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Martin, N.

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International Institute for Applied Systems Analysis
Schlossplatz 1 • A-2361 Laxenburg • Austria
Telephone: (+43 2236) 807 342 • Fax: (+43 2236) 71313
E-mail: publications@iiasa.ac.at • Internet: www.iiasa.ac.at

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Population, Households and Domestic Water Use In Countries of the Mediterranean Middle East (Jordan, Lebanon, Syria, the West Bank, Gaza and Israel)

Nicola Martin
N.Martin@gmx.net

Approved by

Wolfgang Lutz
Leader, Population Project

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Contents

Abstract

This report analyzes the relationship between the increase in domestic water use, population growth and the growth in the number of households in Jordan, Lebanon, Syria, the West Bank, Gaza, and Israel. The aim was to find out if the rate of growth of the number of households could be a more adequate variable to model future domestic water demand than the rate of population growth, as was suggested for energy consumption in a former IIASA study decomposing records of CO_2 emissions on a per-person as well as a per-household basis.

Although the analysis of historical data from 1975 to 1994 cannot sufficiently prove that it would be more adequate to relate domestic water use to the household, it seems likely that the expected decrease in household size will affect future domestic water demand not only due to straightforward household-related economies of scale, but also because a decrease in household size will reduce the effectiveness of investments into technical water-saving measures.

Based on population projections for Jordan, Lebanon, Syria, the West Bank and Gaza carried out in another IIASA study and on UN population projections for Israel, the development of household sizes from 1994 to 2044 were calculated. The expected shift in the age structure to a higher proportion of the population being in older age groups with higher age-specific headship rates will lead to a strong decrease in household size over the next 50 years even if age-specific headship rates will remain constant.

Projections of domestic water demand from 1994 to 2044 were carried out on a per-person and on a per-household basis. Projections based on a per-household approach resulted in up to 75% higher estimates of domestic water demand in 2044 than projections based on a per-person approach, which shows that the expected strong decrease in household size in the countries of the Middle East might have a significant impact on domestic water demand in the future. This should be given some consideration when projecting future demand.

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About the Author

Nicola Martin holds a scholarship from the Robert Bosch Foundation. This paper was written while she was a Guest Research Scholar with the Population Project at IIASA.

The study presented in this paper is part of a project on sustainable management of water resources in Syria, on which the author is working within the foundation's post-graduate program for international affairs.

She can be contacted at Montzener Strasse 9, D-52074, Aachen, Germany, tel. +49-241-74522.

Population, Households and Domestic Water Use In Countries of the Mediterranean Middle East (Jordan, Lebanon, Syria, the West Bank, Gaza and Israel)

Nicola Martin

Introduction

The Middle East is known as a region where water resources are rare. In many countries of the Middle East the annual withdrawal of water already greatly exceeds the renewable amount, and water scarcity increases with the rapid population growth in the region. Many authors have pointed to the impact of population growth on exacerbating the conflict over shared water resources in Middle Eastern countries (Kolars 1992; Libiszewski 1995; Isaak and Shuval 1994).

Studies which estimate future water demand in countries of the Middle East forecast that the allocation of water within a country to different end users will change (GTZ 1997). Whereas at present the largest portion of water is used for irrigation (60% in Israel to more than 90% in Syria), the portion used for domestic purposes will substantially increase to 50% or 60% by 2040 due to an increase in domestic water demand related to population growth and the implementation of more efficient irrigation techniques.

However, forecasts of future water demand divert profoundly from each other due not only to the uncertainty of population projections but especially due to the uncertain development of per capita water consumption. In 1994, average per capita water use for domestic purposes in the countries of the Middle East reached from 75 lcd (liters per capita per day) in the West Bank to 290 lcd in Israel (calculated from GTZ 1997). The minimum requirement for drinking, cooking and hygiene estimated by the WHO is 30 lcd. It is usually perceived that a general increase in the standard of living that will accompany further development will be connected to an increase of the per capita water demand, or even that this is a prerequisite of development. Keeping in mind that the hot climate in those countries surely causes a domestic water demand higher than that in Western Europe, it should be pointed out here that the present domestic water demand in Germany is 128 lcd with declining tendency.

It becomes clear, though, that projections of domestic water demand are not only a question of population size, but also of the use of efficient technology (e.g. low consumption toilets), behavior and awareness. Moreover, one would expect that some water consumption such as that related to watering the garden or laundry is tied more closely to the household than to the individual so that a change in the size of households would also have an impact.

This paper analyzes the relationship between population growth and the development of domestic water use. Although population size also influences the area of cultivated land and therefore the amount of water used for irrigation, agricultural water use is not included here, since its relationship to population size is less straightforward. Since a former IIASA study (MacKellar et al. 1995) analyzing the environmental impact of demographic change found that energy consumption and CO_2 emission were more closely related to the growth in household numbers than to the growth of population, the relationship between domestic water use and the number of households will be looked at in this paper, to see if the number of households might be more closely linked to domestic water use than population size alone.

The results will finally be used to project the development of domestic water demand for the countries considered.

Availability of data

The choice of the time period considered in this paper (1975–1994) had to be made on grounds of data availability. While data on population size since the 1960s is easy to get, sufficient historical data on household size could only be obtained for Israel, Jordan and Syria. The real limiting factor, though, is the availability of records on water use. Data on domestic water use had to be gathered from various sources, which often give contradictory values. Growth rates of domestic water use therefore had to be calculated from regression lines.

History and outlook of population growth

Population growth for the countries Syria, Lebanon, Jordan, Israel and for the West Bank and Gaza is shown in Figures 1a to 1e (at the end of this paper). One has to be careful when using demographic data for this region: Population data for Israel usually includes East Jerusalem and sometimes even the West Bank. Data for Jordan sometimes includes the West Bank, etc. In this paper data given for Israel includes East Jerusalem. The data given for Jordan does not include the population of the West Bank.

To allow growth rates of population to be compared to growth rates of the number of households and of domestic water use, which could only be obtained from interpolation, population growth rates from 1975 to 1994 were also calculated from regression lines. Data on population and calculated growth rates are displayed in Table 1.

Population growth rates in these countries are among the highest in the world. From 1975 to 1994 Israel had the lowest average growth rate of 2.1% per year of the countries considered in this paper, excluding Lebanon. Syria and the West Bank and Gaza were in between with 3.4% and 3.1% respectively. However, from 1990 to 1994 the population growth rate in the West Bank and Gaza was much higher with an average of 5.4% per year. Jordan had the highest average growth rate over the time period 1975 to 1994 of 4.3% per year. From 1990 to 1994 the average growth rate was even 5% per year. Shown in the table are only those growth rates that will be used later.

Table 1: Population and households, 1975, 1990 and 1994.

						average annual change in % (calc. from regression)	
			1975	1990	1994	1975 - 1994	1990 - 1994
West Bank & Gaza	Population	Mio	1.220	1.580	1.843		5.4%
	Households (interpolated)	Mio					
	Persons per household (estimated)	-			7.01		
Jordan	Population	Mio	1.773	3.306	4.066		5.0%
	Households (interpolated)	Mio	0.269	0.486	0.568		3.9%
	Persons per household (interpolated)	-	6.40	6.73	6.63		
Lebanon	Population	Mio	2.767	2.555	2.915	-0.1%	
	Households (estimated)	Mio			0.87		
	Persons per household (estimated)	-			4.00		
Syria	Population	Mio	7.438	12.388	13.840	3.4%	
	Households (interpolated)	Mio	1.256	1.960	2.206	2.9%	
	Persons per household (interpolated)	-	6.09	6.16	6.08		
Israel	Population	Mio	3.455	4.660	5.408	2.1%	
	Households (interpolated)	Mio	0.973	1.507	1.692	2.8%	
	Persons per household (interpolated)	-	3.70	3.52	3.46		

In some of the countries population size has been strongly influenced by migration and war. For example, population growth in Israel is strongly influenced by immigration, especially since the breakdown of the Soviet Union. In Lebanon the overall average population growth rate from 1975 to 1994 is –0.1% because of the declining tendency during the 16-year civil war, although population growth jumped to over 3% per year after the end of the civil war.

Figures 1a to 1e also display projections of population size for the next 50 years. Detailed population forecasts have been carried out by the United Nations (1997), by IIASA (Goujon 1997) and within the GTZ-coordinated Middle East Regional Study on Water Demand and Supply Development (GTZ 1997). The IIASA forecasts take into account the impact of the increase in women's education on fertility rates. These forecasts are based on population data for 1994 (UN-ESCWA 1995), which differs significantly from the number given by the United Nations (1996) or the FAO (1997). Since the population data given by UN-ESCWA yields a more sensible per capita water use of 300 lcd (as opposed to 360 lcd), this data was used for projecting domestic water demand for Lebanon.

All of these forecasts present a central or base scenario, which the authors expect most likely to occur, as well as a low and high scenario as the lower and upper margin. In addition GTZ also presented a sustainable forecast, which is based on assumptions that have to be met to attain a sustainable development with regards to water resources.

Although the different projections result in quite different forecasts over the period of 50 years, most base or central scenario projections show a more or less linear population growth for Syria, Jordan, Israel and the Palestinian areas. Only in Lebanon is a decrease in population growth expected.

History and outlook of household size

The development of household size is shown in Figure 2a. The figure shows that Israel has the lowest household size in the region and that the average household size in Israel has decreased slightly since the early 1970s. Average household sizes in Syria, Jordan, Gaza and the West Bank are much higher than in Israel. In Jordan there was a steep increase in household size to the mid 1970s, with no significant change since then. In Syria a slow increase in household size can be seen until the early 1980s, with a slight decrease since then. There is not enough data available for the West Bank and Gaza to comment on a trend, and for Lebanon there is no data on household size available at all. For an estimation of the average household size in 1994 it was assumed that the age-specific headship rates in Lebanon are similar to the ones in Israel.

To calculate growth rates of the number of households, the household sizes were interpolated for the year needed (the regression line and the corresponding formula are also displayed in the figures). The population data given by FAO (1997) (which is identical to the UN 1996 data) was then divided by the respective interpolated household size to derive the number of households, and growth rates were calculated based on the non-linear regression lines.

Data on the number of households and calculated growth rates are also presented in Table 1. Over the time period from 1975 to 1994 the average growth rate of the number of households in Israel was 2.8% per year and therefore larger than the population growth rate due to the decline in household size. In Syria and Jordan the average growth rates of the number of households of 2.9% and 3.8% per year respectively were smaller than the population growth rates due to the overall increase in household size, although household sizes have been decreasing in recent years. No growth rates of the number of households could be calculated for Lebanon or the West Bank and Gaza.

MacKellar et al. (1995) found that between 1950 and 1990 household size decreased in more developed regions while it increased in less developed regions, which can be confirmed by the growth rates found here, since it seems appropriate to classify Israel as more developed and the other countries as less developed.

Taking into account a change in age structure and headship rates, average household sizes were estimated for the next 50 years. The projection of the age structures is described in detail in Goujon (1997). The headship rates for Israel were taken from the U.S. Census Bureau (1997). For lack of data on headship rates in the other countries, average headship rates for West and Central Asia were taken from MacKellar et al. (1995) and used to calculate household sizes for Jordan, Syria, the West Bank and Gaza. Furthermore it was assumed that the headship rates in Lebanon are similar to the ones in Israel.

The estimates show that average household sizes in all of the countries considered will eventually decrease. The decrease will be more pronounced for the countries where household sizes are relatively high at present. The main reason for the projected decrease in household size is the fertility decline resulting in a rise in the portion of the

population belonging to the older age groups characterized by high age-specific headship rates.

By combining the estimated household sizes with the IIASA population projections for Jordan, Lebanon, Syria, the West Bank and Gaza (Goujon 1997) and with the UN (1997) population projection for Israel, the development of the number of households was calculated. The historical and estimated number of households is shown in Figure 2b. Because of the expected substantial decline of household sizes, the number of households will grow faster than the population.

History of domestic water use and outlook on future demand

The availability of historical data on domestic water use is rather poor except for Israel. Growth rates of domestic water use, therefore, had to be calculated from regression lines. For Jordan only two data points could be found for the time period prior to 1990, which are contradictory (the water use given in one source for 1975 is much higher than the water demand for 1985 given by another source). For the West Bank and Gaza no data on water use prior to 1990 could be found at all. For this reason only the rather short time period from 1990 to 1994 will be considered for Jordan, Gaza and the West Bank.

Table 2: Domestic water use, 1975, 1990 and 1994.

						average annual change in % (calc. from regression)	
			1975	**1990**	**1994**	**1975 - 1994**	**1990 - 1994**
West Bank & Gaza	domestic water use	MCM/a		47.6	65.8		8.0%
	domestic water use per person	l/d		83	98		
	domestic water use per household	l/d			564		
Jordan	domestic water use	MCM/a		175.5	228.3		6.5%
	domestic water use per person	l/d		145	154		
	domestic water use per household	l/d		990	1102		
Lebanon	domestic water use	MCM/a	124.5	327.0	381.0	5.3%	
	domestic water use per person	l/d	123	351	358		
	domestic water use per household	l/d			1199		
Syria	domestic water use	MCM/a	179.2	593.1	703.4	6.3%	
	domestic water use per person	l/d	66	131	139		
	domestic water use per household	l/d	391	829	874		
Israel	domestic water use	MCM/a	293.6	476.3	541.2	3.1%	
	domestic water use per person	l/d	233	280	274		
	domestic water use per household	l/d	826	866	876		

Records on domestic water use are presented in Figures 3a to 3e. Also shown in the figures are the regression lines used to calculate growth rates. Table 2 displays the values of domestic water use which were calculated from the regression lines. Also included in the table are the calculated growth rates and the calculated per person and per household use. Per person domestic water use was derived by dividing domestic water use in MCM/a (million cubic meters per year) as displayed in the table by the FAO/UN population data displayed in Table 1. Per household domestic water use was derived by dividing domestic water use in MCM/a as displayed in the table by the interpolated number of households displayed in Table 1.

The historical data available shows that domestic water use has increased steadily in all the countries considered. From 1975 to 1994 the average growth rate of domestic water use was 3.1% per year in Israel. In Lebanon and Syria growth rates were substantially higher with 5.3% and 6.3% per year, respectively. However, one has to keep in mind that since data on domestic water use in Syria and Lebanon was difficult to obtain, these growth rates are not very reliable. For Jordan, the West Bank and Gaza growth rates could only be calculated for the time period from 1990 to 1994, when average growth rates of domestic water use were rather large with 6.9% and 8% per year.

Detailed projections of future demand have been carried out for Israel, Jordan, the West Bank and Gaza within the GTZ-coordinated Middle East Regional Study on Water Demand and Supply Development (GTZ 1997) and by the World Bank (1994). A few estimates, which do not reach beyond the year 2000, have been put forward for Syria, but no projections of future domestic water demand are available for Lebanon so far. The projections presented in Figures 3a to 3e together with the historical data on water use show that estimates for the year 2044 cover a very wide range due to the uncertainty about the development of per capita water demand.

The individual or the household as the consuming unit in modeling environmental impact

MacKellar et al. (1995) suggested that considering households as the consuming unit instead of the individual could be more adequate when analyzing the environmental impact of demographic change. They found that in more developed regions, where the average household size had changed substantially over the time period studied, energy consumption and CO_2 emission were more closely related to the growth in household numbers than to the growth in population. They concluded that the number of households can be a better demographic variable to estimate environmental impact than merely population size. The underlying idea is that of economies of scale, i.e. that four people living together consume less than four people living by themselves.

To describe the relation between population growth and environmental impact the I = PAT identity was introduced by Ehrlich and Holdren in 1971 (cited in MacKellar et al. 1995), where environmental impact (I) is seen as the product of population (P), affluence (A), which is measured by the gross national product per person, and technological efficiency (T), which is expressed as impact per unit of gross national product. This model therefore focuses on the individual as the demographic variable. Expressed in growth rates (G) the I = PAT identity is

$$Gi = Gp + Ga + Gt$$

According to this model, the growth rate of environmental impact (natural resource used or pollution generated) can be explained by the sum of population growth, change of the standard of living represented by the change of per-person income and the change in technology, e.g. technologies allowing more efficient use of resources.

MacKellar et al. derived an I = HAT identity from this, where population is substituted by households, and the number of households is the demographic variable. They showed that this approach can produce results rather different from estimates based on population size only when projecting future CO_2 emissions.

Growth rates of population, of the number of households and of domestic water have already been presented in Tables 1 and 2. Data on gross national product (GNP) and calculated per-person and per-household growth rates are displayed in Table 3 as background information on the economic situation and development in the countries considered. Change of GNP will not be analyzed here, because the rate of change of technological efficiency remains an unknown variable so that it will not be possible to validate either the I = PAT or the I = HAT model. Therefore the evaluation of the two models is limited to a comparison of population and number of households growth rates to domestic water use growth rates. For this purpose it is not necessary to look at GNP change rates in more detail.

Table 3: Gross national product, 1975, 1990 and 1994.

						average annual change in % (calc. from regression)	
			1975	1990	1994	1975 - 1994	1990 - 1994
Jordan	GNP per person	1987 US$		1594	1775		1.3%
	GNP per household	1987 US$		237	268		1.7%
Lebanon	GNP per person	1987 international $			4220		
	GNP per household	1987 international $					
Syria	GNP per person	1987 US$	999	972	1246	1.8%	
	GNP per household	1987 US$	164	158	205	1.8%	
Israel	GNP per person	1987 US$	6894	8892	9963	1.9%	
	GNP per household	1987 US$	1862	2528	2883	2.2%	

In the following section, growth rates of domestic water use are compared to growth rates of population and the number of household sizes to see which one could be the better variable to predict future domestic water demand.

Growth of domestic water use related to population and household changes

In Table 4 growth rates of domestic water use are compared to growth rates of population. As an additional information growth rates of GNP per capita are also displayed (calculated from World Bank 1998). With the exception of Lebanon, it can be seen that population growth rates account for approximately two-thirds of the growth rate of domestic water use (from 54% in Syria to 76% in Jordan). MacKellar et al. found that only about one-third of the energy consumption in more and in less developed regions was accounted for by population growth. So, in comparison population growth can already explain a rather large portion of the increase in domestic water use.

Table 4: Comparison of growth rates on per-person terms (I = PAT model).

	Time period	Average growth rate of dom. water use Gi	due to growth of population Gp	due to change in income per person Ga	due to change in technology Gt	percent pop. growth rate of dom. water use growth rate
Jordan	1990-1994	6.5%	5.0%	1.3%	0.2%	**76.1%**
Lebanon	1975-1994	5.3%	-0.1%			**-1.6%**
Syria	1975-1994	6.3%	3.4%	1.8%	1.0%	**53.8%**
West Bank & Gaza	1990-1994	8.0%	5.4%			**67.4%**
Israel	1975-1994	3.1%	2.1%	1.9%	-0.8%	**67.0%**

Since there was no significant change in population size in Lebanon from 1975 to 1994, population growth rates cannot account for the strong increase in domestic water use. However, the data given for Lebanon can hint at the development in the country, but should not been given too much weight, because of the unreliable data basis especially concerning water use. Although there obviously has been a large increase in water use, a reliable growth rate can not be determined from the data available, and it can be assumed that most of the increase in water use took place in the more recent years after the end of the civil war. Data on GNP is only available for the most recent years and is therefore not included in the table. Between 1994 and 1996 the GNP per person was more than twice as high as in Jordan or Syria with an average growth rate of 6%.

Table 5 compares growth rates of domestic water use to growth rates of the number of households. When comparing Tables 4 and 5 it can be seen that for Israel the rate of growth of the number of households accounts for a larger portion of the change in domestic water use than the rate of population growth, since it accounts for 91% of the increase as opposed to 67% accounted for by population growth. However, for Syria and Jordan the rate of growth of the number of households accounts for only 46% and 60% of the change in domestic water use and is therefore less able to explain the increase in domestic water use than the rate of population growth.

Table 5: Comparison of growth rates on per-household terms (I = HAT model).

	time period	average growth rate of domestic water use Gi	due to growth of number of households Gh	due to change in income per household Ga	due to change in technology Gt	percent household number growth rate of dom. water use growth rate
Jordan	(1990-1994)	6.5%	3.9%	1.7%	1.0%	**60%**
Lebanon	(1975-1994)	5.3%				
Syria	(1975-1994)	6.3%	2.9%	1.8%	1.5%	**46%**
West Bank & Gaza	(1990-1994)	8.0%				
Israel	(1975-1994)	3.1%	2.8%	2.2%	-1.9%	**91%**

As described earlier, an overall increase in household size could be observed in Syria and Jordan over the time period considered, resulting in a rate of growth of the number of households being smaller than the rate of population growth. It could therefore be concluded that the number of households can better explain a change in domestic water use than population growth when a significant decrease in household size occurs, but

not when household sizes are increasing. The reason for this could be that per-person domestic water use is strongly influenced by changes in habit, which covers up any influence of economies of scale, and that a decrease in household size is often accompanied by a change in habit. In this case the decrease in household size would rather be an indicator for behavioral change than a variable taking into account economies of scale.

In order to answer the question whether a scale effect should be expected with regards to domestic water use, it can be useful to look in more detail at domestic water consumption patterns. In Germany approximately one-third of domestic water use is used for toilet flushing and another third is used for baths and showers. At first glance, at least these two purposes should be expected to be more closely linked to the individual than to the household, and economies of scale should only be expected to matter regarding the remaining third (house cleaning, car washing, laundry, dishwashing, lawn water).

Unfortunately no data could be found on the composition of domestic water use in the Middle Eastern countries. In some dry areas of the USA and Australia as much as 80% of domestic water use is used as lawn water. These figures can surely not been applied 1:1 to the countries considered here, but it should be kept in mind that the portion of domestic water use which is more closely related to the household in countries of the Middle East might be larger than that in Germany.

Another aspect will gain importance in the future: The impact of water saving measures on domestic water consumption should strongly depend on household size. For example, investing in a low consumption toilet will cut the water use in a six-person household twice as much as in a three-person household. Technical water saving measures in the domestic field such as low consumption toilets, water-saving shower heads or installation of water meters have not been implemented or have only most recently started to be implemented in the countries considered here, but will become more important as water scarcity increases (urging a change in water policy and water pricing).

Since the estimated strong future decrease in household size will counteract the implementation of water-saving measures, the rate of growth of the number of households should be considered as the potentially more suitable variable for calculating future domestic water demand.

Projections of future domestic water demand

This section shows that choosing the individual or the household as the demographic variable can result in rather different projections of future domestic water demand in Middle Eastern countries, where the household size will strongly decrease according to the projections of population age structure.

Projections of domestic water demand from 1994 to 2044 were carried out on a per-person and a per-household basis for different assumptions concerning the change of per-person or per-household water demand.

A first projection was carried out assuming that the per-person or per-household domestic use will remain constant at the 1994 values given in Table 2 (except for Lebanon, where a 1994 per-person domestic water use of 300 lcd was used, which is based on the UN-ESCWA population data as explained earlier).

Next, it was assumed that all the countries will eventually converge to the same sustainable per person domestic water demand of 200 lcd, i.e. that domestic water use in Syria, Jordan, the West Bank and Gaza will increase to 200 lcd within 30 years and remain at this level afterwards, and that Israel and Lebanon will manage to decrease domestic water use to 200 lcd within 50 years. To be able to compare this to a similar projection on a per-household basis, the annual percent change of per-person domestic water demand resulting from the scenario described above was calculated and used to calculate per-household change.

These assumed consumption paths were then combined with the low, central and high scenario IIASA population projections for Jordan, Lebanon, Syria, the West Bank and Gaza, and with the UN (1997) population projections for Israel to calculate domestic water demand on a per-person basis. Equally, the consumption paths were combined with the central scenario household projections to calculate domestic water demand on a per-household basis.

Table 6: Projected domestic water demand in MCM/a.

	1994	**2044**			
Assumption:		**constant 1994 per-person domestic water use**			**constant 1994 per-household domestic water use**
		Low scenario	central scenario	high scenario	
Jordan	228	598	685	779	1195
Lebanon	381	630	657	741	1032
Syria	698	1656	1987	2547	3437
West Bank & Gaza	80	328	362	404	452
Israel	510	734	897	1072	1073

Assumption:		**final per-person domestic water use of 200 lcd**			**change of per-household domestic water use at same rate as per-person use**
		Low scenario	central scenario	High scenario	
Jordan	228	778	890	1013	1554
Lebanon	381	420	439	494	689
Syria	698	2379	2853	3658	4936
West Bank & Gaza	80	672	741	826	925
Israel	510	536	654	782	783

	Projections from the Middle East regional water study (GTZ 1997)			
	1994	**2040**		
		Low scenario	central scenario	High scenario
Jordan	219	1075	1209	1343
Lebanon				
Syria				
West Bank & Gaza	85	318	642	1158
Israel	545	961	1853	1853

The results are displayed in Table 6. Projections from the Middle East Regional Study on Water Demand and Supply Development (GZT 1997) are also displayed for comparison. The projected domestic water demands for 2044 made on per-household

terms are from 20% (Israel) to 75% (Jordan) larger than the projections based on the per-person central scenarios, and up to 50% (Jordan) larger than the projections based on the per-person high scenarios.

Although the analysis of historical data cannot sufficiently prove that it would be more adequate to relate domestic water use to the household, the results presented in this paper suggest that the estimated large decrease in household size in the Middle Eastern countries might have a significant impact on domestic water demand in the future, which should be given some consideration when projecting future demand.

Conclusion

The analysis of data from 1975 to 1994 revealed that only for Israel, where there has been a slight but significant decrease in household size over the time period studied, the increase in domestic water use could be statistically better explained by the growth of the number of households than by population growth. For Jordan and Syria, where an overall increase in household size could be observed over the same time period, the rate of growth of the number of households statistically accounted for a smaller portion of the increase in domestic water use than the rate of population growth (no historical data on household size were available for Lebanon or the West Bank and Gaza). Population growth already accounted for approximately two-thirds of the increase in domestic water use in all of the countries considered in this paper.

The expected fertility decline in the region, which will cause a shift in the age structure to a higher proportion of the population in older age groups with higher age-specific headship rates, will lead to a strong decrease in household size over the next 50 years even if age-specific headship rates will remain constant.

It seems likely that this decrease in household size will affect future domestic water demand not only due to straightforward household-related economies of scale (e.g. that six people living together use less than twice the amount of water for housecleaning, laundry, car washing, lawn watering, etc., than a three-person-household), but also because a decrease in household size will reduce the effectiveness of investments into technical water saving measures, which will gain in importance as water scarcity in the region increases.

An approach taking into account the expected decrease in household size should therefore be considered when estimating future domestic water demand in countries of the Middle East.

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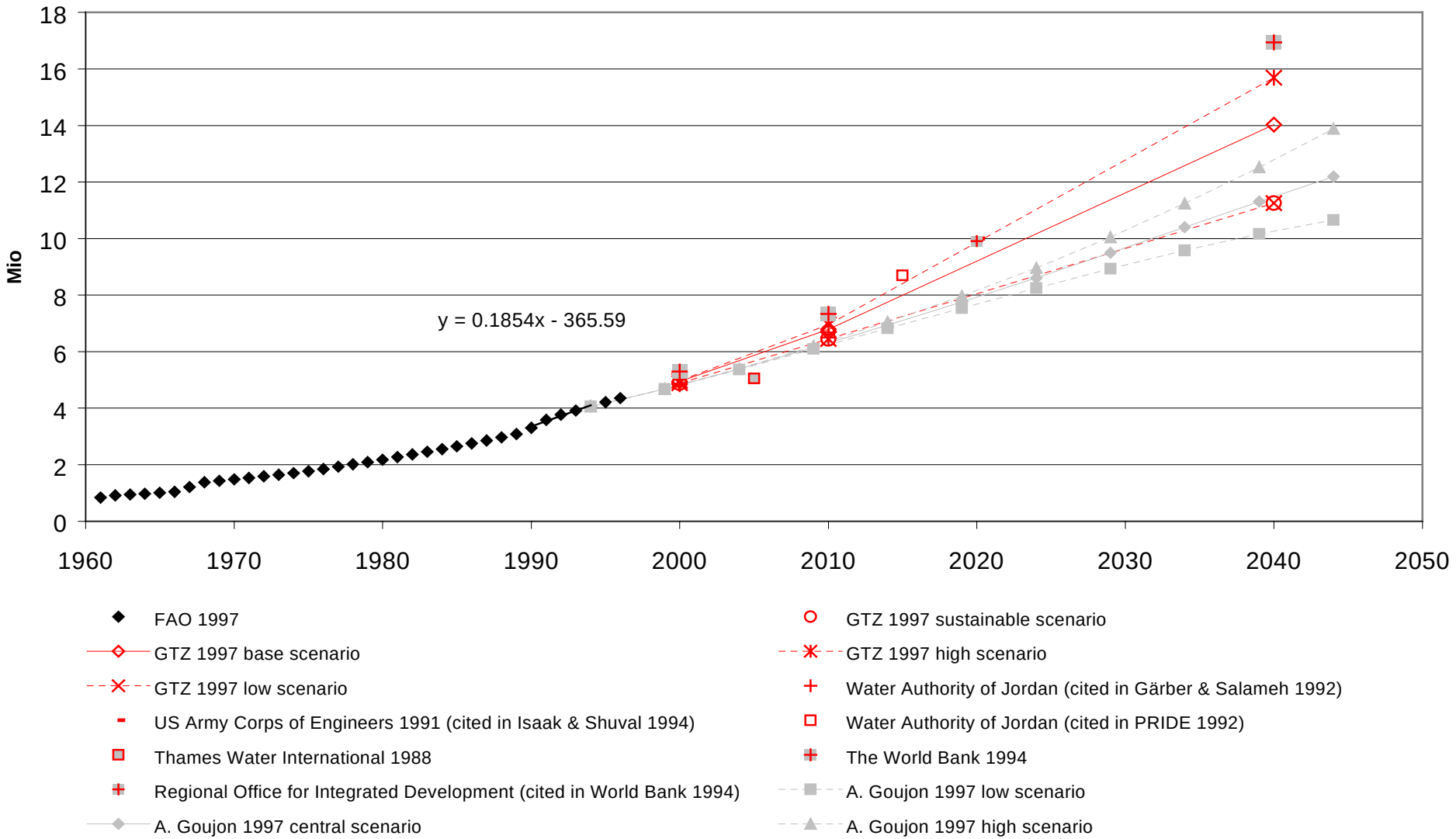

Figure 1a: Historical and projected population in Jordan.

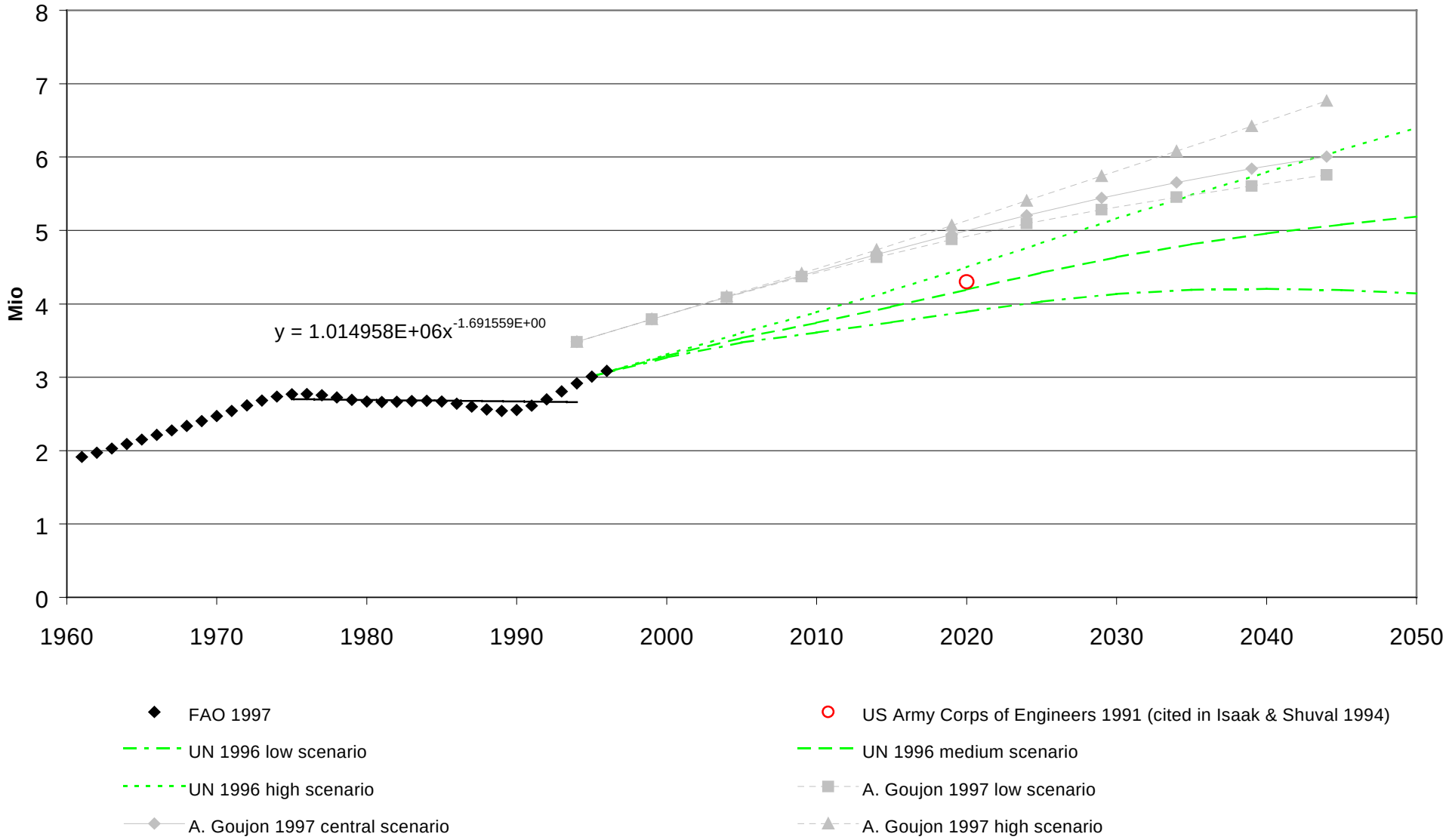

Figure 1b: Historical and projected population in Lebanon.

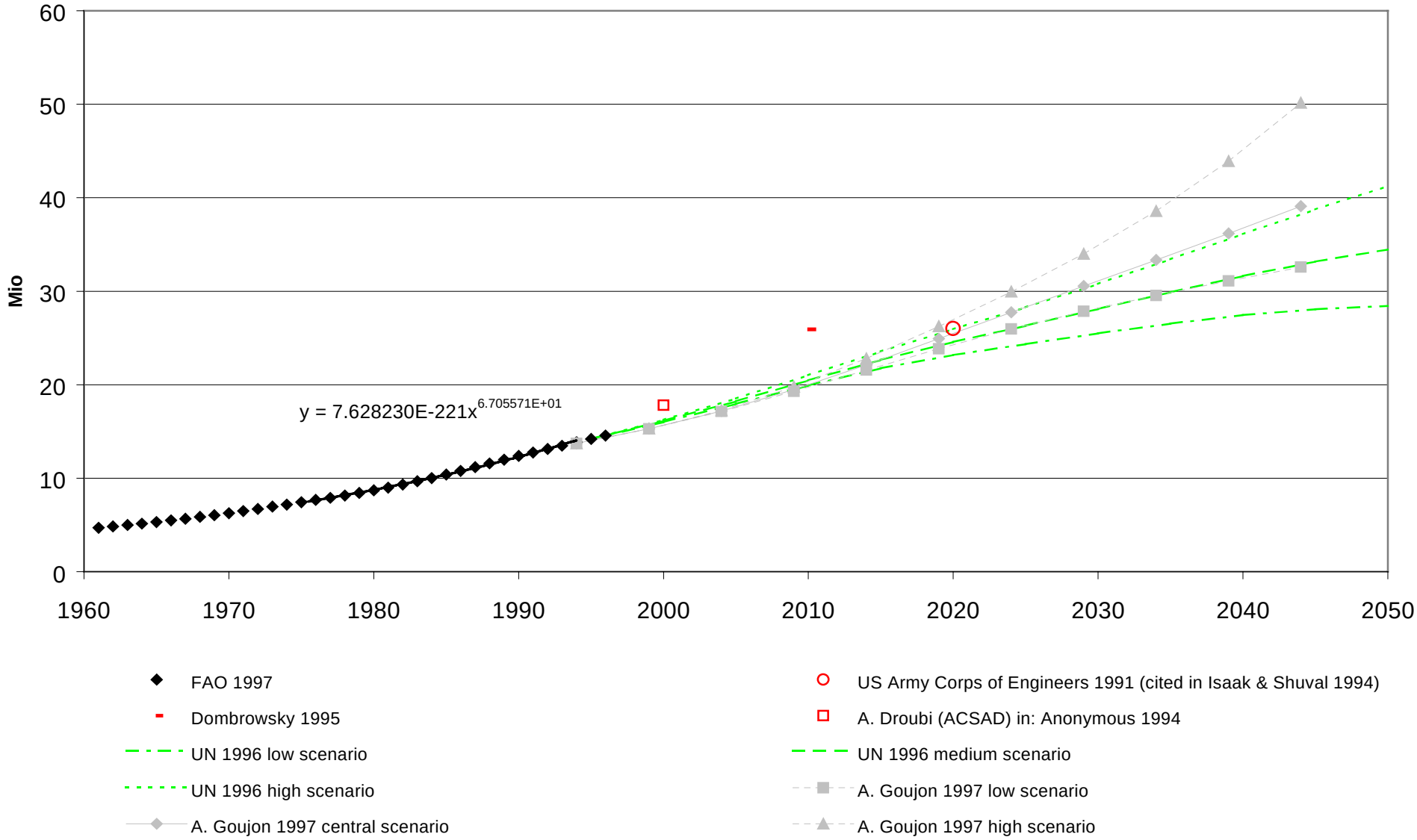

Figure 1c: Historical and projected population in Syria.

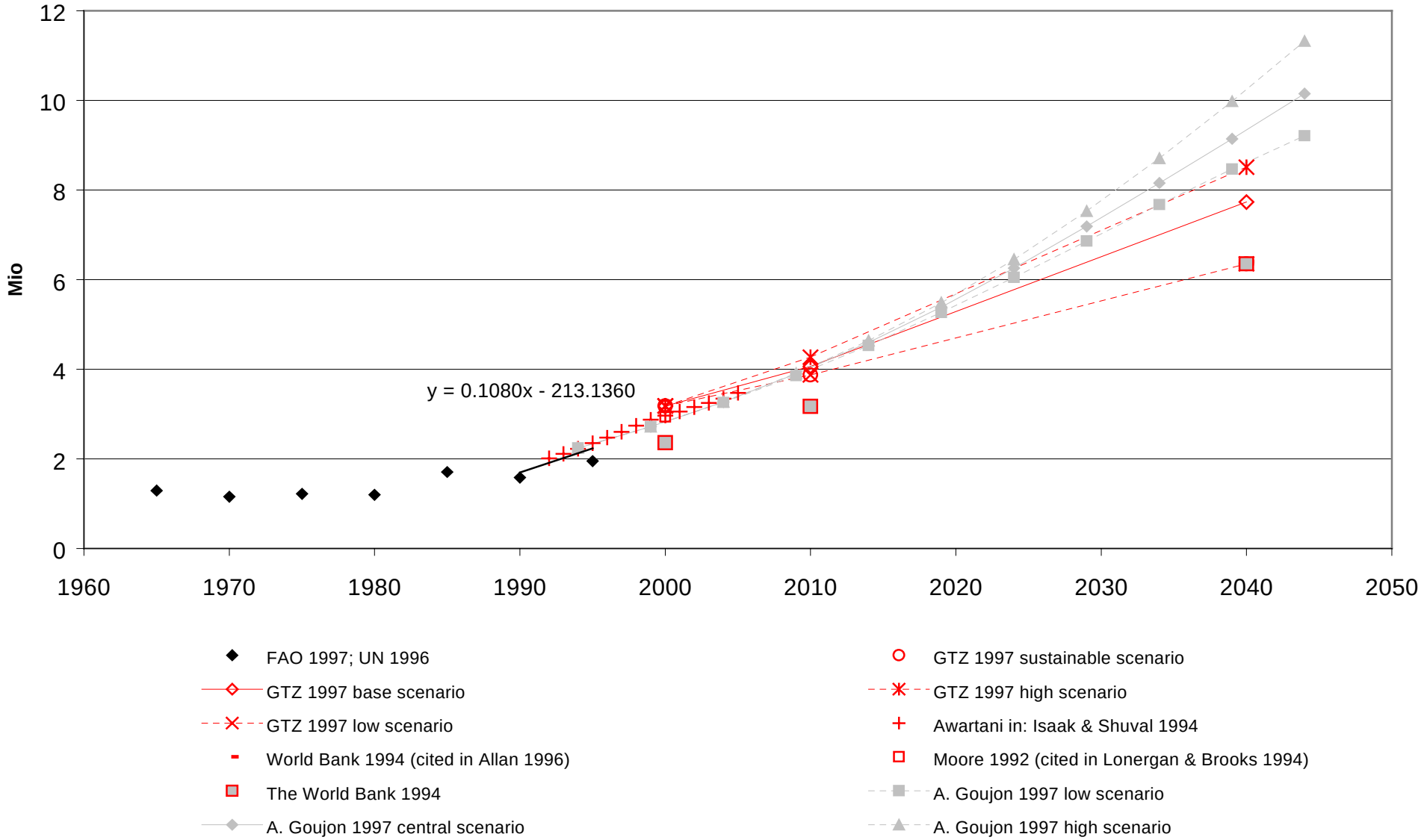

Figure 1d: Historical and projected population in the West Bank and Gaza.

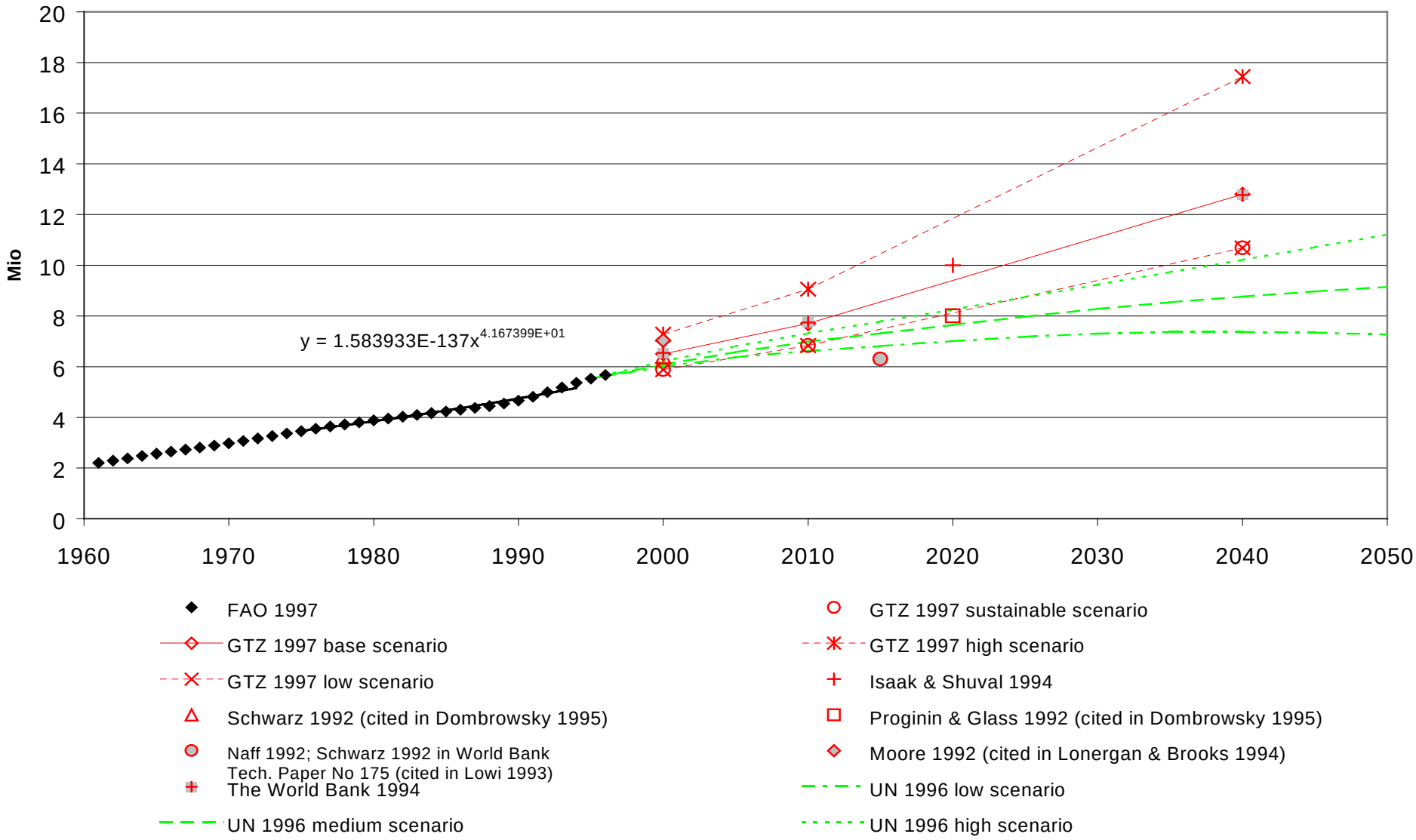

Figure 1e: Historical and projected population in Israel.

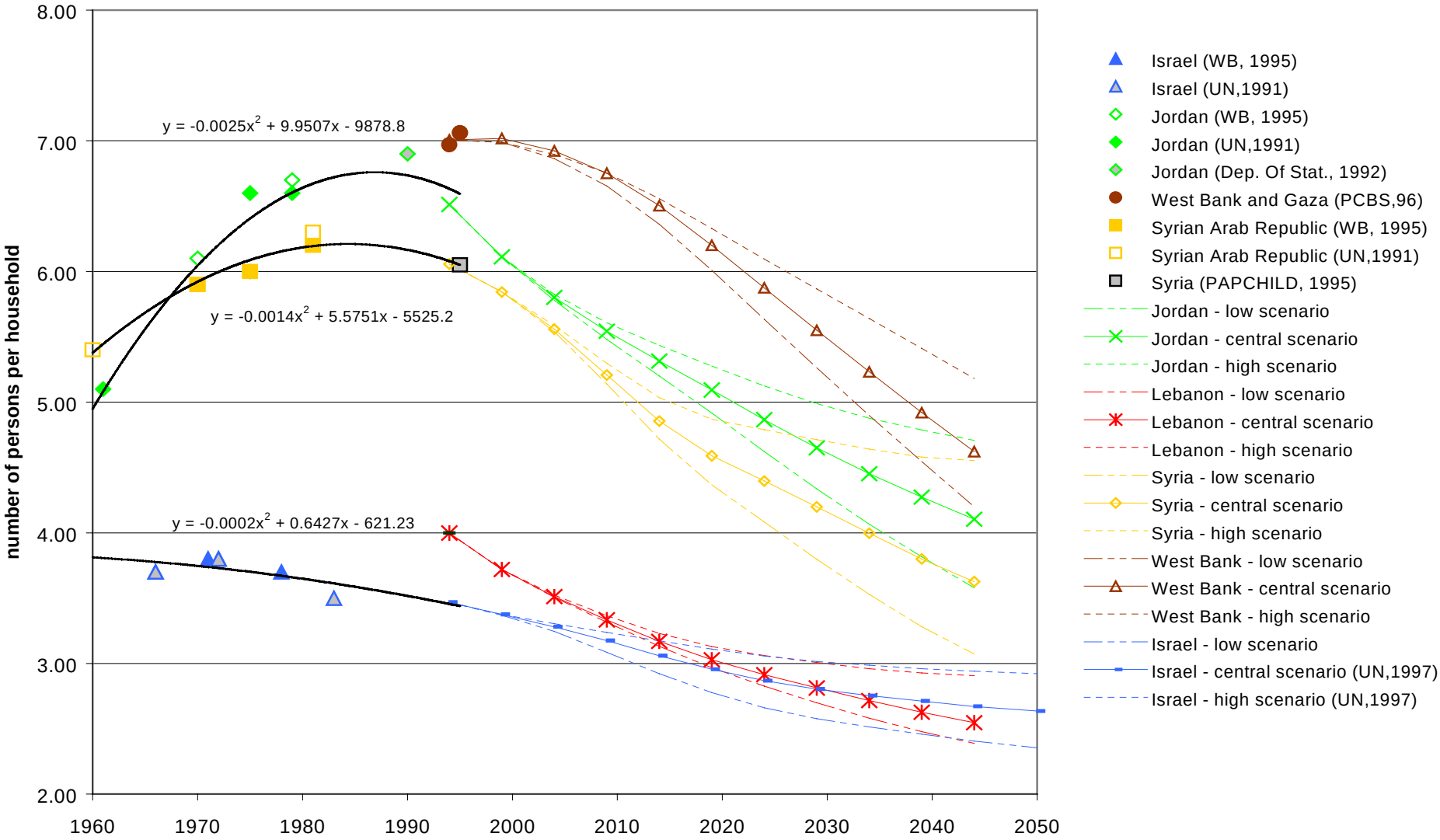

Figure 2a: Historical and projected average household sizes.

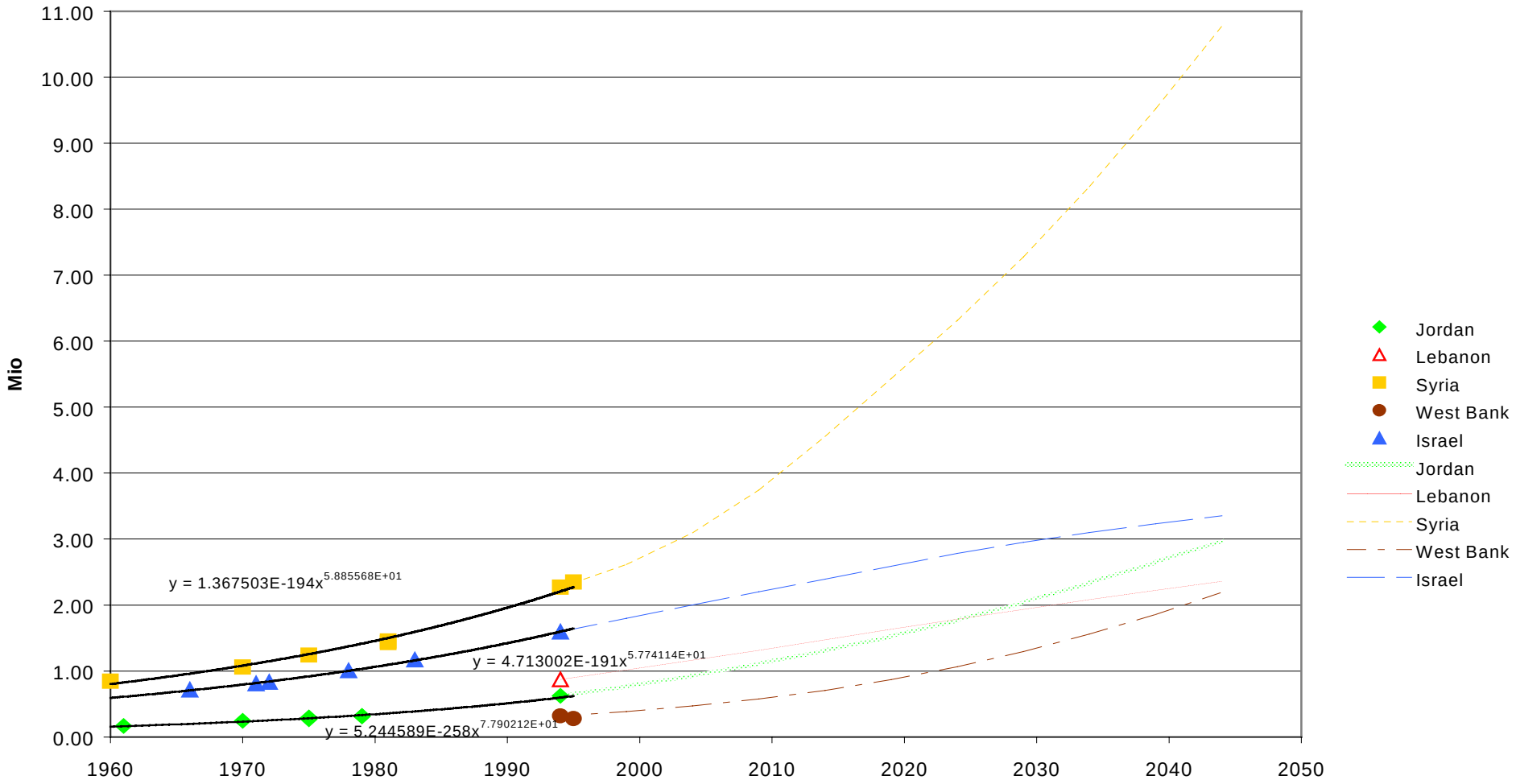

Figure 2b: Historical and projected number of households.

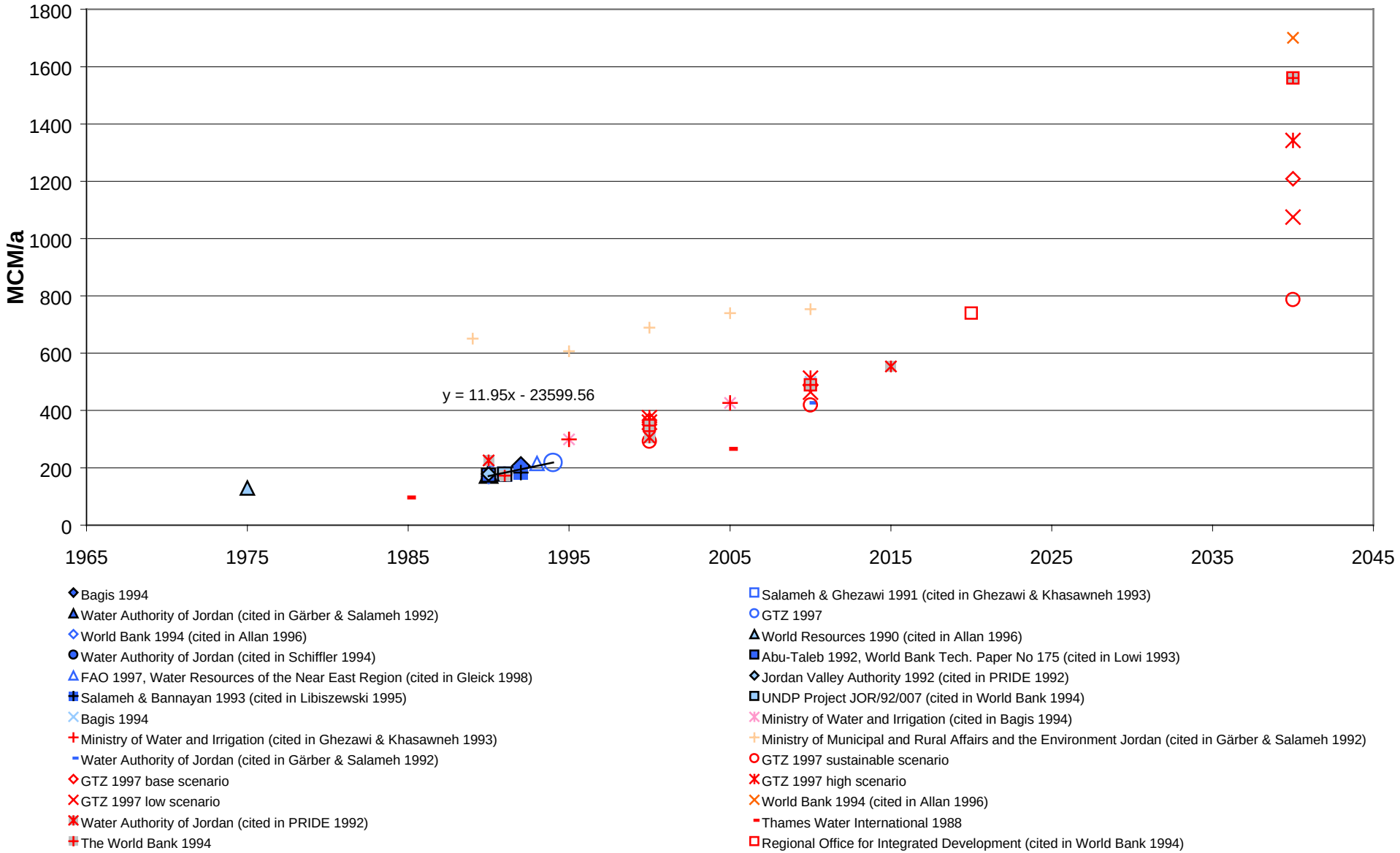

Figure 3a: Domestic water use and projected demand in Jordan.

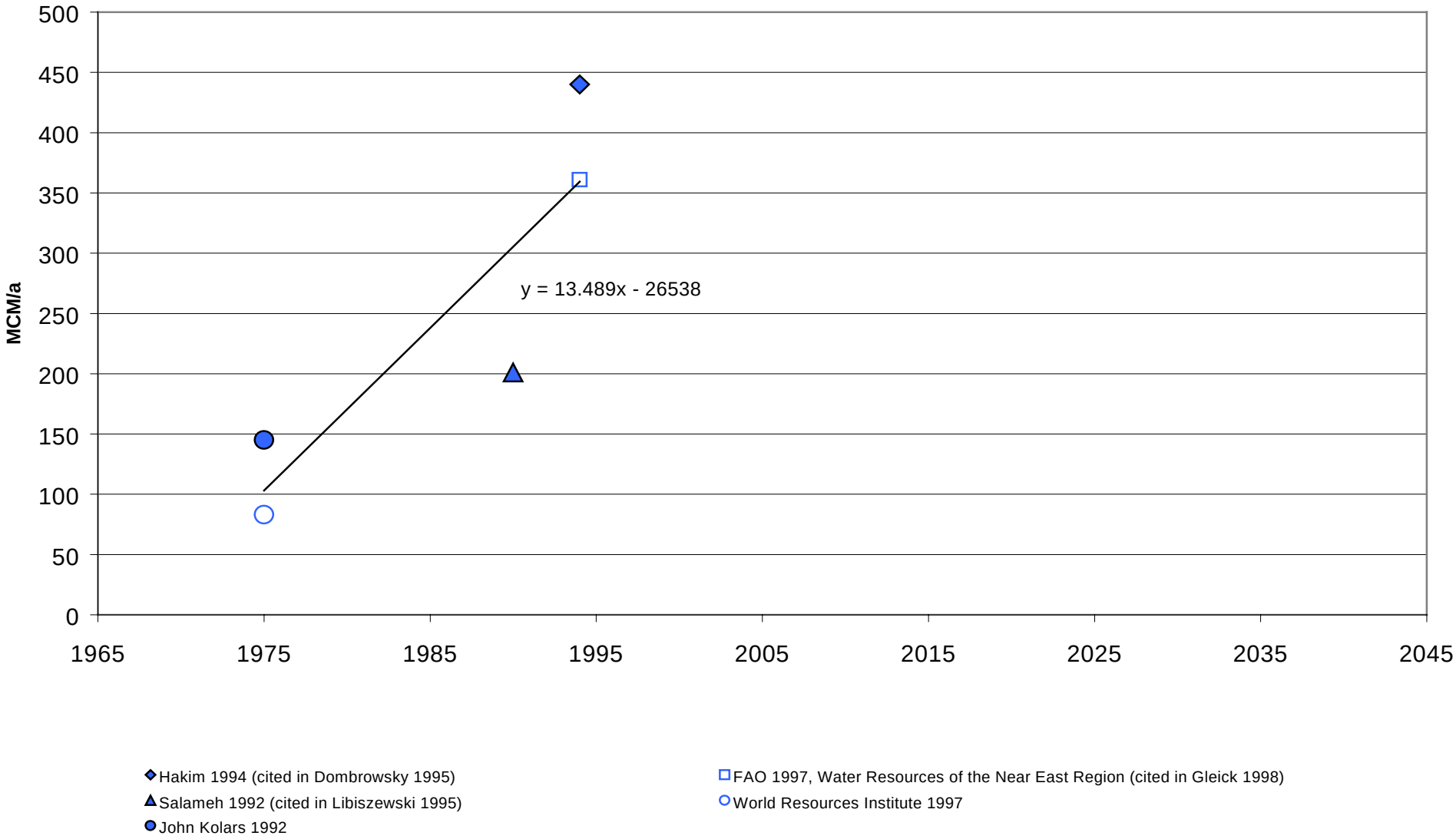

Figure 3b: Domestic water use and projected demand in Lebanon.

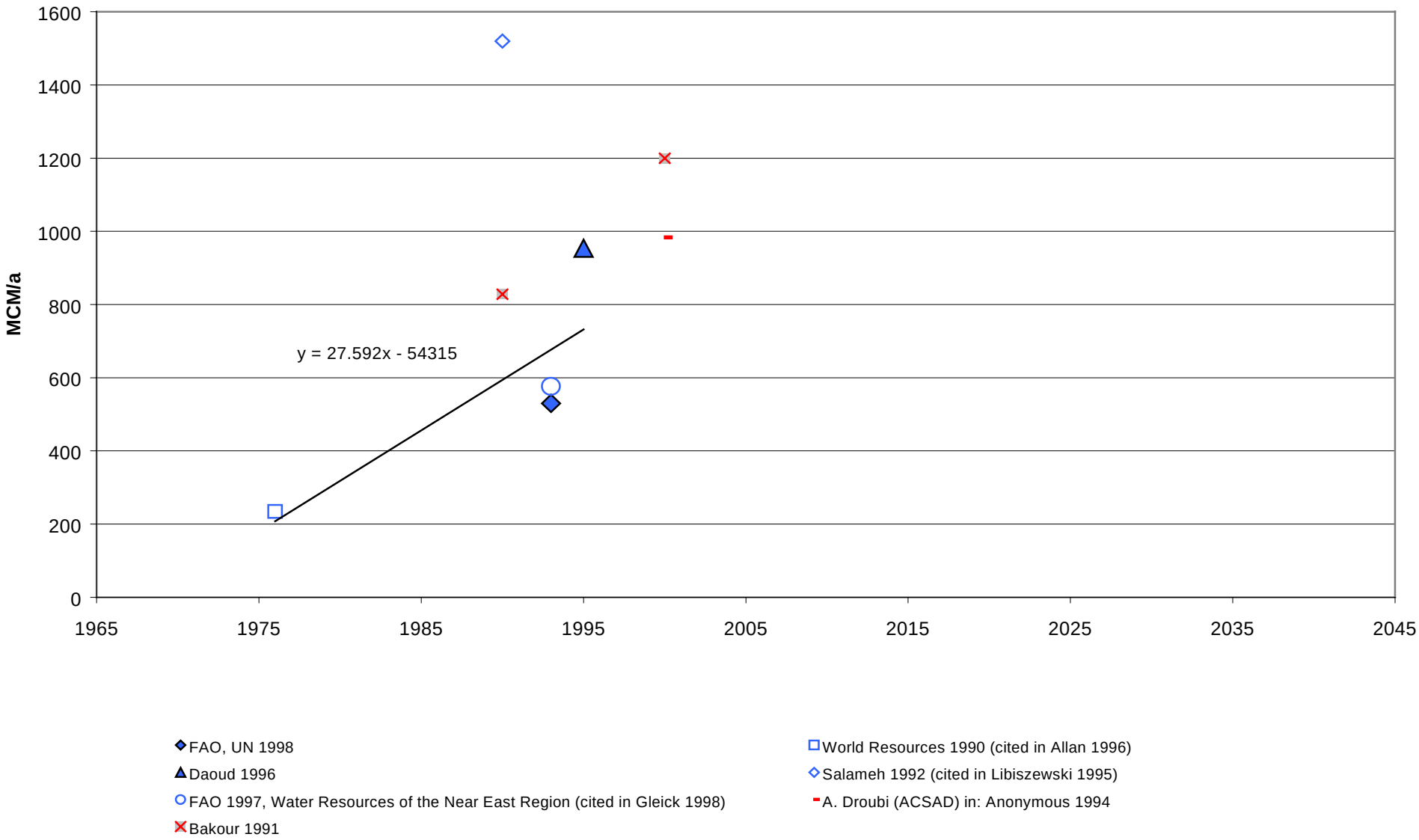

Figure 3c: Domestic water use and projected demand in Syria.

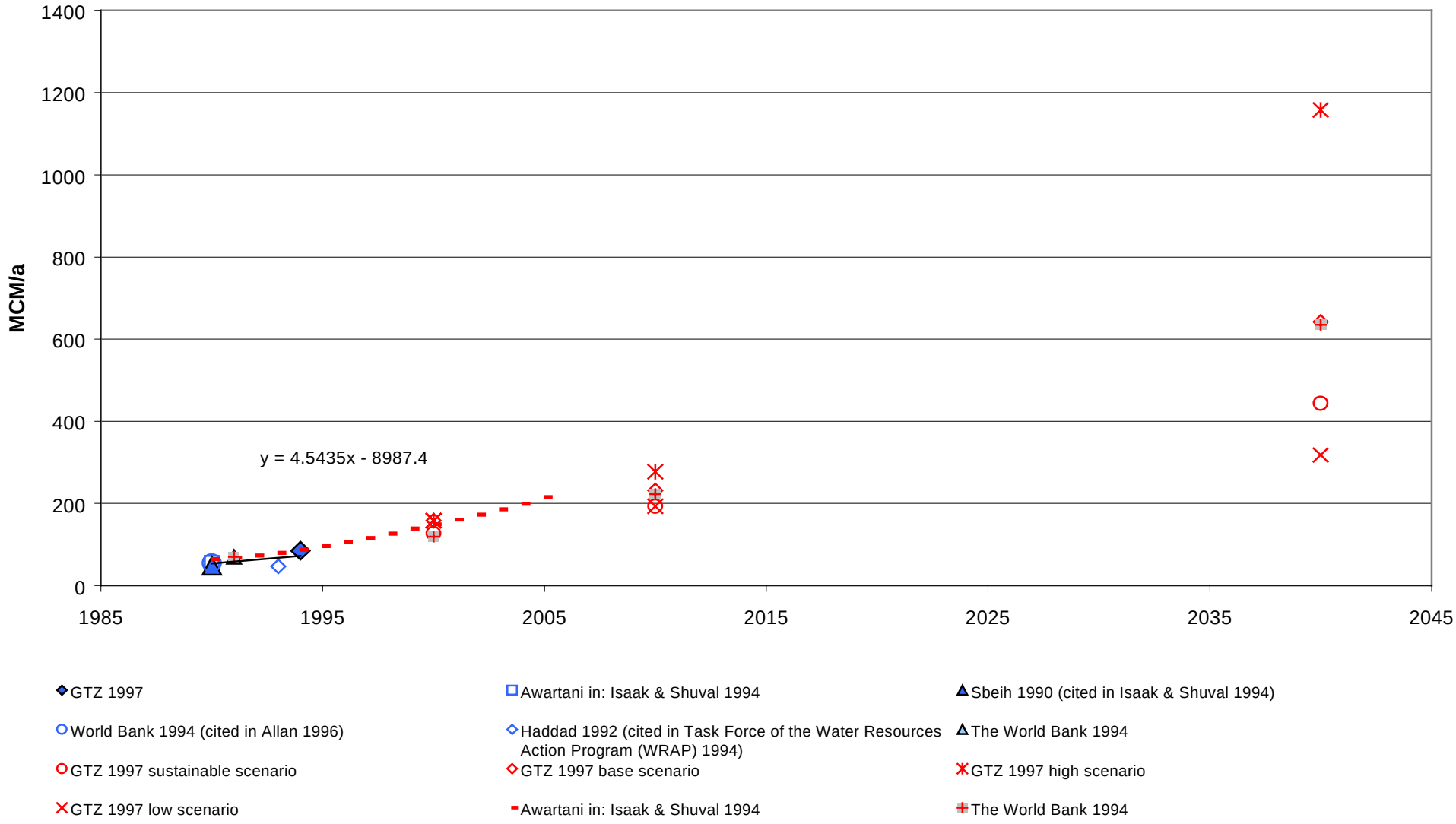

Figure 3d: Domestic water use and projected demand in the West Bank and Gaza.

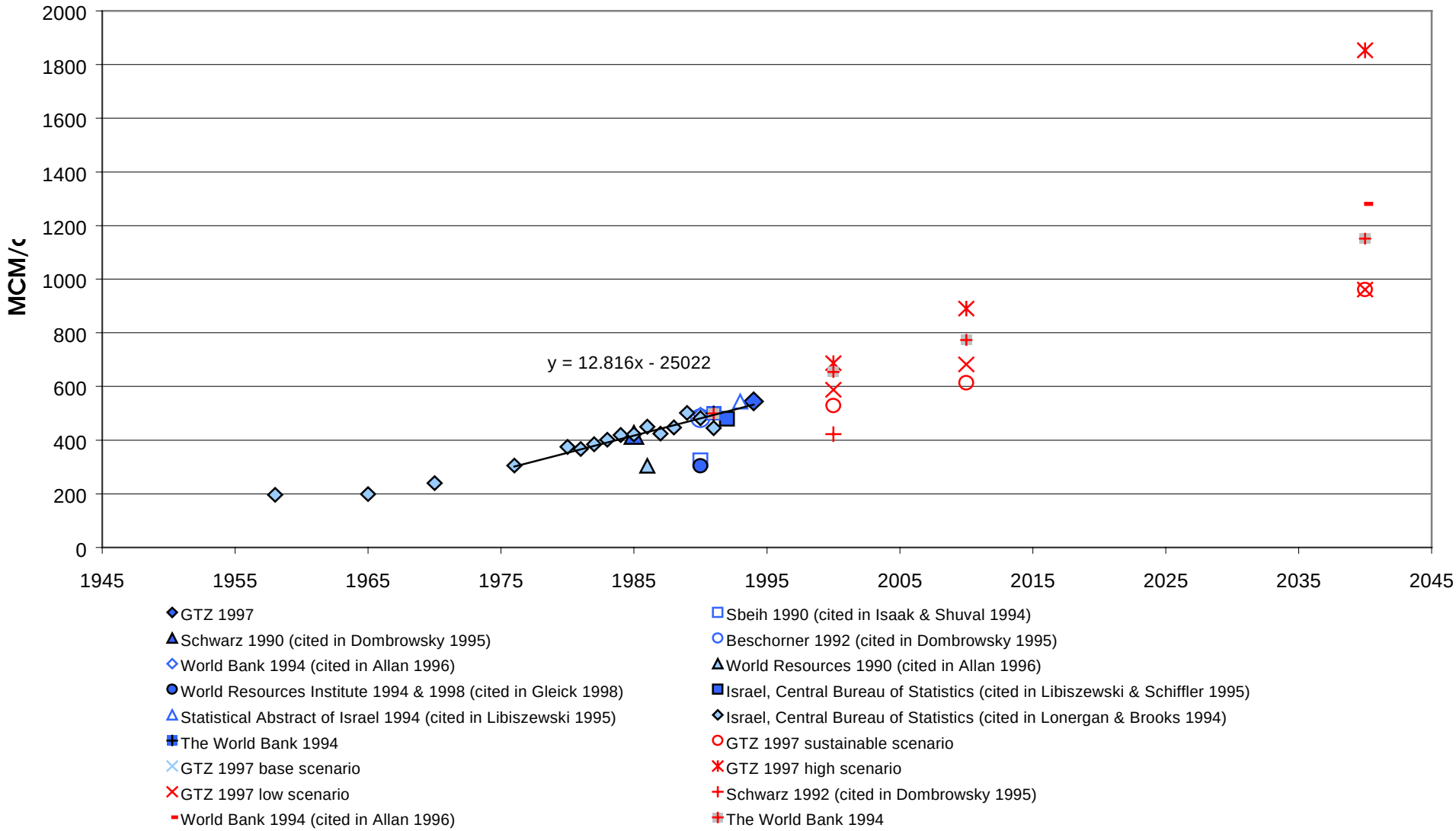

Figure 3e: Domestic water use and projected demand in Israel.