

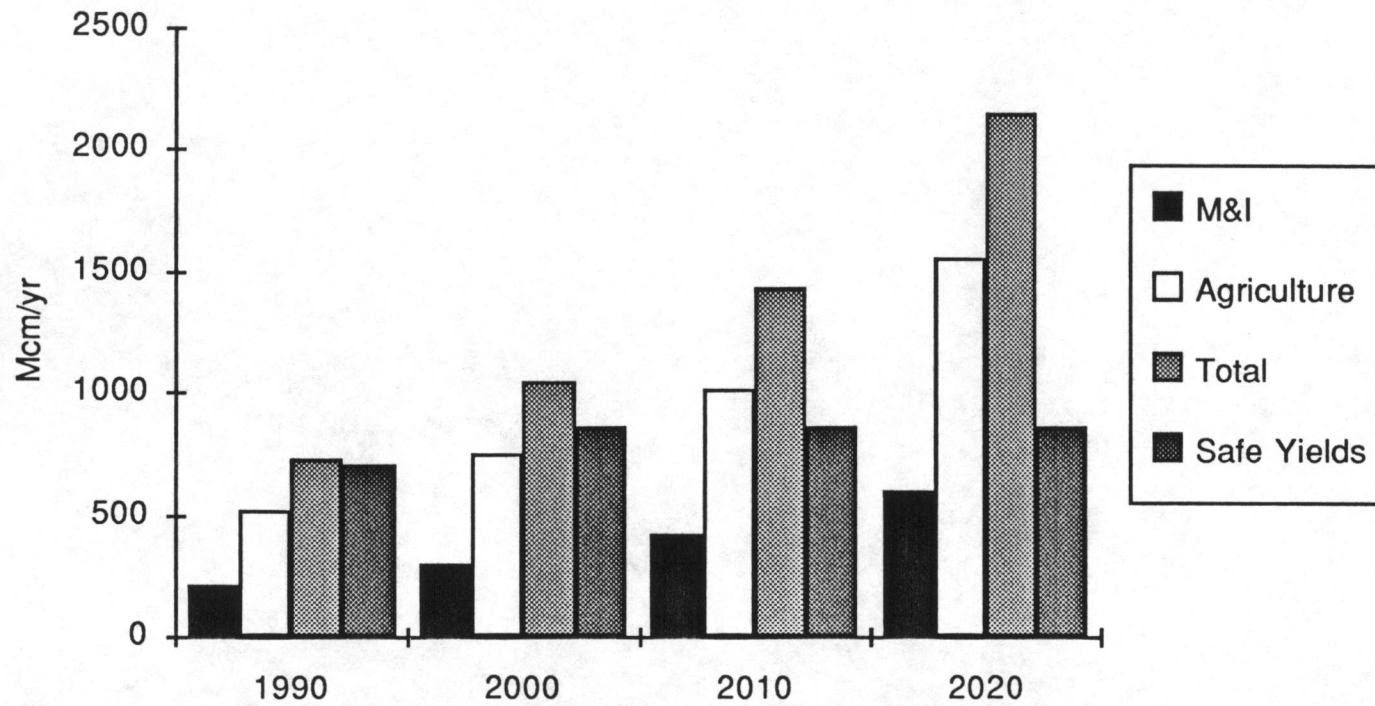
Water Supply and Demand in Jordan Basin
(in Mcm/yr)

	1987-1991 Average Supply Non-Drought Conditions	Average Supply Current Drought Conditions	1987-1991 Average Total Demand	1987-1991 Average Deficits Non-Drought Conditions	Average Deficits Current Drought Conditions	Projected Demand 2015-2020
Israel	1950	1600	2100*	150-200	200	2500-2800
Jordan	900	700-750	800	100-125	100	1600-1800
Occupied Territories	650	450-550	600-650	750-800	100	**

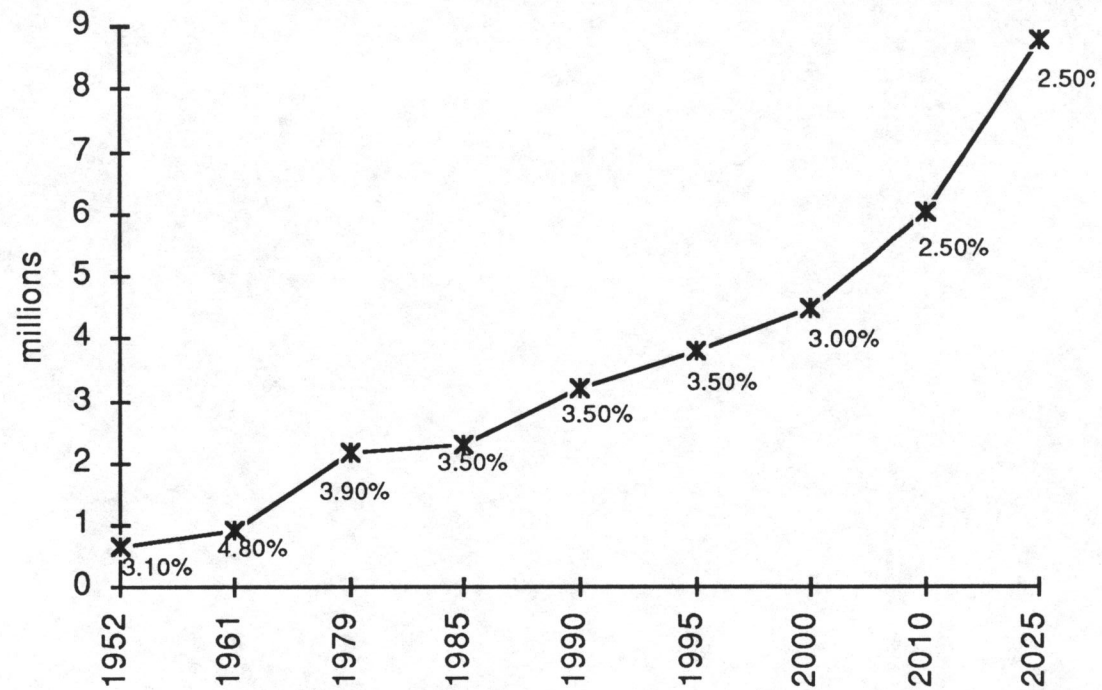
* Includes settlements in Occupied Territories and Golan Heights

** Future status indeterminate

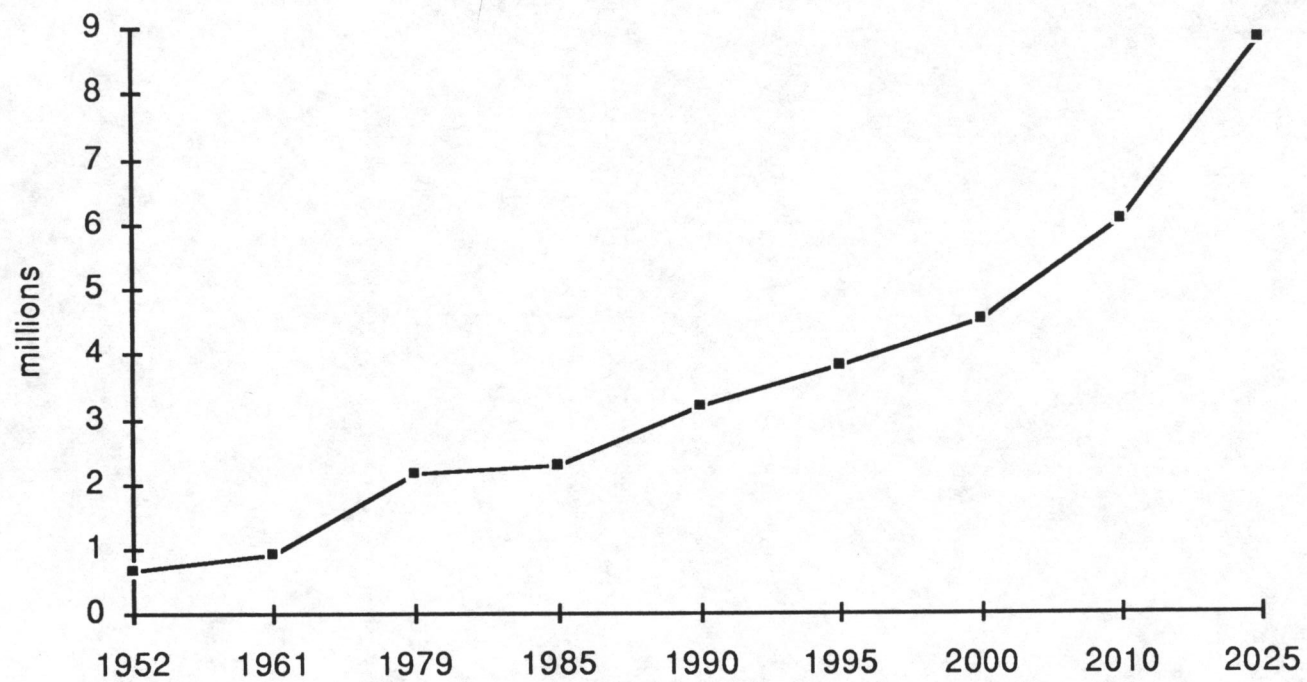
Projected Water Demand in Jordan by Sector (in Mcm/yr)



Jordanian Population Growth (in percentages)

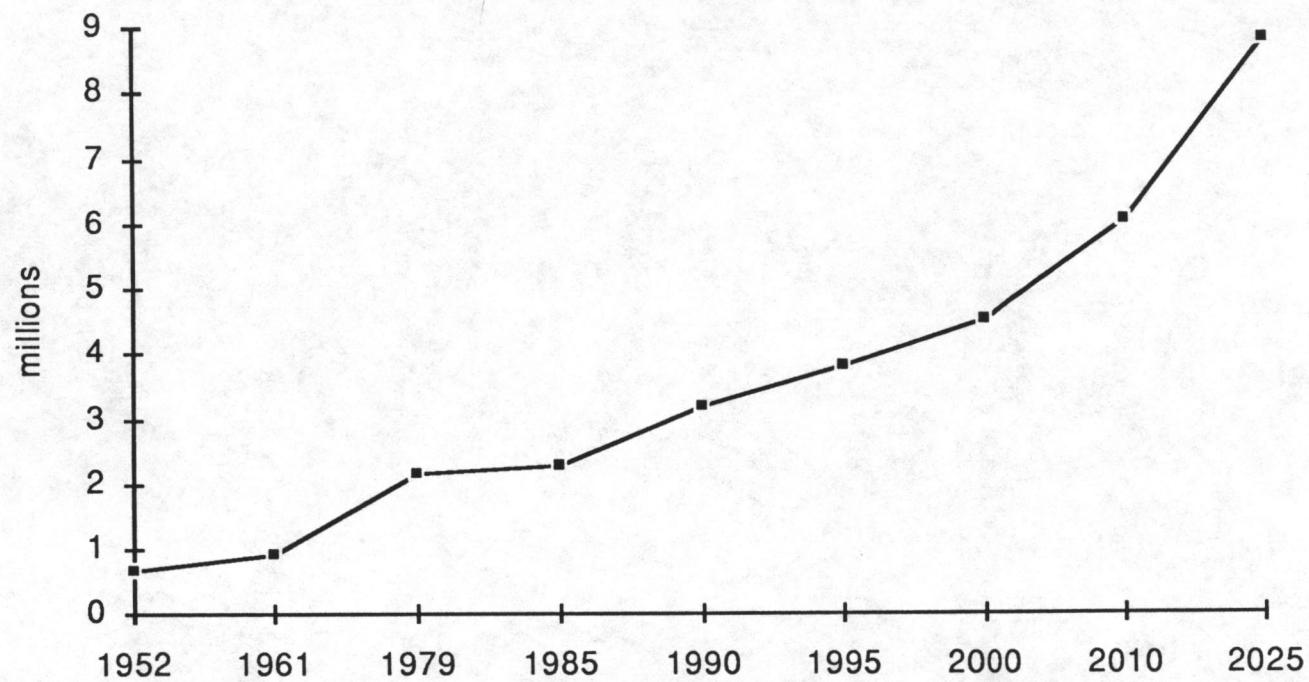


Population Growth in Jordan (in millions)



AMER, 1992

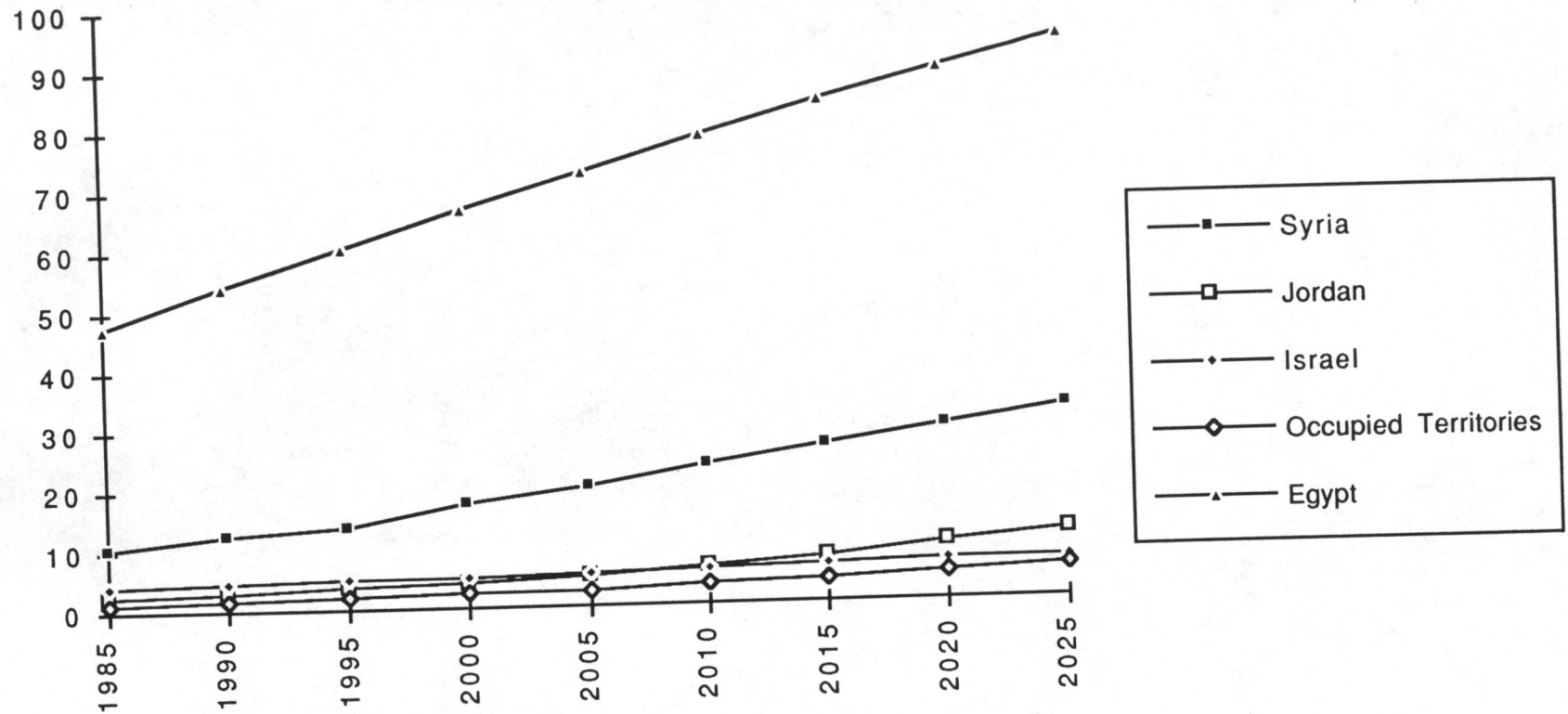
Population Growth in Jordan (in millions)



Israeli Balance of Trade in Agriculture (in millions of dollars)

		1989			1990		
		Import	Export	Balance	Import	Export	Balance
Fresh Products	Field crops	454.7	120.1	(334.6)	439.4	111.1	(328.3)
	Cotton	71.9	103.3	31.4	97.5	88.4	(9.1)
	Vegetables	17.7	63.0	45.3	23.3	97.2	73.9
	Garden products	2.6	138.9	136.3	3.5	165.2	161.7
	Citrus	—	131.7	131.7	—	180.5	180.5
	Other fruit	87.2	55.2	(32.0)	92.4	92.4	0.0
	Fish and seafood	47.6	4.3	(43.3)	54.2	6.6	(47.6)
	Animal /related products	14.4	12.5	(1.9)	20.7	11.0	(9.7)
	Lumber	127.3	—	(127.3)	171.2	—	(171.2)
	TOTAL	823.4	629.0	(204.5)	902.2	752.4	(149.8)
Processed Products	Meat and fish	95.5	50.5	(45.0)	147.5	42.4	(105.1)
	Vegetables/fruit	80.3	405.3	325.0	78.3	460.1	381.8
	Oil	34.7	0.2	(34.5)	39.5	1.8	(37.7)
	Sugar	146.5	0.2	(146.3)	158.4	0.1	(158.3)
	Others	142.7	111.2	(31.5)	166.4	147.6	(18.8)
	TOTAL	499.7	567.4	67.7	590.1	652.0	61.9
GRAND TOTAL		1323.1	1196.4	(136.8)	1492.3	1404.4	(87.9)

Population Projections for Jordan Basin* and Egypt (population in millions)



* Soviet immigration not included

Projections on Syria and Israel based on *UN World Population Prospects 1989*
 Projections on the Occupied Territories and Jordan are based on in-country data obtained by author

Population Projections for Euphrates-Tigris Basin
(population in millions)

	1985	1990	1995	2000	2005	2010	2015	2020	2025
Iraq	15.9	18.9	22.4	26.3	30.7	35.3	40.1	45.1	50.0
Syria	10.5	12.5	14.9	17.6	20.6	23.3	26.6	29.5	32.2
Turkey	50.4	55.6	61.2	66.7	71.8	76.6	81.2	85.4	89.6

Projections based on *UN World Population Prospects 1989*

Population Projections for Jordan Basin and Egypt
(population in millions)

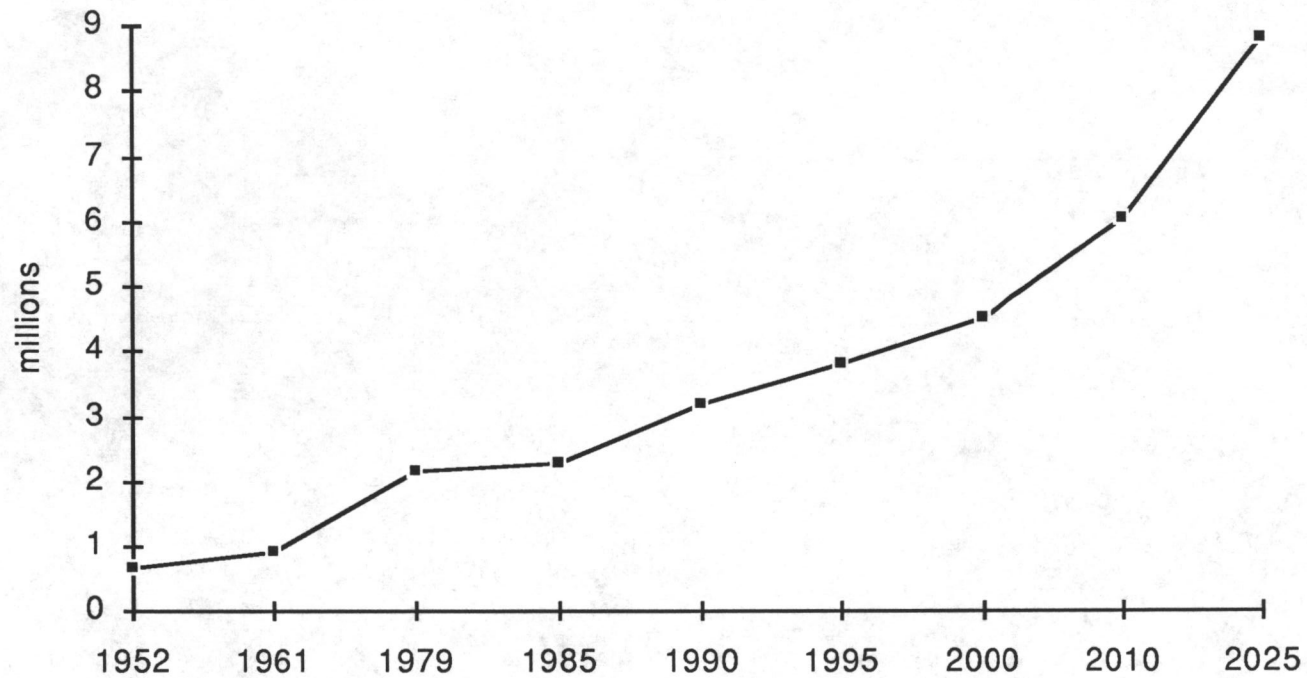
	1985	1990	1995	2000	2005	2010	2015	2020	2025
Syria	10.5	12.5	14.9	17.6	20.6	23.3	26.6	29.5	32.2
Jordan	2.7	3.2	3.8	4.4	5.4	6.4	7.6	9.8	11.6
Israel*	4.2	4.6	5.0	5.3	5.6	6.0	6.3	6.7	7.0
Occupied Territories	1.5	1.8	2.1	2.5	2.9	3.4	4.0	4.7	5.5
Egypt	47.6	54.1	60.5	66.7	72.7	78.4	84.0	89.0	94.0

* Soviet immigration not included

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Population Growth in Jordan (in millions)



Lake Tiberias
(in Mcm/yr)

Inflow from Jordan River	500
Diversion before entering	100-110
Storage volume	670
Utilization	470
Evaporation	200-220
<i>Salinity</i>	250-400 (ppm)
Pumped into NWC*	390
Outflow	40
<i>Average level, 1990-91</i>	212.2m
<i>Current level, Nov '91</i>	211.89m

* National Water Carrier

Israeli Withdrawals from Yarmuk River
(in Mcm/yr)

	Normal Conditions	Drought Conditions
Total withdrawal	100	80-85
Diversion to Golan	15-20	8-10
Diversion to Tiberias	80-85	70
to Coastal Plain	60-65	63-65
to Irrigation	15	5-8

Groundwater Potential and Actual Production, 1985/6-1989/90
(in Mcm/yr)

Reservoir	Potential Production	Average Actual Production	Average Overproduction
Coastal	283	317	34
Mountain	330	379	49
TOTAL	613	696	83

Citation? Source: State Comptroller

Water Consumption in Israel and West Bank
(in Mcm/yr)

	Israel	West Bank
Urban consumption		
Present	500	25
<i>Predicted (2020)</i>	950	180
Agri consumption		
Present	1300	100
<i>Predicted (2020)</i>	2500	350
Domestic fresh water supply	1800	120
Deficit under 1989-90 practices	1000	350
Deficit under water use reform	500	300

Citation? Source: Gideon Fishelson,
Figures based on Gideon Fishelson and Elisha Kalley.

Flows in the Main Tributaries of the Jordan River System

Tributary	Average annual flow, MCM
Dan	245
Hisbani	138
Banias	121
Yarmouk	400
Side Wadis; springs; runoff	350

Addendum
Negotiating Strategies
Supplemental Data

Annual Flow of of the Jordan Into Lake Tiberias (in Mcm)

<u>Year</u>	<u>Actual Flow</u>
1985-86	390
1986-87	639
1987-88	659
1988-89	305
1989-90	214
Avg. 1980-85	404

(N.B. For overall total inflow, add an average of 216 Mcm/yr direct rainfall and surface runoff).

Annual Flow of the Jordan Out of Lake Tiberias (in Mcm)

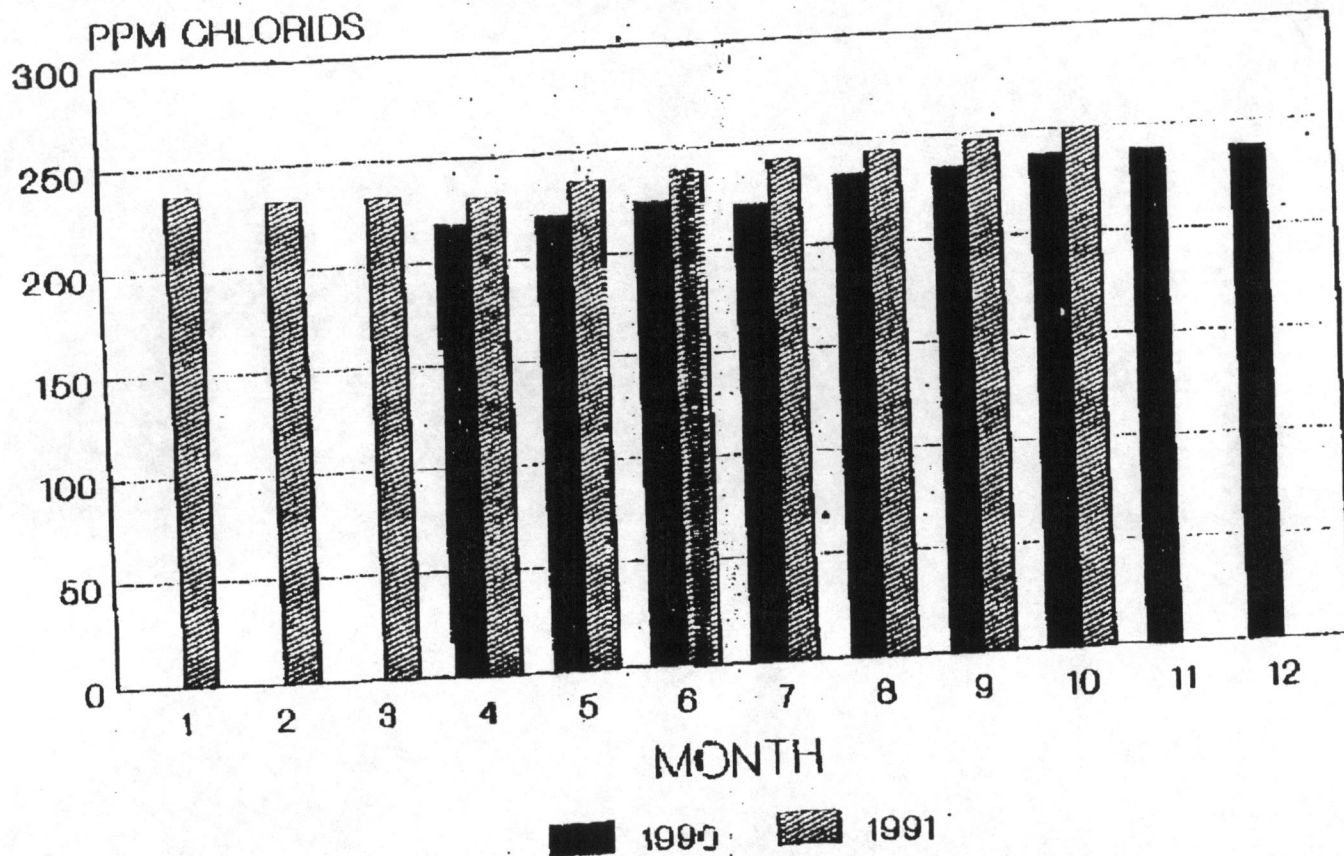
<u>Year</u>	<u>Actual Flow</u>
1985-86	14.47
1986-87	11.76
1987-88	127
1988-89	13.12
1989-90	56.4
Avg. 1980-85	42

Annual rate of evaporation from Lake Tiberias: 294 Mcm

Annual rate of withdrawal from Lake Tiberias to the National Water Carrier: 525 Mcm

Annual amount of saline water diverted around Lake Tiberias: 10/Mcm

KINNERTH WATER SALINITY PPM CHLORIDS

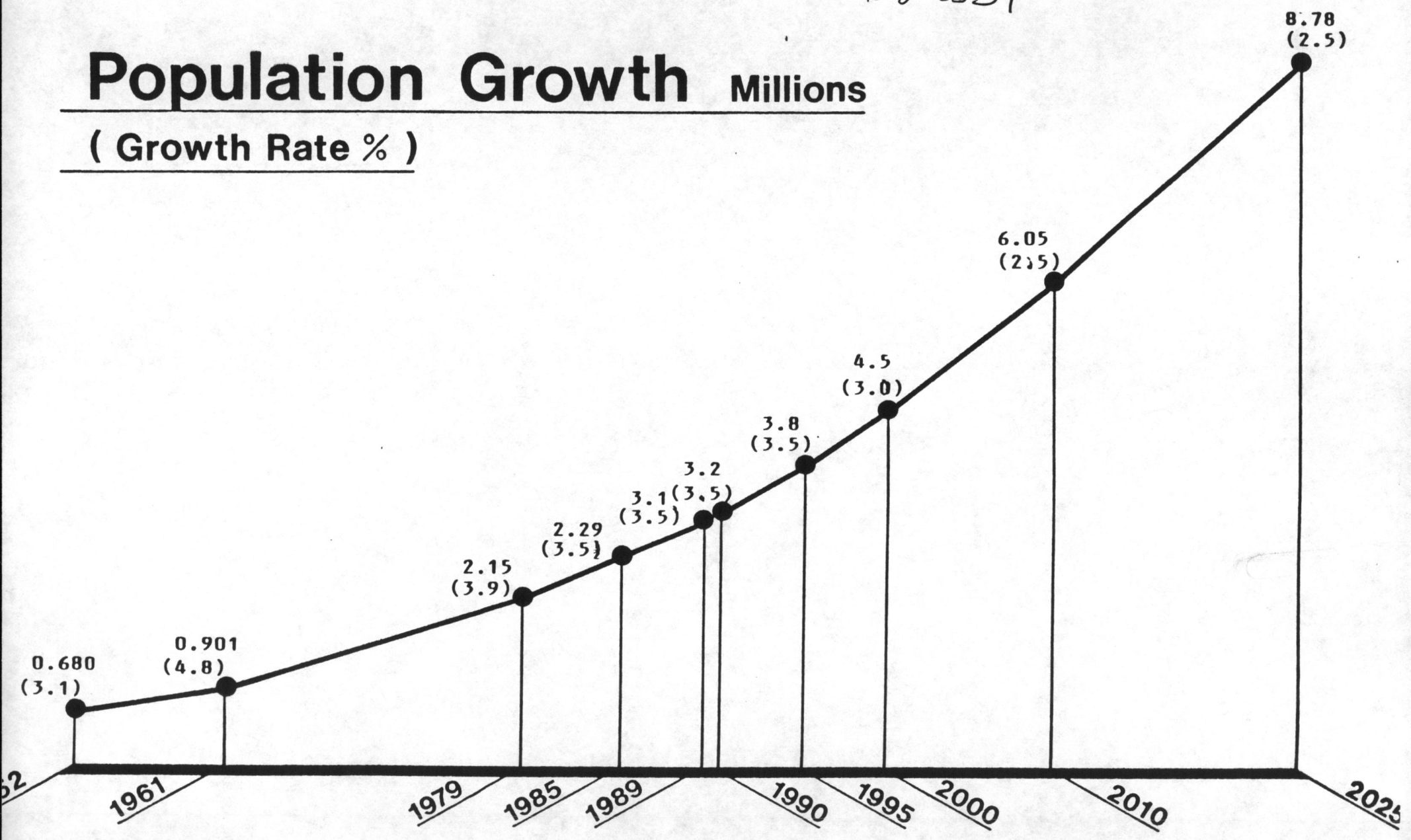


06.10.1990

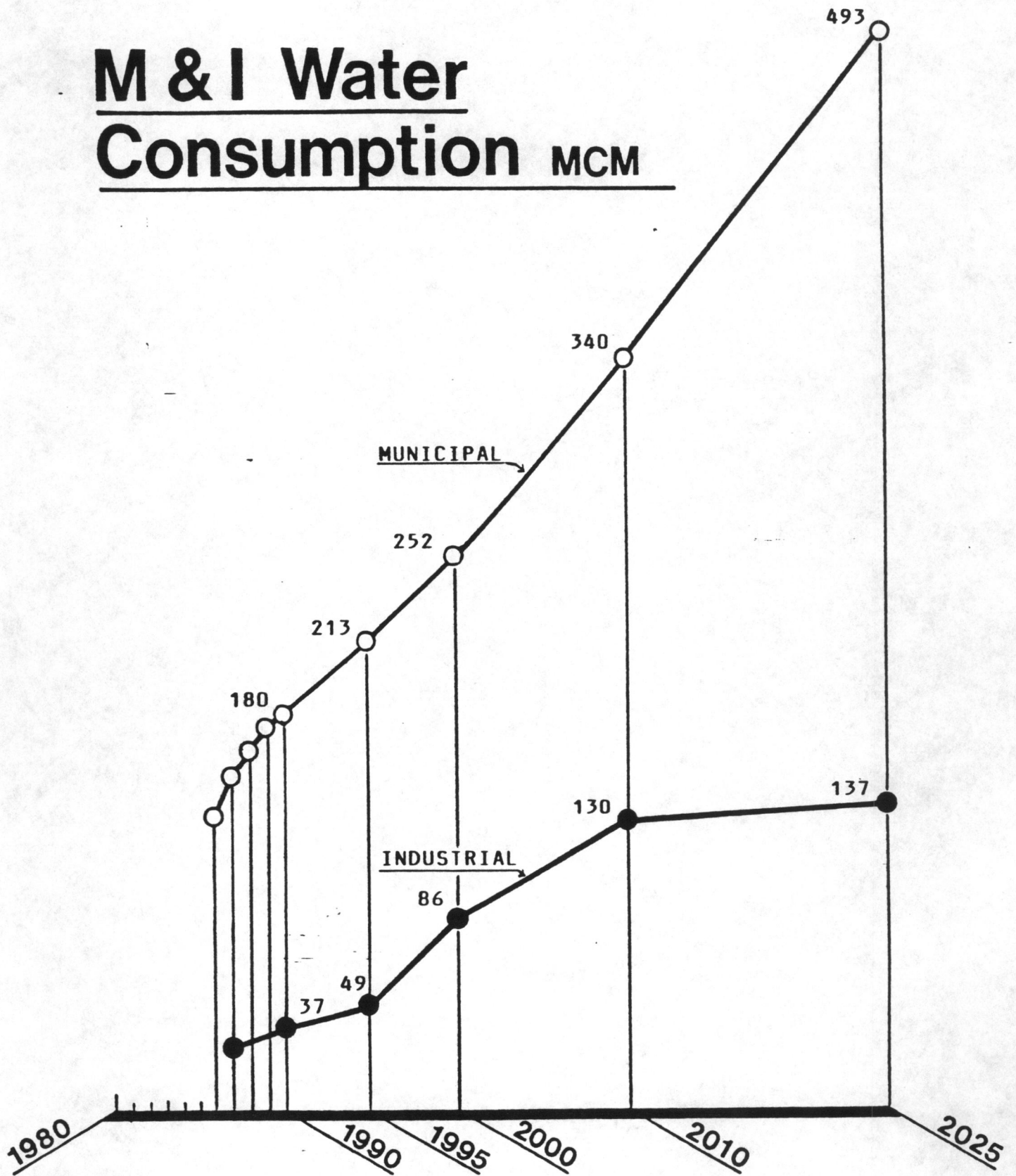
DB# 5539

Population Growth Millions

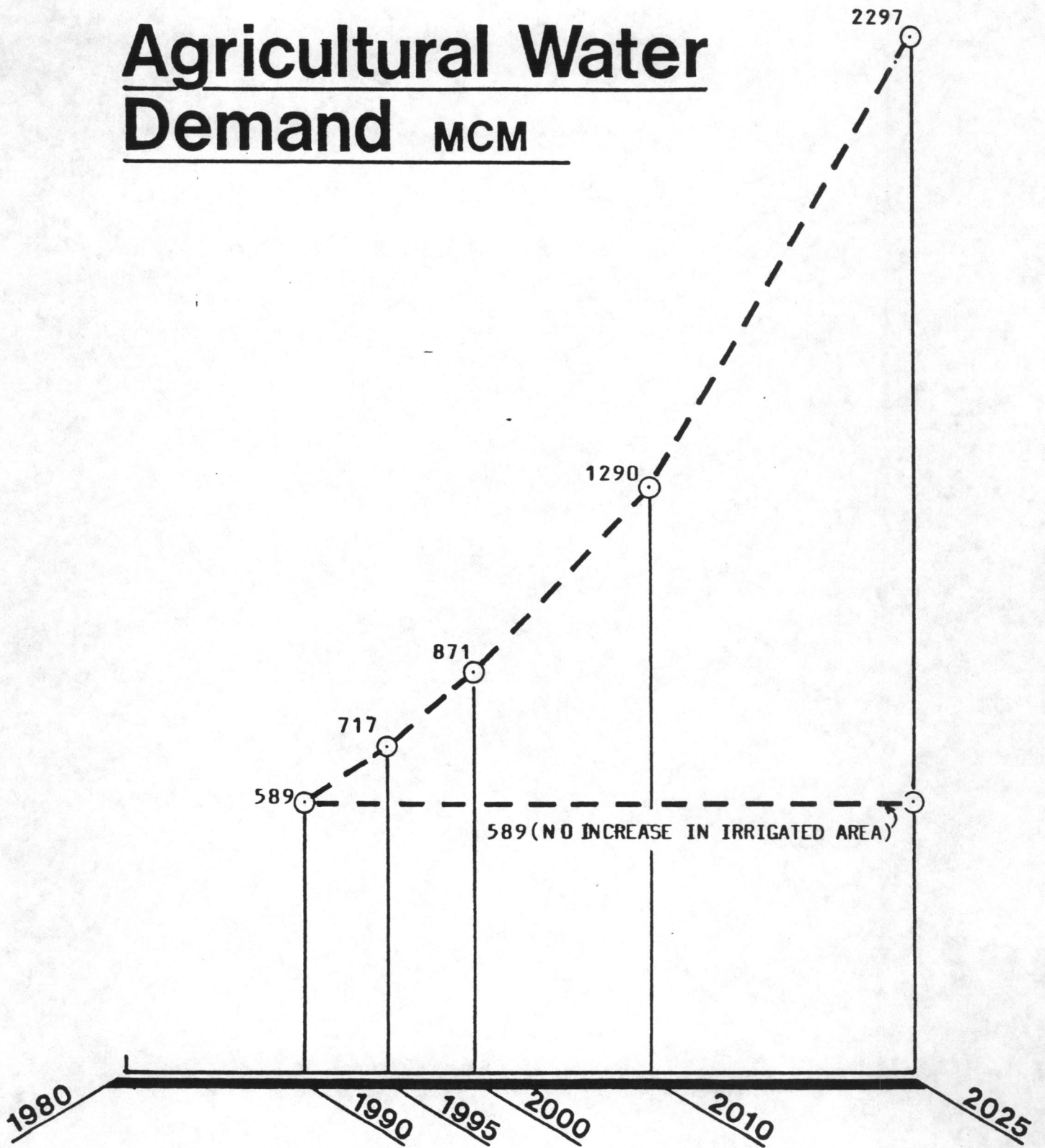
(Growth Rate %)



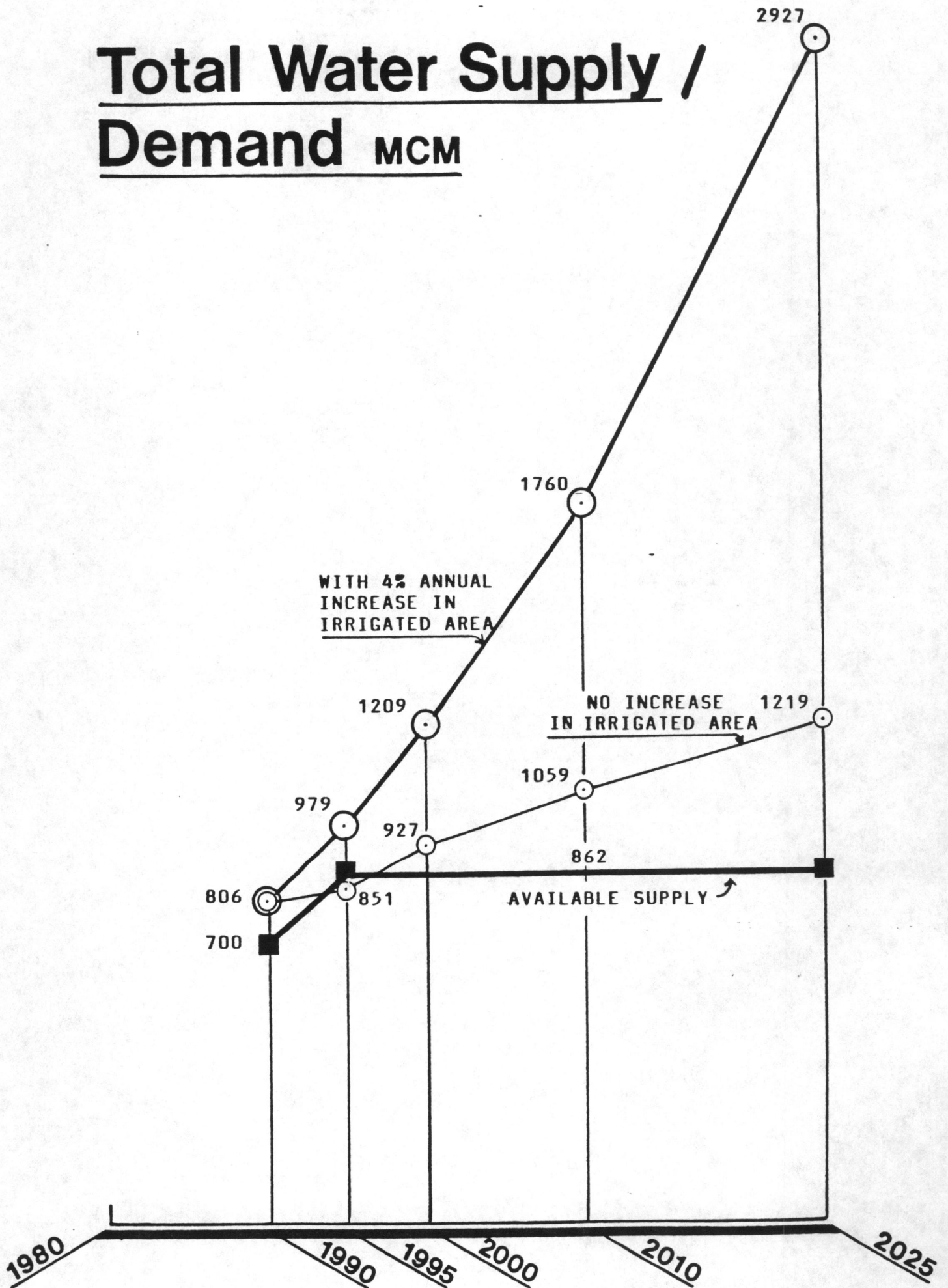
M & I Water Consumption MCM

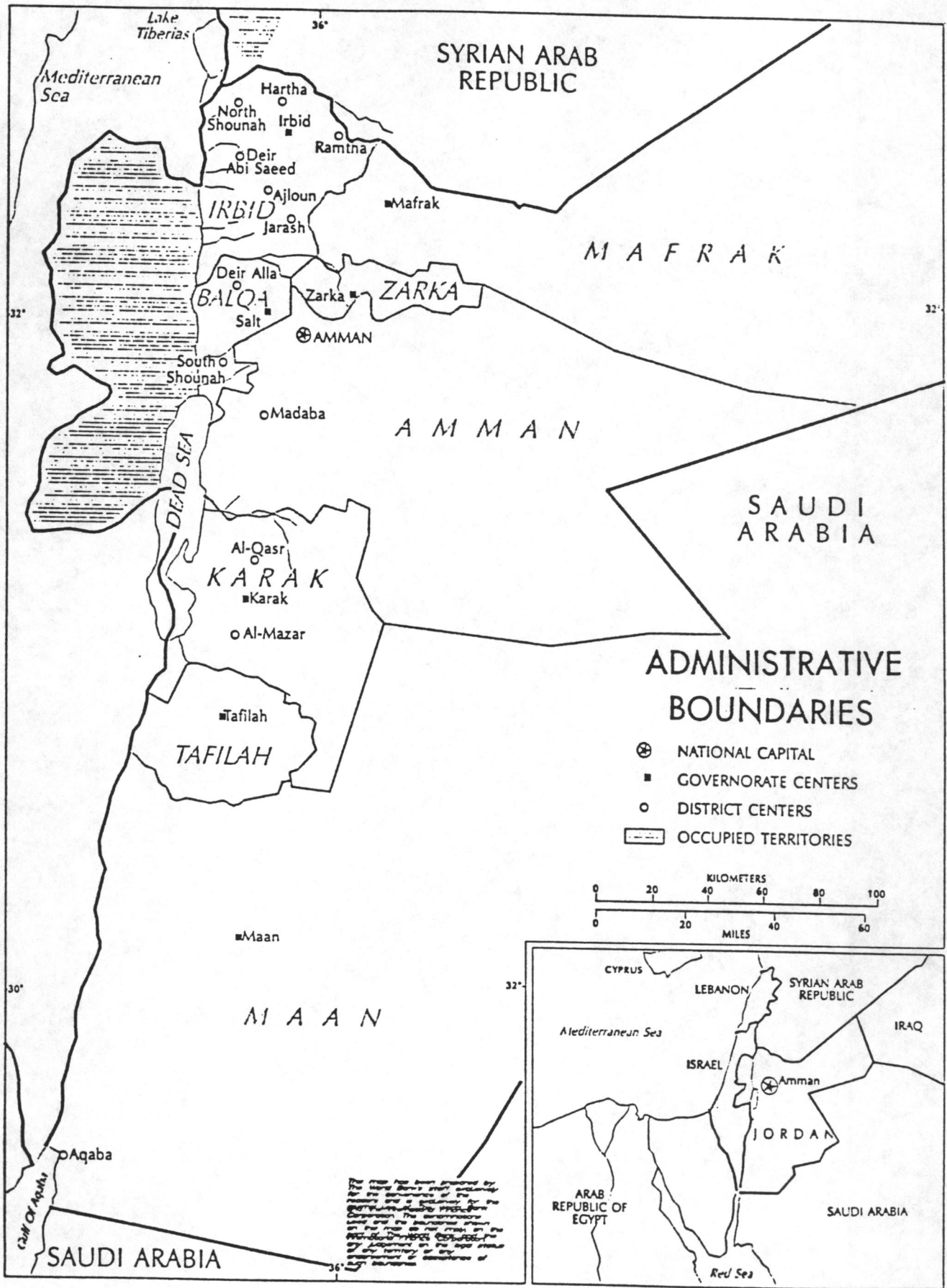


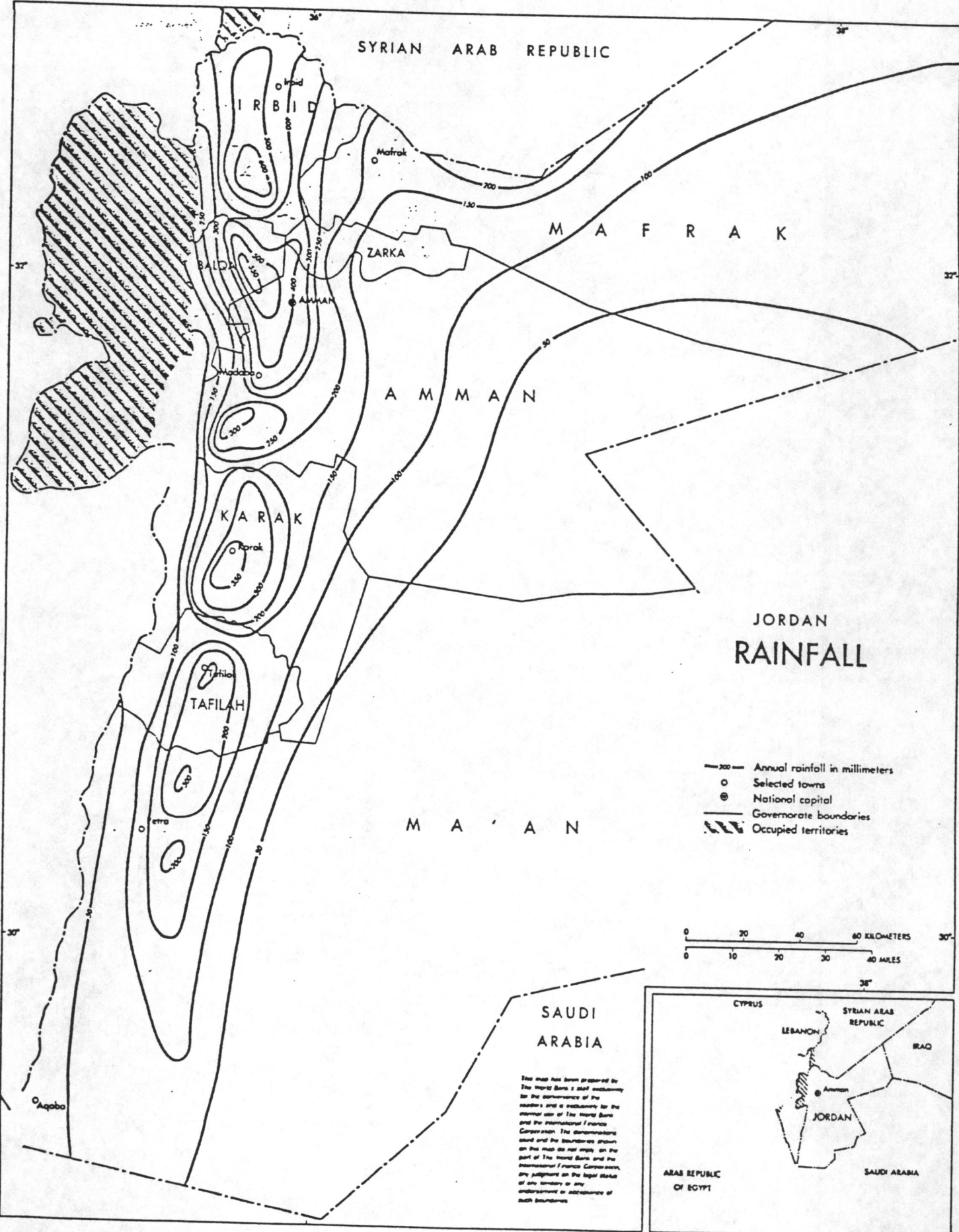
Agricultural Water Demand MCM



Total Water Supply / Demand MCM







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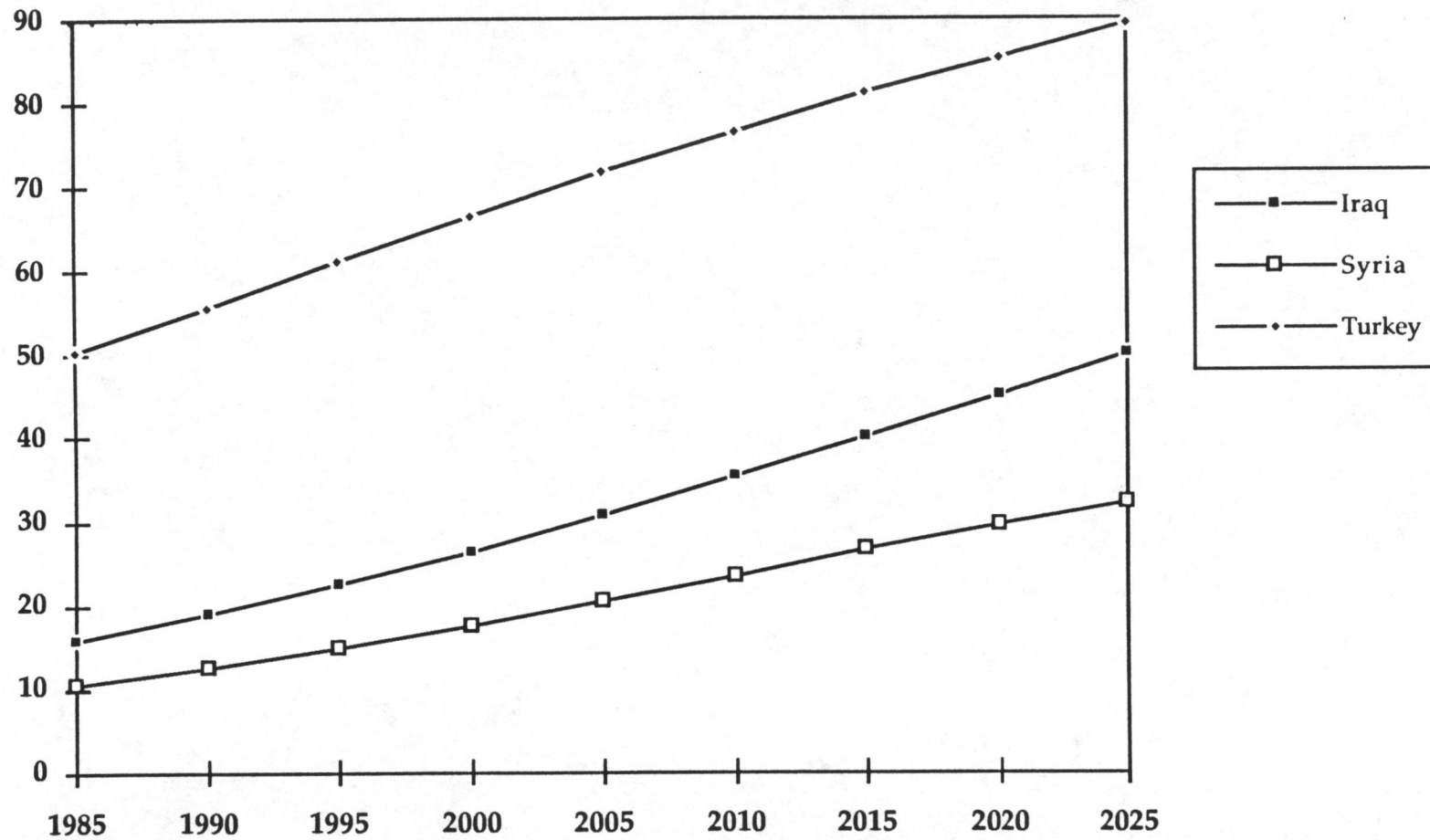
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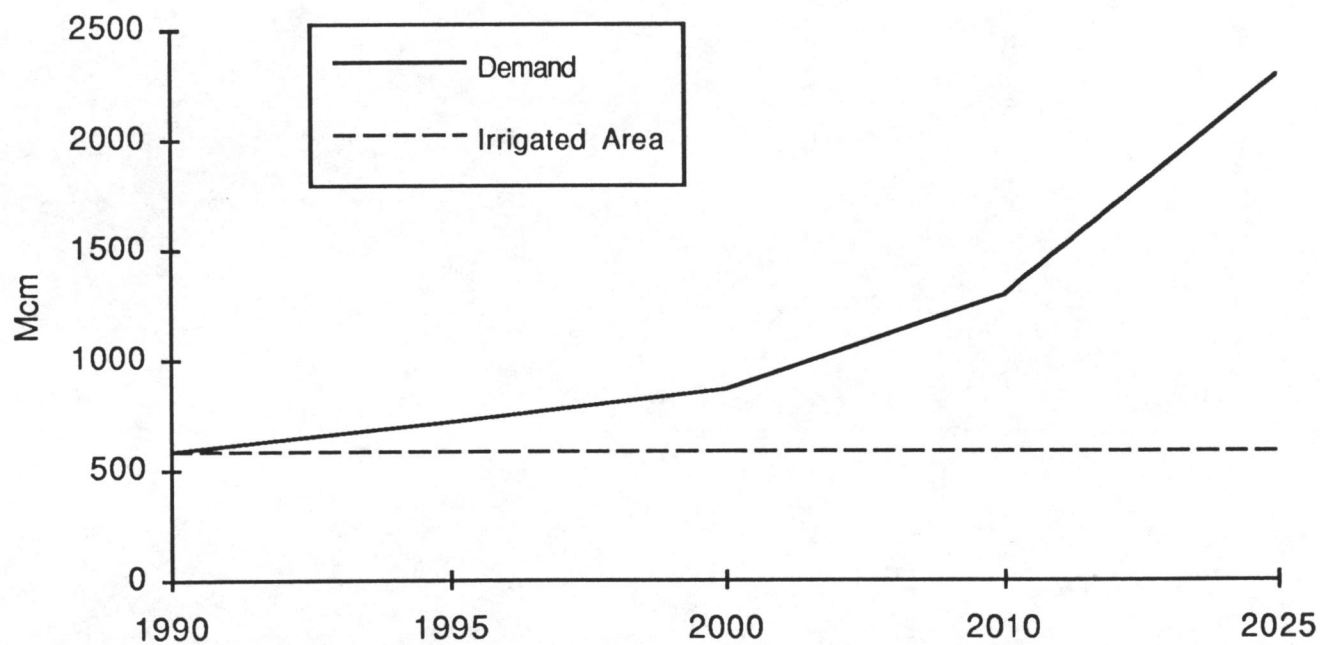
Annual amount of saline water diverted around Lake Tiberias: 10/Mcm

Euphrates-Tigris Basin Population Projections (population in millions)

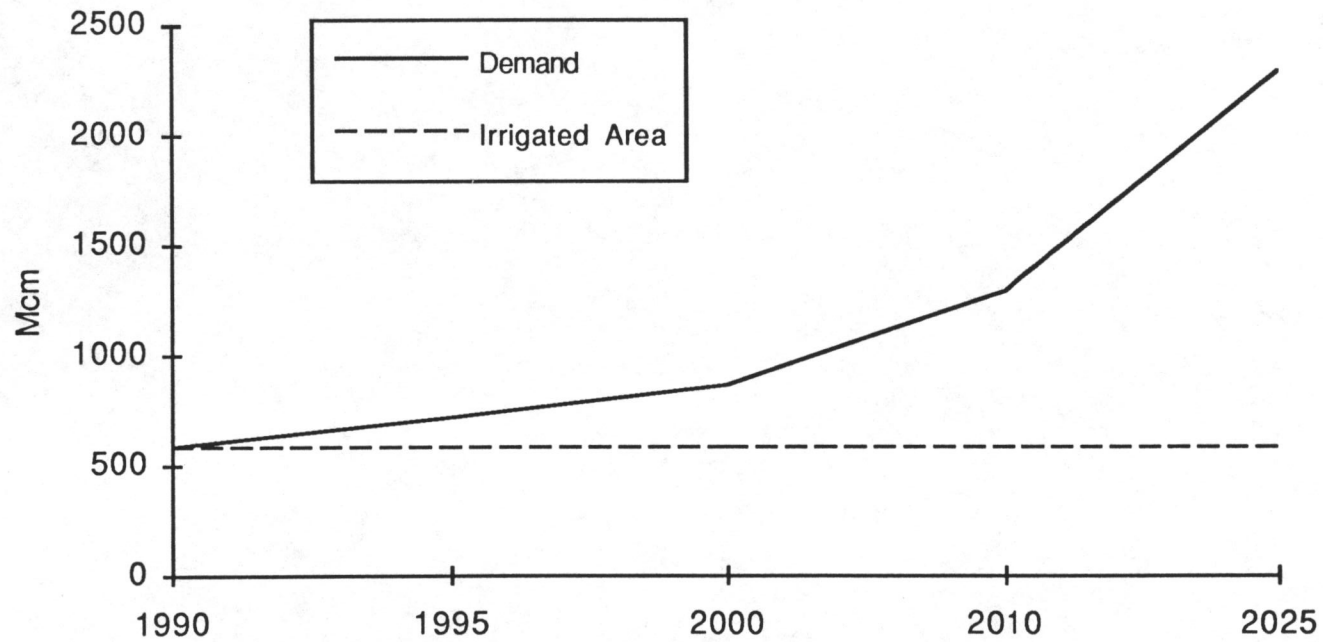


Projections based on *UN World Population Prospects 1989*

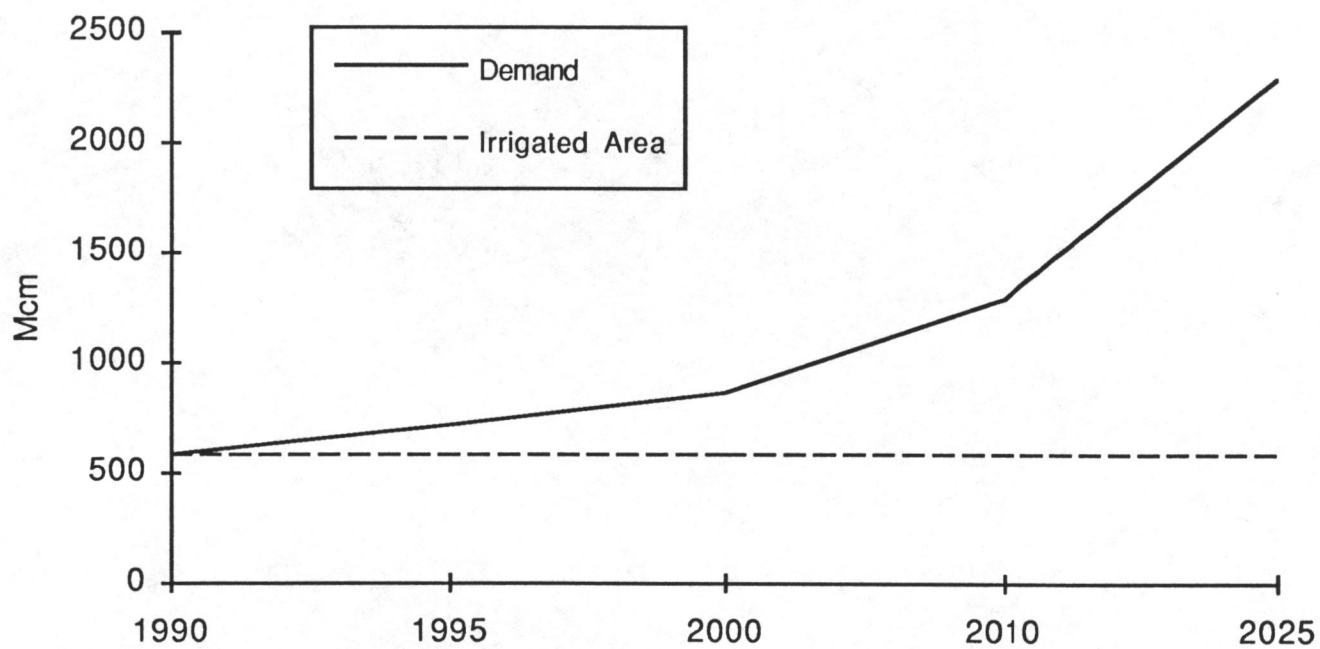
Agricultural Water Demand in Jordan (in Mcm/yr)



Agricultural Water Demand in Jordan (in Mcm/yr)



Agricultural Water Demand in Jordan (in Mcm/yr)



Jordan Flow at Lake Tiberias (in Mcm/yr)

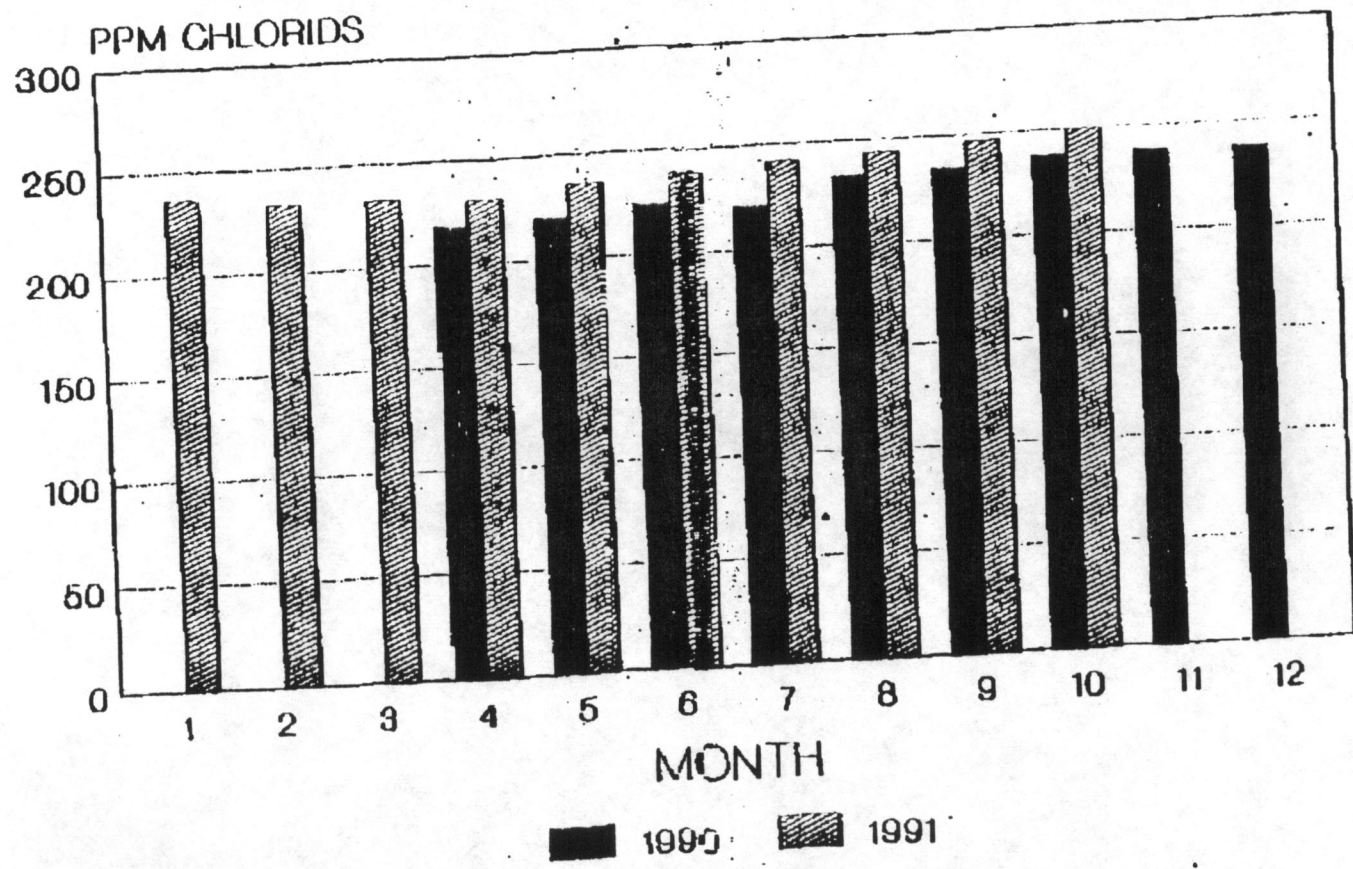
	<i>Average</i>	<i>Actual</i>				
	1980–85	1985–86	1986–87	1987–88	1988–89	1989–90
Jordan flow into Tiberias	404	390	639	659	305	214
<i>(For overall inflow, add approximately 216 Mcm/yr direct rainfall and surface runoff)</i>						
Jordan flow out of Tiberias	42	14.47	11.76	127	13.12	56.4

Rate of evaporation from the lake approximately 294 Mcm/yr
 Annual rate of withdrawal to National Water Carrier 500 Mcm/yr
 Salinity varies between 235–45 mg/l and is not affected significantly by lake level
 Saline water diverted around Lake Tiberias <10 Mcm/yr

Flows in the Main Tributaries of the Jordan River System

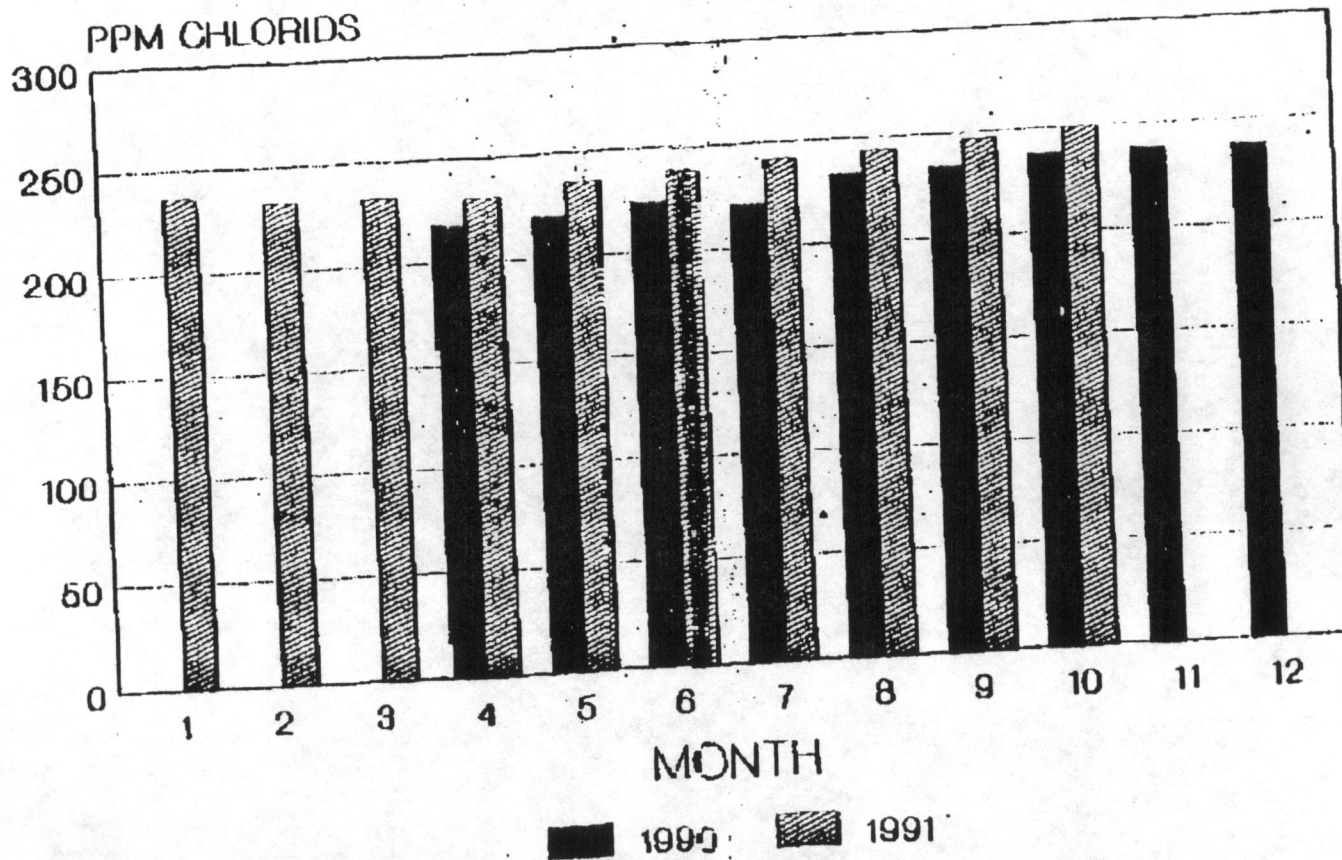
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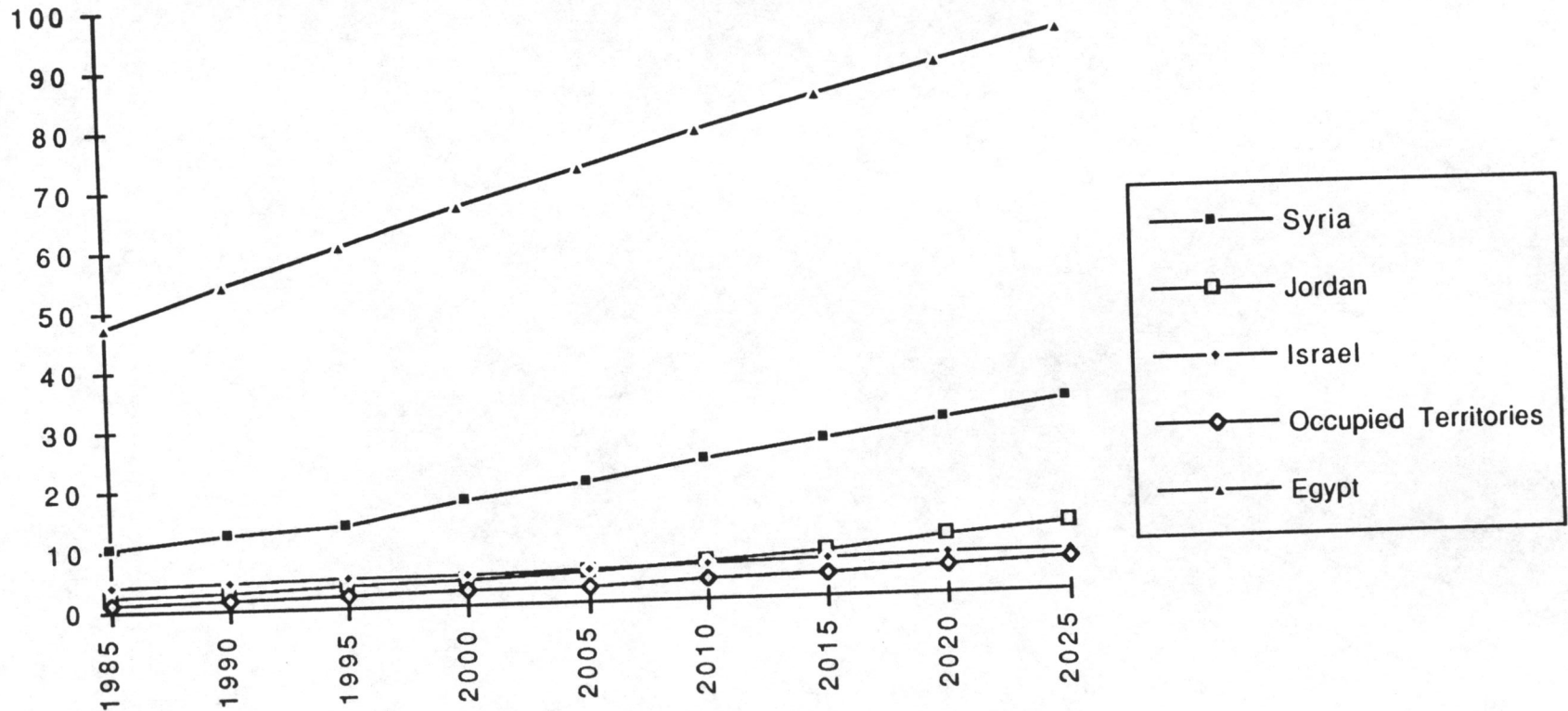
06.10.1990

KINNERTH WATER SALINITY PPM CHLORIDS



08.10.1990

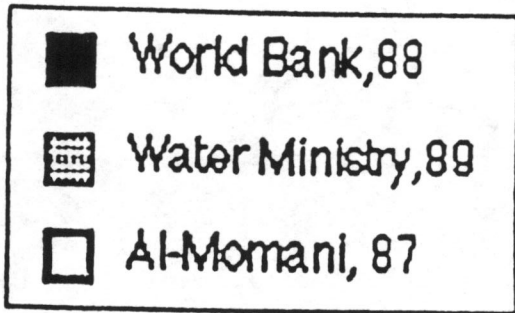
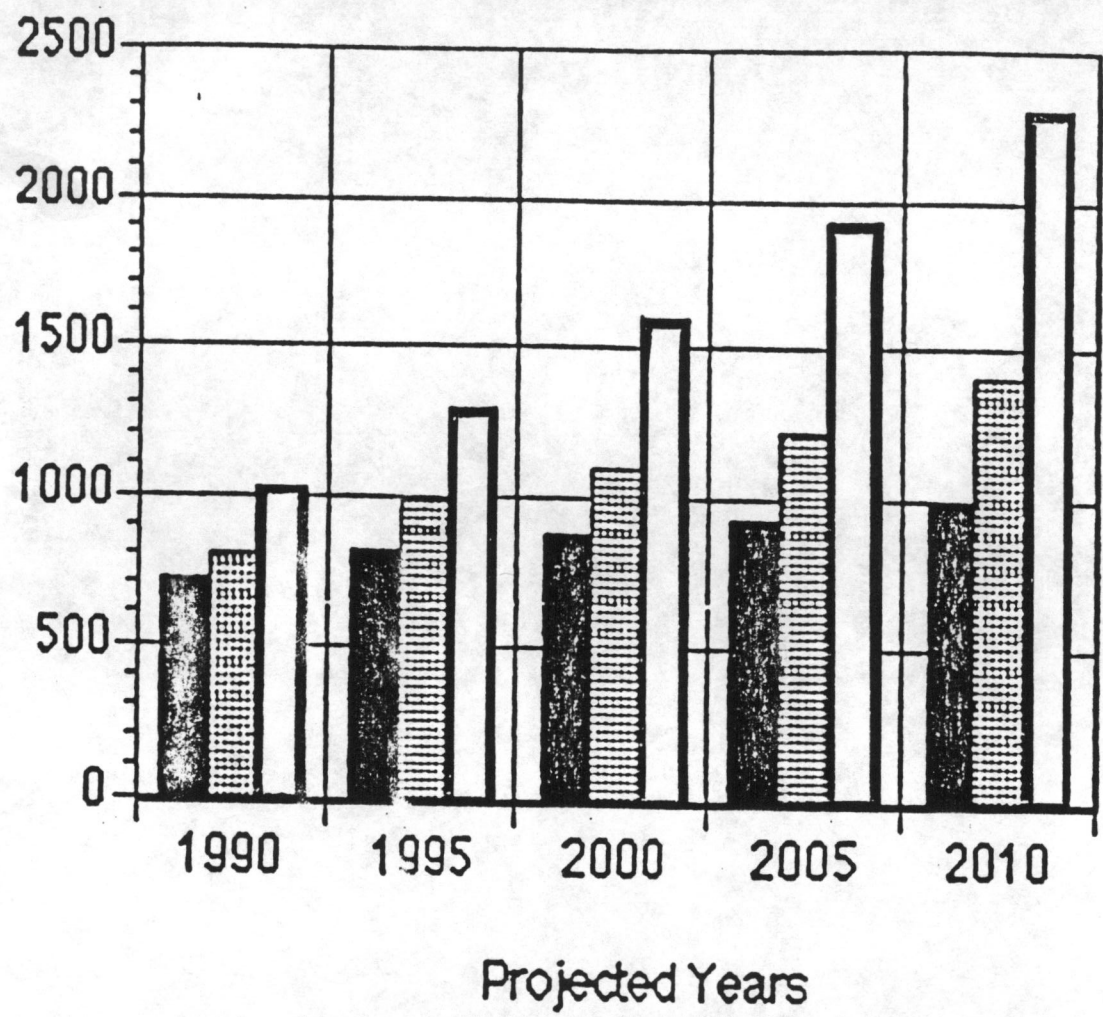
Population Projections for Jordan Basin* and Egypt (population in millions)



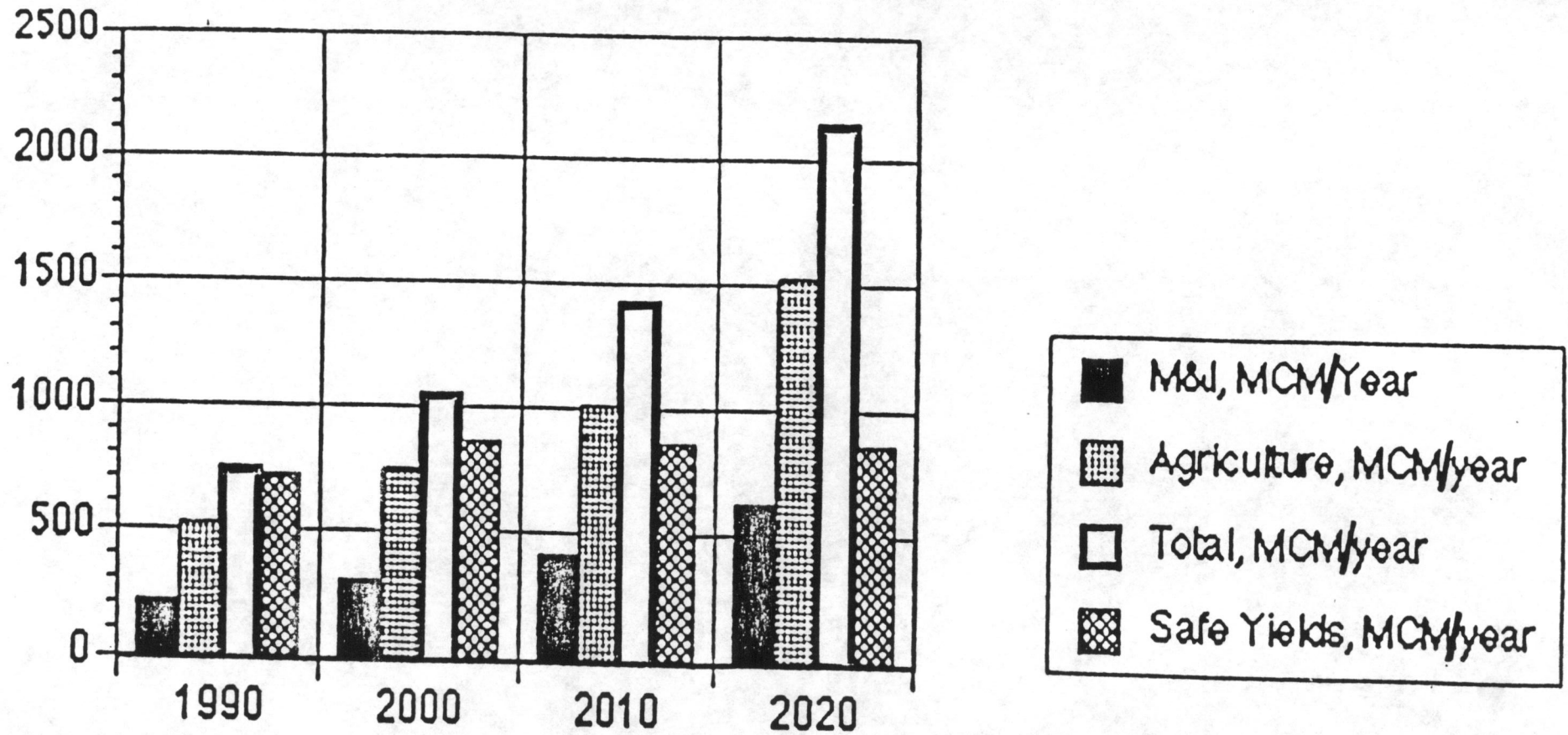
* Soviet immigration not included

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Forecasts of Total Water Demand, MCM per year



Projected water demand by each subsector



Characterization of Water Resources Problems in Terms
of Social and Economic Significance

Physical Manifestation	Consequences	Economic and Social Significance
1. Semi-arid climate, low precipitation, high evap. rates.	Fluctuations in water supply; periodic droughts; naturally limited water resource base.	Planning, development targets plagued with uncertainty.
2. High population growth rates.	Increased demand and competition for water; non-renewable ground water depletion; pollution.	Reduced living standards; health problems.
3. Conflicting demands	Inequitable allocations and subsidies, regional price structuring.	Emergence of water lobbyists.
4. Riparian conflicts	Critical supply augmentation projects cannot be undertaken.	Destabilizing to the economy.
5. Absence of effective conservation program.	Water logging, environmental impacts, overall inefficiencies, losses.	Decline in productivity.
6. Financial constraints.	Supply augmentation cannot meet demand requirements.	Increasing health problems, loss of productivity (chain reaction).
7. Lack of integrated water policy.	Most of the above apply.	Low potential for social and economic development.

SUPPLY

DEMAND

INCREASE SUPPLY

DECREASE DEMAND

TECH.
OPTIONS

CONSERVATION
OPTIONS

MANAGERIAL POLICY
& REGULATORY OPTIONS

- * ABSTRACTION FROM EXISTING AND NEW AQUIFERS
- * SURFACE WATER - DAMS
- * REGIONAL PROJECTS
- * IRRIGATION W/SALINE WATER
- * DESALINATION
- * RECYCLING TREATED WASTEWATER
- * RAINWATER HARVESTING
- * CLOUD SEEDING

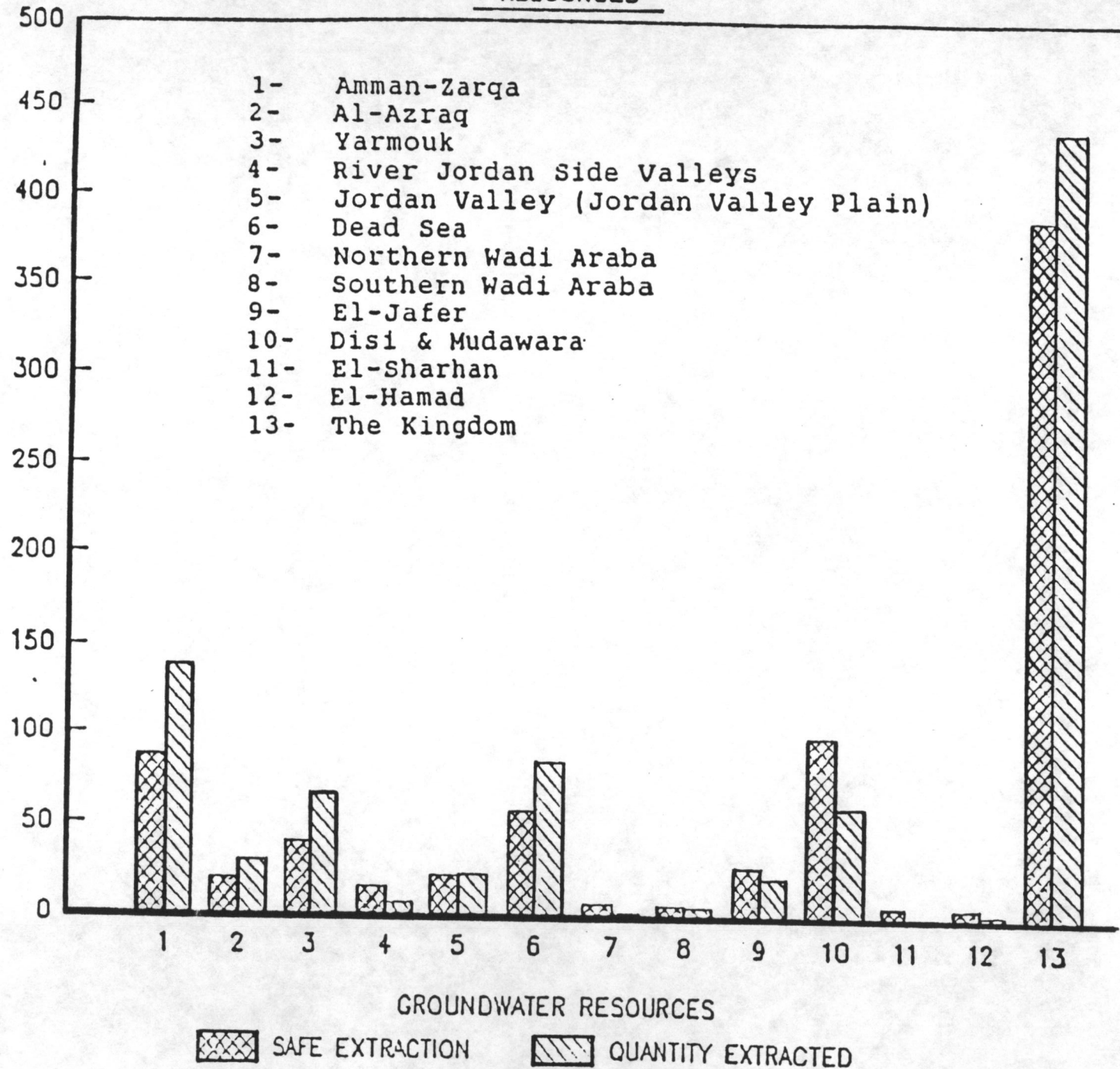
- * REDUCTION OF LOSSES FROM MUNICIPAL WATER SUPPLY NETWORK
- * REDUCTION OF LOSSES FROM IRRIGATION NETWORKS
- * DRIP IRRIGATION
- * EVAPORIZATION MINIMIZATION
- * CULTIVATION OF PLANTS USING LESS WATER
- * OPTIMIZATION OF AGRICULTURAL WATER CONSUMPTION
- * ADOPT CERTAIN RESIDENTIAL MEASURES
- * CHANGE PATTERN OF CONSUMPTION
- * PREVENTION OF POLLUTION
- * PREVENTION OF OVER EXTRACTION

- * MODIFICATION OF PRICING POLICY (LRMC)
- * RATIONALIZATION OF GROWTH RATE
- * ANNUAL VOLUMETRIC ALLOCATIONS
- * INCENTIVES FOR RECYCLING
- * EDUCATION
- * CONSERVATION SUBSIDIES
- * IMPROVE METERING, BILLING AND REVENUE COLLECTION
- * MONITOR WELL EXTRACTION

ALL WITHIN AN INTEGRATED FRAMEWORK.

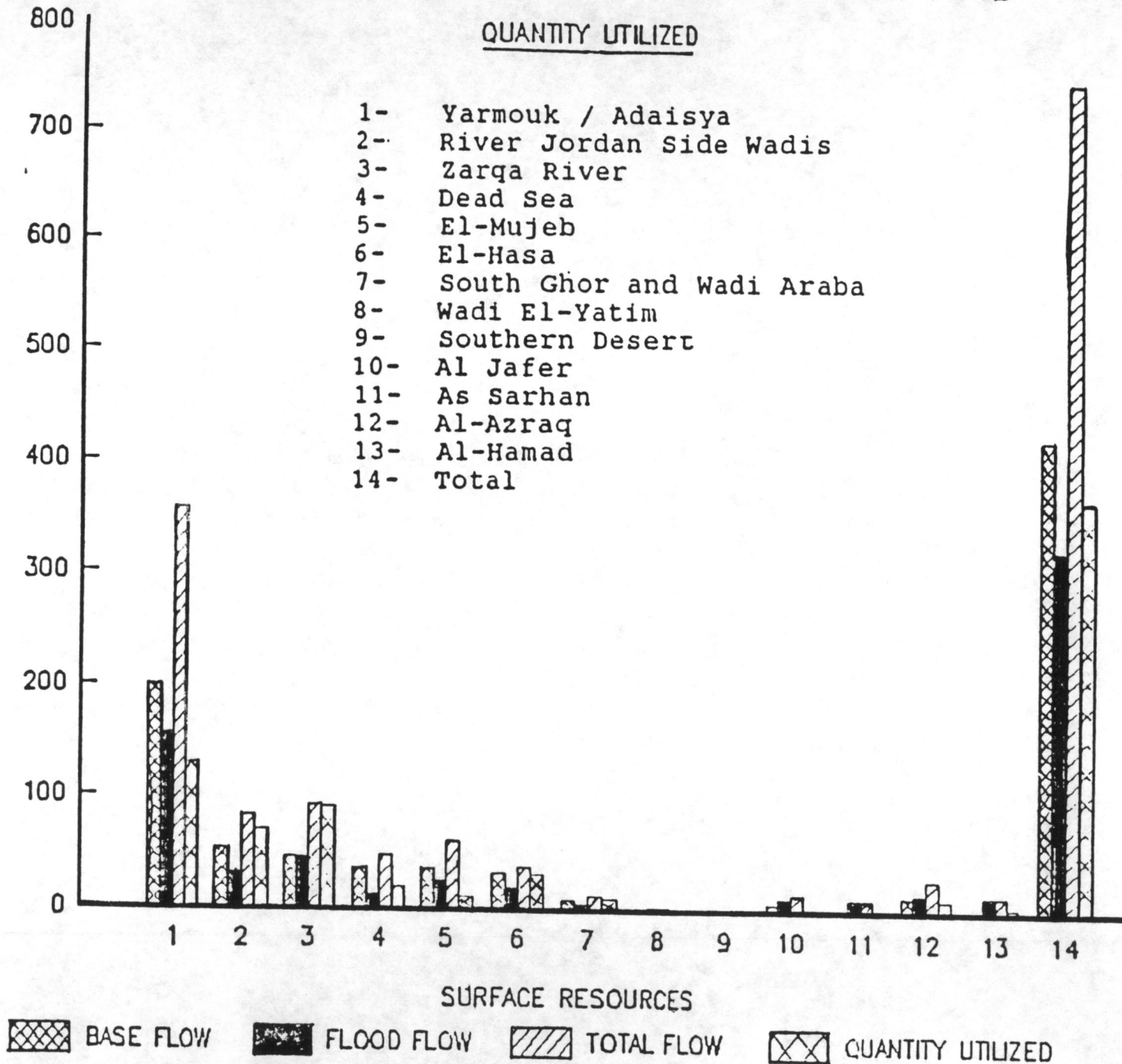
AVAILABLE AND EXPLOITABLE GROUNDWATER

RESOURCES



AVAILABLE SURFACE RESOURCES AND

QUANTITY UTILIZED



EXISTING DAMS IN JORDAN

DAM NAME	RIVER OR WADI	YEAR COMPLETED	CAPACITY MCM	PURPOSE
KING TALAL	ZARQA	1986	82.00	IRRIGATION, POWER
WADI AL-ARAB	W.AL-ARAB	1984	20.00	STORAGE, POWER
KAFREIN	KAFREIN	1976	4.80	IRRIGATION
SHUIEB	SHUIEB	1964	2.30	G.W. RECHARGE
SHARHABEIL	ZIGLAB	1964	4.30	IRRIGATION
SULTANI	MUJIB	1962	1.20	IRRIGATION, LIVE STOCK
QATRANA	MUJIB	1962	2.30	G.W.RECHARGE,LIVE STOCK
LAHFI	DHULIEL	1967	0.70	LIVE STOCK WATERING
BUWEIDA	YARMOUK	1967	0.70	LIVE STOCK WATERING
GHADEIR AL-ABYAD	YARMOUK	1967	0.70	LIVE STOCK WATERING
SAMMA SIRHAN	YARMOUK	1965	0.70	LIVE STOCK WATERING
AGIB	DHULIEL	1983	1.40	G.W. RECHARGE
BURGU'	RUWEISHID	1950	1.50	LIVE STOCK WATERING
SHAL'AN	RUWEISHID	1970	1.00	IRRIGATION
DEIR AL-KAHF	DEIR AL-KAHF	1950	1.50	LIVE STOCK WATERING

PROPOSED DAMS IN JORDAN

DAM NAME	BASIN	STORAGE CAPACITY MCM	STUDY CONDITION	WATER USES
WEHDA	YARMOUK	220	FEASIBILITY	MULTIPURPOSE
KUFRINJA	J.V.SIDE WADIS	5.2	FEASIBILITY	IRRIGATION
W.YABIS	J.V.SIDE WADIS	5.2	FEASIBILITY	IRRIGATION
KARAMA	J.V.SIDE WADIS	45	FEASIBILITY	IRRIGATION & STORAGE
RUMIEL	WADI WALA	25	UNDER STUDY	IRRIGATION
HAMAM	WADI WALA	3	REFEASIBILITY	G.W.RECHARGE
NUKHILA	WADI MUJIB	12	UNDER STUDY	MULTIPURPOSE
AL-ABYAD	WADI MUJIB	12	REFEASIBILITY	IRRIGATION
SWAQA	WADI MUJIB	2.8	REFEASIBILITY	G.W.RECHARGE
TANNUR	WADI HASA	14	REFEASIBILITY	IRRIGATION
DABA'A	WADI MUJIB	2.8	REFEASIBILITY	MULTIPURPOSE
ZATARI	ZARQA RIVER	2	REFEASIBILITY	IRRIGATION
RUWEISHID	WADI RUWEISHID	10.8	UNDER STUDY	MULTIPURPOSE
ABU HAFNA	WADI RUWEISHID	2.5	UNDER STUDY	MULTIPURPOSE
RAJIL	AZRAQ	2	UNDER STUDY	G.W.RECHARGE
RATAM	AZRAQ	2	UNDER STUDY	G.W.RECHARGE
BUTUM	AZRAQ	2	UNDER STUDY	G.W.RECHARGE
ABU SAFAT	JAFR	2.8	UNDER STUDY	IRRIGATION
JURDHAN	JAFR	4	UNDER STUDY	MULTIPURPOSE
USHEISHAT	JAFR	2.4	PROPOSED	G.W.RECHARGE
MATHK	JAFR	2	PROPOSED	LIVE STOCK WATERING
FASSU'A	JAFR	2	PROPOSED	LIVE STOCK WATERING
ABYAD	JAFR	2	PROPOSED	LIVE STOCK WATERING
UQEIQQA	JAFR	2	PROPOSED	LIVE STOCK WATERING
AL-JAHDANIYA	JAFR	2	PROPOSED	LIVE STOCK WATERING

DESALINATION TECHNIQUES

- 1) DISTILLATION METHODS
 - MULTI-FLASH DISTILLATION (MSF)
 - MULTI-EFFECT DISTILLATION (MED)
 - VAPOR COMPRESSION (VC)

- 2) MEMBRANE PROCESSES
 - REVERSE OSMOSIS (RO)
 - ELECTRODIALYSIS (ED)
 - ELECTRODIALYSIS REVERSAL (EDR)

- 3) ION EXCHANGE

- 4) HYBRID SYSTEMS

CONSIDERATION

ENVIRONMENTAL BIOLOGICAL CHEMICAL PHYSICAL

INCREASED CHEMICAL IN BRINE
I.E. CHLORIDE, BIOCIDES, DESCALING CHEMICALS, HEAVY METALS
SLUDGE DISPOSAL
POST TREATMENT

COST COMPONENTS

INVESTMENT, ENERGY, CHEMICAL, O&M

COST COMPARISON (BY PROF. KEENAN
FROM SEVERAL SOURCES)

R.O. \$1.21 - 2.82/M³ 1991 PRICES
DISTILLATION \$1.25 - 3.07/M³ 1991 PRICES

Energy Requirements for Various Desalination Methods. The energy units are MJ/cu m of product.

Process	Energy
Seawater RO	21-36
Brackish RO	4-8
Seawater EDR	32-48
Brackish EDR	3-14
Seawater MSF	46-60
Seawater VC	45-68
Seawater MED	33-37

Cost comparison of distillation with RO desalination. The costs are in units of 1st Quarter 1991 U. S. dollars per cu m of product.

RO Cost	Distillation Cost
1.50-2.82	1.90-4.15
1.21-1.54	1.25-1.80
1.34-1.96	1.40-2.13
1.24-1.87	1.85-3.07
1.44	2.55
1.31-1.36	1.36-1.82

Cost comparison of EDR with RO desalination. The costs are in
units of 1st Quarter 1991 U. S. dollars per cu m of product.

TDS mg/L	RO Cost	EDR Cost
1000	1.25	1.56
5000	2.25	4.88

RECYCLING OF TREATED WASTEWATER

* QTY. 44 MCM - 1989

75-100 MCM - 2000

* ADVANTAGES: ADDITIONAL SOURCE OF WATER WITH
NUTRIENTS

* LIMITATIONS

SALINITY

TRACE ELEMENTS & HEAVY METALS

MICROBIOLOGICAL CONTAMINATION SOIL, PLANTS, AIR
GROUND AND SURFACE WATER POLLUTIONS

RAINWATER HARVESTING

CAPTURE MAX. QTY OF RAINWATER

- MICRO CATCHMENTS
- MACRO CATCHMENT
- LOW HEIGHT WATER RETENTION STRUCTURES
- LARGE WATERING HOLES
- IMPREVIOUS SURFACES
- DESERT DAMS
- LARGE DAMS

QTY: RAIN DEPENDENT
ECONOMY

Lake Tiberias
(in Mcm/yr)

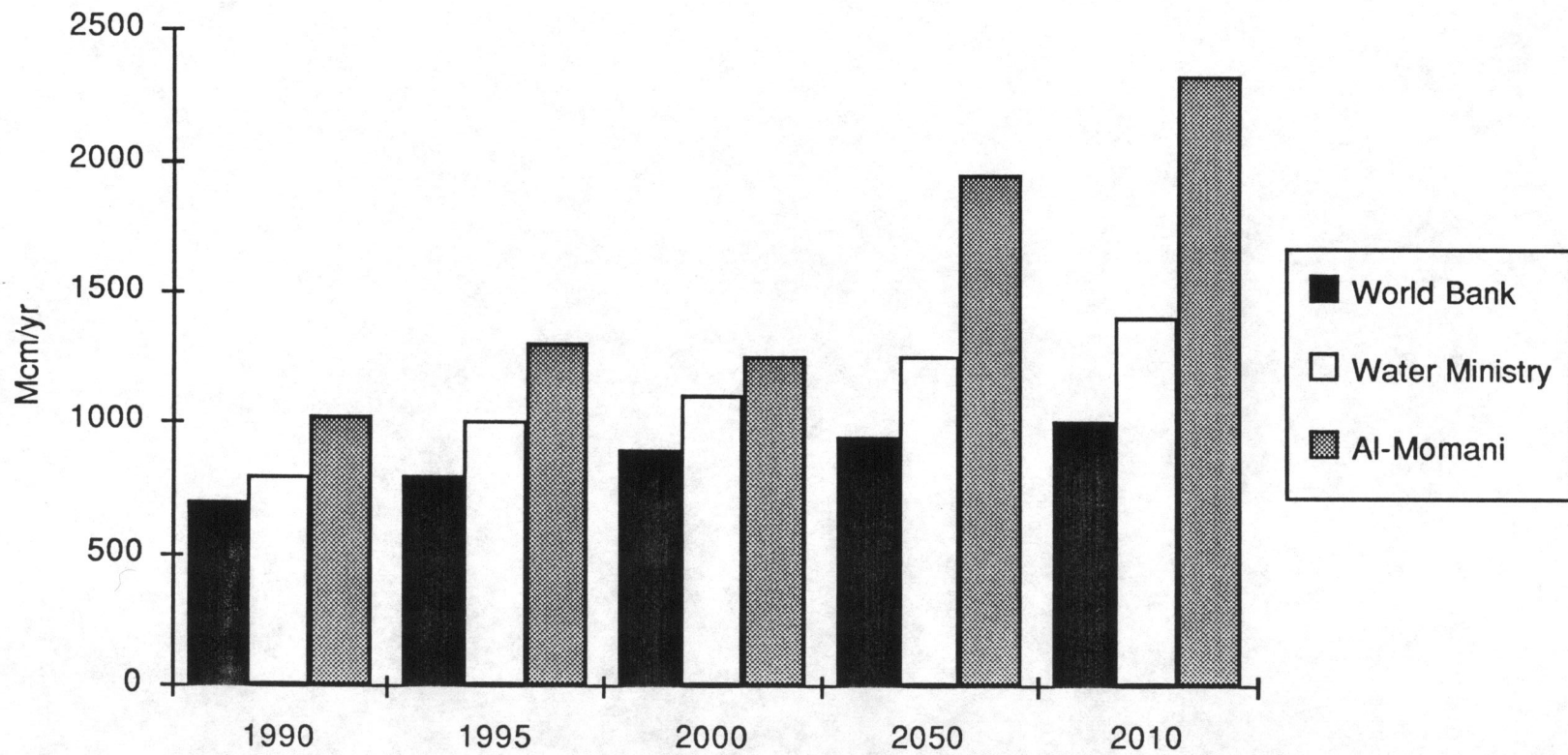
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Evaporation	200-220
Salinity	250-400 (ppm)
Pumped into NWC*	390
Outflow	40
Average level, 1990-91	212.2m
Current level, Nov '91	211.89m

* National Water Carrier

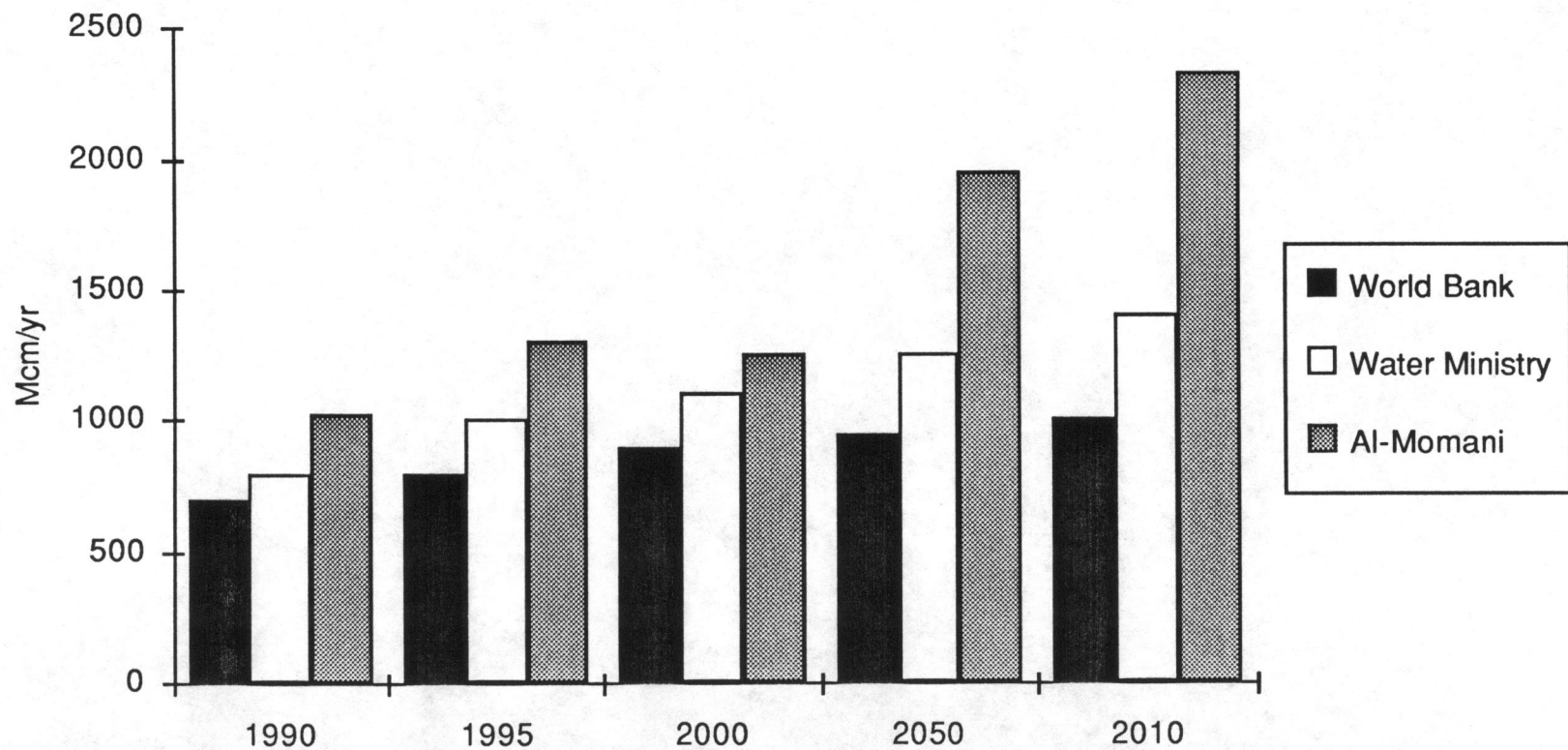
Israeli Withdrawals from Yarmuk River
(in Mcm/yr)

	Normal Conditions	Drought Conditions
Total withdrawal	100	80-85
Diversion to Golan	15-20	8-10
Diversion to Tiberias	80-85	70
to Coastal Plain	60-65	63-65
to Irrigation	15	5-8

Forecasts of Total Water Demand in Jordan (in Mcm/yr)



Forecasts of Total Water Demand in Jordan (in Mcm/yr)



Groundwater Potential and Actual Production, 1985/6-1989/90
(in Mcm/yr)

Reservoir	Potential Production	Average Actual Production	Average Overproduction
Coastal	283	317	34
Mountain	330	379	49
TOTAL	613	696	83

Citation? Source: State Comptroller

Water Consumption in Israel and West Bank
(in Mcm/yr)

	Israel	West Bank
Urban consumption		
Present	500	25
<i>Predicted (2020)</i>	950	180
Agri consumption		
Present	1300	100
<i>Predicted (2020)</i>	2500	350
Domestic fresh water supply	1800	120
Deficit under 1989-90 practices	1000	350
Deficit under water use reform	500	300

Citation? Source: Gideon Fishelson,
Figures based on Gideon Fishelson and Elisha Kalley.

Israeli Balance of Trade in Agriculture (in millions of dollars)

		1989			1990		
		Import	Export	Balance	Import	Export	Balance
Fresh Products	Field crops	454.7	120.1	(334.6)	439.4	111.1	(328.3)
	Cotton	71.9	103.3	31.4	97.5	88.4	(9.1)
	Vegetables	17.7	63.0	45.3	23.3	97.2	73.9
	Garden products	2.6	138.9	136.3	3.5	165.2	161.7
	Citrus	—	131.7	131.7	—	180.5	180.5
	Other fruit	87.2	55.2	(32.0)	92.4	92.4	0.0
	Fish and seafood	47.6	4.3	(43.3)	54.2	6.6	(47.6)
	Animal /related products	14.4	12.5	(1.9)	20.7	11.0	(9.7)
	Lumber	127.3	—	(127.3)	171.2	—	(171.2)
	TOTAL	823.4	629.0	(204.5)	902.2	752.4	(149.8)
Processed Products	Meat and fish	95.5	50.5	(45.0)	147.5	42.4	(105.1)
	Vegetables/fruit	80.3	405.3	325.0	78.3	460.1	381.8
	Oil	34.7	0.2	(34.5)	39.5	1.8	(37.7)
	Sugar	146.5	0.2	(146.3)	158.4	0.1	(158.3)
	Others	142.7	111.2	(31.5)	166.4	147.6	(18.8)
	TOTAL	499.7	567.4	67.7	590.1	652.0	61.9
GRAND TOTAL		1323.1	1196.4	(136.8)	1492.3	1404.4	(87.9)

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Population Projections for Euphrates-Tigris Basin
(population in millions)

	1985	1990	1995	2000	2005	2010	2015	2020	2025
Iraq	15.9	18.9	22.4	26.3	30.7	35.3	40.1	45.1	50.0
Syria	10.5	12.5	14.9	17.6	20.6	23.3	26.6	29.5	32.2
Turkey	50.4	55.6	61.2	66.7	71.8	76.6	81.2	85.4	89.6

Projections based on *UN World Population Prospects 1989*

Population Projections for Jordan Basin and Egypt
(population in millions)

	1985	1990	1995	2000	2005	2010	2015	2020	2025
Syria	10.5	12.5	14.9	17.6	20.6	23.3	26.6	29.5	32.2
Jordan	2.7	3.2	3.8	4.4	5.4	6.4	7.6	9.8	11.6
Israel*	4.2	4.6	5.0	5.3	5.6	6.0	6.3	6.7	7.0
Occupied Territories	1.5	1.8	2.1	2.5	2.9	3.4	4.0	4.7	5.5
Egypt	47.6	54.1	60.5	66.7	72.7	78.4	84.0	89.0	94.0

* Soviet immigration not included

Projections on Syria and Israel based on *UN World Population Prospects 1989*

Projections on the Occupied Territories and Jordan based on in-country data obtained by author

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