Water Transfer and Distribution Schemes

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I. INTRODUCTION

1. The Middle East is the region that is facing the most serious water problems in the world. There are several reasons for these problems: The very limited availability of water in the desert to semi-desert climate; the rapid population growth; the high cost of developing new sources of water; and the tensions between countries preventing cooperations in the water sector.

2. The most arid regions in the world are North Africa and the Middle East and, in addition, some parts of southern Africa, South America and, of course, Australia (Figures 1 & 2). While the low rainfall in these areas is the most obvious reason for the water shortages, the phenomenon which causes the most difficult problems is the inter-annual variability of rainfall (Figure 3): the irregularity of the rains which are typical for desert regions are, of course, the reason for the frequent droughts. During the past twenty years, two very severe droughts have hit the Middle East and Africa, the most recent drought ended only during the past winter. Such droughts represent, of course, serious risks to water resource planners and managers.

3. Population growth is causing concern in many countries, but the growth in the Middle East, especially in Israel and in Jordan, is creating unusual problems to the governments. Population growth rates in most Middle East countries are above

world averages, thus increasing the water demand faster than in other regions where more water is available.

4. In the Middle East, the limited water resources have been developed and exploited for a long time. What is left for development today is much more expensive than the construction of water development works in previous years. Perennial streams are being used, more economic dam sites have been developed, the shallower groundwater is being exploited or has been exhausted. Thus, only the more expensive technical options are left: costly reservoirs, deep aquifers, desalination plants, which will increase the cost of water substantially. But capital is scarce and costly. The worldwide demand for capital is increasing, and the Middle East is facing the competition of the former socialist countries which appear to attract most of the attention in recent years.

5. Although there is some hope that political tensions in the Middle East may abate, real international collaboration in the water sector does not exist. The Middle East is still one of the regions where serious conflicts are threatening peace. Seen together with the problems of water availability, population growth and the high cost of capital, the Middle East appears to be area where water problems are more severe than anywhere else.

II. TECHNICAL SOLUTIONS

6. Where water is needed, solutions have been sought to bring water to the cities, to irrigation schemes, to industries. Civilizations in arid regions are famous for ingenious technical solutions. In the Indus valley, in Mesopotamia, in Egypt, irrigation schemes date back thousands of years. The water transfer schemes of the Roman Empire can still be seen in several mediterranean countries. In modern times, such magnificent technical solutions still fascinate engineers and laymen. Besides the building of large dams, large-scale water transfer schemes seem to be the most popular idea for solving the Middle East water Crisis. Canals and pipelines have been proposed which would bring water from the Nile, from the Euphrates and from other Turkish rivers to Syria, Jordan, Israel and Saudi Arabia.

7. During the past decades, new technical solutions have been added to the traditional engineering approach: desalination plants, cloud seeding and water re-use and recycling.

8. Water storage, for a long time associated only with surface water reservoirs, exists of course also in groundwater aquifers where evaporation losses are insignificant and the quality

of treated waste water can be improved. Groundwater storage has thus become an important water management instrument.

9. The increasing cost of water has also led to the development of water saving techniques in irrigation, in industry and in household water uses.

10. One solution for dealing with water management problems, which has received less attention, is the development of large-scale national water distribution networks. These build up from local networks and gradually produce an integrated nationally managed facility.

11. Water managers have thus a wide variety of technical solutions at their disposal. But growing water demand has forced them to consider also demand management solutions: Increasing water prices, restrictions to the use of water at certain times or for some purposes, strict control of water supplies through metering and physical restrictions, and in some cases the introduction of free water markets with the expectation that this would lead to the allocation of water to the most economic use.

III. LARGE-SCALE DISTRIBUTION NETWORKS

A. National Water Systems

12. There is a certain fascination with the idea of transferring water over large distances from wet to dry regions. The famous California Aqueduct is bringing water over hundreds of miles to arid southern California (1). The Libyan pipeline transfers water from a well field in the southeastern part of the country to the coastal region. And the Israeli National Water Carrier channels water from Lake Kinneret/Galilee in the North to the coastal regions and into the South (2).

13. While the construction of these large transfer schemes has found wide interest and publicity, the gradual transformation of these transfer schemes into large-scale distributions networks has found less attention. The Israeli National Water Carrier (Figure 4) is probably the best example. Its original and main feature, the transfer of water from Lake Kinneret/Galilee to the Negev is usually highlighted. But the Water Carrier has, over the years, become a large-scale distribution network, comparable to the system serving a large urban-industrial complex. The various sources of water available to Israel, surface and groundwater, are brought into the Water Carrier and distributed to the various

regions, to cities and towns and to the irrigation districts. Over the years, more and more towns and villages which had originally their own water supply systems have become connected to the Water Carrier.

14. In addition to the gradual spatial expansion of the Water Carrier, some modifications are taking place. One important addition to the system is a pipeline which is taking reclaimed waste water for irrigation from Tel Aviv to irrigation districts further south. The Water Carrier which initially carried only high quality water of almost drinking water standard, has thus been expanded to distribute water of a different quality. A further modification could take place if large desalination plants are developed which would produce water of the highest quality. Such water may also require the replacement of parts of the pipeline system of the Water Carrier.

15. Jordan has also developed an extensive water distribution system (Figure 5), which is bringing water over hundreds of kilometers from various sources to the main consumption centers, especially Amman (3). The system which is serving the more densely populated areas is expected to be enlarged substantially.

16. Looking at these and other systems which have been constructed during the past decades, it is obvious that a gradual expansion of large-scale national water distribution systems is

taking place which may be compared to the gradual expansion of electrical distribution networks. Electrical networks initially served relatively small confined areas. Over time, the networks expanded and became interconnected covering large areas with many electricity generating facilities and numerous customers. Eventually, national networks became operative, and the final step was the interconnection of national networks which allows supply and demand to be balanced over very large areas, to manage networks in a flexible manner and to provide a large factor of safety in case of emergencies.

17. Will water supply networks develop in a similar form?

18. History shows that national large-scale water supply networks are advantageous. They are attractive to water managers and they make economic sense, just as electrical networks, oil and gas pipelines and telephone connections make sense. There are very convincing examples showing how various water supply entities facing the need for expansions of their systems discovered that a combined system sharing several sources of water and managing an overall system jointly, reduced the necessary amount of new investments to a fraction of the cost which would have been needed, had the various entities continued to operate separately and expanded their systems on their own.

19. It can be expected that, particularly in arid regions, water supply networks will gradually cover larger and larger areas linking most water sources and most consumption centers, if not most consumers. Probably water of different quality will be provided for various uses. High quality water is needed for human consumption and certain industries. Irrigation and industries do not require the same water quality, they may even utilize treated waste water. Loops in the water networks may thus recycle water at a large scale.

20. Such comprehensive networks allow water managers a combined water quantity and water quality management, more flexibility and more safety in emergencies. However, managing these systems requires great skill, advanced management techniques and adequate human and financial resources to utilize the full potential.

B. Expanding the Concept

21. Could water supply networks also be connected across national borders to balance supply and demand over larger areas?

22. And why is it so difficult to collaborate on water issues and to reach international agreements over water?

23. There are many aspects to consider when dealing with water. It is vital for human life, for animals and plants. It has symbolic meanings in religious ceremonies. Water is so vital that access to water has to be assured to everybody. In arid regions, this principle has led societies to declare water a common entitlement. Modern laws generally declared water to be state property or provide for public ownership of all waters (4).

24. There are also economic aspects. The International Conference on Water and the Environment in January 1992 stated that "water is an economic good" (5). This is a clear departure from previous declarations stressing the "public good" nature of water. If water is considered to be an economic good, it could also be traded like other goods. In the Middle East, water has been traded for centuries at local levels. In a recent Treaty between Lesotho and South Africa which allowed the construction of the Lesotho Highlands Water Transfer, the payment of royalties to Lesotho for the water supplied to South Africa was an essential element of the agreement. These royalties will be equivalent to no less than 25% of the total export earnings of that country (6).

25. As Lesotho and South Africa were able to agree on the water transfer schemes and on payment for water at a time when the governments of these countries had to deal with serious conflicts between them, it may not be overly optimistic to predict that more

cooperation between the countries in the Middle East will also develop in the foreseeable future.

26. Despite the problems and risks inherent in international connections between national water supply networks, it would be very interesting to explore their feasibility and advantages. Internationally connected large distribution systems would be less vulnerable to interruptions through hostile actions and natural disasters than large-scale water transfer schemes. Additional water could be fed into the networks and distributed through an integrated management system. Consequently, trunk and distribution lines would have to be designed or redesigned. Joint water quality standards would have to be adopted and monitored. Rights of way would have to be secured for major connections. The locations and dimensions of reservoirs within the combined systems would have to be determined. Controls and joint management structures would have to be agreed upon to deal with conflicts and uncertainties.

27. While the idea of internationally connected water networks may appear to be premature, a discussion of the proposal could contribute to a better understanding of the various aspects of collaboration in the water sector which would also have to be addressed in connection with large scale water transfer schemes.

IV. WORLD BANK EFFORTS

28. The World Bank has assisted the countries in the Middle East for a long time in their development efforts in general and to water development in particular. Financing and technical assistance has been provided to Jordan, Israel, Lebanon and Syria. Currently, an emergency reconstruction program is under preparation for Lebanon which includes substantial efforts in the water sector.

29. The World Bank has also supported international water development. The Indus valley development is the best known and by far the largest investment of that kind. More recently, the Bank assisted in two large international river basin developments in southern Africa: in Lesotho and in the Kumati basin which is shared by Swaziland, South Africa and Mozambique. Some developing countries feel that the Bank should be more active in this field and have asked the Bank during an international workshop on water management policy in June 1991 to take the initiative in cases where international water issues are remain unresolved and impede the development of the river basin.

V. CONCLUSIONS

30. The Middle East region is probably the region with the most serious water problems. Among the technical solutions that have been proposed to deal with the water crisis in this region, large-scale water transfer schemes have stimulated the greatest interest. However, the development of large-scale water distribution systems which has already been started, deserves greater attention. As national networks are gradually developing, connecting local networks and balancing national water supply and demand, some consideration should also be given to the possibility of international connections of national networks.

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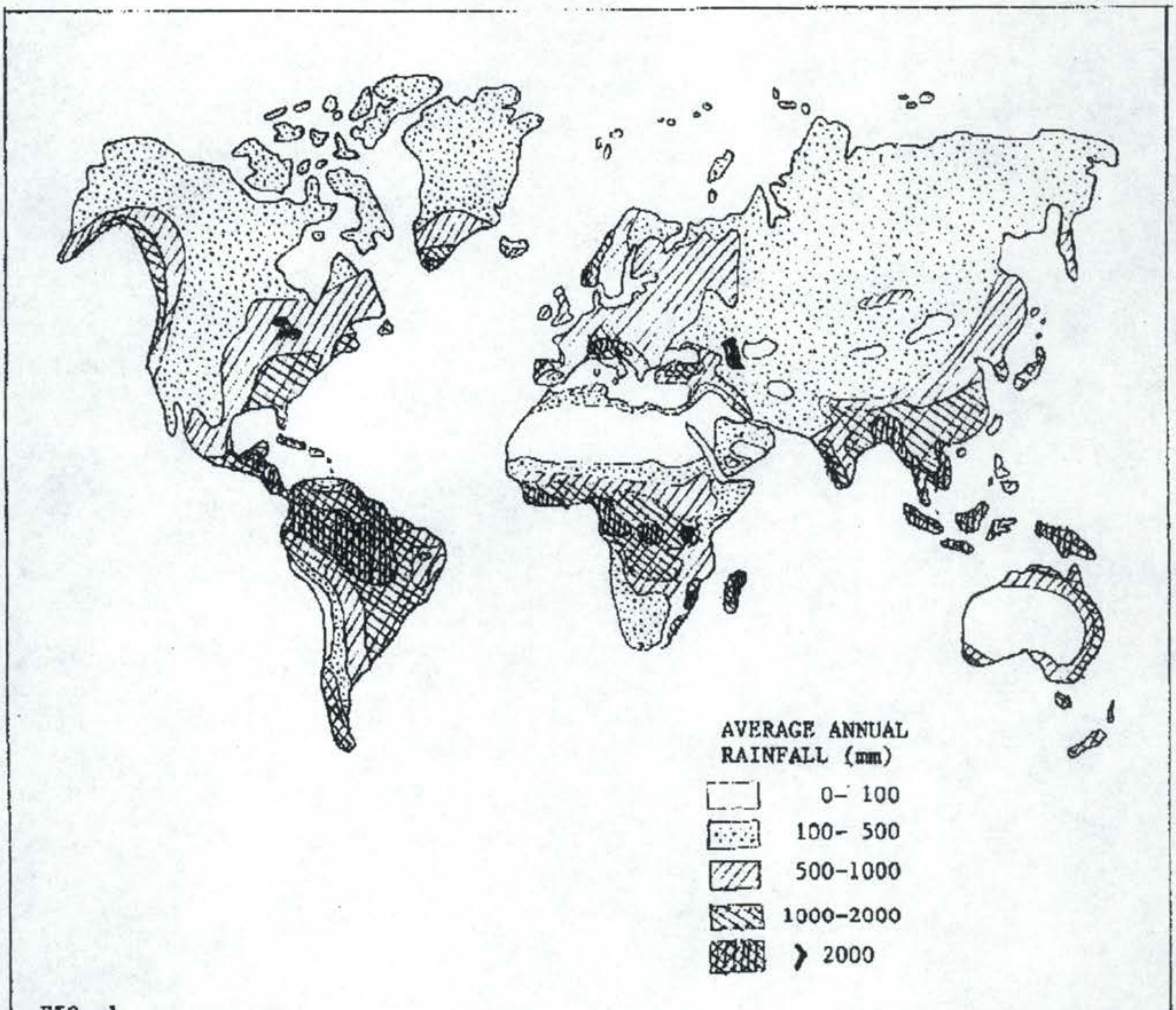

FIG. 1

AVERAGE ANNUAL RAINFALL

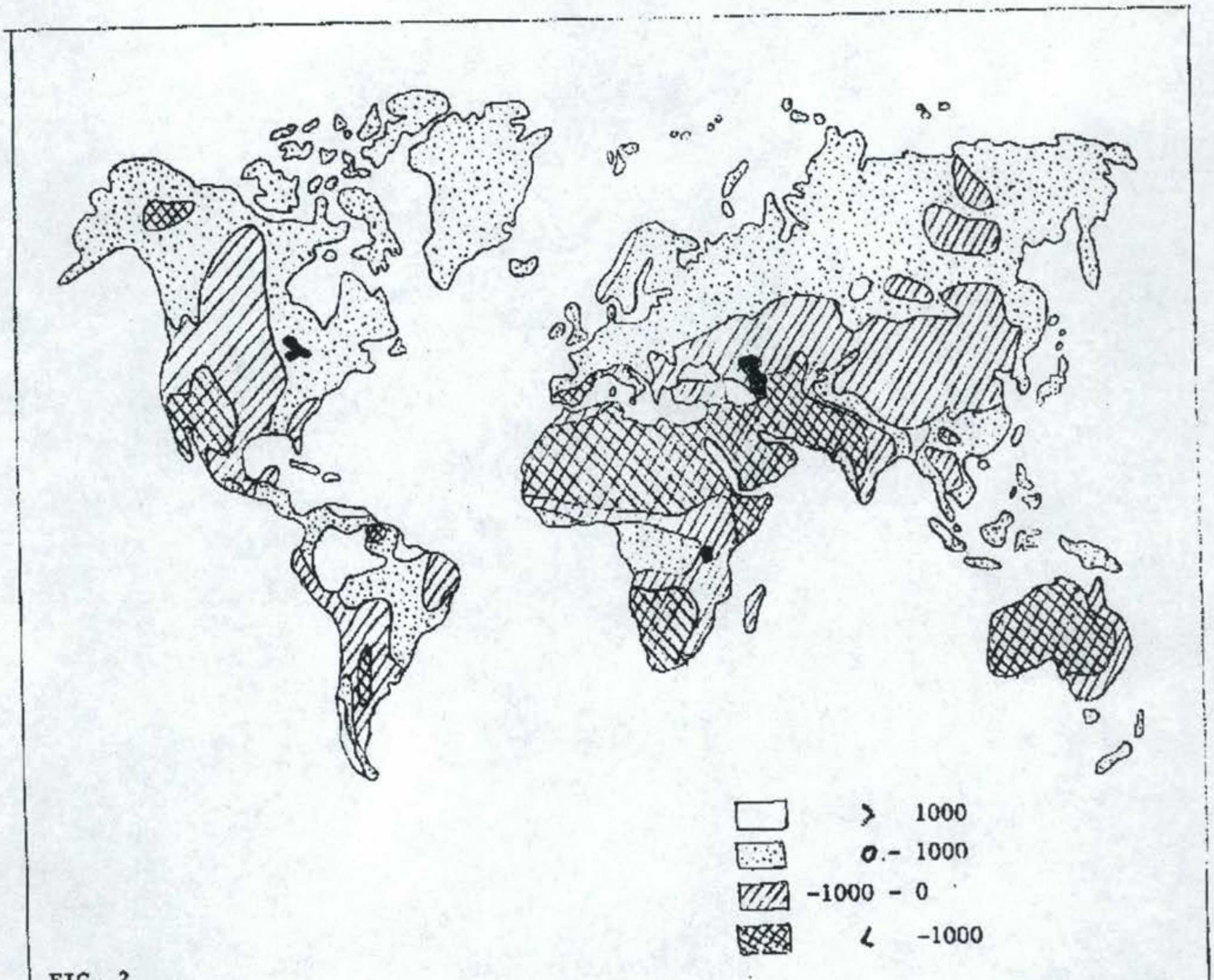

FIG. 2

GLOBAL WATER SURPLUS AND DEFICIENCY (DIFFERENCE BETWEEN RAINFALL AND EVAPOTRANSPIRATION)

Source: Falkenmark, 1977

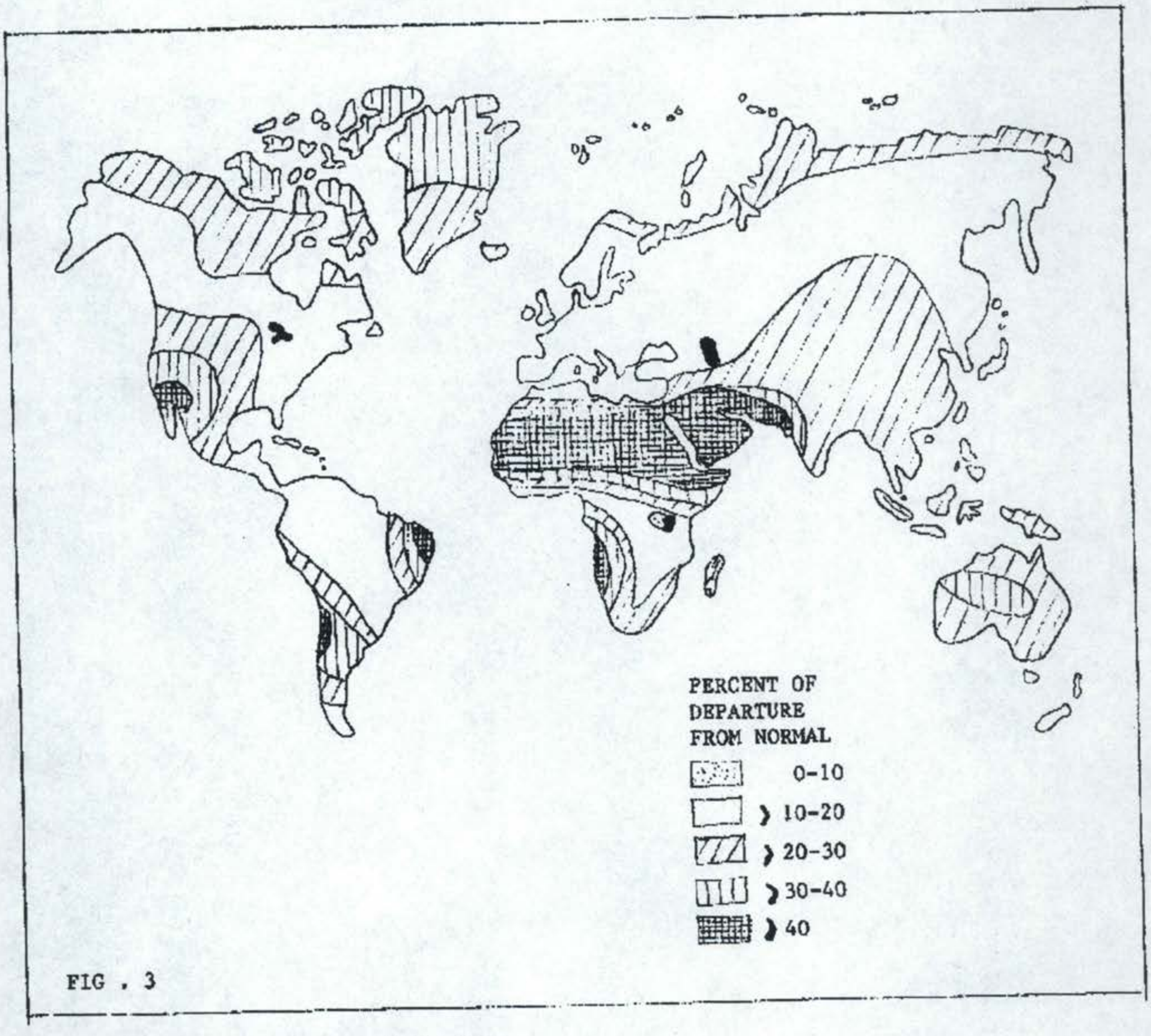

FIG . 3

INTERANNUAL VARIABILITY OF RAINFALL

Source: Biswas, 1984

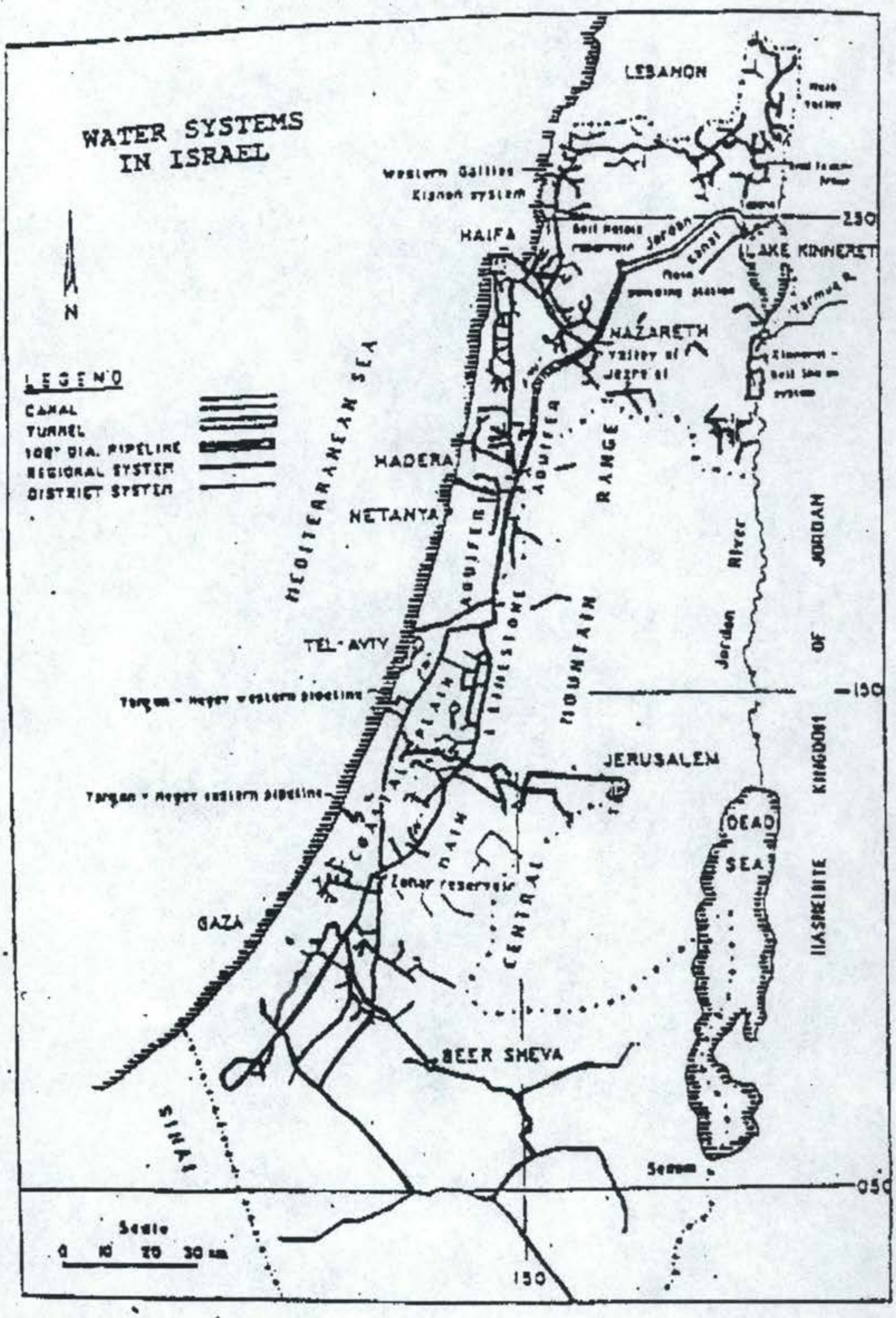

FIG. 4

Source: Schwarz

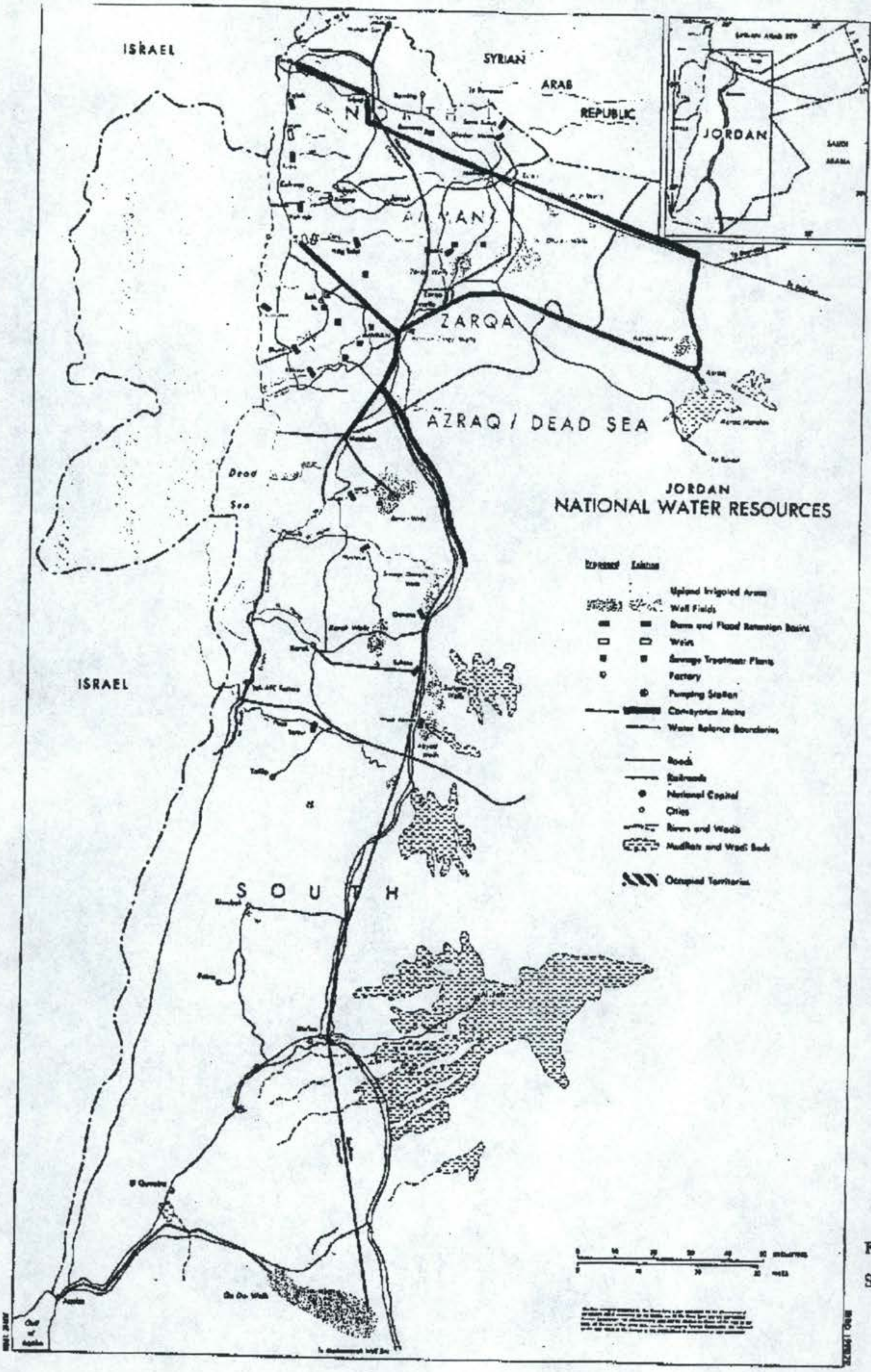

FIG. 5

Source:
World Bank

WATER FOR PEACE

by

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No solution has yet been found for the Arab/Israeli dispute. Many Israelis, many Arabs, and most of the rest of the world are weary of each side's propaganda, each side's rightful (and wrongful) claims, and each side's intransigence. The entire world would welcome an end to it.

The solution may be elusive only because an important element of the problem has hardly been admitted, let alone addressed. The secret problem is the region's most precious resource - fresh water. Water, that secret problem, is the key to peace.

Almost one third (127 billion gallons) of Israel's fresh water is derived from aquifers in what Israel calls Judea and Samaria, what the Arabs call the West Bank, and what we, for the sake of neutrality, shall call the "disputed area". Israel, exclusive of the Gaza Strip and the disputed area, uses 400 billion gallons of water annually; it cannot survive, especially with the prospect of increased immigration of Jews and the natural population increase of both Jews and Arabs, without the 127 billion gallons of water or its replacement from some other source. That is a real security problem.

It has been proposed to reward Israel for peace by allowing it to import water from Turkey through Syria. Such ideas are conducive to war, not peace. Possible threats to withhold water are intolerable to contemplate. Israel is not likely to allow itself to be dependent upon Turkey, Syria or Palestinians for its vital water. Water cannot be a reward for peace; it is a condition for making peace. An important reason for the failure of the autonomy talks between Israel and the Palestinians in 1982 was a dispute about water rights. The only reasonable source of new fresh water is desalination of sea water.

The desalting of water requires an enormous amount of power. Israel does not have coal or oil. Nuclear power is a solution but Israel's neighbors are sufficiently nervous without Israel building nuclear facilities. There are ecologic arguments against the use of nuclear power but the political objections are sufficient to make it impractical. There would be powerful international opposition to nuclear power plant construction in the region and there is no possibility of international financing of such construction. Hydroelectric power is the only practical possibility.

Geologically, Israel may be viewed as a dam that holds back the Mediterranean Sea and all the world's oceans from pouring down into a great rift whose most famous feature, the Dead Sea, shared by Israel and Jordan, is 1,300 feet below sea level. It is the lowest point on earth, a unique resource to produce power. Indeed, it may be possible to smite the arid rock and make water pour forth, with the aid of modern technology.

A passageway must be constructed for sea water to pass at approximately sea level toward the Dead Sea and then be dropped vertically at least 1,200 feet. A flow of water of 2.5 trillion gallons annually would enable turbines to generate 1000 megawatts of power. The power would then be transmitted back to the Mediterranean shore where it would be used to desalt 350 to 400 billion gallons of water per year, almost all of Israel's current water consumption.

The scheme is not simple, problem-free or cheap. But it would work.

To make it work, areas adjacent to the Dead Sea, in Israel and in Jordan, amounting to 440 sq. miles must be excavated to the altitude of the Dead Sea, 1,300 feet below sea level, so that a surface area of 840 sq. miles, including the present Dead Sea, would be available to evaporate the 2.5 trillion gallons of Mediterranean Sea water being brought to the area annually. Evaporation is the only means of keeping a state of equilibrium in the size and altitude of the 840 sq. mile enlarged Dead Sea. (Pumping water out from the lowest point on earth would expend a huge amount of energy.)

The necessary excavation dwarfs the 200 million cubic yards removed in the construction of the Panama Canal; it is estimated that this excavation would be 350 times greater. However, modern earth moving equipment and the more favorable conditions of the Dead Sea area make the task considerably easier than the dredging of the Panama Canal.

The entire area must be excavated to the depth of 1,300 feet below sea level because the altitude differential between the Mediterranean and the area is the basis of the power to be generated by the vertical drop. There is some compensation for the cost of increasing the size of the Dead Sea. Since it will extend further south, there will be a wider choice of routes from the Mediterranean for the conduit to be constructed. Since the conduit should be as close as possible to sea level along its entire route to maintain the altitude differential when it reaches the generators, a wider choice of routes would be very beneficial in this hilly country.

The ecologic considerations are significant. Additional condensation in the area, even though the prevailing winds will blow much of it to Israel's west coast, may alter the climate. The saltiness of the Dead Sea will increase over time. There is some wildlife in the area. There may be geologic consequences from the removal of the earth and replacement by water, reducing the weight of the surface over the rift. All these consequences must be evaluated carefully.

This plan's cost is beyond the means of Israel and Jordan. Therefore it will require international sponsorship and financing. Only then can Israel and Jordan discuss its implementation and the user's fees by which the original cost would be repaid.

The plan is expandable. If greater amounts of power are required, larger areas must be excavated. It should be noted that expansion beyond the areas envisaged in this plan to areas with higher altitudes would require significantly greater excavation, with disproportionately greater cost.

A collateral benefit of the plan would be to reduce the unemployment problems in the area. There is an existing pool of engineers, technicians, construction workers and unskilled labor to draw from.

There are other benefits. The plan requires, at the very least, the cooperation of the Israelis and the Jordanians. The Jordananians would be asked to allow several hundred square miles of desert in their country to be flooded with salt water, in addition to the roughly equivalent portion of Israeli desert to be inundated. The engineers and construction workers of both countries would have to plan together and to build together. Working together in harmony might be habit-forming.

Much of the excavated material will be useful. Some, of course, will be used to build the sea level passageway from the Mediterranean to the New Dead Sea. Most of the excavated material could be used to produce a substantial level plain for future solar energy production. The production of solar energy on a significant scale requires a flat surface but the Negev desert is hilly. A huge amount of landfill would be an investment in the not-so-distant future when solar power will be economically feasible.

This project would be one of the great engineering enterprises of modern times. Intensive study is required to ensure its feasibility. Several years will be required to develop the plans, arrange the financing, assemble the specialists and the equipment, complete the excavation, build the conduit and the generators, and, finally, generate the power and desalinate water. Then, Israel's fears about their need for water will be diminished and the probability of fruitful negotiations greatly enhanced. When cooperation replaces confrontation it might be time to give the Dead Sea a new name: the Sea of Peace.