journal of
peace
RESEARCH

Journal of Peace Research
49(1) 241–257

DOI: 10.1177/0022343311427575
jpr.sagepub.com
SAGE

Climate change and security in the Israeli–Palestinian context

Eran Feitelson

Hebrew University of Jerusalem

Abdelrahman Tamimi

Palestinian Hydrology Group for Water and Environmental Resources Development

Gad Rosenthal

Kivun Consulting

Abstract

The Middle East is among the least stable and most fragile regions. It is not surprising, therefore, that concerns have been raised regarding the potential implications of climate change. This article critically examines the potential interactions between climate change and conflict in the Israeli–Palestinian case. Based on a review of the possible effects of climate change, water is identified as the main issue which may be affected, and it also has transboundary implications. We illustrate the potential implications of reduced freshwater availability by assessing the ability to supply normative domestic water needs under rapid population growth scenarios, including return of refugees. In addition, the ability to supply environmental needs and the needs of peripheral farmers under extremely reduced availability scenarios is examined. The normative domestic demand in Israel and the West Bank can be supplied on the basis of natural resources, though re-allocation of water from Israel to the Palestinians is necessary. The Gaza Strip cannot supply the normative domestic needs under any scenario and hence requires immediate augmentation, regardless of climate change. Desalination can supply Gaza's needs and augment water resources in Israel and the West Bank, thereby partially decoupling domestic and agricultural use from climate. Thus, it is unlikely that climate change will directly affect the conflict. However, framing water as a security issue, along with the potential for furthering such securitization with reference to climate change, may adversely affect the readiness of the parties to take adaptive measures and lead them to rigidify their negotiating positions. Possible effects of climate change on other regional players, particularly Egypt and Jordan, may have indirect effects on the Israeli–Palestinian scene. But this hypothesis requires further study.

Keywords

climate change, Israel, Middle East, Palestine, water

Introduction

As fears of the destabilizing effects mount, climate change is increasingly being referred to as a security issue. In 2009 the UN General Assembly adopted a non-binding resolution on climate change as an international security problem (A/Res/63/281 11 June). However, how climate change affects security has not been made clear. Barnett & Adger (2007) suggest that such effects may be an outcome of reduced access to natural resources that sustain livelihoods or of undermining states' capacity to provide opportunities and services.

Corresponding author:
msfeitel@mscc.huji.ac.il

But they also note that the extent to which these factors may actually lead to violence requires empirical research.

The Middle East is among the least stable and most fragile regions. The Israeli–Arab conflict has assumed international dimensions and receives widespread attention, well beyond the realm of the parties which are at the core of the conflict – Israelis and Palestinians. It is not surprising, therefore, that concerns have been raised about the potential deleterious effects of climate change in the Middle East (Brown & Crawford, 2009; Trondalen, 2009).

The purpose of this article is to critically examine the extent to which climate change may aggravate the Israeli–Palestinian conflict. To this end we take a four-stage approach. First we review the possible effects of climate change on the Israeli–Palestian area. Then we search for those issues that are acute enough to lead a party to take action that it would not take otherwise and which may also impact the other party – notably water. To assess the extent to which climate change may reduce access to water, we conduct a scenario analysis. We examine whether water resources can supply the needs of the population under extreme climate change and population growth scenarios. These include a partial return of Palestinian refugees to the area west of the Jordan. We assess the extent to which the populations' welfare or livelihoods are vulnerable to disruptions due to the effects of climate change on water availability.

In the fourth stage, we discuss three possible second-order aspects that go beyond the scope of Barnett & Adger's study (2007) – how greater climate uncertainty may affect the negotiating positions of the parties, the possible constraints of security considerations on the ability to implement adaptive policies, and the possible implications of regional climate-change effects.

Implications of climate change

Figure 1 depicts the approach used to identify the effects of climate change on the Israeli–Palestinian region. The regional effects of climate change were first outlined on the basis of IPCC (2007). A wide-ranging literature survey was conducted to identify the main local effects, and an attempt was made to assess the degree of consensus regarding the direction and magnitude of these effects. Table I shows that there is little agreement.

The key variables identified in Figure 1 for assessing the local implications of global climate change are sea-level rise and regional climate changes, mainly in precipitation patterns. While a warming trend has been observed in the last few decades (Saaroni, Ziv & Alpert, 2003; Zhang et al., 2005), the trends in precipitation are ambiguous due to the difficulties inherent in downscaling global circulation models (Alpert et al., 2008; Golan-Engelko & Bar Or, 2008). But the regional climatic models have largely underestimated precipitation in Israel and Jordan (Black, 2009). The scenario analyses that have been prepared for the Israeli–Palestinian region using such models have suggested that precipitation levels may decrease and that extreme events may rise (Alpert et al., 2008; Black, 2009; Sowers, Vengosh & Weinthal, 2011). These effects vary, however, by scenario. Thus, while the IPCC A2 scenario leads to significant reduction in average precipitation, the effects of the B2 scenario on average rainfall is unclear (Alpert et al., 2008).[1]

However, the most important variable in this region from a water-management perspective is groundwater recharge. Groundwater constitutes the main interannual storage, which is crucial for addressing the multi-year droughts to which semi-arid and arid regions are prone (Amiran, 1995). Groundwater recharge and surface flows are influenced by the intensity, duration, frequency, and timing of precipitation events (USEPA, 1990). These can vary significantly and are non-linear with respect to average levels of precipitation. Moreover, recharge rates and stormwater runoff are affected by soil types and local variations (Yair, 1994; Yair & Kossovsky, 2002). As a result, climate change impacts on groundwater are not well understood worldwide (Kundzewicz et al., 2007). In a review of climate change effects on Israel, Golan-Engelko & Bar Or (2008) conclude that the currently available climate-related models are not detailed enough to allow for assessments of the impacts of climate change on rate of groundwater recharge.

The only effect which is fairly certain is that sea-level rise will lead to further intrusion of seawater into the already over-utilized coastal aquifer thereby causing a potential movement of the base of the aquifer basin (Golan-Engelko & Bar Or, 2008; Sowers, Vengosh & Weinthal, 2011). Melloul & Collins (2006) estimate that the storage capacity of this aquifer will diminish by 16.3 million cubic meters (MCM) per 1 km of coast for a 50 cm rise in sea level. While surface runoff may increase and enhance the flows into the sea of Galillee, higher temperatures may increase evaporation from the lake and reduce spring flows. This will lead to algae blooms that will adversely affect the water quality in

[1] Both scenarios suggest a greater frequency of droughts but differ in the extent to which these will be offset by rainy years.

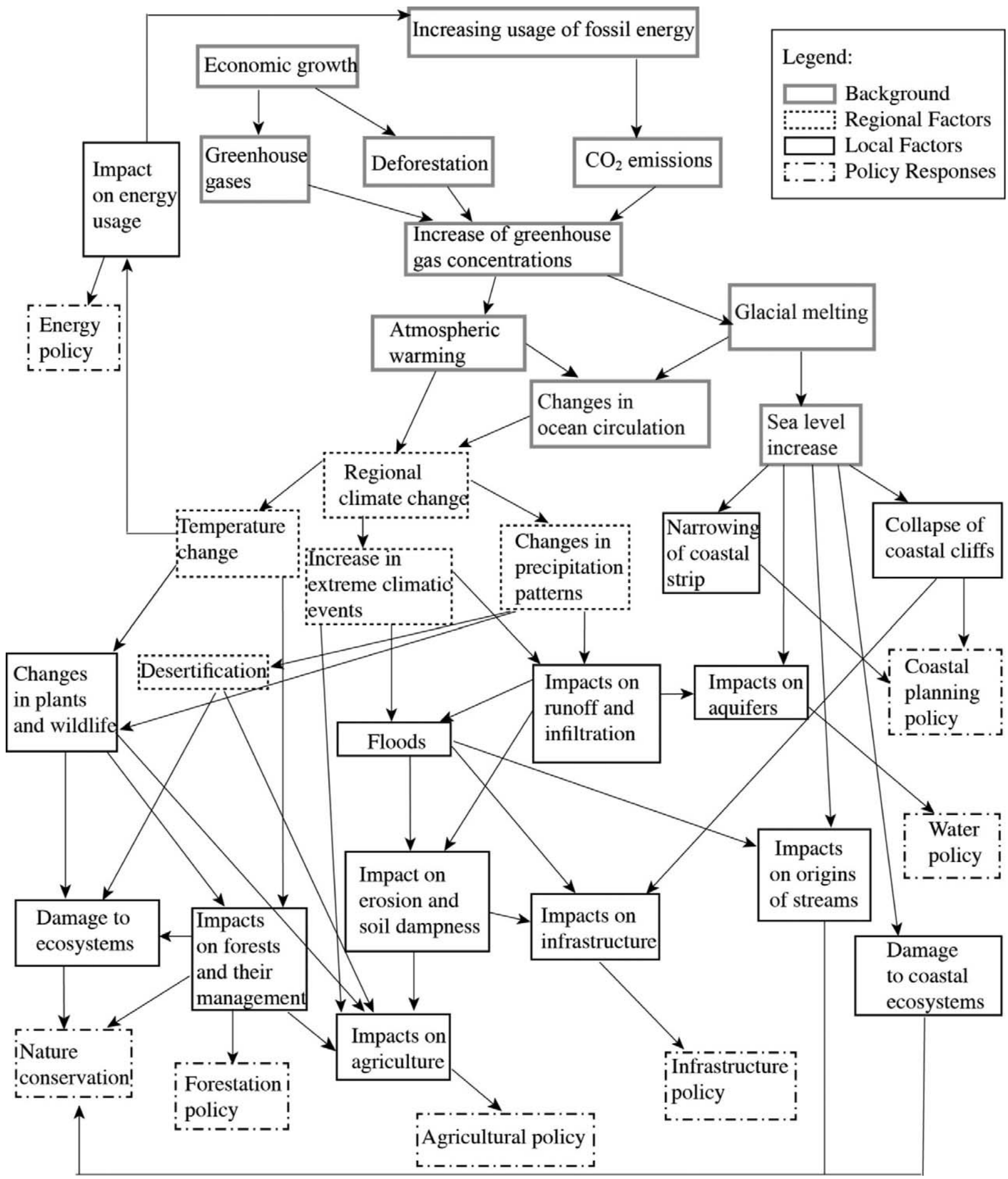

Figure 1. The methodology for identifying the climate change impacts in Israel
Source: Feitelson (2007). For a color version of this figure, see the replication file at www.prio.no/jpr/datasets.

the lake and decrease its potential for storage (Sowers, Vengosh & Weinthal, 2011). However, these are highly uncertain. Thus, with the exception of the loss of storage capacity in the coastal aquifer, the magnitude of effects on the major water resources is uncertain at present.

A rise in the Mediterranean sea-level will lead to loss of beach areas and accelerate cliff erosion. The extent of these effects will be a function of the extent of sea-level rise (Klein, Lichter & Tzviely, 2004). Other potential climate-related effects, on public health, agriculture, and bio-diversity, have received only scant attention so far. However, the studies that were conducted in these fields found no agreed-upon effects (Golan-Engelko & Bar Or, 2008). The public health effects are very small, if any, while the effects on agriculture are largely limited to the effects of the uncertain changes in precipitation patterns on rain-fed agriculture. Irrigated agriculture is likely to be less affected, at least within Israel, as agriculture is increasingly shifting to recycled wastewater, which is insensitive to climate change (Feitelson & Rosenthal, 2011). The impacts on the Palestinians, however, may be more substantial due to the greater reliance on rain-fed agriculture in the West Bank (Mason, Mimi & Zeitoun, 2010).

Clearly, changes in precipitation patterns and temperatures may affect ecosystems. The Israeli–Palestine area is a biodiversity hotspot due to the exceptional diversity of its landscape and climate over short distances. Hence, there is a wide discrepancy in scale between climate models and ecosystem dynamics in Israel, thereby making any analysis of the impacts of climate change on ecosystems highly uncertain. Historical studies of the effects of past climate change suggest that ecosystems adapt by moving northward or southward. However, given the unprecedented extent of human habitation at present, it is unclear to what extent such adaptation options are still viable. Thus, local losses of ecosystems can be expected, as well as invasion by species migrating northward (Hatzophe & Yom Tov, 2002).

In the last part of the preliminary analysis we identify the policy implications for Israel. To this end the possible adaptive policies were enumerated, and the extent to which they deviate from policies that are taken in any case assessed. This analysis, summarized in Table II, shows that with the exception of policies geared to address sea-level rise, these policies do not deviate substantially from those undertaken in any case.

The main response to reduced water availability is a combination of wider conservation and desalination. Israel has already embarked on a wide-ranging desalination program (Feitelson & Rosenthal, 2011). Water rates in the urban sector (with more than 50% of freshwater use) have been raised substantially, to encourage urban water conservation, and saving devices have been distributed to households free of charge.

To mitigate the greater danger of flooding, floodplains have to be protected. Such protection has largely been regulated in district plans that designate most of the vulnerable area for recreation (Feitelson, 1999). Similarly, buffers around nature reserves and corridors that may allow ecosystems to migrate, have increasingly been incorporated in Israeli national and regional master plans, regardless of climate change (Feitelson, 1999). The only issues that arise from the climate-change scenarios and have not been addressed are those that pertain to sea-level rise and infrastructure. These will require shoreline protection measures in built-up areas, and possibly a change in infrastructure standards. Feitelson (2007) concludes that climate change is not a top priority policy issue for Israel. Nor are these issues likely to have a major effect on people's welfare or livelihood or serve as a source of internal discontent.

The implication of this analysis is that Israel has the capacity to address the potential implications of climate change internally and, hence, is unlikely to take action on the regional level solely or mainly on the basis of climate change or due to it. The same cannot be said with any certainty for the Palestinians, as the effects on livelihoods may be greater (Mizyed, 2009). Due to the greater reliance on rain-fed agriculture in the West Bank, the lesser amounts of water available to Palestinians overall, the dire water situation in Gaza and particularly Gaza's dependence on a highly over-utilized coastal aquifer, the Palestinians are much more vulnerable to climate change (Mason, Mimi & Zeitoun, 2010). Among the Palestinians the most vulnerable are likely to be the marginal semi-nomadic farmers in the Jordan Valley. In order to identify whether any of these effects may have potential ramifications for Israeli–Palestinian relations, the effects noted in Table I were scrutinized to discover whether they may have transboundary implications.[2] These are summarized in the right-hand column in Table I.

The only transboundary issue that seems to have potentially significant transboundary effects is water. This is also the issue which may increase Palestinians' vulnerability (e.g. Mason, Mimi & Zeitoun, 2010), and this issue received most of the attention in the environmental field in previous agreements (Feitelson & Levy, 2006). Hence, the potential effects of a reduction of renewable water in the Israeli–Palestinian context are analyzed further here.

Effects of reduced water availability

In semi-arid regions, the most important water management issue is the extent to which water can be stored from the rainy season to the dry season. Hence, the main concerns are the storage capacity of the aquifers and lakes, and the extent that replenishment rates might be affected. As noted, it is uncertain what the effects of

[2] This assessment was based on the extent to which there are natural transboundary flows between the two parties and the extent to which actions by one party may affect the other.

Table I. Possible local effects of climate change in Israel/Palestine

Issue	*Main effect*	*Unanimity*	*Transboundary*
Water resources	Increasing variability of precipitation may affect groundwater replenishment and surface runoff, loss of storage in coastal aquifer	no	Yes – shared resources (Mountain aquifers and Jordan River)
Mediterranean coast	Loss of few sq km of beach area, accelerated cliff erosion	high	Limited – sand flows along Mediterranean coast
Public health	Heat effects	no	No – mainly local
Agriculture	Less water for rain-fed crops	no	No – local
Biodiversity	Northward migration of ecological systems, loss of sensitive ecosystems	no	Limited – mainly limits on corridor continuity

Source: Feitelson (2007), partially based on Golan-Engelko & Bar Or (2008).

Table II. Possible policy responses to climate change in Israel

Issue	*Climate-change effect*	*Policy responses*	*Already discussed or undertaken?*
Water	Loss of coastal aquifer storage	Desalination;	Yes
	Lesser recharge to aquifers	Conservation in urban sector and agriculture;	Yes
	More flooding due to extreme events	Protection of flood plains and water-sensitive urban development	Yes
Infrastructure	Coastal erosion	Protection of cliffs, mainly in built-up areas;	Partially
	Peak floods	Changes in design standards;	No
	Sea-level rise	Adaptation of moorings	No
Ecosystems	Shift in ecosystems	Buffers around nature reserves;	Partially
		Wildlife corridors;	Yes
	Sea-level rise	Protection of open seashore and stream mouths	Yes
Agriculture	Less precipitation affects rain fed crops	Widen irrigation based on recycled wastewater	Yes

Source: Feitelson (2007).

climate change on replenishment rates will be. Yet, it is quite certain that sea-level rise will reduce the storage capacity of the coastal aquifer, which is central to Israel's water management system and the only source of water for Gaza (Melloul & Collins, 2006).

In order to assess whether climate change will necessarily have an adverse effect on welfare and livelihood under worst-case scenarios, several population and water-availability scenarios, described in the next subsection, were assessed. In essence, these scenarios are used to test what will be the effects of an extreme-case reduction in water availability on the potential ability to supply the normative freshwater needs in Israel, the West Bank, and Gaza under very high population growth scenarios. As desalination is coming on-line in Israel gradually, thereby potentially mitigating the effects of climate change in the long run, the target year chosen for all scenarios was 2030 (though an interim period of 2020 was assessed too). In other words, we strive to examine the ability to supply the normative needs, as defined by Feitelson (2012) and presented below, under the most extreme circumstances we could identify.

The scenarios

Four basic scenarios were compiled, as part of a cooperative Israeli–Palestinian study on water needs (Feitelson et al., 2011). The scenarios are comprised of two elements – population growth and water availability. We used the official medium population growth forecasts of the Israeli and Palestinian Central Bureaux of Statistics. The Israeli growth rate used is 1.58% until 2015 and 1.34% from 2015 until 2030, while the Palestinian agency uses a fixed rate of 2.3% in the West Bank and 3.3% in Gaza.[3] The base year from which all scenarios were

[3] Such a fixed rate is unlikely to persist in practice. But as the Palestinian agencies do not allow for lower fertility rates these were adopted. This means that the Palestinian population forecasts are probably upward biased.

Table III. The population and water needs scenarios (population in thousands, needs in MCM)

	Base scenario				Economic development scenario			
Year entity	*Pop.*	*Domestic need*	*Envi. need*	*Peripheral farming*	*Pop.*	*Domestic need*	*Envi. need*	*Peripheral farming*
2010								
Israel	7,464	448	65	120	7,464	448	65	120
WB	2,487	149	12	209	2,487	149	12	157
Gaza	1,562	94	5	129	1,562	94	5	98
Total	11,513	691	82	458	11,513	691	82	376
2020								
Israel	8,628	518	65	120	8,628	518	65	120
WB	2,958	177	12	209	2,958	177	12	157
Gaza	1,929	116	5	129	1,929	115	5	98
Total	13,516	811	82	458	13,516	811	82	376
2030								
Israel	9,857	591	65	120	9,857	591	65	120
WB	3,430	206	12	209	3,430	205	12	157
Gaza	2,323	139	5	129	2,323	139	5	98
Total	15,610	937	82	458	15,610	937	82	376
	Stepwise refugee return scenario				*Late large refugee return scenario*			
Year entity	*Pop.*	*Domestic need*	*Envi. need*	*Peripheral farming*	*Pop.*	*Domestic need*	*Envi. need*	*Peripheral farming*
2010								
Israel	7,464	448	65	120	7,464	448	65	120
WB	2,487	149	12	209	2,487	149	12	209
Gaza	1,562	94	5	129	1,562	94	5	129
Total	11,513	691	82	458	11,513	691	82	458
2020								
Israel	8,628	518	65	120	8,628	518	65	120
WB	3,338	200	12	209	2,958	177	12	209
Gaza	1,929	116	5	129	1,929	116	5	129
Total	13,896	834	82	458	13,516	811	82	458
2030								
Israel	9,857	591	65	120	9,857	591	65	120
WB	4,342	261	12	209	4,878	293	12	209
Gaza	2,323	139	5	129	2,323	139	5	129
Total	16,522	991	82	458	17,058	1023	82	458

Source: Feitelson et al. (2011).
Pop. = population in thousands
Domestic need = water used for domestic needs in MCM (60*Pop.)
Envi. Need = minimal water needed for viable ecosystems in MCM
Peripheral farming = water needed to maintain peripheral farming communities in MCM

calculated is 2007, in which there were 7.12 million Israelis and 3.76 million Palestinians. As this is a high estimate of the total Palestinian population,[4] these scenarios can be considered an extreme case, which is consistent with the purpose of this article.

We first consider a 'business-as-usual scenario', based on the above assumptions, but allowing all normative needs to be supplied. The second scenario assumes rapid economic development in Palestine, thereby increasing economic demand in the urban sector (above the normative demand) and widening the integration of the rural population in the urban economy. Then two scenarios of return of refugees were added. One scenario suggests a return by 10% of all Palestinian refugees to the West Bank by 2020 and another 10% by 2030, while the second scenario suggested a 30%

[4] For a critique of Palestinian population figures, arguing that they do not take into account emigration and hence are upward biased, see Faitelson (2009).

return by 2030. All scenarios were run for three time periods: 2010, 2020, and 2030 (Feitelson et al., 2011). The population and water use implications of each scenario are presented in Table III. The calculation of the water use implications are detailed in the subsection.

We focus on the implications of climate change, hence the four scenarios presented in Table III were run for three different freshwater availability scenarios. The first used current multi-year replenishment rates, as detailed in Appendix 1.[5] The second reduced the available freshwater (without desalination) by 20%, which is slightly less than the maximal reduction predicted by Ragab & Prudhomme (2002), Milly, Dunne & Vecchia (2005), and by Heming et al. (2020) for the 2020–50 period, and by other analysts (e.g. Alpert et al., 2008; Evans, 2009) for the end of the century (2070–2100). Finally, as some of the analyses of climate change suggest more drastic reduction in precipitation either toward the end of the century, or further east (in Jordan) by mid-century (Mason, Mimi & Zeitoun ,2010; Sowers, Vengosh & Weinthal, 2011), the third scenario assumed a 40% reduction in precipitation over the Israeli–Palestinian area. These are very large effects, and hence the total stress analyzed in these scenarios, combining high population growth and rapid decline in precipitation, must be considered extreme cases.

The sufficiency of water was first calculated for each climate-related scenario for the total population of Israelis and Palestinians, regardless of the division of water between them. This allows us to analyze whether it is possible to address the needs of both peoples based on the shared freshwater resources. The water in the shared Mountain aquifers was arbitrarily divided equally between the two parties (50% for each). This implies that the Palestinians in the West Bank were allotted 350 MCM, which is considerably more than the 142 MCM allocated under the Oslo B agreement, and also more than the current amounts used by Palestinians.[6] This allotment is an arbitrary assumption, as while it is more than the Palestinians use at present, it is less than the amount the Palestinians demand and does not relate to the Jordan River (Phillips et al., 2007).[7] Thus, the 50/50 allocation used in this article is merely a measuring rod to assess the extent to which each party may suffer from lack of water, focusing mainly on the Palestinians in the West Bank. In the case of the Gaza Strip, it is assumed that the freshwater resources are the natural replenishment of the local aquifer. While Abu Sway et al. (1994) suggest that the replenishment amounts to 55–70 MCM, we use a lower figure (45 MCM) due to the dire situation of this aquifer, which does not allow for the full replenishment to be stored within it without being polluted.

The analysis

Water use is divided into normative needs and economic demand (Feitelson, 2012). There are several normative needs. The highest priority is the water that is necessary to allow for a dignified level of living (Feitelson, 2012). The quantities used beyond the normative needs are viewed as an economic demand, whose supply is a function of the users' willingness to pay. On the basis of Chenoweth (2008), Feitelson et al. (2011) defined normative domestic needs as 60 m^3/capita/year.[8] To these domestic needs several second-tier normative needs can be added. These include spiritual water needs, environmental needs, and the needs of peripheral agricultural communities (Feitelson, 2012). Peripheral agriculture was defined by us as the irrigated agriculture in areas where no alternative employment exists within a reasonable commute-shed (Feitelson et al., 2011). The water needs of peripheral agriculture are thus the minimal quantity needed for irrigation to maintain peripheral agriculture-based communities.

The domestic normative needs presented in Table III were calculated by multiplying the four population scenarios by 60 m^3/capita/year. The environmental needs were assessed on the basis of expert judgments, as there is insufficient detailed work to quantify them.

[5] These replenishment rates exceed the current estimates of the Israel Water Authority (IWA, 2010). However, as IWA figures are based on a short (17-year) series while ours is based on a longer (30-year) series, we chose the higher figure. But as the sensitivity tests we conduct include a 40% reduction in replenishment rate, the figures we test exceed the average expected effect of climate change, even if we were to take the IWA figures.

[6] According to the IWA (2009), Palestinian water consumption in 2006 amounted to 180 MCM and was expected to rise to 200 MCM in 2007.

[7] The Jordan River is already fully utilized and hence is considered a 'closed basin' (Venot, Molle & Courcier, 2008). It has five riparian parties, all of which have claims to the river's water. Hence, any change in use of the river's water is likely to require multilateral agreements. Thus, it is difficult to foresee how much water the Palestinians may ultimately use from this source, and when this will come about. For this reason the Jordan River was not included in our scenario analysis.

[8] This is a quantity of water that allows for a viable advanced non-agricultural economy that allows households to maintain a high level of living, while implementing substantial conservation measures in domestic and municipal consumption.

Table IV. Water balances: Freshwater vis-à-vis normative domestic needs, 2030 (in MCM)

Scenario		*Average recharge*	*Recharge –20%*	*Recharge –40%*
Base	WB	74	18	–38
	Gaza	–94	–103	–122
	Israel	775	502	228
	Israel + WB	849	520	190
With 20% refugee return	WB	19	–36	–92
	Gaza	–94	–103	–112
	Israel	775	502	228
	Israel + WB	794	466	136
With 30% refugee return	WB	–13	–69	–125
	Gaza	–94	–103	–122
	Israel	775	502	228
	Israel + WB	762	433	103

Based on: Feitelson et al. (2011), Table 12.

These needs do not vary by scenario. Given the very limited quantities of water needed to supply the spiritual needs in Judaism and Islam, spiritual needs were not quantified.

Peripheral farming was defined to apply to those farmers for whom there is no alternative source of income within a reasonable commute. In Israel, Feitelson et al. (2011) defined these farmers to include the communities in the Arava area, a remote area with no nearby urban centers, and part of those located in the north Jordan rift valley. As the Arava Valley farmers rely on local sources, which are not shared with the Palestinians, their needs are of minor importance for our purpose. On the Palestinian side, Feitelson et al. (2011) regarded most of the farmers in the West Bank as peripheral farmers, despite most of them being within commuting distance of urban centers, due to the travel impediments in the West Bank at the time the study was conducted. Similarly, the farmers in Gaza were also included under this rubric, despite their access to urban centers in the Gaza Strip, due to the lack of alternative employment opportunities. By accepting these assumptions, we greatly increase the peripheral agriculture needs on the Palestinian side, relative to what is warranted from the more narrow interpretation put forward by Feitelson (2012) for these needs (termed 'community needs'). Hence, the quantity of water noted in Table III under the peripheral agriculture column can be seen as an upper bound to this need.

Food supply is not included as a need in this article, as most of the Middle East, including both Israel and Palestine, is supplied through the international market. Hence, the water needed to supply this region is mostly 'virtual water' (Allan, 2001), that is, water embedded in food. Thus, the effects of climate change on local water sources is not expected to have direct implications for food supply, though it may affect regional food prices, a point picked up later.

Table IV presents the ability to supply the normative domestic needs under three population scenarios (with no refugee return, a 20% refugee return, and a 30% refugee return) with adverse climate-change effects for the year 2030.[9] It can be seen that with the exception of the Gaza Strip, where shortages are imminent, freshwater resources will suffice to supply the total domestic needs of Israel and the West Bank under all scenarios. The total supply of Israel and the West Bank is presented separately from the Gaza Strip's, as the shared water resources (the Mountain aquifers[10]) underlie Israel and the West Bank, while Gaza's coastal aquifer is largely unaffected by Israel and does not affect Israel's supply.[11] Thus, while Gaza requires immediate augmentation, Israel and the West Bank can conceivably supply the

[9] The economic development scenario does not differ in this balance from the base scenario, as it affects economic demand and peripheral agriculture needs, both of which are not part of this balance. Hence, this scenario is not included in Table IV.

[10] The shared groundwater resources between Israel and the West Bank are comprised of three aquifers, shown in Figure 2, collectively named the Mountain aquifers.

[11] The Gaza aquifer is vulnerable to various sources of salinity, including sea-water intrusion for the west, intrusion of saline water from the east, and pollution from surface activities (Vengosh et al., 2005). Due to the saline water bodies to the east of the Gaza Strip, pumping in Israel actually reduces the rate of salinization of the Gaza aquifer. Thus while there are subterranean inter-effects they are not the expected upper–lower riparian zero-sum competition (Weinthal et al., 2005).

Table V. Water balances: Fresh+brackish water vs. normative domestic+environmental+peripheral agriculture needs, 2030 (in MCM)

Scenario		*Average recharge*	*recharge –20%*	*Recharge –40%*
Base	WB	–87	–142	–199
	Gaza	–223	–232	–241
	Israel	748	475	202
	Israel + WB	661	333	3
With Palestinian economic development	WB	–35	–91	–147
	Gaza	–192	–202	–211
	Israel	748	475	202
	Israel + WB	713	384	55
With 30% refugee return	WB	–173	–230	–286
	Gaza	–223	–232	–241
	Israel	748	475	202
	Israel + WB	575	245	–84

Based on: Feitelson et al. (2011), Table 13.

normative domestic needs. However, if the Palestinian supply is reduced due to the decline in recharge resulting from climate change in proportion to their 50% share, the water at their disposal will not be sufficient to meet their domestic needs with either a refugee return or a 40% decline in recharge. But if the initial Palestinian allocation of 50% of the Mountain aquifer is seen as fixed, thereby requiring Israel to shoulder the full burden of the reduced recharge, this quantity of water, 350 MCM, will suffice to supply the Palestinian domestic needs under all of the scenarios.

Normative domestic needs are supplied by freshwater. The environmental, and particularly the peripheral agriculture needs can be supplied by brackish water. Therefore, the balances for the year 2030 that include such needs on the demand side include both fresh and brackish water on the supply side. These balances are presented in Table V for all scenarios. Due to the travel restrictions on Palestinians in the West Bank and the economic situation in Gaza, most of the Palestinian farmers were included in the 'peripheral farming' category.[12] However, if the economic situation improves, commuting options and employment opportunities will probably widen. Hence the economic development in Palestine scenario was added in Table III to partially account for this eventuality, in which the number of villages included in the peripheral farming category was reduced on the basis of expert judgment.

As can be seen in Table V, the water resources available for the Palestinians under a 50% arbitrary allocation will be insufficient to supply the peripheral agriculture. Hence the livelihoods of peripheral farmers may be adversely affected. This is particularly likely to occur in the Jordan Valley where farmers largely depend on local sources, and for which there is keen competition from the Kingdom of Jordan (whose agriculture is largely concentrated in the Jordan Valley and is likely to suffer acute scarcity – a point picked up later in this article). Furthermore, reduced productivity in the Jordan Valley may have deleterious effects on the Palestinian economy, due to its current reliance on agriculture. Also particularly vulnerable are the semi-nomads in the southern part of the West Bank, who rely on rain-fed agriculture and on livestock for their livelihood. However, if the climate-change effects are borne by Israel rather than jointly, leaving the 350 MCM allocations for the Palestinians unaltered, this allocation (plus local brackish water in the West Bank) can suffice for all the Palestinian needs, except for the very extreme situation of a massive return of refugees, with a 40% drop in water availability within 20 years and no economic development. This combination is unlikely as such a return is contingent upon a comprehensive agreement, which arguably will bring new capital flows to Palestine. Moreover, agriculture can utilize recycled wastewater, which was not included in these scenarios. The availability of recycled wastewater is likely to increase as total domestic use rises, but is contingent on adequate treatment. Thus, some of the needs for peripheral agriculture, and probably all of

[12] The extent of villages which should be regarded as peripheral was determined by Palestinian experts well familiar with the situation on the ground in the West Bank. As the quantity of water used in these villages is very limited, it was assumed that it constitutes the minimal quantity needed.

them in the case of Gaza, can conceivably be supplied from recycled wastewater. This is also partially true for the Jordan Valley, which can conceivably receive some recycled wastewater from Jerusalem and Nablus.[13]

Implications

Climate change may worsen the water situation in Israel/Palestine, and particularly in the West Bank and Gaza (Mason, Mimi & Zeitoun, 2010). However, desalination can address gaps between availability and normative needs. The Gaza strip requires augmentation regardless of climate change. The amount needed to supply the current gap between the normative domestic demand and the potable water supply, supposing desalination replaces all of the over-utilized highly polluted Gaza aquifer, is about 100 MCM (to supply 60 m^3/person/year and assuming the population is slightly more than 1.5 million). This is less than the quantity currently being desalinated in Israel's nearby desalination plant in Ashkelon (see Figure 2). As the cost of water supplied from such a plant is not more than 60 cents per m^3, including capital costs,[14] such a plant is seen as technically and financially viable. As desalination largely decouples water supply from climate change, and the recyclable wastewater is also insensitive to climate change,[15] any solution to Gaza's current water crisis will essentially make the Gaza Strip much less vulnerable to climate change.

Israel has embarked on a widespread desalination program (see Figure 2). At present over 250 MCM are online, including the recently built 127 MCM plant near Hadera. The total quantity to be desalinated according to the latest government decision is 800 MCM which is more than 50% of Israel's current freshwater consumption. The Israeli water master plan currently being prepared suggests that this amount may increase substantially by 2050 (IWA, 2010).

Desalination reduces the sensitivity to weather and climate change, while contributing to global greenhouse gas emissions. Potentially, desalination can supply the Palestinians on the West Bank, too. At present Israel retains a site near Hadera for this purpose (Figure 2). There is a basic understanding within both parties that desalination will be needed some time in the future (Gvirtzman, 2010; Phillips et al., 2007). However, the question of whether desalinated seawater is an alternative to freshwater resources in transboundary contexts remains contentious (Feitelson & Rosenthal, 2011). The Palestinian position is that desalination is an alternative source, and hence Israel should desalinate while the Palestinians use most of the water from the Mountain aquifer (Phillips et al., 2007). The Israeli position is that only the shared resources are subject to negotiations, while desalinated seawater is an augmentation that each party should finance for itself (Gvirtzman, 2010). If this question is not resolved and the Palestinians get no more than 50% of the Mountain aquifers' total average annual water, thereby sharing also the burden of climate change, then households in the West Bank may suffer a welfare loss if recharge is reduced by 40% within 20 years, or there is a massive return of refugees. Both are unlikely. Moreover, even if the limited reallocation implied in the 350 MCM figure for Palestinian use is seen as a one-time reallocation and hence as a priority right (thereby implying that Israel shoulders the burden of climate change due to its greater adaptive capacity), it will suffice to address the West Bank's normative needs even under the most extreme scenarios.

In contrast to Israel and the West Bank, the fresh and brackish water will not suffice to meet Gaza's needs under any scenario. Regardless of climate change, there is a need to augment the water sources in Gaza. Climate change may make this need only more acute due to the intrusion of rising seawater into the aquifer. The only feasible source for additional water for Gaza is desalination (Al Yaqubi, Aliewi & Mimi, 2007). The quantities needed to supply the normative domestic needs are not greater than those supplied by a single large-scale desalination plant, of the type that is now built in Israel. If such a plant is built, the vulnerability of Gaza to climate change will be greatly reduced. But the ability to build such a plant is contingent upon the degree to which some level of accommodation can be reached between the Hamas leadership in Gaza, Israel, and the Palestinian Authority – issues that are beyond the scope of this article.

Climate change may, however, affect the livelihood of 'peripheral' farmers – those who are based on rain-fed agriculture or irrigated agriculture, and who do not have alternative employment options within a 'reasonable' commute from their current location. Given the short distances in the West Bank and within Gaza it could be argued that there would be very few farmers in this state. The numbers used in the scenarios were high, due

[13] On the options and impediments for such re-use from Jerusalem, under the current geo-political circumstances, see Dombrowsky et al. (2010).

[14] This cost estimate is based on the Israeli experience, assuming the plant uses reverse osmosis and is based on the off-shore natural gas fields.

[15] Feitelson & Rosenthal (2011) make the point that as desalinated seawater is geared toward the domestic sector, desalination results in greater quantities of recyclable wastewater, and of higher quality.

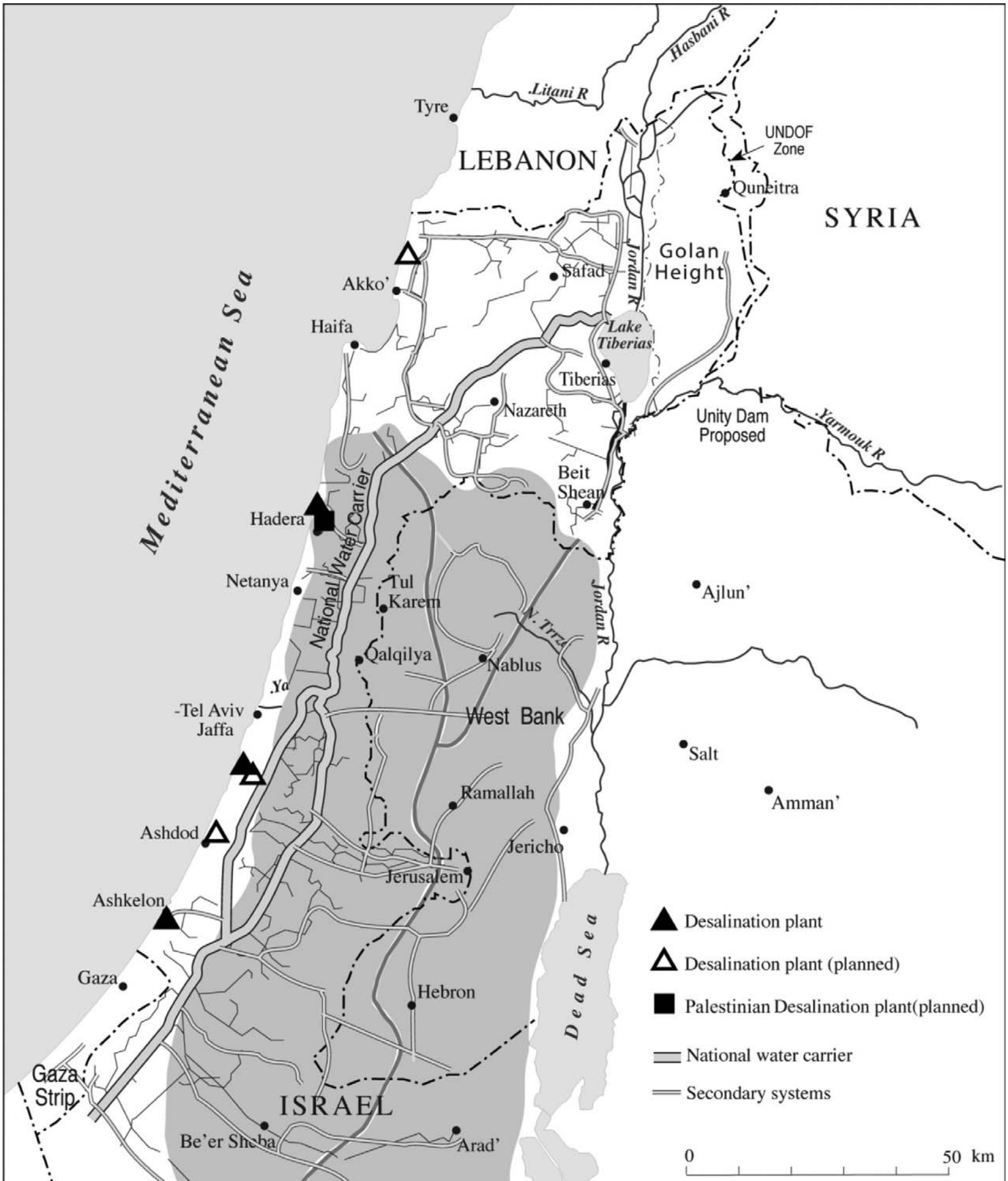

Figure 2. Desalination plants in Israel
The gray area depicts the shared Mountain aquifers.

to the current mobility restrictions and the shaky economic situation in Palestine. However, if any agreement is reached, and implemented, this situation is likely to be altered. Hence, as the scenarios used here are extreme, the actual impact of climate change on the livelihood options of Palestinians is likely to be less than implied in the results presented in Table V, thereby suggesting that the immediate human security concerns identified by Barnett & Adger (2007) as critical variables in analyses of the climate-change induced risks are not likely to materialize in the Israeli–Palestinian case, despite the increasing likelihood of droughts.

Indirect implications of climate change

Discussions of adaptation to climate change usually focus on the country level. However, the options may be affected by transboundary relationships. In the Israeli–Palestinian case, transboundary relations are typified by concurrent cooperation and conflict (Zeitoun, 2007). Yet, these relations are highly unstable. How might climate change affect these relations, particularly the positions of the parties in future negotiations? How are the prospects for implementing transboundary adaptive measures affected by security perceptions? At what scale should the security implications of climate change be discussed? Can the relations between Israel and the Palestinians be disassociated from the wider Israeli–Arab setting?

Effects on parties' negotiating positions

The main potential transboundary effect of climate change in the Israeli–Palestinian context is an increasing likelihood of multi-year droughts, which adversely affect freshwater availability to both parties. The actions and statements of the two parties during the series of droughts that afflicted the area in the past decade allow us to assess the potential implications of series of drought years on their negotiating positions.

The Palestinian position is that the joint institutions established under the Oslo accord are inequitable, and hence they strive to obtain property rights ('water rights') over the shared aquifers and reduce their dependence on Israel for water supply. Climate change is likely to become an additional argument for greater Palestinian control over the Mountain aquifers (Lautze & Kirshen, 2009). Due to their greater vulnerability and Israel's greater adaptive capacity (mainly due to desalination), the Palestinians argue that they should obtain control over most of the Mountain aquifers.

Israel has increased the amount of water supplied to the West Bank, beyond the amounts stipulated under the Oslo accords, but argues that desalination is the real answer to the increasing threats of droughts (Gvirtzman, 2010). However, desalination does not substitute for storage capacity. Desalinated water is increasingly viewed in Israel as a base flow, whereas the aquifers serve as storages to be used to address fluctuations in precipitation patterns and replenishment rates.[16] Thus, in previous negotiations the Israelis insisted on retaining the operational flexibility of the water-supply system, and particularly the ability to adjust abstractions from the Western Mountain aquifer to shifts in precipitation and replenishment patters (Feitelson, 2006). As the storage capacity of the coastal aquifer may be reduced due to sea-level rise, the importance of the storage capacity of the Western Mountain aquifer from an Israeli water-management perspective is likely to rise. Hence, Israel is less likely to forgo its control over abstractions from the Western Mountain aquifer due to climate-change scenarios. This is reflected in the Israeli official argumentation, where the use of a lower average annual recharge is related to climate change (IWA, 2009: 20).

Security limitations on adaptation

In recent years there has been increasing emphasis on the importance of adaptive capacity to climate change, particularly as the prospects for mitigation seem low (Pielke et al., 2007). But there are limitations on the ability to adapt (Adger et al., 2009). These limitations can be exogenous (i.e. a function of ecological or technological limits) or endogenous (e.g. social and cultural factors) to society. Yet, the extent to which the framing of climate change as a security issue (securitization) constrains adaptability has not been discussed.

There are two adaptive policies that are of central importance in the Israeli–Palestinian case: desalination and cooperation. Desalination provides the potential to address the gaps between natural replenishment and domestic needs, as well as domestic economic demand, and subsequently to increase the quantity and improve the quality of wastewater. Thereby desalination widens the scope for wastewater recycling for agriculture. Desalination thus effectively decouples both domestic supply and irrigation from climate change. Yet, desalination affects power relationships, as the seashore party, which is usually the lower riparian on freshwater flows, becomes the upper riparian on the desalination flows (Feitelson & Rosenthal, 2011). Due to these power implications the Palestinians and the Jordanians try to avoid any reliance on desalination plants located along the Mediterranean seashore, as such desalination will place Israel in the

[16] The desalination plants are built through Build Operate Transfer tenders. In order to keep the average cost down, the government needs to provide purchase assurances (Feitelson & Rosenthal, 2011). For the official Israeli position on this point, see IWA (2009: 22–23).

position of an upper riparian on the flow of desalinated water. Perhaps for the same reason Israel insists on a Palestinian desalination plant at Hadera as the 'best' solution to the northern West Bank's water stress. Thus, the securitization of desalination seems to limit its ability to serve as an adaptive approach to climate change.

Several scholars have argued that cooperation is essential for meeting the water challenges facing Israelis and Palestinians (Feitelson & Haddad, 1998; Haddad et al., 2001; Brooks & Trottier, 2010). This is particularly true when adjustments have to be made, such as is the case when precipitation patterns change. But the growing mistrust between the parties and the securitization of perceptions, manifest in the framing of discussions of cooperation within a power perspective, have discredited cooperative proposals, mainly by the Palestinians. Thus, the prospects for cooperation on climate change, when they are set within a security and power nexus, are arguably lower, thereby impeding the coordination of adaptation strategies.

Regional effects

The potential for conflict between Israel and the Palestinians, both over water and in other fields, is strongly affected by other parties in the Middle East. The four Arab countries neighboring Israel (the 'first circle' of Arab countries) are of particular importance. Two of these four countries (Egypt and Jordan) have signed peace agreements with Israel and have been heavily criticized in the Arab world. Thus, if climate change affects the political stability of these countries, the chances for peace between Israel and its neighbors, as well as with the Palestinians, may be compromised.

The most likely effect of climate change to materialize in the Eastern Mediterranean is sea-level rise. In the Israeli–Palestinian context this may affect low-lying areas in southern Israel and along the Gaza Strip. Given the shoreline characteristics, sea-level rise is likely to have smaller effects the further north we move along the eastern Mediterranean. Areas to the north of Israel are not likely to be greatly affected. However, in Egypt, sea-level rise may have severe implications for the Nile delta and Alexandria region (El Raey, 1997; Dasgupta et al., 2007). If the effects on these areas contribute to further instability, they may adversely affect Egypt's position in the region. Egypt may also be particularly sensitive to shifts in world food prices, particularly the price of staples that Egypt imports. In this context, the extent to which food prices had a role in the fall of the Mubarak regime would be worth investigating.

The second country to sign a peace accord with Israel is Jordan. Jordan has thrived on its image as a stable state in a highly unstable Middle East, thereby attracting investments in finances and tourism. But if the water situation in Jordan turns to the worst, as it may well (Abu-Taleb, 2000), given the dire state of water in Jordan and its limited options (Venot, Molle & Courcier, 2008), water may become a destabilizing issue. However, the study of these admittedly somewhat speculative hypotheses is beyond the scope of this article.

Conclusions

Climate change has been portrayed as a potential security threat in the Middle East, mainly due to its potential effect on water availability (Brown & Crawford, 2009; Trondalen, 2009). Water is indeed found to be the main issue also in the more limited Israeli–Palestinian context analyzed here. However, based on analysis of extreme scenarios we find that the likely direct effects of climate change per se are limited. While climate change may affect the livelihood of Palestinian farmers and semi-nomads, particularly in remote areas, it is unlikely to affect the welfare of the urban population substantially if some water re-allocation occurs, even under extreme scenarios. The exception to this finding is the situation in Gaza, which requires additional water regardless of climate change. Within Israel it is highly unlikely that citizens will feel the direct effects of climate change, as Israel has embarked already on an extensive desalination program, which largely decouples urban supply from climate change, though some ecosystems and rain-fed agriculture may be affected. Thus, the likelihood that climate change will lead to a conflagration and violence beyond what might occur without climate change is low.

Water is scarce in Israel and Palestine. Hence, water issues need to be addressed regardless of climate change. Desalination is increasingly seen as an essential and central element in this response. In the case of Gaza, it is virtually impossible to supply even normative domestic needs without desalination (Al Yaqubi et al., 2007). But the ability to desalinate in Gaza is currently curtailed by the 'high politics' of the Israeli–Palestinian conflict. Once built, desalination and the increasing potential for wastewater recycling resulting from it, partially decouples water supply for both the domestic and the agricultural sector from climate-change effects. Hence, following the logic outlined by Barnett & Adger (2007), climate-change effects on water resources are unlikely to have a discernible effect on Israeli–Palestinian relations, which will continue to be dominated by 'high politics' (Lowi, 1993).

However, climate change may be used by the parties to justify their bargaining positions. Perceptions of climate change and the possible reduction in storage capacity may lead to the hardening of negotiating positions. Thus, climate change may hinder the ability to reach agreements regarding water. Yet, such agreements are crucial for implementing the type of measures that may mitigate the effects of climate change. Without such agreements it is unlikely that desalination plants will be built in Gaza in the near future or in the West Bank later, or that abstractions from the shared aquifer (particularly the Western Mountain aquifer) will be regulated. A major obstacle is the securitization of the water discourse and perceptions. If water is viewed as a security issue, the steps that can be taken to mitigate the effects of climate change may not be taken due to the view that such cooperative mechanisms impinge on sovereignty (Fischhendler, 2004).

In conclusion, climate change does not seem to pose a major direct security risk in the Israeli–Palestinian context. However, the framing of water issues and of climate change as security issues, and the subsequent subservience of water and environmental issues to the 'high politics' of the conflict may hinder the ability to undertake the adaptive measures that may mitigate the effects of climate change.

In a wider regional perspective, the potential effects of climate change cannot be completely discounted. If climate change adversely affects the stability of key countries vulnerable to sea-level rise (e.g. Egypt) or facing greater losses of water and where the reliability of water supply is tenuous (e.g. Jordan), this may have an indirect effect on the Israeli–Palestinian conflict.

Replication data

The replication data for this article can be found at http://www.prio.no/jpr/datasets.

Acknowledgements

The inputs of participants in an international workshop held as part of this study in Geneva, and of Amos Bein, Amer Marai, Sand Salahout, Richard Laster, Avital Gasith and the two research assistants, Amit Tubi and Ram Almog, are gratefully acknowledged, as are the constructive comments of four reviewers. Finally we thank Nils Petter Gleditsch for his encouragement and helpful comments.

Funding

This article is partially based on a study funded by Green Cross International, the Peres Center for Peace Research, and the Jerusalem Institute for Israel Studies.

References

Abu Sway, Basma; Khairy Al-Jamal, Nader Al-Khatib, Sami Hamdan, Yousef Nasser & Hisham Zarour (1994) *Palestine Water Resources: A Rapid Interdisciplinary Sector Review and Issues Paper*. Jerusalem: Water Resources Action Program – Palestine.

Abu-Taleb, Maher F (2000) Impacts of climate change scenarios on water supply and demand in Jordan. *Water International* 25(3): 457–463.

Adger, W Neil; Suraje Dessai, Marisa Goulden, Mike Hulme, Irene Lorenzoni, Donald R Nelson, Lars Otto Neass, Johanna Wolf & Anita Wreford (2009) Are there social limits to adaptation to climate change? *Climatic Change* 93(3–4): 335–354.

Allan, J A (Tony) (2001) *The Middle East Water Question: Hydropolitics and the Global Economy*. London: Tauris.

Alpert, Pinhas; S O Krichak, H Shafir, D Haim & I Osetinsky (2008) Climatic trends to extremes employing regional modeling and statistical interpretation over the E. Mediterranean. *Global Planetary Change* 63(2–3): 163–170.

Al Yaqubi, Ahmad; Amjad Aliewi & Ziad Mimi (2007) Bridging the domestic water demand gap in Gaza Strip–-Palestine. *Water International* 32(2): 219–229.

Amiran, David (1995) *Rainfall and Water Policy in Israel*. Jerusalem: Jerusalem Institute for Israel Studies.

Barnett, Jon & W Neil Adger (2007) Climate change, human security and violent conflict. *Political Geography* 26(6): 639–655.

Black, Emily (2009) The impact of climate change on daily precipitation statistics in Jordan and Israel. *Atmospheric Science Letters* 10(3): 192–200.

Brooks, David & Julie Trottier (2010) Confronting water in an Israeli–Palestinian peace agreement. *Journal of Hydrology* 382(1–4): 103–114.

Brown, Oli & Alec Crawford (2009) *Rising Temperatures, Rising Tensions: Climate Change and the Risk of Violent Conflict in the Middle East*. Winnipeg: International Institute for Sustainable Development (http://www.iisd.org/pdf/2009/rising_temps_middle_east.pdf).

Chenoweth, Jonathan (2008) Minimum water requirements for social and economic development. *Desalination* 229(1–3): 245–256.

Dasgupta, Susmita; Benoit Lalante, Craig Meisner, David Wheeler & Jiaping Yan (2007) *The Impact of Sea Level Rise on Developing Countries*. Research Working Paper 4136, Washington DC: World Bank.

Dombrowsky, Ines; Ram Almog, Nir Becker, Eran Feitelson, Simone Klawitter, Stefan Lindemann & Natalie Mutlak (2010) How widely applicable is river basin management? An analysis of wastewater management in an arid transboundary case. *Environmental Management* 45(5): 1112–1126.

El-Raey, Mohamed (1997) Vulnerability assessment of the coastal zone of the Nile delta of Egypt to impacts of sea level rise. *Ocean & Coastal Management* 37(1): 29–40.

Evans, Jason P (2009) 21st century climate change in the Middle East. *Climatic Change* 92(3–4): 417–432.

Faitelson, Yacov (2009) The politics of Palestinian demography. *Middle East Quarterly* 16(2): 51–59.

Feitelson, Eran (1999) Social norms, rationales and policies: Reframing farmland protection in Israel. *Journal of Rural Studies* 15(4): 431–446.

Feitelson, Eran (2006) Impediments to the management of shared aquifers: A political economy perspective. *Hydrogeology Journal* 14(3): 319–329.

Feitelson, Eran (2007) The main policy questions following climate change. Paper presented at the Israeli Geographical Association Annual Meeting, Beer Sheba, 9–10 December.

Feitelson, Eran (2012) What is water? A normative perspective. *Water Policy*, in press.

Feitelson, Eran & Marwan Haddad (1998) A stepwise open-ended approach to the identification of joint management structures for shared aquifers. *Water International* 23(4): 227–237.

Feitelson, Eran & Nitsan Levy (2006) The environmental aspects of reterritorialization: Environmental facets of Israeli–Arab agreements. *Political Geography* 25(4): 459–477.

Feitelson, Eran & Gad Rosenthal (2011) Desalination, space and power: The ramifications of Israel's changing water geography. *Geoforum*, in press, doi:10/1016/j.geoforum.2011.08.011

Feitelson, Eran; Abdelrahman Tamimi, Amos Bein, Reuven Laster, Amer Marei, Gad Rosenthal & Sand Salhout (2011) *Defining Water Needs for Fully Exploited Resources: A Necessary Step for Israeli–Palestinian Reconciliation*. Jerusalem: Green Cross International, Peres Center for Peace, and the Jerusalem Institute for Israel Studies.

Fischhendler, Itay (2004) Legal and institutional adaptation to climate uncertainty: A study of international rivers. *Water Policy* 6(4): 281–302.

Golan-Engelko, Irit & Yeshayahu Bar-Or (2008) *Israel's Preparation for Global Climatic Changes, Phase I – The Implications of Climate Change for Israel*. Jerusalem: Ministry of Environmental Protection, Office of Chief Scientist (http://www.sviva.gov.il/Enviroment/Static/Binaries/ModulKvatzim/adaptation_report_to_yeshayahu_revised_2010-_remarks_2.pdf).

Gvirtzman, Haim (2010) The water question between Israel and the Palestinians: The Israeli position. *Ekologia vSviva* 2: 46–56 [in Hebrew].

Haddad, Marwan; Eran Feitelson, Shaul Arlosoroff & Taher Nasseredin (2001) A proposed agenda for joint Israeli–Palestinian management of shared groundwater. In: Eran Feitelson & Marwan Haddad (eds) *Management of Shared Groundwater Resources: The Israeli–Palestinian Case with an International Perspective*. Boston, MA: Kluwer, 475–493.

Hatzophe, Ohad & Yoram Yom Tov (2002) Global warming and recent changes in Israel's avifauna. *Israel Journal of Zoology* 48(4): 351–357.

Hemming, Debby; Carlo Buontempo, Elinor Burke, Mart Collins & Neil Kay (2010) How uncertain are climate change projections of water availability indicators across the Middle East. *Philosophical Transactions of the Royal Society A – Mathematical Physical and Engineering Sciences* 368(1931): 5117–5135.

IPCC (2007) *Climate Change 2007: Synthesis Report*. Geneva (www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf).

IWA (2009) *The Issue of Water between Israel and the Palestinians*. Tel Aviv: Israel Water Authority (http://siteresources.worldbank.org/INTWESTBANKGAZA/Resources/IsraelWaterAuthorityresponse.pdf).

IWA (2010) Long-Term National Masterplan for the Water Sector: Policy Document, draft, December. Tel Aviv: Israel Water Authority [in Hebrew].

Klein, Micha; Michal Lichter & Dov Tzviely (2004) Recent sea-level changes along Israeli and Mediterranean coasts. *Ofakim Begeograpia* 60–61: 167–176 [in Hebrew].

Kundzewicz, Zbigniew W; Luis Jose Mata, Nigel Arnell, Petra Doll, Pavel Kabat, Blanca Jimenez, Kathleen Hiller, Taikan Oki, Zeki Sen & Igor Shiklomanov (2007) Freshwater resources and their management. In: Martin Parri, Osvaldo Cnziani, Jean Palutikof, Paul van der Linden & Clair Hanson (eds) *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the IPCC. Cambridge: Cambridge University Press, 173–210.

Lautze, Jonathan & Paul Kirshen (2009) Water allocation, climate change, and sustainable water use in Israel/Palestine: The Palestinian position. *Water International* 34(2): 189–203.

Lowi, Miriam (1993) *Water and Power: The Politics of a Scarce Resource in the Jordan River Basin*. Cambridge: Cambridge University Press.

Mason, Michael; Ziad Mimi & Mark Zeitoun (2010) *Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority*. Jerusalem: United Nations Development Program, Programme of Assistance to the Palestinian People.

Melloul, Abraham J & Martin L Collins (2006) Hydrological changes in coastal aquifers due to sea level rise. *Ocean and Coastal Management* 49(5–6): 281–297.

Milly, Paul CD; Krista A Dunn & Aldo V Vecchia (2005) Global pattern of trends in stream flow and water availability in a changing climate. *Nature* 438(7066): 347–350.

Mizyed, Numan (2009) Impacts of climate change on water resource availability and agricultural water demand in the West Bank. *Water Resource Management* 23(10): 2015–2029.

Phillips, David JH; Shaddad Attili, Stephen McCaffrey & John S Murray (2007) The Jordan River basin: Potential future allocations to the co-riparians. *Water International* 32(1): 39–62.

Pielke, Rofer; Gwyns Prins, Steve Rayner & Daniel Sarewitz (2007) Climate change 2007: Lifting the taboo on adaptation. *Nature* 445(7128): 597–598.

Ragab, Ragab & Christel Prudhomme (2002) Climate change and water resources management in arid and semi-arid regions: Prospective and challenges for the 21st century. *Biosystems Engineering* 81(1): 3–34.

Saaroni, Hadas; Baruch Ziv & Pinahs Alpert (2003) Long term variation in summer temperatures over the Eastern Mediterranean. *Geophysical Letters* 30(18): 1946, doi 10. 1029/2063GL 017742.

Sowers, Jeannie; Avner Vengosh & Erika Weinthal (2011) Climate change, water resources and the politics of adaptation in the Middle East and North Africa, *Climatic Change* 104(3–4): 599–627.

Trondalen, Jon Martin (2009) *Climate Changes, Water Security and Possible Remedies for the Middle East*. Paris: UNESCO (http://unesdoc.unesco.org/images/0018/001818/181886e.pdf).

USEPA (1990) *Ground Water Handbook*. Washington, DC: Office of Research and Development, United States Environmental Protection Agency.

Vengosh, Avner; W Kloppmann, A Marie, Y Livshitz, A Gurierrez, M Banna, C Guerrot, I Pankratove & H Ranan (2005) Sources of salinity and boron in the Gaza strip: Natural contaminant flow in the Southern Mediterranean coastal aquifer. *Water Resources Research* 41(1):W01013, doi: 10.1029/2004WR003344.

Venot, Jean-Phillipe; Francois Molle & Remy Courcier (2008) Dealing with closed basins: The case of the lower Jordan River basin. *International Journal of Water Resources Development* 24(2): 247–263.

Weinthal, Erika; Avner Vengosh, Amer Marei, A Gutierrez & W Kloppmann (2005) The water crisis in the Gaza Strip: Prospects for remediation. *Ground Water* 43(5): 653–660.

Yair, Aharon (1994) The ambiguous impact of climate change at a desert fringe: Northern Negev, Israel. In: AC Millington & K Pye (eds) *Environmental Changes in Drylands: Biogeographical and Geomorphological Perspectives*. New York: Wiley, 199–227.

Yair, Aharon & A Kossovsky (2002) Climate and surface properties: Hydrological response of small arid and semi-arid watersheds. *Geomorphology* 42(1–2): 43–57.

Zeitoun, Mark (2007) The conflict vs cooperation paradox: Fighting over or sharing of Palestinian–Israeli groundwater? *Water International* 32(1): 105–120.

Zhang, Xuebin, et al. (2005) Trends in Middle East climate extreme indices from 1950 to 2003. *Journal of Geophysical Research* 110, D22104, doi:10.1029/2005JD006181.

Appendix

Table AI. The water resources of Israel and Palestine

*Basin**	*Annual replenishment**(in MCM)*	*Riparian parties*
Sea of Galilee	520***	Israel, Lebanon, Syria
Mountain aquifers:		
Western	350–360	Israel, Palestinians
North-eastern	140–150	Israel, Palestinians
Eastern: upper	40	Mainly Palestinians
lower	170	Palestinians, Israel
Coastal aquifer	250	Israel
Gaza aquifer	45–70	Palestinians
Western Galilee aquifer	140	Israel
Carmel aquifer	35	Israel

Sources: IWA (2009); Golan-Engelko & Bar-Or (2008);
Al Yaqubi, Aliewi & Mimi (2007), for the Gaza aquifer.
* There are additional smaller basins in Israel. The lower Jordan River, currently shared by Israel, Jordan, and the West Bank, is not included. Most of the river's replenishment below the Sea of Galilee originates in Syria and Jordan.
** Multi-year average.
*** The annual replenishment is presented after deducting evaporation from the lake.

ERAN FEITELSON, b. 1956, Professor (Hebrew University of Jerusalem, 1990–), former Head of the Federmann School of Public Policy and Government (2004–09) and Chair of the Israeli National Parks and Nature Reserves Commission. Main interests: environmental policy, sustainable development, water management and policy, transport policies, and land use policy.

ABDELRAHMAN TAMIMI, b. 1959, lecturer (Al-quds university, 2004–); Director General, Palestinian Hydrology Group (2002–). Main interests: hydropolitics, multi disciplinary water research. Most recent book in English: *Pro-Poor Water Tariff*.

GAD ROSENTHAL b. 1952, private economic consultant, owner and manager of Kivun Ltd, external lecturer (Hebrew University of Jerusalem, 1993–); main interest: environment, water, and agriculture – economy, policy, and business development.