WATER SUPPLY AND DEMAND IN PALESTINE:

1990 BASELINE ESTIMATES AND PROJECTIONS FOR 2000, 2010, AND 2020

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1. Introduction

This report provides baseline data and projections for water supply and demand in Palestine for the Harvard Middle East Water Project. It emphasizes data compilation, documentation, and projection, leaving the application and interpretation of this data to later stages of the project. The report represents an intensive effort by a team of analysts to obtain scarce and often dispersed data on a newly emerging country. Although our projections are based on the best available information, the projections should be treated cautiously. The Israeli Occupation has restricted the consumption of water in the domestic, agricultural, and industrial sectors and has prohibited the expansion of the Palestinian water supply since 1978, thereby distorting the historical basis for projections.

Palestine shall be defined as the West Bank including East Jerusalem, and the Gaza Strip. For convenience, data is presented using district divisions enforced by the Israeli administration within the West Bank, and Gaza is divided into northern and southern districts, with the southern district beginning below Gaza city. This approach has allowed us to use existing information on domestic, agricultural, and industrial consumption. In the case of supply, we present the average cost of extraction and provide information on the spatial distribution and yield of aquifers within each district. Unless otherwise stated, our estimates exclude Israeli settlements.

This report is organized into the following remaining sections:

(1) Section 2 presents our estimates of water supply;

(2) Section 3 presents our baseline estimates and projections of water demand for the household, industrial, and agricultural sectors;

(3) The References section includes every report, interview, or other primary data source used in this analysis; and

(4) The Data Appendix contains all the data tables and figures referred to in the text.

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2. Water Supply Estimates

2.0 Introduction

As Palestinians have been denied access to the Jordan River, the only source of surface water in Palestine, groundwater is at present Palestine's primary water resource. Aquifers (water-bearing rock formations) vary spatially in the quantities and quality of groundwater they yield. Figure 1 presents a schematic cross-section of the mountainous region underlying the West Bank and of the coastal plain underlying Gaza, both of which contain aquifers. The hydro-geology determines the spatial distribution, quantity, quality and extraction cost of ground water. It therefore provides the framework within which the economics of water supply are analyzed. Table 1a presents estimates by various authors of the annual renewable water resources in Palestine.

In the following, we provide an inventory of the quantities of the ground water available by administrative district and then group these quantities by their average cost of extraction. Water resources which are outside the geographical boundaries of Palestine, but which are under contention, are analyzed separately and in a similar way.

2.1 West Bank Water Supply

The mountain range in the West Bank partitions groundwater supply into three basins: the Western, Northeastern and Eastern basins. Within each basin, the groundwater flows in the same direction, as shown by Figure 2. The aquifer(s) in the Western basin flow(s) from the mountains toward the Mediterranean Sea. Aquifers in the Northeastern basin flow from the mountain range toward Lebanon. Aquifers in the Eastern basin flow from the mountains to the Jordan Valley. The Western and

Northeastern basins contain two aquifers, while the Eastern basin contains six as presented in Figure 3.[1] In each case, aquifers differ in their depth from the ground surface and in the quantity and quality of water they contain.

2.1.1 Quantity of Water Supply in the West Bank

We begin by identifying the quantity of water available to each district based on the capacity of its underlying aquifers. We then estimate the quantities of water currently extracted from these aquifers in order to estimate the potentially available groundwater currently unused by Palestine.

Maximum Sustainable Yield by District. It is generally acknowledged that the Western, Northeastern, and Eastern basins contain between 335-360, 120-140, and 105-125 million cubic meters (mcm) respectively (Boneh and Baida, 1977-78; Schwartz in Elazar, 1982; UN, 1991; Al Khatib et al., 1993; Zarour and Isaac, 1993). However, there are no estimates for the maximum sustainable yield (MSY) of the seven administrative districts. Estimating the MSY by district requires 1) knowing the spatial extent of the aquifers beneath each district and 2) knowing the MSY of the underlying aquifers. We estimate the percent of each aquifer underlying each district by overlaying a map of administrative districts on a map of the ten aquifers. Percents are shown in Table 1d.

Two studies estimate the MSY for each the ten aquifers (Boneh and Baida, 1977-78; Schwartz in Elazar, 1982). We select the Boneh and Baida estimates because they offer a more refined delineation of aquifers and reliable hydro-geologic data. Having obtained values for the MSY in mcm for each aquifer and the percentage of the aquifer

[1]We adopt the identification and delineation of aquifers used by Boneh and Baida (1977-78). Also see Elmusa (forthcoming).

for piped supply is differentiated by source (springs versus wells) and further differentiated by use (domestic versus agricultural) as presented in the second and third columns of Table 1b. Unpiped supply is also differentiated by use (domestic versus agriculture). For unpiped domestic supply we used the percentage of the population without piped water provided by survey data collected in 1992 by the Health Development Information Project (1993, 31). This percentage is then multiplied by a per capita consumption figure estimated for each district and summed over all districts. The average per capita consumption across the West Bank districts is 36 cm annually. (See Section 3.1.1 for a full description of the derivation of the unpiped consumption estimates.)

To obtain an estimate of the unpiped supply to agriculture, we estimate the total water required using the crop type and number of dunams under cultivation in each district. We obtained data on number of dunams under cultivation from An-Najah National University (1990) and data on water use per dunam by crop type from Awartani (1990) and the ARIJ agricultural database (1994). We then subtract the quantity of piped water from the total agricultural requirement to estimate the quantity of unpiped water extracted, as presented in column 4 in Table 1d.

In addition to Palestinians, Israeli settlements extract water from aquifers for both domestic and agricultural uses. Although the precise estimates of extraction by settlements are not currently available, estimates range from 36-40 mcm by Benvenisti and Gvirtzman (1992) to 65-100 mcm by Tamini, (1992) and Al Khatib (1992). The Agricultural Ministry in 1983 planned to extract 90 mcm annually from the West Bank by the year 1990 (Ministry of Agriculture, 1983; Kahan, 1987) . Based on this literature, we assume that 65 mcm are currently being extracted from wells in the West Bank. We estimate the quantity extracted from each district by identifying the location of Israeli settlements with wells. Table 1b presents the number and location of known settlement

within each district, we multiply these values to obtain the quantity of water available from that aquifer for that district. By performing this exercise, we can estimate the MSY available for each district as presented in Table 1d.

In these aquifers groundwater flow is dynamic, always moving down the anticline that constitutes the mountain range. Groundwater that is not extracted from an aquifer flows through that aquifer either leaving the system through springs or by entering an adjacent aquifer system. Similarly, a district that does not extract the MSY within its boundaries allows a portion of its water to flow out of its jurisdiction to the downstream district or country. If this occurs, in addition to the natural recharge of its own underlying aquifers, the downstream district or country receives the water that flows from the upstream district or country. Note that the values presented in Table 1, in the "Total Available Water" column, ignore this fact. This column represents the natural recharge of the aquifers underlying each district, implicitly assuming that each district extracts 100% of its MSY and receives no surplus from the upstream districts.

Groundwater Extraction by District. In reality districts are not extracting 100% of their MSY either because the Israeli Occupation prohibits them from doing so or because it would be too costly. As a result, a quantity of water, representing the difference between a district's current extraction and its MSY, flows out of each district to the downstream district or country. We turn next to estimating this quantity of outflow or surplus water for each district. Since we have estimated MSY for each district above, we need only to estimate the current quantity extracted within each district to calculate the outflow or available surplus.

We estimate the current water extracted in Table 1b. We add water quantities extracted within a district for piped supply, unpiped supply and supply to Israeli settlements. Data on piped supply is obtained from Nuseibeh (1994). Water extracted

2.1.2 Cost of Water Supply in the West Bank

The quantities of water presented above will now be grouped by the cost of transporting them to the ground surface. Table 1 presents the quantities associated with each cost category. Costs of extraction will vary from $0.00 to $0.74 per cm depending upon the mode of transport, depth of extraction and treatment.

Springs. Groundwater brought to the surface by springs has no extraction costs, assuming it does not require treatment. Table 1b presents the quantity of spring water available by district. Where available spring water represents the first increment in the supply step function at zero cost in Table 1.

Shallow Wells and Cisterns. Increasing in cost, is water extracted from shallow wells and cisterns. Table 1b presents the quantity of water extracted from shallow wells for irrigation and for unpiped domestic supply. In Table 1 the average cost of extraction for this increment to the supply step function is estimated at $.16 per cm based on several sources. Awartani (1990) estimated $.16 based on 30 irrigation wells across the Jordan Valley. Similarly, Tahal (1990), and Eckstein (1993, Table 2 and 2a), note costs in this range ($.10 to $.20 per cm) for extraction from shallow aquifers.

Deep Wells. Increasing further in costs, is water extracted from deep wells for domestic consumption. The quantity available is presented in Table 1b. For Table 1, the average cost assigned to this increment in the supply step function is estimated at $.33 per cm. This estimate represents a mid range value based on Tahal (1990), Eckstein (1993, Table 2 and 2a), DeShazo (1994a), and World Bank (1993, 21).

New Deep Wells. The next increment of water added to the supply step function would come from the construction of new wells. It is unlikely that any new wells will be constructed during Israeli Occupation. Therefore, the cost of constructing new wells may be 3 to 5 times lower if Jordanian drillers were employed (World Bank 1993, 21; Al

wells by district. We obtained the location of settlements and number of wells from the West Bank Data Project (1986, 2 and 33). To identify the quantity extracted by district we assumed that the quantity extracted is in proportion with the number of settlement wells within a district. Column 4 of Table 1b presents these proportionally by district, while Column 5 of Table 1a presents quantities which settlements extract.

Potentially Available Water by District. The difference between the MSY and current extraction rates represents the potential available surplus of water. Based on our estimates, users extract 199 mcm annually from aquifers in the West Bank (Table 1b) while the MSY for all aquifers and districts in the West Bank is 660 mcm annually (Table 1d and Boneh and Baida, 1977-78). This means that about 461 mcm are potentially available to West Bank districts. We also estimate the MSY, current extraction, and available surplus for each district in Table 1d[2]. Table 1d shows that all districts but one may have a significant quantity of potentially available water.

Jericho, located in the Jordan Valley, is the one district that extracts more than its underlying aquifers can naturally recharge. This is because the water not extracted by districts upstream, such as Bethlehem, Ramallah, and Nablus, flows downward into the district of Jericho. Since Jericho is currently extracting quantities beyond its aquifers' MSY, we assume in Table 1 that this water comes from Bethlehem (12 mcm), Ramallah (13 mcm) and Nablus (13 mcm), and subtract this from the potentially available water in these districts. (see footnote 2.)

[2]These estimates do not capture the dynamic nature of aquifer interaction and regional groundwater flow. Ideally, a dynamic mass balance model of the aquifer systems should be developed for coordinating extraction among districts in order to minimize the cost of extraction and transportation.

Khatib et al., 1993; and DeShazo, 1994a). Because of limited information on both Israeli pumping beyond the green line and West Bank hydro-geology, it is difficult to accurately estimate the average cost of extracting the remaining available surplus. Given existing pumping costs, the expected lower fixed cost of using Jordanian drillers, and improved hydro-geologic information, we estimate the remaining quantities that can be extracted at an average cost of $.34 per cm.

Jordan River. The Jordan River represents an important water resource to Palestine that is not currently available. Table 1e presents three scenarios under which water from the Jordan River could be used to meet Palestine water needs. Scenario 1 is based on the construction of the Ghor Canal which should provide 125 mcm annually at a cost of about $.08 per cm (Al Khatib et al., 1993; Baskin (ed.) 1993; Isaac and Hosh, 1992). Scenario 2 is based on the desalination of Jordan River water currently available at an average cost of $.74 (Shuval in Al Khatib et al., 1993). The third scenario assumes that Israel will release enough river water upstream to allow the Palestinians to withdraw 200 mcm annually without having to desalinate (DeShazo and Newell, 1994a). In addition to the Jordan River, recycled waste water has been noted as a future source although currently less than 10% of households have adequate sewerage disposal (World Bank, 1993e).

2.2 Gaza Water Supply

Aside from the intermittent flow of wadis, groundwater constitutes all of Gaza's freshwater resources. This water is part of the shallow, highly permeable coastal aquifer. Because water can be cheaply extracted from shallow wells, overpumping has resulted. Because this aquifer abuts the sea, overpumping has led to saltwater intrusion, causing

saltwater contamination of much of the aquifer which has in turn decreased the quality and quantity of existing freshwater, while increasing the cost of supply.

2.2.1 Quantity of Water Supply in Gaza

The aquifer underlying Gaza is estimated to have 60-65 mcm of renewable water, yet current extraction exceeds 100 mcm annually (Shawwa, 1993; Shuval in Al Khatib et al., 1993; World Bank, 1993e). In addition to this shortage, water quality is deteriorating rapidly due to overpumping in proximity to the sea, leading to high levels of salinity in groundwater (Shawwa, 1993). The quality and quantity of ground water is generally greater in North Gaza as compared with South Gaza.

Alternative Supplies. The quantity of groundwater available in the coastal plain aquifer beneath Gaza is highly dependent upon the use of both surface and groundwater. Two areas of contention are 1) an estimated 1.2 mcm from Wadi Gaza that is impounded upstream and 2) 44 mcm of groundwater that is purportedly extracted by Israeli wells on the perimeter of Gaza. The latter figure is based on the purported existence of 20 wells pumping continuously at a rate of 250 cm/hour (Shawwa in Baskin (ed.), 1993; DeShazo and Newell, 1994a). The availability of these two sources of water is considered in Table 1e under alternative scenarios.

2.2.2 Cost of Water Supply in Gaza

The estimated cost of extraction differs slightly between North Gaza and South Gaza. The average cost of extraction in the south is estimated to be $.15 per cm and $.20 per cm in the North (World Bank, 1993; DeShazo and Newell, 1994a). These costs are based upon the assumption that overpumping and the need for desalination will not occur in the future.

Desalination. Costs of desalination range from a low of $ .30 per cm for mildly brackish water to over $1.00 per cm for highly saline water (Commission for European Communities, 1993; World Bank, 1993e; and Kally in Al Khatib et al., 1993). Based on an average of Kally's estimates for multi-staged distillation and reverse osmosis we assume an average desalination cost of $.74 per cm (Al Khatib et al., 1993).

3. Water Demand: Baseline Estimates and Projections

3.0 Introduction

This section of the report describes and documents the methods used to estimate the 1990 baseline level of water demand in Palestine and to project the water demand for the years 2000, 2010, and 2020. Water demand is divided into consumption by three sectors: (1) households; (2) industry; and (3) agriculture. All tables that contain water demand data are presented in the Data Appendix. All water quantity figures are in millions of cubic meters (mcm) unless otherwise noted.

Table 2 presents the 1990 baseline estimate and projections of total water demand for each of the demand sectors. We estimate that the total water consumption in Palestine was 225 mcm in 1990. Total water demand projections for the years 2000, 2010, and 2020 are approximately 497 mcm, 826 mcm, and 1,263 mcm respectively.

The projections presented in Table 2 summarize the middle scenarios shown in Tables 3, 4, and 5 for each sector of demand. We also present high and low scenario projections for each of the demand subsectors, as described in the following subsections. We present these in lettered tables within each of the Table 3, 4, and 5 series (e.g., 4a, 4b). The following subsections describe and document the methods used for each demand sector for medium, high, and low scenarios.

3.1 Household Water Demand

The household water demand sector comprises primarily domestic water use, although the baseline estimate contains some water used for light industry that cannot be separated from domestic use due to the existence of common connections.

Table 3 presents the 1990 baseline estimate and projections of household demand for the middle scenario. We estimate that total household water consumption in Palestine was 78 mcm in 1990. Household demand projections for the years 2000, 2010, and 2020 are approximately 263 mcm, 484 mcm, and 787 mcm respectively for the middle scenario.

3.1.1 1990 Estimate of Household Water Demand

We estimate that the household sector consumed 78 mcm of water in Palestine in 1990, as detailed in Table 3a. This estimate is based on household consumption of piped water from regional and municipal systems and unpiped water from local wells, springs, and cisterns. The World Bank (1993f, 55) estimated that domestic water consumption in Palestine was about 56 mcm in 1990, but this estimate does not account for unpiped water consumption and does not seem to include East Jerusalem.

Piped Water. The estimate for piped household water consumption in Nablus, Jenin, Tulkarem, and Bethlehem is based on data from annual meter readings taken in 1990/1991 by the Water Department of the Israeli Civil Administration (Water Department 1993). These districts do not rely on water from sources outside the district for household use.

For Hebron, the amount piped from wells within the district is from the Water Department data (1993), while the amount imported from other districts via the Water Department was estimated by subtracting the amount from wells from a total household

consumption figure given by Haddad and Abu-A'isheh (1992, 75) and supported by interviews with the Hebron Municipal Water Department (ARIJ 1993c).

For Jericho, the amount of water piped from springs and from the Water Department is from data gathered through interviews with the Jericho Municipal Water Department (ARIJ 1993d). For Ramallah, 1990 baseline estimates of household water consumption are from a comprehensive report by the Jerusalem Water Undertaking: Ramallah District (1991, 22).

Household water consumption estimates for East Jerusalem are difficult to make since Israeli statistics include East Jerusalem in the larger municipality of Jerusalem. We estimated baseline household water consumption in East Jerusalem using a 1990 population estimate of 151,200 for East Jerusalem and an annual water consumption per capita of 45 cm based on an interview with the Head of the Hydrology Division for the Civil Adminstration.

The estimates of 1990 household water demand for Gaza are based on data from Isam Shawwa (ARIJ 1993a). The population is distributed across North and South Gaza based on the 1990 population estimates shown in Table 3a.

Unpiped Water. Because 26 percent of households in the West Bank do not have access to piped water, we also estimated household consumption of unpiped water based on the proportion of households without piped water within each district as given by the Health Development Information Project (1993, 31). This estimate assumes a per capita consumption level for unpiped water equal that of piped per capita consumption levels for piped water. This may represent a slight overestimate of unpiped water consumption, but the quantities are not large.

Population Projections. The detailed supporting analyses for the population projections are shown in Tables 3b, 3d, and 3f respectively for the middle, high, and low scenarios. All population growth rates are based on the well-documented population projections of Abdeen and Abu Libdeh (1993; FAFO, 1993), which employ estimates of age and sex cohorts, fertility rates, life expectancies, and net migration rates specific to the West Bank and Gaza. Abdeen and Abu Libdeh (1993, 26) present seven different scenarios for population growth, based on assumptions about the above parameters, and ranging from optimistic (Projection 1) to pessimistic (Projection 7).

The middle scenario for household water demand is based on Abdeen and Abu Libdeh's central projection (Projection 4). The high and low scenarios are based on their highest (Projection 7) and lowest (Projection 1) projections of annual growth rates. Because Abdeen and Abu Libdeh did not provide growth rates for the specific time ranges of interest (e.g., 1990-2000), we used an average of their 5-year growth rates covering the 10-year periods. Despite these simplifications, our projections compare favorably with their estimates for similar years. The net migration estimates used by Abdeen and Abu Libdeh (1993, 21) did not include returning refugees, and assumed net migration of -4,000 per year in the West Bank and -6,000 in Gaza for the low scenario, zero net migration for the middle scenario, and +4,000 for the West Bank and +4,000 for Gaza for the high scenario.

Returning Refugees. In addition to the projected natural growth in population, the above method assumes the return of 500,000 Palestinians to the West Bank and Gaza by the year 2000 (PLO 1993, 35). Other sources have estimated the number of returnees at between 500,000 and 1 million. (Al Khatib et al., 1993). The projections assume that refugees will return to their points of origin in the West Bank and Gaza (i.e., about 80%

3.1.2 Household Water Demand Projections

Projections of household water demand are shown in Table 3 for the middle scenario, amounting to approximately 263 mcm, 484 mcm, and 787 mcm respectively for the years 2000, 2010, and 2020. Under the high scenario, household water demand is projected to be 280 mcm, 576 mcm, and 1,082 mcm for the respective projection years, as shown in Table 3c. And under the low scenario, household water demand is projected to be 251 mcm, 425 mcm, and 619 mcm for the respective projection years, as shown in Table 3e.

Current Water Constriction. At present, water consumption is constricted in the Occupied Palestinian Territories due to intermittent water service, inadequate infrastructure, and Israeli restrictions on the number of wells that may pump water for domestic use (World Bank, 1993f, 52). Under these circumstances, and assuming no future supply constriction, projections adjusted by only income elasticity would significantly underestimate household demand. In addition, neither reliable estimates of future household income nor income elasticities of water demand for Palestinians are available.

Projection Method. Our projections of household demand therefore assume a household water demand per capita of 75 cm in 2000, 100 cm in 2010, and 125 cm per person. These estimates are based on reasonable expectations for water demand if supply restrictions are eliminated and in approximate accordance with other studies (Al Khatib et al., 1993). Using these per capita demand projections, we estimated total household demand by district by multiplying per capita demand by the sum of projections of population and the number of "visitor equivalents," as shown in Table 3 for the middle scenario.

Palestine was about 7 mcm in 1990 (World Bank 1993f, 55), beyond that which is included in household demand. Industrial water demand projections for the years 2000, 2010, and 2020 are approximately 18 mcm, 37 mcm, and 61 mcm respectively for the middle scenario.

3.2.1 1990 Baseline Industrial Water Demand

We estimate that the industrial sector consumed 7 mcm of water in Palestine in 1990, as detailed in Table 4. Lacking data on district-specific industrial water consumption, we distributed total industrial water consumption by district within the West Bank and Gaza according to the percentage of water-intensive industrial establishments located within each district. Table 4c presents the data on the number of textile, food, and quarry industrial establishments located within each district (Abd-Alraziq 1991, 84, 86, 96).

3.2.2 Industrial Water Demand Projections

Projections of industrial water demand are shown in Table 4 for the middle projection scenario, amounting to approximately 18 mcm, 37 mcm, and 61 mcm respectively for the years 2000, 2010, and 2020. Under the high scenario, industrial water demand is projected to be 23 mcm, 59 mcm, and 122 mcm for the respective projection years, as shown in Table 4a. And under the low scenario, industrial water demand is projected to be 14 mcm, 24 mcm, and 30 mcm for the respective projection years, as shown in Table 4b.

Projection Method. Middle scenario projections assume an initial annual growth rate of 10% for industrial water demand from 1990 to 2000, decreasing to 7.5% from 2000 to 2010 and then to 5% from 2010 to 2020. Awartani (1991, 14-15) describes how

to the West Bank and 20% to Gaza). Returnees are distributed among districts within the West Bank and Gaza according to the percentage of total population within each district.

Visitors. Because households in the West Bank and Gaza receive a large number of family visitors from abroad during the summer months, we have included an estimate of "visitor equivalents" in our projections of household water demand. "Visitor equivalents" represent the equivalent number of visitors to Palestine if they were to stay for an entire year. Our estimates assume that, if the occupation were lifted, there would be 200,000 visitors in 2000, 250,000 in 2010, and 300,000 in 2020 staying for an average of 3 months each. Awartani (1991) assumed that there would be 214,000 visitors by the year 2000, using an annual growth rate of 20 percent. Visitors are distributed among districts within Palestine according to the percentage of the total Palestinian population within each district.

3.2 Industrial Water Demand

The industrial water demand sector comprises water use by industry beyond that which is included in household demand. As described in section 3.1 on household demand, the baseline estimate for household demand contains some water used for light industry that cannot be separated from domestic use due to the existence of common connections. Other studies, including those by the World Bank (1993f), Awartani (1991), and Al Khatib et al. (1993), have recognized the current difficulty of precisely estimating industrial water use in Palestine. Water-intensive industry in Palestine is comprised primarily of textile manufacturing, food processing, and stone cutting and washing (i.e., quarrying).

Table 4 presents the 1990 baseline estimate and projections of household water demand for the middle scenario for industry. Total industrial water consumption in

expanding industrial activity beyond the household will result in a rapidly rising demand for industrial water. He uses a baseline 1990 estimate of 8 mcm and employs a 10% growth rate between the years 1990 and 2000 based on estimates from the Chamber of Commerce and the Industrial Planning Committee. This growth rate also reflects the expectation of a rapid increase in tourism and construction in Palestine once the occupation is lifted; both of these sectors are water-intensive. Beyond the year 2000, our projections assume that this growth rate will eventually slow to a level that is closer to a reasonable expectation for growth in a developing economy.

To provide a range of projections given the significant uncertainty involved, we have also projected high and low scenarios for industrial water demand. High scenario projections assume an initial annual growth rate of 12.5% for industrial water demand from 1990 to 2000, decreasing to 10% from 2000 to 2010 and then to 7.5% from 2010 to 2020. The results are presented in Table 4a. Low scenario projections assume an initial annual growth rate of 7.5% for industrial water demand from 1990 to 2000, decreasing to 5% from 2000 to 2010 and then to 2.5% from 2010 to 2020. The results are presented in Table 4b.

3.3 Agricultural Water Demand

The agricultural water demand sector comprises water used for irrigated agriculture; it does not include rainfed agriculture. Table 5a presents the 1990 baseline estimate and Table 5 presents the projections of agricultural water demand for the middle scenario. We estimate that total agricultural water consumption in Palestine was 140 mcm in 1990. Agricultural water demand projections for the years 2000, 2010, and 2020 are approximately 217 mcm, 305 mcm, and 415 mcm respectively for the middle scenario.

3.3.1 1990 Estimate of Agricultural Water Demand

We estimate that the agricultural sector consumed 140 mcm of water in Palestine in 1990, as detailed in Table 5a. This estimate is found by summing over the product of average water use per dunam of irrigated land and the amount of land under irrigated cultivation by crop type and then by district. The estimate is slightly lower than the 152 mcm of agricultural water use estimated by the World Bank (1993f, 55), but is within the range of estimates that report presents (World Bank 1993f, 53).

The areas under irrigated cultivation for each crop type (i.e., vegetables, citrus, fruit, and field crops) are from the Rural Research Center (1990) for the West Bank and from the Department of Agriculture for Gaza (ARIJ 1993a), as shown in Table 5a. Rates of water use per dunam are from Awartani (1991, 18) for the West Bank and from the Department of Agriculture for Gaza (ARIJ, 1993a).

3.3.2 Agricultural Water Demand Projections

Projections of agricultural water demand are shown in Table 5 for the middle projection scenario, amounting to approximately 217 mcm, 305 mcm, and 415 mcm respectively for the years 2000, 2010, and 2020. Under the high scenario, agricultural water demand is projected to be 217 mcm, 334 mcm, and 479 mcm for the respective projection years, as shown in Table 5b. Under the low scenario, industrial water demand is projected to be 217 mcm, 273 mcm, and 352 mcm for the respective projection years, as shown in Table 5c.

Projection Method. Projections are based on the expansion of irrigated agriculture to land within each district that is well-suited for irrigated agriculture. Suitability is based on soil type and other factors such as climate (ARIJ 1992, 1993b, e). As shown in Table 5, land available for irrigated agriculture is grouped into two classes

based on the aforementioned factors. More than half of the highly desirable Class 1 land is currently under irrigation, while Class 2 land available presents a significant opportunity for expansion. In addition to Palestinian irrigation, irrigation on Israeli settlements has ranged from 23,000 to 40,000 dunams between 1986 and 1992 (Statistical Abstract of Israel, 1986, 1993). This will become available once the occupation is lifted.

Projections of agricultural water demand are the product of the weighted average water use per dunam for each district in 1990 (see Table 5a) and the projected irrigated land area for each district. By implication, this approach assumes that the proportion of each crop type irrigated and the water use per dunam within each district will remain constant. Middle scenario projections assume that all Class 1 land area will be irrigated by year 2000, 35% of Class 2 by 2010, and 70% of Class 2 by 2020.

To provide a range of projections given the significant uncertainty involved, we have also projected high and low scenarios for agricultural water demand. High scenario projections assume that all Class 1 land area will be irrigated by year 2000, 45% of Class 2 by 2010, and 90% of Class 2 by 2020. The results are presented in Table 5b. Low scenario projections assume that all Class 1 land area will be irrigated by 2000, 25% of Class 2 by 2010, and 50% of Class 2 by 2020. The results are presented in Table 5c.

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WATER SUPPLY AND DEMAND IN PALESTINE:

1990 BASELINE ESTIMATES AND PROJECTIONS FOR 2000, 2010, AND 2020

Data Appendix

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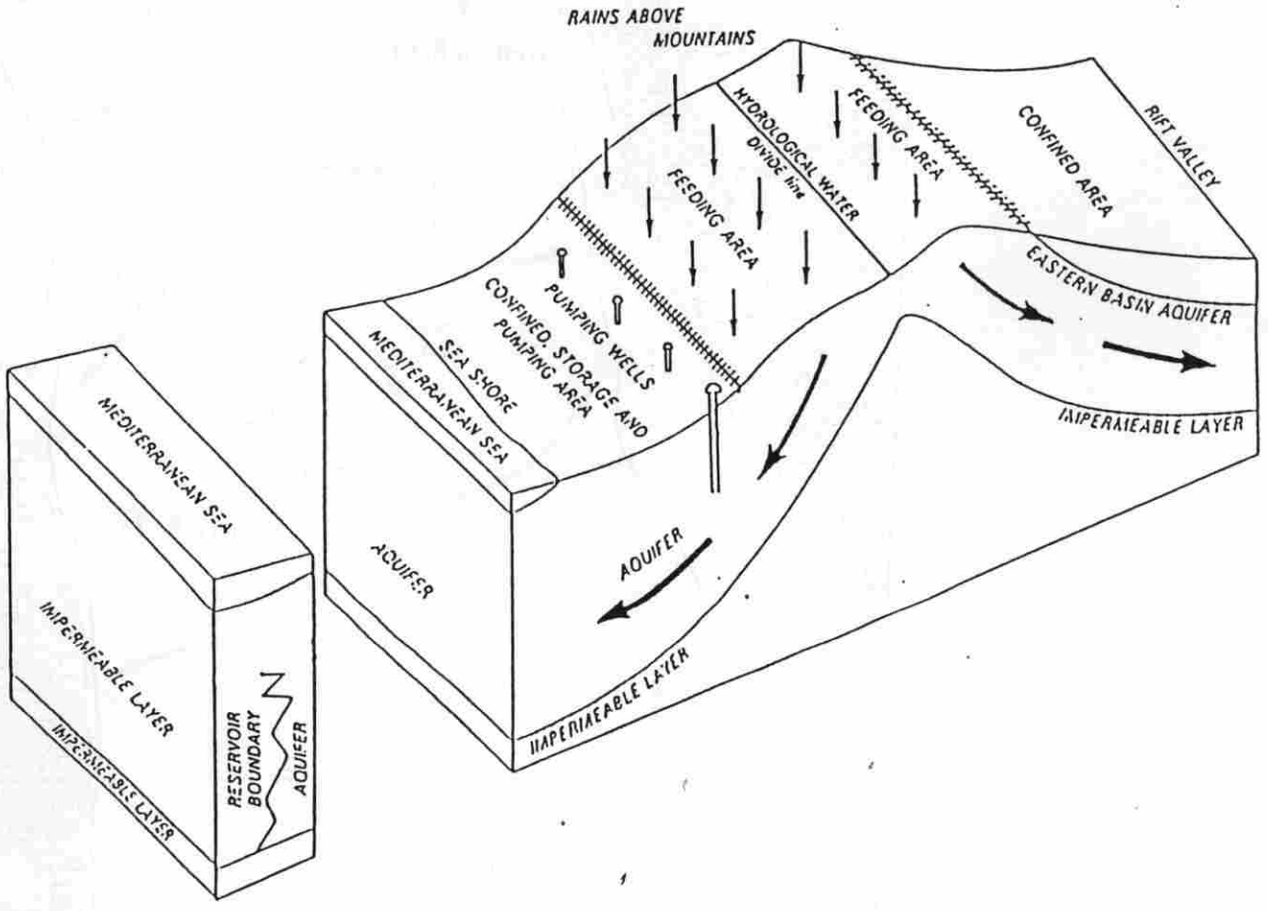
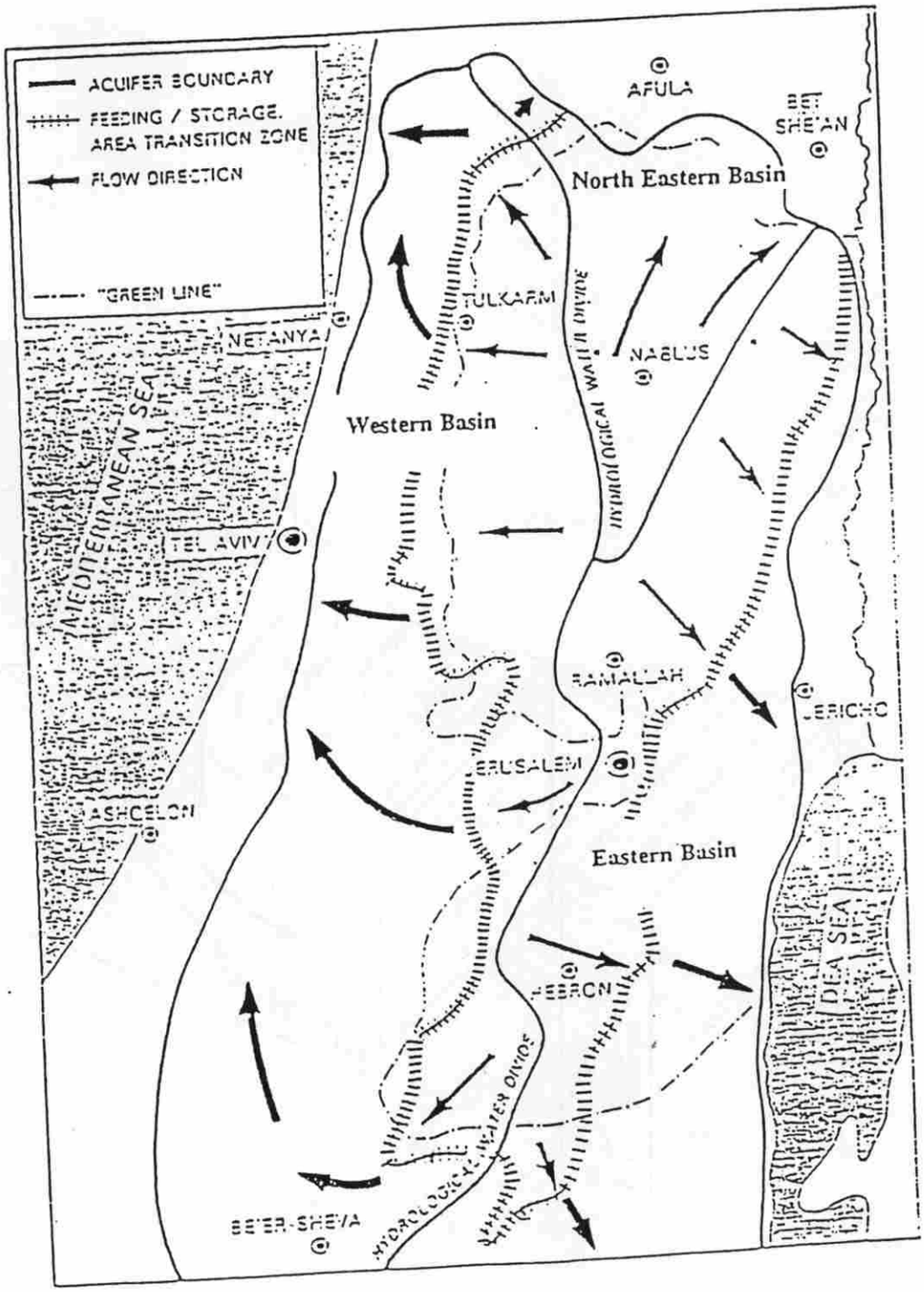
Contents of Data Appendix

Figure 1. Cross-section of the West Bank Aquifer and Coastal Plain



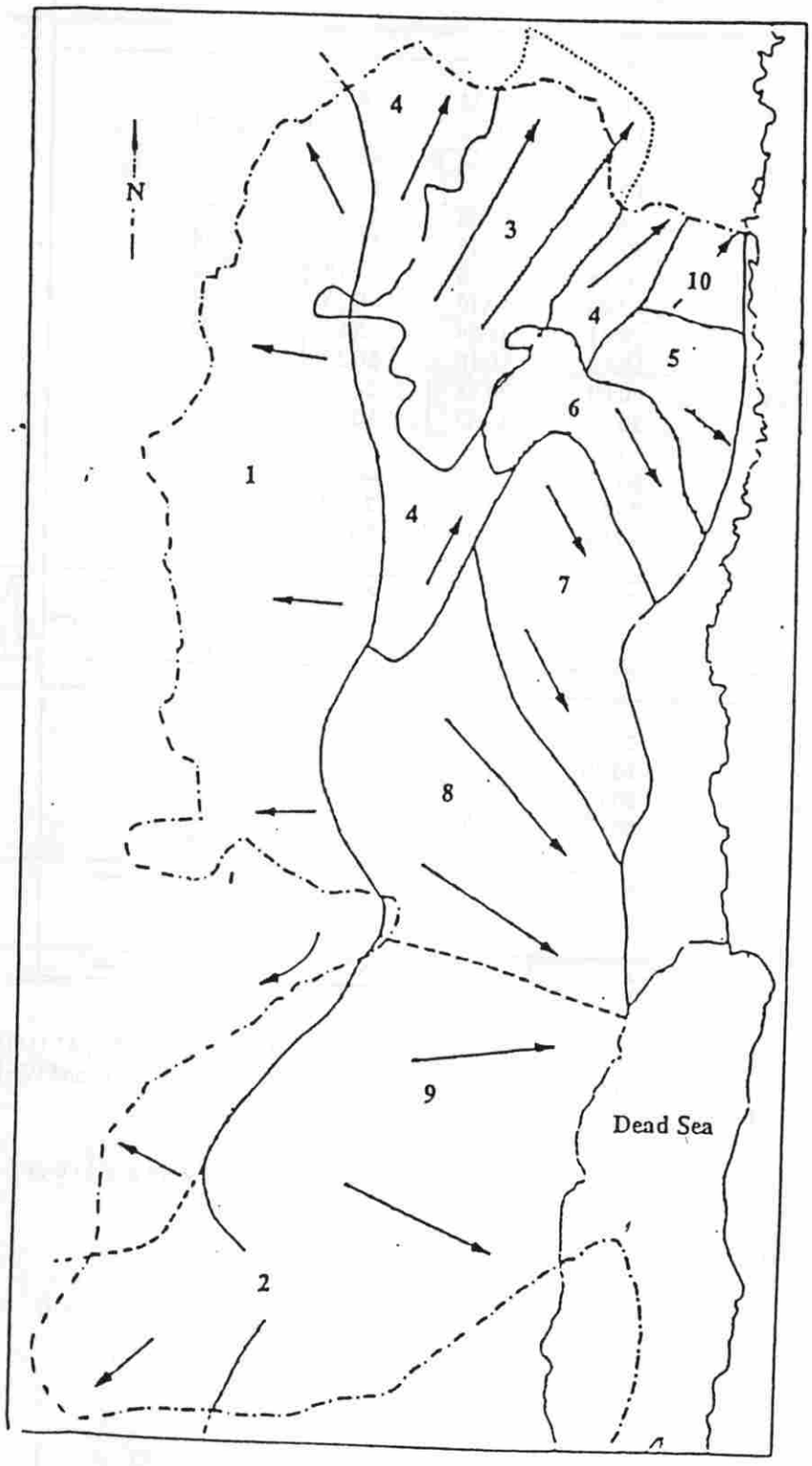
Source: Adapted from Gvirtzman, H. (1993).

Figure 2. Map of the Western, Northeastern, and Eastern Basins of the West Bank Aquifer



Source: Gvirtzman, H. (1993).

Fig. 3 Map of Aquifers Within the Western, Northeastern, and Eastern Basins



1. Auja Tamaseeh
2. Hebron-Beer-Sheba
3. Samarian (overlies Nablus-Jenin
4. Nablus-Jenin
5. Buquei'a-Wadi Malih
6. Fari'ah
7. Auja-Fasajil
8. Ramallah-Jerusalem
9. Jerusalem Desert
10. Bardala

Source: Boneh, Yohanan and Baida, Uri (1977-78).

Table 1. Water Supply in Palestine

Sub-district	Steps in Quantity (mcm/yr) and Average Cost ($/cm)						Total Supply (mcm)
		1	2	3	4	5	
West Bank							
W1: Nablus	*Quantity*	7.73	7.32	4.36	20.59		40.0
	Cost	$0.00	$0.16	$0.33	$0.34		
W2: Hebron	*Quantity*	5.90	9.62	46.68			62.2
	Cost	$0.16	$0.33	$0.34			
W3: Ramallah	*Quantity*	0.12	13.68	17.67	128.57		160.0
	Cost	$0.00	$0.16	$0.33	$0.34		
W4: Jenin	*Quantity*	0.28	11.78	2.18	98.33		112.6
	Cost	$0.00	$0.16	$0.33	$0.34		
W5: Tulkarem	*Quantity*	0.04	24.54	6.68	134.95		166.2
	Cost	$0.00	$0.16	$0.33	$0.34		
W6: Bethlehem	*Quantity*	0.00	24.88	28.79			53.7
	Cost	$0.16	$0.33	$0.34			
W7: E. Jerusalem	*Quantity*	4.80					4.8
	Cost	$0.34					
W8: Jericho	*Quantity*	21.56	14.30	25.28			61.1
	Cost	$0.00	$0.16	$0.28	$0.74		
Sub-total: West Bank	-->	-->	-->	-->	-->	-->	660.6
Gaza							
G1: North Gaza	*Quantity*	39.00					39.0
	Cost	$0.20	$0.74				
G2: South Gaza	*Quantity*	26.00					26.0
	Cost	$0.15	$0.74				
Sub-total: Gaza	-->	-->	-->	-->	-->	-->	65.0
Total: Palestine	-->	-->	-->	-->	-->	-->	725.6

Notes: Quantity estimates are from Nuseibeh (1994), the Health Development Information Project (1993), ARIJ (1993b,e), Baskin (1993), and WBDP (1988). Cost estimates are from Mekorot (1992), Awartani (1990), DeShazo (1994a), and World Bank (1993d). Any amount of water is available at $0.74 per cm through desalination.

Per cm

$ 0 – GW brought to surface by spring has no extraction costs

$ .16 – shallow wells & Cisterns

$ .33 – Deep Wells

– New Deep wells (no new wells are expected to be drilled during the Israeli occupation)

~ $ .34 – remaining unexploited quantities

– Jordan River (currently NOT available to J & S)

$ 0.08-0.12 via the Ghor canal (125 mcm/yr – 150 mcm)

0.74 • desalination of the JR (200 mcm)

Table 1a. Estimates of Annual Renewable Water in Palestine (mcm)

Basin	Aquifer	Source of Estimate					
		Bonch & Baida	Schwartz	WBDP	Isaac	Shuval**	UN*
West Bank				335	335	350	335
Western	*Auja-Tamaseeh*	360	335				
	Hebron-Beer-Sheba	19		140	140	131	140
North Eastern	*Samarian*	88	93				
	Nablus-Jenin	45	45	105	125	151	125
Eastern	*Buquei'a-Wadi Malih*	3	1				
	Fari'ah	13	4				
	Auja-Fasajil	32	22				
	Jerusalem-Ramallah	60	58				
	Judean Desert	38	21				
	Bardala	5					
Jordan River						100	120
Sub-total: West Bank		661	578	580	600	732	720
Sub-total: Gaza	*Gaza (part of the Auja-Tamaseeh)*			55	65	70	65

Notes: When authors offer a range of quantities the average is presented. Sources are: Boneh & Baida (1977-78, 36-40); Schwartz in Elazar (ed.) (1982, 83-90); WBDP (1987); Shuval in Al Khatib et al. (1993, 20); UN (1992); Isaac (1992). *The Jordan River is currently not used by the Palestinians - - these are estimates of anticipated use. **Shuval's estimates include brackish water (Al Khatib et al,1993, 14).

Table 1b. Estimate of Current Water Extraction in Palestine (mcm)

Sub-district	Piped from Springs		Piped from Wells		Unpiped Use		Jewish Settlements	Total Quantity Extracted
	For Irrigation	For Households	Deep Wells (Primarily for Domestic Use)	Shallow Wells (Primarily for Irrigation)	For Households	For Irrigation		
West Bank								
W1: Nablus	6.0	1.7	4.4	2.7	4.6	0.0	0.0	19.4
W2: Hebron	0.0	0.0	0.6	0.0	0.9	5.0	9.0	15.5
W3: Ramallah	0.0	0.1	5.0	12.6	1.0	0.0	12.6	31.3
W4: Jenin	0.0	0.3	2.2	4.0	2.8	5.0	0.0	14.3
W5: Tulkarem	0.0	0.0	4.9	16.6	3.1	4.8	1.8	31.2
W6: Bethlehem	0.0	0.0	8.6	0.0	0.0	0.6	16.3	25.5
W7: E. Jerusalem	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
W8: Jericho	20.7	0.9	0.0	14.1	0.3	0.0	25.3	61.
Sub-total: West Bank	26.7	3.0	25.7	50.1	12.7	15.3	65.0	198.

Notes: Data on piped water is from Nuseibeh (1994). Data on unpiped household consumption is based on the Health Development Information Project (1993). Data on unpiped agricultural consumption is based on ARIJ (1993a,b). (See discussion of agricultural demand in text.) For derivation of data on settlements see Table 1c. See text for further documentation.

Table 1c. Location and Number of Known Settlement Wells

Sub-districts	Settlement	Number of Wells	District Total	Portion of District Total
W1: Nablus		0	0	0.00
W2: Hebron	*Asel*	1	5	0.14
	Carmel	2		
	Yatir	2		
W3: Ramallah	*Bet Elb*	1	7	0.19
	Shiloh	1		
	Kokahv Hashahar	3		
	Rimonim	2		
W4: Jenin		0	0	0.00
W5: Tulkarmen	*Kokhav Yan*	1	1	0.03
W6: Bethlehem	*Rosh Tsurim*	2	9	0.25
	Kfar Etzion	2		
	Efriat	2		
	Teqo'a	3		
W7: Jericho	*Mitpze Shalem*	5	14	0.39
	Beit Haarava	1		
	Ma'aleh Ephraim	2		
	Petzael	1		
	Giigac	1		
	Netiv Hagdud	2		
	Shedemot	1		
	Gitit	1		
Total	-->	36	36	1.00

Notes: Using WBDP (1988), wells located (p.3) in Jewish settlements (p.24) were identified by district. Also see Al khatib et al. (1993), Kahan (1988) and the Ministry of Agriculture (1983).

Table 1d: Maximum Sustainable Yield, Current Extraction, and Available Surplus of Water in the West Bank

Sub-district	Aquifer Basin(s)	Aquifers	Percentage of Aquifer Area	Quantity Available from Aquifer	Total Water Available	Total Extracted	Surplus Available
West Bank							
W1: Nablus	*North-Eastern*	*Samarian*	0.19	16.63	53.00	19.41	33.59
		Nablus-Jenin	0.19	8.55			
	Eastern	*Fari'ah*	0.61	7.93			
		Buquei'a-Wadi Malih	0.15	0.38			
		Auja-Fasajil	0.61	19.52			
W2: Hebron	*Western-Eastern*	*Hebron-Beer-Sheba*	1.00	19.00	62.20	15.52	46.68
	Western	*Auja -Tamaseeh*	0.12	43.20			
W3: Ramallah	*Western*	*Auja -Tamaseeh*	0.33	118.80	173.04	31.47	141.57
	Eastern	*Jerusalem-Ramallah*	0.76	45.60			
		Auja-Fasajil	0.27	8.64			
W4: Jenin	*North-Eastern*	*Samarian*	0.69	60.38	112.58	14.24	98.34
		Nablus-Jenin	0.44	19.80			
	Western	*Auja -Tamaseeh*	0.09	32.40			
W5: Tulkarem	*Western*	*Auja -Tamaseeh*	0.39	140.40	166.20	31.25	134.95
	North-Eastern	*Samarian*	0.12	10.50			
		Nablus-Jenin	0.34	15.30			
W6: Bethlehem	*Western*	*Auja -Tamaseeh*	0.06	21.60	66.30	25.51	40.79
	Eastern	*Jerusalem Desert*	1.00	37.50			
		Jerusalem-Ramallah	0.12	7.20			
W7: E. Jerusalem	*Western*	*Ajua -Tamaseeh*	0.01	3.60	4.80	0.00	4.80
	Eastern	*Jerusalem-Ramallah*	0.02	1.20			
W8: Jericho	*North-Eastern*	*Nablus-Jenin*	0.03	1.35	22.89	61.14	(38.25)
	Eastern	*Bardala*	1.00	4.50			
		Buquei'a-Wadi Malih	0.85	2.13			
		Fari'ah	0.39	5.07			
		Jerusalem-Ramallah	0.10	6.00			
		Auja-Fasajil	0.12	3.84			
Sub-total: West Bank	-->	-->	-->	661.00	661.00	198.55	462.45

Notes: Aquifer delineation and yields are from Boneh & Baida (1977-78). See Elmusa (forthcomming) for a discusion of Boneh and Baida and related sources in English. See Table 1b for data on current extraction. See text for a full discussion of this table.

Table 1e. Alternative Scenarios for Water Supply in Palestine

Sub-district	Quantity (mcm/yr) and Average Cost ($/cm) 1	2	3	4	5	Total Supply (mcm)
West Bank						
S1: Jordan River	*Quantity*	150.00				150.00
	Cost	$0.12				
S2: Jordan River	*Quantity*	200.00				200.00
	Cost	$0.74				
S3: Jordan River	*Quantity*	240.00				240.00
	Cost	$0.00				
Gaza						
S1: Gaza	*Quantity*	44.00				44.00
	Cost	$0.16				

Notes: Based on information from Kahan (1987) and Al Khatib (1993). See text for further documentation.

Table 2. Total Water Demand in Palestine

1990 Baseline Estimate and Projections for 2000, 2010, and 2020 (mcm)

Sub-district	Household				Industry				Agriculture				Total			
	1990	2000	2010	2020	1990	2000	2010	2020	1990	2000	2010	2020	1990	2000	2010	2020
West Bank																
W1: Nablus	10.4	27.7	50.6	80.9	0.8	2.2	4.5	7.3	3.4	9.7	23.6	37.6	14.6	39.6	78.7	125.8
W2: Hebron	5.0	31.2	56.9	90.9	1.6	4.3	8.8	14.3	0.5	1.8	23.6	45.5	7.1	37.2	89.3	150.7
W3: Ramallah	7.4	27.6	50.3	80.5	0.6	1.5	3.0	5.0	0.5	2.2	9.6	17.0	8.5	31.2	63.0	102.4
W4: Jenin	5.2	23.7	43.2	69.1	0.2	0.6	1.2	1.9	9.0	74.7	101.4	128.1	14.5	99.0	145.8	199.1
W5: Tulkarem	8.0	24.3	44.4	70.9	0.7	1.9	3.9	6.4	21.4	21.4	21.8	34.0	30.1	47.6	70.1	111.3
W6: Bethlehem	3.0	16.7	30.4	48.7	0.7	1.7	3.6	5.8	0.6	2.0	9.0	15.9	4.3	20.5	43.0	70.4
W7: E. Jerusalem	6.8	19.9	36.2	57.9	0.2	0.6	1.2	1.9	0.0	0.0	0.0	0.0	7.0	20.4	37.4	59.8
W8: Jericho	2.2	3.1	5.7	9.1	0.1	0.3	0.6	1.0	34.6	34.6	45.3	67.0	36.9	38.0	51.6	77.2
Sub-total: West Bank	48.2	174.2	317.8	508.0	5.0	13.0	26.7	43.5	69.9	146.3	234.3	345.0	123.0	333.5	578.8	896.6
Gaza																
G1: North Gaza	15.5	46.0	86.3	144.9	1.0	2.6	5.3	8.7	33.0	33.0	33.0	33.0	49.5	81.6	124.7	186.6
G2: South Gaza	14.5	42.5	79.8	133.9	1.0	2.6	5.3	8.7	37.2	37.2	37.2	37.2	52.7	82.3	122.4	179.8
Sub-total: Gaza	30.0	88.5	166.1	278.8	2.0	5.2	10.7	17.4	70.2	70.2	70.2	70.2	102.2	163.8	247.0	366.4
Total: Palestine	78.2	262.6	483.9	786.8	7.0	18.2	37.4	61.0	140.1	216.5	304.5	415.2	225.2	497.3	825.9	1,263.0

Notes: Figures are from the 1990 baseline estimates and middle scenario projections presented in Tables 3, 4, and 5. See Tables 3, 4, and 5 and text for further documentation.

Table 3. Household Water Demand in Palestine: Middle Scenario

1990 Baseline Estimate and Projections for 2000, 2010, and 2020

-district	Baseline Estimate	Projection for 2000				Projection for 2010				Projection for 2020			
	1990 (mcm)	Population (1,000s)	Visitor Equivalents (1,000s)	Demand Per Capita (cm)	Total Demand (mcm)	Population (1,000s)	Visitor Equivalents (1,000s)	Demand Per Capita (cm)	Total Demand (mcm)	Population (1,000s)	Visitor Equivalents (1,000s)	Demand Per Capita (cm)	Total Demand (mcm)
t Bank													
Nablus	10.4	364.7	5.3	75	27.7	499.7	6.5	100	50.6	639.7	7.7	125	80.9
Hebron	5.0	409.8	5.9	75	31.2	561.5	7.3	100	56.9	718.8	8.7	125	90.9
Ramallah	7.4	362.6	5.3	75	27.6	496.9	6.5	100	50.3	636.1	7.7	125	80.5
Jenin	5.2	311.4	4.5	75	23.7	426.6	5.6	100	43.2	546.1	6.6	125	69.1
Tulkarem	8.0	319.6	4.6	75	24.3	437.9	5.7	100	44.4	560.6	6.8	125	70.9
Bethlehem	3.0	219.3	3.2	75	16.7	300.5	3.9	100	30.4	384.7	4.6	125	48.7
E. Jerusalem	6.8	261.0	3.8	75	19.9	357.6	4.7	100	36.2	457.8	5.5	125	57.9
Jericho	2.2	41.0	0.6	75	3.1	56.2	0.7	100	5.7	71.9	0.9	125	9.1
-total: West Bank	48.2	2,289.4	33.2	–	174.2	3,137.0	41.0	–	317.8	4,015.6	48.4	–	508.0
za													
North Gaza	15.5	604.1	8.7	75	46.0	852.1	11.1	100	86.3	1,145.1	13.8	125	144.9
South Gaza	14.5	558.5	8.1	75	42.5	787.8	10.3	100	79.8	1,058.7	12.8	125	133.9
-total: Gaza	30.0	1,162.5	16.8	–	88.5	1,639.9	21.5	–	166.1	2,203.9	26.6	–	278.8
tal: Palestine	78.2	3,451.9	50.0	–	262.6	4,776.9	62.5	–	483.9	6,219.5	75.0	–	786.8

tes: See Table 3a for derivation of 1990 baseline estimates and Table 3b for middle scenario population projections. "Vistor equivalents" are based on the assumption that visitors will number 0,000 in 2000, 250,000 in 2010, and 300,000 in 2020, and will stay for an average of 3 months. See text for further documentation.

Table 3a. Household Water Demand in Palestine: 1990 Baseline Estimate

(mcm)

-district	Piped Consumption					Unpiped Consumption		Total	1990 Population (1000s)	Consumption Per Capita (cm)
	Wells Within District	Springs	Imported Via Water Department	Imported from Other Sources	Total	Proportion	Estimated Total	Consumption		
t Bank										
Nablus	4.15	1.70	0.00	0.00	5.84	0.44	4.59	10.4	211.3	49
Hebron	0.59	0.00	3.49	0.00	4.08	0.18	0.90	5.0	237.5	21
Ramallah	2.00	0.12	3.72	0.53	6.37	0.14	1.04	7.4	210.1	35
Jenin	2.18	0.28	0.00	0.00	2.46	0.53	2.78	5.2	180.4	29
Tulkarem	4.87	0.04	0.00	0.00	4.91	0.39	3.14	8.0	185.2	43
Bethlehem	3.00	0.00	0.00	0.00	3.00	0.01	0.03	3.0	127.1	24
E. Jerusalem	–	–	–	–	6.80	0.00	0.00	6.8	151.2	45
Jericho	0.00	1.74	0.25	0.00	1.99	0.11	0.25	2.2	23.7	94
-total: West Bank	16.79	3.87	7.46	0.53	35.46	–	12.71	48.2	1,326.5	36
a										
North Gaza	15.50	0.00	0.00	0.00	15.50	–	–	15.5	369.4	42
South Gaza	11.50	0.00	3.00	0.00	14.50	–	–	14.5	341.5	42
-total: Gaza	27.00	0.00	3.00	0.00	30.00	–	–	30.0	711.0	42
al: Palestine	–	–	–	–	–	–	–	78.2	2,037.5	38

es: Data for 1990 piped water consumption is from the Water Dept. (1993), Hebron Municipal Water Dept. (ARIJ 1993c), Jericho Municipal Water Dept. (ARIJ 1993d), the Jerusalem Undertaking: nallah District (1991, 22), ARIJ (1993a) for Gaza, and Haddad and Abu-A'isheh (1992, 75). 1990 water consumption for E. Jerusalem assumes a per capita rate of 45 cm/yr. The proportion of households hout piped water is from the Health Development Information Project (1993). See text for further documentation.

Table 3b. Population Projections for Palestine: Middle Scenario

1990 Baseline Estimate and Projections for 2010 and 2020 (1,000s)

Sub-district	1990 Baseline Estimate	1990-2000 Average Annual Growth Rate	1990-2000 Total Natural Growth	Returnees	2000 Projection	2000-2010 Average Annual Growth Rate	2010 Projection	2010-2020 Average Annual Growth Rate	2020 Projection
West Bank									
W1: Nablus	211.3	3.6%	301.0	63.7	364.7	3.2%	499.7	2.5%	639.7
W2: Hebron	237.5	3.6%	338.2	71.6	409.8	3.2%	561.5	2.5%	718.8
W3: Ramallah	210.1	3.6%	299.3	63.4	362.6	3.2%	496.9	2.5%	636.1
W4: Jenin	180.4	3.6%	257.0	54.4	311.4	3.2%	426.6	2.5%	546.1
W5: Tulkarem	185.2	3.6%	263.8	55.8	319.6	3.2%	437.9	2.5%	560.6
W6: Bethlehem	127.1	3.6%	181.0	38.3	219.3	3.2%	300.5	2.5%	384.7
W7: E. Jerusalem	151.2	3.6%	215.4	45.6	261.0	3.2%	357.6	2.5%	457.8
W8: Jericho	23.7	3.6%	33.8	7.2	41.0	3.2%	56.2	2.5%	71.9
Sub-total: West Bank	1,326.5	–	1,889.4	400.0	2,289.4	–	3,137.0	–	4,015.6
Gaza									
G1: North Gaza	369.4	4.1%	552.1	52.0	604.1	3.5%	852.1	3.0%	1,145.1
G2: South Gaza	341.5	4.1%	510.4	48.0	558.5	3.5%	787.8	3.0%	1,058.7
Sub-total: Gaza	711.0	–	1,062.5	100.0	1,162.5	–	1,639.9	–	2,203.9
Total: Palestine	2,037.5	–	2,951.9	500.0	3,451.9	–	4,776.9	–	6,219.5

Notes: Population average annual growth rates are based on Projection 4 of Abdeen and Abu-Libdeh (1993, 26). Returning refugees are assumed to total 500,000 and to return to the West Bank and Gaza in proportion to where they departed from (i.e., about 80% West Bank and 20% Gaza). Returnees are distributed among districts according to the percentage of total population within each district. See text for further documentation.

Table 3c. Household Water Demand in Palestine: High Scenario

1990 Baseline Estimate and Projections for 2000, 2010, and 2020

ub-district	Baseline Estimate	Projection for 2000				Projection for 2010				Projection for 2020			
	1990 (mcm)	Population (1,000s)	Visitor Equivalents (1,000s)	Demand Per Capita (cm)	Total Demand (mcm)	Population (1,000s)	Visitor Equivalents (1,000s)	Demand Per Capita (cm)	Total Demand (mcm)	Population (1,000s)	Visitor Equivalents (1,000s)	Demand Per Capita (cm)	Total Demand (mcm)
est Bank													
1: Nablus	10.4	385.7	5.2	75	29.3	587.6	6.4	100	59.4	869.7	7.6	125	109.7
2: Hebron	5.0	433.4	5.9	75	32.9	660.2	7.2	100	66.7	977.3	8.5	125	123.2
3: Ramallah	7.4	383.5	5.2	75	29.2	584.2	6.4	100	59.1	864.8	7.6	125	109.0
4: Jenin	5.2	329.3	4.5	75	25.0	501.6	5.5	100	50.7	742.5	6.5	125	93.6
5: Tulkarem	8.0	338.0	4.6	75	25.7	514.9	5.6	100	52.1	762.2	6.7	125	96.1
6: Bethlehem	3.0	231.9	3.2	75	17.6	353.3	3.9	100	35.7	523.0	4.6	125	66.0
7: E. Jerusalem	6.8	276.0	3.8	75	21.0	420.5	4.6	100	42.5	622.4	5.4	125	78.5
8: Jericho	2.2	43.3	0.6	75	3.3	66.0	0.7	100	6.7	97.7	0.9	125	12.3
ub-total: West Bank	48.2	2,421.0	32.9	–	184.0	3,688.4	40.5	–	372.9	5,459.7	47.7	–	688.4
aza													
1: North Gaza	15.5	653.7	8.9	75	49.7	1,044.7	11.5	100	105.6	1,622.4	14.2	125	204.6
2: South Gaza	14.5	604.4	8.2	75	45.9	965.9	10.6	100	97.6	1,500.0	13.1	125	189.1
ub-total: Gaza	30.0	1,258.1	17.1	–	95.6	2,010.6	22.0	–	203.3	3,122.3	27.3	–	393.7
otal: Palestine	78.2	3,679.1	50.0	–	279.7	5,698.9	62.5	–	576.1	8,582.0	75.0	–	1,082.1

lotes: See Table 3a for derivation of 1990 baseline estimates and Table 3d for high scenario population projections. "Vistor equivalents" are based on the assumption that visitors will number 200,000 in 2000, 50,000 in 2010, and 300,000 in 2020, and will stay for an average of 3 months. See text for further documentation.

Table 3d. Population Projections for Palestine: High Scenario

1990 Baseline Estimate and Projections for 2000, 2010, and 2020 (1,000s)

Sub-district	1990	1990-2000			2000	2000-2010	2010	2010-2020	2020
	Baseline Estimate	Average Annual Growth Rate	Total Natural Growth	Returnees	Projection	Average Annual Growth Rate	Projection	Average Annual Growth Rate	Projection
West Bank									
W1: Nablus	211.3	4.3%	321.9	63.7	385.7	4.3%	587.6	4.0%	869.7
W2: Hebron	237.5	4.3%	361.8	71.6	433.4	4.3%	660.2	4.0%	977.3
W3: Ramallah	210.1	4.3%	320.1	63.4	383.5	4.3%	584.2	4.0%	864.8
W4: Jenin	180.4	4.3%	274.9	54.4	329.3	4.3%	501.6	4.0%	742.5
W5: Tulkarem	185.2	4.3%	282.1	55.8	338.0	4.3%	514.9	4.0%	762.2
W6: Bethlehem	127.1	4.3%	193.6	38.3	231.9	4.3%	353.3	4.0%	523.0
W7: E. Jerusalem	151.2	4.3%	230.4	45.6	276.0	4.3%	420.5	4.0%	622.4
W8: Jericho	23.7	4.3%	36.2	7.2	43.3	4.3%	66.0	4.0%	97.7
Sub-total: West Bank	1,326.5	–	2,021.0	400.0	2,421.0	–	3,688.4	–	5,459.7
Gaza									
G1: North Gaza	369.4	5.0%	601.7	52.0	653.7	4.8%	1,044.7	4.5%	1,622.4
G2: South Gaza	341.5	5.0%	556.3	48.0	604.4	4.8%	965.9	4.5%	1,500.0
Sub-total: Gaza	711.0	–	1,158.1	100.0	1,258.1	–	2,010.6	–	3,122.3
Total: Palestine	2,037.5	–	3,179.1	500.0	3,679.1	–	5,698.9	–	8,582.0

Notes: Population average annual growth rates are based on Projection 7 of Abdeen and Abu-Libdeh (1993, 26). Returning refugees are assumed to total 500,000 and to return to the West Bank and Gaza in proportion to where they departed from (i.e., about 80% West Bank and 20% Gaza). Returnees are distributed among districts according to the percentage of total population within each district. See text for further documentation.

Table 3e. Household Water Demand in Palestine: Low Scenario

1990 Baseline Estimate and Projections for 2000, 2010, and 2020

ıb-district	Baseline Estimate	Projection for 2000				Projection for 2010				Projection for 2020			
	1990 (mcm)	Population (1,000s)	Visitor Equivalents (1,000s)	Demand Per Capita (cm)	Total Demand (mcm)	Population (1,000s)	Visitor Equivalents (1,000s)	Demand Per Capita (cm)	Total Demand (mcm)	Population (1,000s)	Visitor Equivalents (1,000s)	Demand Per Capita (cm)	Total Demand (mcm)
·st Bank													
1: Nablus	10.4	350.5	5.3	75	26.7	444.3	6.6	100	45.1	515.6	7.9	125	65.4
2: Hebron	5.0	393.8	6.0	75	30.0	499.2	7.4	100	50.7	579.4	8.9	125	73.5
3: Ramallah	7.4	348.5	5.3	75	26.5	441.8	6.6	100	44.8	512.7	7.9	125	65.1
4: Jenin	5.2	299.2	4.5	75	22.8	379.3	5.7	100	38.5	440.2	6.8	125	55.9
5: Tulkarem	8.0	307.1	4.7	75	23.4	389.3	5.8	100	39.5	451.9	6.9	125	57.4
6: Bethlehem	3.0	210.8	3.2	75	16.0	267.2	4.0	100	27.1	310.1	4.8	125	39.4
7: E. Jerusalem	6.8	250.8	3.8	75	19.1	317.9	4.7	100	32.3	369.0	5.7	125	46.8
8: Jericho	2.2	39.4	0.6	75	3.0	49.9	0.7	100	5.1	57.9	0.9	125	7.4
b-total: West Bank	48.2	2,200.1	33.4	–	167.5	2,789.0	41.6	–	283.1	3,236.8	49.8	–	410.8
za													
North Gaza	15.5	568.0	8.6	75	43.2	727.1	10.9	100	73.8	852.2	13.1	125	108.2
South Gaza	14.5	525.2	8.0	75	40.0	672.3	10.0	100	68.2	787.9	12.1	125	100.0
b-total: Gaza	30.0	1,093.2	16.6	–	83.2	1,399.4	20.9	–	142.0	1,640.1	25.2	–	208.2
al: Palestine	78.2	3,293.4	50.0	–	250.8	4,188.4	62.5	–	425.1	4,876.9	75.0	–	619.0

es: See Table 3a for derivation of 1990 baseline estimates and Table 3f for low scenario population projections. "Vistor equivalents" are based on the assumption that visitors will number 200,000 in 2000, 250,000 010, and 300,000 in 2020, and will stay for an average of 3 months. See text for further documentation.

Table 3f. Population Projections for Palestine: Low Scenario

1990 Baseline Estimate and Projections for 2000, 2010, and 2020 (1,000s)

Sub-district	1990	1990-2000			2000	2000-2010	2010	2010-2020	2020
	Baseline Estimate	Average Annual Growth Rate	Total Natural Growth	Returnees	Projection	Average Annual Growth Rate	Projection	Average Annual Growth Rate	Projection
West Bank									
W1: Nablus	211.3	3.1%	286.8	63.7	350.5	2.4%	444.3	1.5%	515.6
W2: Hebron	237.5	3.1%	322.2	71.6	393.8	2.4%	499.2	1.5%	579.4
W3: Ramallah	210.1	3.1%	285.1	63.4	348.5	2.4%	441.8	1.5%	512.7
W4: Jenin	180.4	3.1%	244.8	54.4	299.2	2.4%	379.3	1.5%	440.2
W5: Tulkarem	185.2	3.1%	251.3	55.8	307.1	2.4%	389.3	1.5%	451.9
W6: Bethlehem	127.1	3.1%	172.5	38.3	210.8	2.4%	267.2	1.5%	310.1
W7: E. Jerusalem	151.2	3.1%	205.2	45.6	250.8	2.4%	317.9	1.5%	369.0
W8: Jericho	23.7	3.1%	32.2	7.2	39.4	2.4%	49.9	1.5%	57.9
Sub-total: West Bank	1,326.5	–	1,800.1	400.0	2,200.1	–	2,789.0	–	3,236.8
Gaza									
G1: North Gaza	369.4	3.4%	516.1	52.0	568.0	2.5%	727.1	1.6%	852.2
G2: South Gaza	341.5	3.4%	477.1	48.0	525.2	2.5%	672.3	1.6%	787.9
Sub-total: Gaza	711.0	–	993.2	100.0	1,093.2	–	1,399.4	–	1,640.1
Total: Palestine	2,037.5	–	2,793.4	500.0	3,293.4	–	4,188.4	–	4,876.9

Notes: Population average annual growth rates are based on Projection 1 of Abdeen and Abu-Libdeh (1993, 26). Returning refugees are assumed to total 500,000 and to return to the West Bank and Gaza in proportion to where they departed from (i.e., about 80% West Bank and 20% Gaza). Returnees are distributed among districts according to the percentage of total population within each district. See text for further documentation.

Table 4. Industrial Water Demand in Palestine: Middle Scenario

1990 Baseline Estimate and Projections for 2000, 2010, and 2020 (mcm)

Sub-district	1990 Proportion of Water-Intensive Industry	1990 Baseline Estimate	1990-2000 Growth Rate	2000 Projection	2000-2010 Growth Rate	2010 Projection	2010-2020 Growth Rate	2020 Projection
West Bank								
W1: Nablus	0.17	0.8	10.0%	2.2	7.5%	4.5	5.0%	7.3
W2: Hebron	0.33	1.6	10.0%	4.3	7.5%	8.8	5.0%	14.3
W3: Ramallah	0.11	0.6	10.0%	1.5	7.5%	3.0	5.0%	5.0
W4: Jenin	0.04	0.2	10.0%	0.6	7.5%	1.2	5.0%	1.9
W5: Tulkarem	0.15	0.7	10.0%	1.9	7.5%	3.9	5.0%	6.4
W6: Bethlehem	0.13	0.7	10.0%	1.7	7.5%	3.6	5.0%	5.8
W7: E. Jerusalem	0.04	0.2	10.0%	0.6	7.5%	1.2	5.0%	1.9
W8: Jericho	0.02	0.1	10.0%	0.3	7.5%	0.6	5.0%	1.0
Sub-total: West Bank	1.00	5.0	–	13.0	–	26.7	–	43.5
Gaza								
G1: North Gaza	0.50	1.0	10.0%	2.6	7.5%	5.3	5.0%	8.7
G2: South Gaza	0.50	1.0	10.0%	2.6	7.5%	5.3	5.0%	8.7
Sub-total: Gaza	1.00	2.0	–	5.2	–	10.7	–	17.4
Total: Palestine	–	7.0	–	18.2	–	37.4	–	61.0

Notes: Baseline estimates of industrial water demand for each district were estimated by distributing total water demand for the West Bank and Gaza according to the proportion of water-intensive industry located within each district (see Table 4c). Middle scenario projections assume an annual growth rate for industrial water demand which decreases from 10% during the 1990s (Awartani 1991) to 7.5% from 2000-2010 and then 5% from 2010-2020. See text for further documentation.

Table 4a. Industrial Water Demand in Palestine: High Scenario

1990 Baseline Estimate and Projections for 2000, 2010, and 2020 (mcm)

Sub-district	1990 Proportion of Water-Intensive Industry	1990 Baseline Estimate	1990-2000 Growth Rate	2000 Projection	2000-2010 Growth Rate	2010 Projection	2010-2020 Growth Rate	2020 Projection
West Bank								
W1: Nablus	0.17	0.8	12.5%	2.7	10.0%	7.0	7.5%	14.5
W2: Hebron	0.33	1.6	12.5%	5.3	10.0%	13.8	7.5%	28.4
W3: Ramallah	0.11	0.6	12.5%	1.8	10.0%	4.8	7.5%	9.9
W4: Jenin	0.04	0.2	12.5%	0.7	10.0%	1.8	7.5%	3.8
W5: Tulkarem	0.15	0.7	12.5%	2.4	10.0%	6.2	7.5%	12.8
W6: Bethlehem	0.13	0.7	12.5%	2.2	10.0%	5.6	7.5%	11.6
W7: E. Jerusalem	0.04	0.2	12.5%	0.7	10.0%	1.8	7.5%	3.8
W8: Jericho	0.02	0.1	12.5%	0.4	10.0%	1.0	7.5%	2.0
Sub-total: West Bank	1.00	5.0	–	16.2	–	42.1	–	86.8
Gaza								
G1: North Gaza	0.50	1.0	12.5%	3.2	10.0%	8.4	7.5%	17.4
G2: South Gaza	0.50	1.0	12.5%	3.2	10.0%	8.4	7.5%	17.4
Sub-total: Gaza	1.00	2.0	–	6.5	–	16.8	–	34.7
Total: Palestine	–	7.0	–	22.7	–	59.0	–	121.5

Notes: Baseline estimates of industrial water demand for each district were estimated by distributing total water demand for the West Bank and Gaza according to the proportion of water-intensive industry located within each district (see Table 4c). High scenario projections assume an annual growth rate for industrial water demand which decreases from 12.5% during the 1990s to 10.0% from 2000-2010 and then 7.5% from 2010-2020. See text for further documentation.

Table 4b. Industrial Water Demand in Palestine: Low Scenario

1990 Baseline Estimate and Projections for 2000, 2010, and 2020 (mcm)

Sub-district	1990 Proportion of Water-Intensive Industry	1990 Baseline Estimate	1990-2000 Growth Rate	2000 Projection	2000-2010 Growth Rate	2010 Projection	2010-2020 Growth Rate	2020 Projection
West Bank								
W1: Nablus	0.17	0.8	7.5%	1.7	5.0%	2.8	2.5%	3.6
W2: Hebron	0.33	1.6	7.5%	3.4	5.0%	5.5	2.5%	7.0
W3: Ramallah	0.11	0.6	7.5%	1.2	5.0%	1.9	2.5%	2.4
W4: Jenin	0.04	0.2	7.5%	0.4	5.0%	0.7	2.5%	0.9
W5: Tulkarem	0.15	0.7	7.5%	1.5	5.0%	2.5	2.5%	3.2
W6: Bethlehem	0.13	0.7	7.5%	1.4	5.0%	2.2	2.5%	2.9
W7: E. Jerusalem	0.04	0.2	7.5%	0.4	5.0%	0.7	2.5%	0.9
W8: Jericho	0.02	0.1	7.5%	0.2	5.0%	0.4	2.5%	0.5
Sub-total: West Bank	1.00	5.0	–	10.3	–	16.8	–	21.5
Gaza								
G1: North Gaza	0.50	1.0	7.5%	2.1	5.0%	3.4	2.5%	4.3
G2: South Gaza	0.50	1.0	7.5%	2.1	5.0%	3.4	2.5%	4.3
Sub-total: Gaza	1.00	2.0	–	4.1	–	6.7	–	8.6
Total: Palestine	–	7.0	–	14.4	–	23.5	–	30.1

Notes: Baseline estimates of industrial water demand for each district were estimated by distributing total water demand for the West Bank and Gaza according to the proportion of water-intensive industry located within each district (see Table 4c). Middle scenario projections assume an annual growth rate for industrial water demand which decreases from 7.5% during the 1990s to 5% from 2000-2010 and then 2.5% from 2010-2020. See text for further documentation.

Table 4c. Distribution of Water-Intensive Industry in Palestine

(number of establishments)

Sub-district	Food	Textiles	Quarry	Total	Proportion
West Bank					
W1: Nablus	20	10	20	50	0.17
W2: Hebron	18	25	55	98	0.33
W3: Ramallah	12	10	12	34	0.11
W4: Jenin	1	2	10	13	0.04
W5: Tulkarem	10	13	21	44	0.15
W6: Bethlehem	8	13	19	40	0.13
W7: E. Jerusalem	9	2	2	13	0.04
W8: Jericho	3	2	2	7	0.02
Sub-total: West Bank	81	77	141	299	1.00
Gaza					
G1: North Gaza	27	35	50	112	0.50
G2: South Gaza	27	35	50	112	0.50
Sub-total: Gaza	54	70	100	224	1.00
Total: Palestine	135	147	241	523	–

Notes: Textiles, quarries, and foods represent the three most water-intensive industrial sectors in Palestine. The number of establishments for each of these industrial branches located within each sub-district are from Abd-Alraziq (1991, 84, 86, 96).

Table 5. Agricultural Water Demand in Palestine: Middle Scenario

Projections for 2000, 2010, and 2020

ıb-district	Weighted Avg. Water Use (cm/dun)	Total Irrigated Area in 1990 (1000 dun)	Class 1 Land Area		Class 2 Land Area		2000 Projection		2010 Projection		2020 Projection	
			Total Available (1000 dun)	Surplus Available (1000 dun)	Total Available (1000 dun)	Surplus Available (1000 dun)	Total Irrigated Area (1000 dun)	Total Water Use (mcm)	Total Irrigated Area (1000 dun)	Total Water Use (mcm)	Total Irrigated Area (1000 dun)	Total Water Use (mcm)
est Bank												
1: Nablus	690	4.9	14.0	9.2	57.8	57.8	14.0	9.7	34.3	23.6	54.5	37.6
2: Hebron	683	0.7	2.6	2.0	91.4	111.4	2.6	1.8	34.6	23.6	66.6	45.5
3: Ramallah	696	0.7	3.1	2.4	30.4	30.4	3.1	2.2	13.8	9.6	24.4	17.0
4: Jenin	687	13.1	108.7	95.5	110.9	130.9	108.7	74.7	147.5	101.4	186.3	128.1
5: Tulkarem	811	26.3	11.9	0.0	42.9	28.4	26.3	21.4	26.9	21.8	41.9	34.0
6: Bethlehem	650	1.0	3.1	2.2	30.4	30.4	3.1	2.0	13.8	9.0	24.4	15.9
7: E. Jerusalem	0	0.0	0.3	0.3	2.5	2.5	0.3	0.0	1.1	0.0	2.0	0.0
8: Jericho	817	42.3	28.9	0.0	75.9	62.5	42.3	34.6	55.5	45.3	82.0	67.0
b-total: West Bank	–	89.0	172.6	83.6	442.3	454.4	200.5	146.3	327.4	234.3	482.2	345.0
ıza												
: North Gaza	825	40.0	40.0	0.0	0.0	0.0	40.0	33.0	40.0	33.0	40.0	33.0
: South Gaza	531	70.0	70.0	0.0	0.0	0.0	70.0	37.2	70.0	37.2	70.0	37.2
b-total: Gaza	–	110.0	110.0	0.0	0.0	0.0	110.0	70.2	110.0	70.2	110.0	70.2
tal: Palestine	–	199.0	282.6	83.6	442.3	454.4	310.5	216.5	437.4	304.5	592.2	415.2

ıtes: Class 1 and 2 land areas available for irrigated cultivation are based on soil maps (ARIJ 1993b,c). Projections of agricultural water demand are the product of the weighted avg. water use per dunam for each trict (from Table 5a) and the projected irrigated land area for that district. Middle scenario projections assume all Class 1 land area will be irrigated by 2000 and that 35% and then 70% of Class 2 land will be igated by 2010 and 2020. See text for further documentation.

Table 5a. Agricultural Water Demand in Palestine: 1990 Baseline Estimate

-district	Total Irrigated Area in 1990 (1000 dun)	Vegetables			Citrus			Fruit			Field Crops			Weighted Avg. Water Use (cm/dun)	Total Agricultural Use (mcm)
		Irrigated Area (1000 dun)	Avg. Water Use (cm/dun)	Total Water Use (mcm)	Irrigated Area (1000 dun)	Avg. Water Use (cm/dun)	Total Water Use (mcm)	Irrigated Area (1000 dun)	Avg. Water Use (cm/dun)	Total Water Use (mcm)	Irrigated Area (1000 dun)	Water Use (cm/dun)	Total Water Use (mcm)		
: Bank															
Nablus	4.86	3.13	650	2.03	1.55	850	1.32	0.00	–	0.00	0.00	–	0.00	690	3.4
Hebron	0.67	0.56	650	0.36	0.11	850	0.09	0.00	–	0.00	0.00	–	0.00	683	0.5
Ramallah	0.70	0.54	650	0.35	0.16	850	0.14	0.00	–	0.00	0.00	–	0.00	696	0.5
Jenin	13.13	10.67	650	6.94	2.46	850	2.09	0.00	–	0.00	0.00	–	0.00	687	9.0
Tulkarem	26.34	9.11	650	5.92	16.54	850	14.06	0.69	2,000	1.38	0.00	–	0.00	811	21.4
Bethlehem	0.97	0.97	650	0.63	0.00	850	0.00	0.00	–	0.00	0.00	–	0.00	650	0.6
E. Jerusalem	0.00	0.00	0	0.00	0.00	–	0.00	0.00	–	0.00	0.00	–	0.00	0	0.0
Jericho	42.29	28.77	650	18.70	2.85	1,200	3.42	5.67	2,000	11.34	5.00	220	1.10	817	34.6
-otal: West Bank	88.96	53.75	650	34.94	23.67	892	21.12	6.36	2,000	12.72	5.00	220	1.10	785	69.9
a															
North Gaza	40.00	15.00	700	10.50	25.00	900	22.50	0.00	300	0.00	0.00	–	0.00	825	33.0
South Gaza	70.00	0.00	700	0.00	27.00	900	24.30	43.00	300	12.90	0.00	–	0.00	531	37.2
-otal: Gaza	110.00	15.00	700	10.50	52.00	900	46.80	43.00	300	12.90	0.00	–	0.00	638	70.2
al: Palestine	198.96	68.75		45.44	75.67	898	67.92	49.36	519	25.62	5.00	220	1.10	704	140.1

es: Areas under irrigated cultivation for each crop type in 1990 are from Rural Research Center (1990) for the West Bank and from the Dept. of Agriculture for Gaza (ARIJ 1993a). Rates of water use per dunam are n Awartani (1991, 18) for the West Bank and from the Dept. of Agriculture for Gaza (ARIJ 1993a). Total agricultural water demand in 1990 is found by summing over the product of irrigated area and average water use rop type and then by district. See text for further documentation.

Table 5b. Agricultural Water Demand in Palestine: High Scenario

Projections for 2000, 2010, and 2020

District	Weighted Avg. Water Use (cm/dun)	Total Irrigated Area in 1990 (1000 dun)	Class 1 Land Area		Class 2 Land Area		2000 Projection		2010 Projection		2020 Projection	
			Total Available (1000 dun)	Surplus Available (1000 dun)	Total Available (1000 dun)	Surplus Available (1000 dun)	Total Irrigated Area (1000 dun)	Total Water Use (mcm)	Total Irrigated Area (1000 dun)	Total Water Use (mcm)	Total Irrigated Area (1000 dun)	Total Water Use (mcm)
Bank												
Nablus	690	4.9	14.0	9.2	57.8	57.8	14.0	9.7	40.1	27.6	66.1	45.6
Hebron	683	0.7	2.6	2.0	91.4	111.4	2.6	1.8	43.7	29.9	84.9	57.9
Ramallah	696	0.7	3.1	2.4	30.4	30.4	3.1	2.2	16.8	11.7	30.5	21.2
Jenin	687	13.1	108.7	95.5	110.9	130.9	108.7	74.7	158.6	109.0	208.5	143.3
Tulkarem	811	26.3	11.9	0.0	42.9	28.4	26.3	21.4	31.2	25.3	50.5	40.9
Bethlehem	650	1.0	3.1	2.2	30.4	30.4	3.1	2.0	13.8	9.0	30.5	19.8
E. Jerusalem	0	0.0	0.3	0.3	2.5	2.5	0.3	0.0	1.4	0.0	2.5	0.0
Jericho	817	42.3	28.9	0.0	75.9	35.9	42.3	34.6	63.0	51.5	97.2	79.4
Total: West Bank	–	89.0	172.6	83.6	442.3	427.8	200.5	146.3	368.6	263.9	570.6	408.3
a												
North Gaza	825	40.0	40.0	0.0	0.0	0.0	40.0	33.0	40.0	33.0	40.0	33.0
South Gaza	531	70.0	70.0	0.0	0.0	0.0	70.0	37.2	70.0	37.2	70.0	37.2
Total: Gaza	–	110.0	110.0	0.0	0.0	0.0	110.0	70.2	110.0	70.2	110.0	70.2
al: Palestine	–	199.0	282.6	83.6	442.3	427.8	310.5	216.5	478.6	334.1	680.6	478.5

es: Class 1 and 2 land areas available for irrigated cultivation are based on soil maps (ARIJ 1993b,c). Projections of agricultural water demand are the product of the weighted avg. water use per dunam for each rict (from Table 5a) and the projected irrigated land area for that district. High scenario projections assume all Class 1 land area will be irrigated by 2000 and that 45% and then 90% of Class 2 land will be irrigated 2010 and 2020. See text for further documentation.

Table 5c. Agricultural Water Demand in [illegible]

Projections for 2000, 2010, and 2020

Sub-district	Weighted Avg. Water Use (cm/dun)	Total Irrigated Area in 1990 (1000 dun)	Class 1 Land Area		Class 2 Land Area		2000 Projection		2010 Projection		2020 Projection	
			Total Available (1000 dun)	Surplus Available (1000 dun)	Total Available (1000 dun)	Surplus Available (1000 dun)	Total Irrigated Area (1000 dun)	Total Water Use (mcm)	Total Irrigated Area (1000 dun)	Total Water Use (mcm)	Total Irrigated Area (1000 dun)	Total Water Use (mcm)
West Bank												
W1: Nablus	690	4.9	14.0	9.2	57.8	57.8	14.0	9.7	28.5	19.7	43.0	29.6
W2: Hebron	683	0.7	2.6	2.0	91.4	111.4	2.6	1.8	25.5	17.4	48.3	33.0
W3: Ramallah	696	0.7	3.1	2.4	30.4	30.4	3.1	2.2	10.7	7.5	18.3	12.8
W4: Jenin	687	13.1	108.7	95.5	110.9	130.9	108.7	74.7	136.4	93.8	164.1	112.8
W5: Tulkarem	811	26.3	11.9	0.0	42.9	28.4	26.3	21.4	22.6	18.3	33.3	27.0
W6: Bethlehem	650	1.0	3.1	2.2	30.4	30.4	3.1	2.0	10.7	7.0	18.3	11.9
W7: E. Jerusalem	0	0.0	0.3	0.3	2.5	2.5	0.3	0.0	0.9	0.0	1.5	0.0
W8: Jericho	817	42.3	28.9	0.0	75.9	62.5	42.3	34.6	47.9	39.1	66.8	54.6
Sub-total: West Bank	–	89.0	172.6	83.6	442.3	454.4	200.5	146.3	283.1	202.7	393.7	281.7
Gaza												
G1: North Gaza	825	40.0	40.0	0.0	0.0	0.0	40.0	33.0	40.0	33.0	40.0	33.0
G2: South Gaza	531	70.0	70.0	0.0	0.0	0.0	70.0	37.2	70.0	37.2	70.0	37.2
Sub-total: Gaza	–	110.0	110.0	0.0	0.0	0.0	110.0	70.2	110.0	70.2	110.0	70.2
Total: Palestine	–	199.0	282.6	83.6	442.3	454.4	310.5	216.5	393.1	272.9	503.7	351.9

Notes: Class 1 and 2 land areas available for irrigated cultivation are based on soil maps (ARIJ 1993b,c). Projections of agricultural water demand are the product of the weighted avg. water use per dunam for each district (from Table 5a) and the projected irrigated land area for that district. Low scenario projections assume all Class 1 land area will be irrigated by 2000 and that 25% and then 50% of Class 2 land will be irrigated by 2010 and 2020. See text for further documentation.

Table 5d. Average Water Use per Dunam Irrigated and Per Ton of Crop Produced in Palestine

Sub-district	Vegetables					Citrus					Fruit					Field Crops				
	Irrigated Area (1000 dun)	Avg. Water Use (cm/dun)	Total Production (tons)	Avg. Product of Land (ton/dun)	Avg. Water Use (cm/ton)	Irrigated Area (1000 dun)	Avg. Water Use (cm/dun)	Total Production (tons)	Avg. Product of Land (ton/dun)	Avg. Water Use (cm/ton)	Irrigated Area (1000 dun)	Avg. Water Use (cm/dun)	Total Production (tons)	Avg. Product of Land (ton/dun)	Avg. Water Use (cm/ton)	Irrigated Area (1000 dun)	Water Use (cm/dun)	Total Production (tons)	Avg. Product of Land (ton/dun)	Avg. Water Use (cm/ton)
West Bank																				
W1: Nablus	3.13	650	7,974	2.55	255	1.55	850	4,750	3.06	277	0.00	–	–	–	–	0.00	–	–	–	–
W2: Hebron	0.56	650	1,006	1.80	362	0.11	850	68	0.62	1,375	0.00	–	–	–	–	0.00	–	–	–	–
W3: Ramallah	0.54	650	890	1.65	394	0.16	850	156	0.98	872	0.00	–	–	–	–	0.00	–	–	–	–
W4: Jenin	10.67	650	28,675	2.69	242	2.46	850	4,900	1.99	427	0.00	–	–	–	–	0.00	–	–	–	–
W5: Tulkarem	9.11	650	18,767	2.06	316	16.54	850	56,802	3.43	248	0.69	850	2,076	3.01	283	0.00	–	–	–	–
W6: Bethlehem	0.97	650	1,619	1.67	390	0.00	850	–	–	–	0.00	–	–	–	–	0.00	–	–	–	–
W7: E. Jerusalem	0.00	–	–	–	–	0.00	–	–	–	–	0.00	–	–	–	–	0.00	–	–	–	–
W8: Jericho	28.77	650	62,053	2.16	301	2.85	1,200	6,265	2.20	546	5.67	2,000	14,902	2.63	761	5.00	220	1,000	0.20	1,100
Gaza																				
G1: North Gaza	15.00	700	37,500	2.50	280	25.00	900	37,500	1.50	600	0.00	–	–	–	–	0.00	–	–	–	–
G2: South Gaza	0.00	–	–	–	–	27.00	900	–	–	–	43.00	300	19,076	0.44	676	0.00	–	–	–	–

Notes: Areas under irrigated cultivation and total output for each crop type in 1990 are from Rural Research Center (1990) for the West Bank and from the Dept. of Agriculture for Gaza (ARIJ 1993a). Rates of water use per dunam are from Awartani (1991, 18) for the West Bank and from the Dept. of Agriculture for Gaza (ARIJ 1993a). Fruit production in Tulkarem is for guava only, in Jericho for bananas and dates only, and in Gaza for guava, dates, and starfruits. See text for further documentation.