10^6 m^3/yr (est. 4,377 ft^3/min.)
Upstream Phase II - 150 x 10^6 m^3/yr (est. 7,727 ft^3/min.) add'l

Birm Cherga

Status = exists
Purpose = flood control and irrigation
Q = 25 x 10^6 m^3/yr (est. 1,282 ft^3/min)

Sidi Salem

Status = under construction
Purpose = power (25 MW)
Q = 500 x 10^6 m^3/yr (est. 25,756 ft^3/min.)

El Aroussia

Status = exists
Purpose = power (3 MW)

Nebeur

Status = exists
Purpose = power (13 MW)
Q = 150 x 10^6 m^3/yr (est. 7,727 ft^3/min.)

Cap Bon

Status = exists
Purpose = irrigation

Bezik

Status = exists
Purpose = irrigation

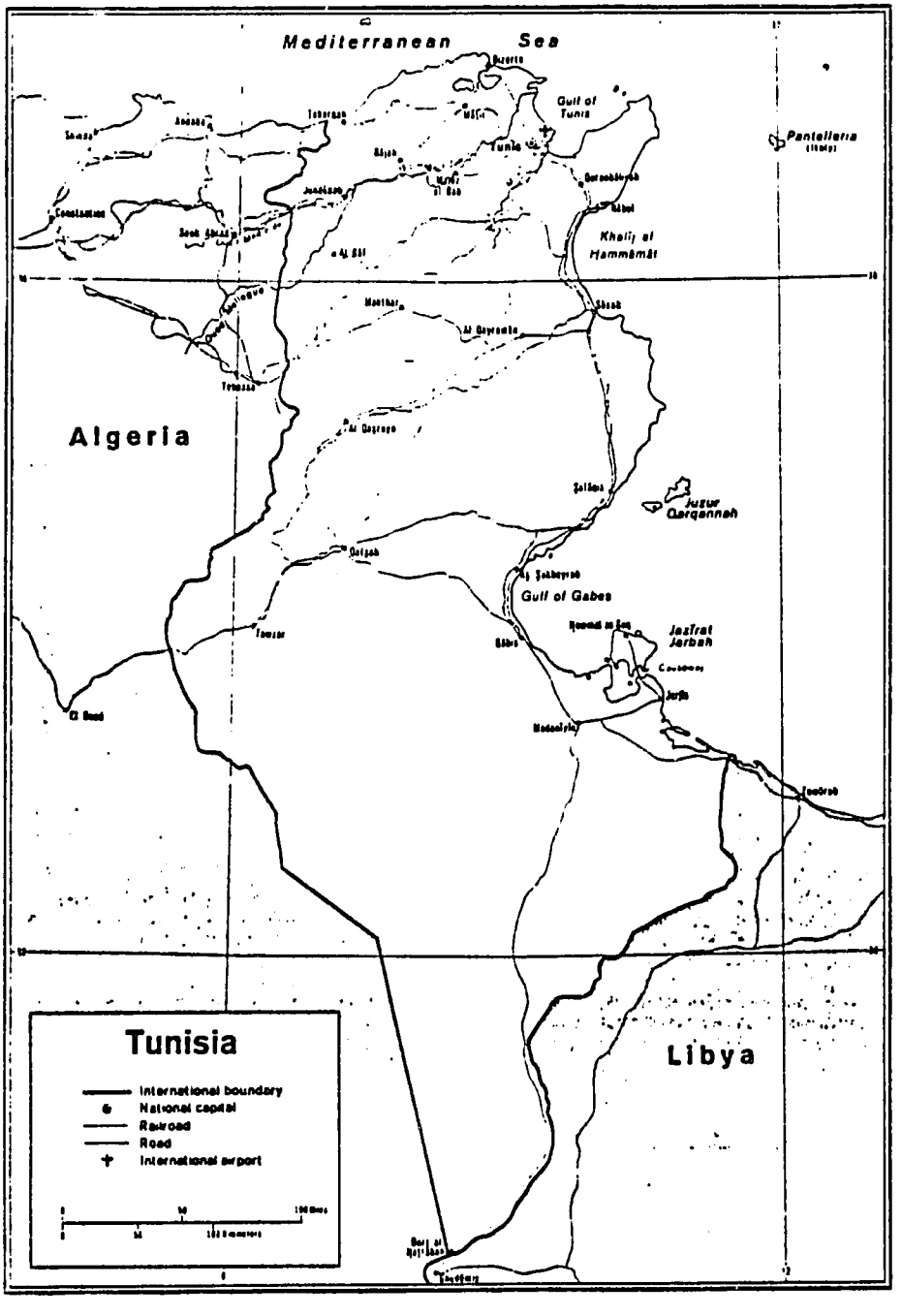
Chiba

Status = exists
Purpose = irrigation

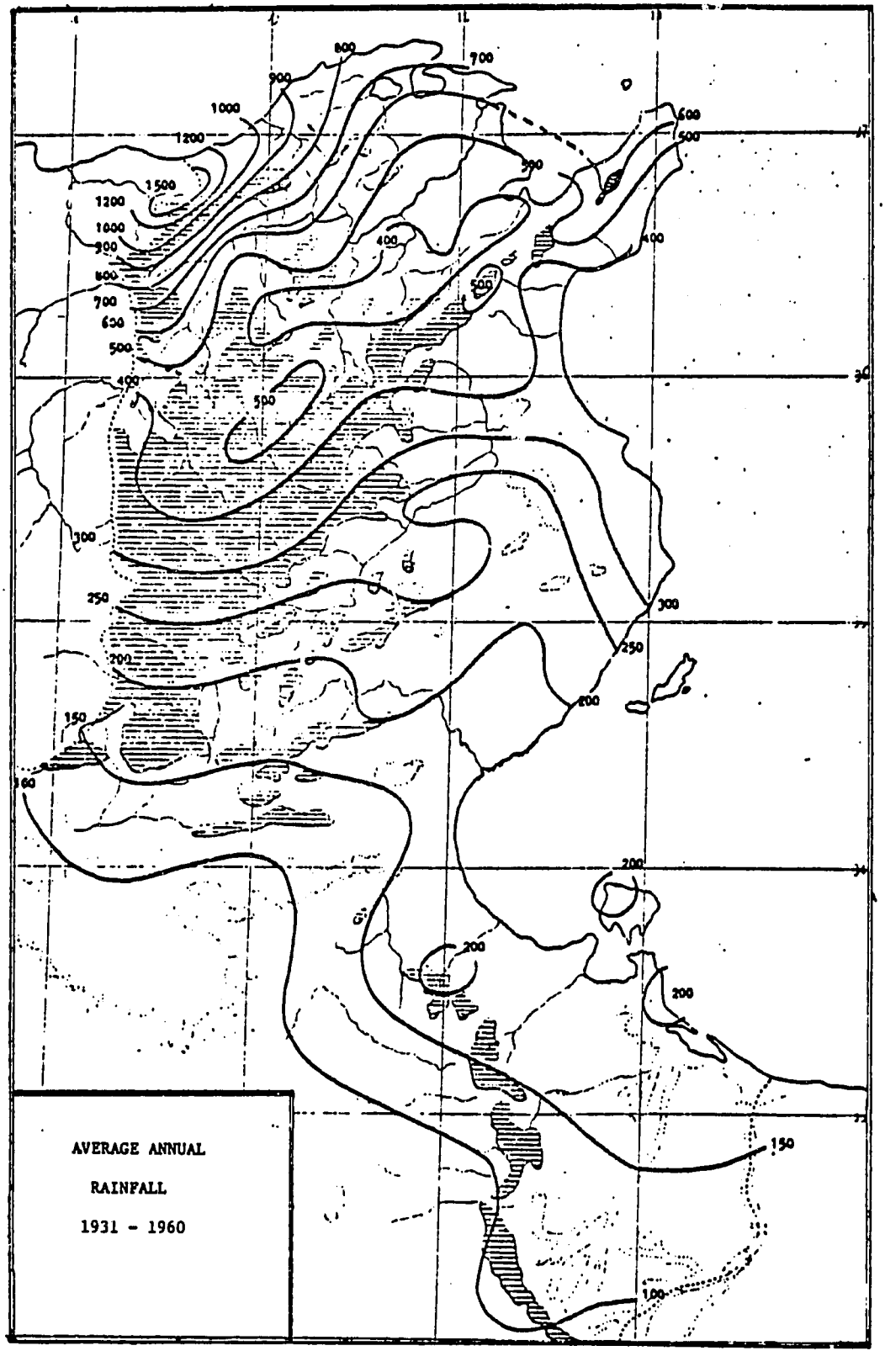
Masr

Status = exists
Purpose = irrigation

Appendix C


Mediterranean Sea
Gulf of Tunis
Pantelleria
Khalij al Hammāmāt
Algeria
Jazīrat Qarqannah
Gulf of Gabes
Jazīrat Jarbah
Libya
Tunisia
International boundary
National capital
Railroad
Road
International airport

Appendix D



Appendix E

Cost estimate of reconnaissance study

Cost

1. Rates

$220/day - 6 days/week
$1,700/per traveler (international)--estimated
$70/day, per diem--Tunis, $50 elsewhere
Local travel to be provided (?)--estimate $25/day

2. Fee	Six weeks	Eight weeks
$7,920/per x 2	$15,840	$21,120
Travel (international) $1,700/per x 2	3,400	3,400
Travel (local $500/per x 2	1,000	1,333
Per diem $1,680/per x 2	3,360	4,480
	$23,600 *	$30,333 *

Specialists

Small of mini-hydropower engineer
Development economist

Sites (taken from Genie Rural map and attached list). Candidate barrages are--

1. Planned--

Sidi Barrak--Oued Zougra
Belif--O. Belif
Madene--O. Madene
Zarga Kebir--O. Ed Deba

2. Under construction--

Djoumine--O. Djoumine

*This amount does not include overhead or fringe charges.

3. Existing--

Sedinane--O. Sediane
Ghezala--O. Ghezala
Bou Heurtma--O. Bou Heurtma
Melleque--O. Melleque
Bir M' Cherga--O. Meliane
Nebhana--O. Nebhana
El Kebir--O. El Kebir
Masri--O. Masri
Chibi--O. Chiba
Bezirk--O. Bezirk
Lakhmess--O. Tfifila
Beni M'Tir--O. El Lil

Level of effort. The level of effort of this survey should be--

Two people for 6 to 8 weeks, e.g., 12 to 16 man-weeks.