Michael Mason, Mark Zeitoun, Rebhy El Sheikh

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Article (Accepted version) (Refereed)

Original citation:
Mason, Michael, Zeitoun, Mark and El Sheikh, Rebhy (2011) *Conflict and social vulnerability to climate change: lessons from Gaza.* Climate and Development, 3 (4). pp. 285-297.
ISSN 1756-5529

DOI: 10.1080/17565529.2011.618386

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1. Introduction

What the Intergovernmental Panel on Climate Change (IPCC) labels "key" vulnerabilities to climate change – those meriting policy attention as symptomatic of "dangerous anthropogenic interference" with the climate system (UNFCCC Article 2) – are seen to depend on the magnitude, timing and distribution of climate impacts. Moreover, deliberations on climate impacts are inherently political: they feature value judgments about the acceptability of potential risks, and potential adaptation and mitigation measures, and oblige consideration of such wider themes as development, equity and sustainability (Schneider et al., 2007, p. 784). This paper reports on, and discusses, representations of climate vulnerability generated from stakeholder deliberations in the highly charged geopolitical context of a territory, the Gaza Strip, marred by routine violence and endemic human insecurity. In these extreme conditions, as argued below, non-climatic determinants of vulnerability set the main conditions of life by which susceptibility to climate harm is increased and response capabilities are impaired.

At least in terms of exposure to climate change, Palestinians in Gaza face disruptive climate impacts on a par with the populations of other semi-arid territories in Western Asia. Climate predictions in the eastern Mediterranean are compromised by deficits in meteorological data and uncertainties regarding the incorporation in climate models of region-specific conditions and processes (Mellouki and Ravishankara, 2007). Nevertheless, climate simulations recently undertaken with regional models have delivered generally consistent results (Khatib, 2009; Kitoh et al., 2008; Somot et al., 2008). Over the course of this century, and depending on the global emissions scenario employed, there is predicted to be: (i) a decrease in precipitation of up to 35% (with significant seasonal variation), (ii) a significant warming of between 2.6^{0}C and 4.8^{0}C, (iii) a tendency towards more extreme weather events, and (iv) a rise in sea-level. For the Gazan population of the occupied Palestinian territory (oPt)[1], the biophysical impacts expected from these trends include an increased probability of flash floods, droughts, desertification and saline intrusion into groundwater (UNDP, 2010a, pp. 9-13).

With reference to United Nations Development Programme (UNDP) consultations on climate vulnerability undertaken with stakeholders in Gaza between December 2008 and August 2009, this paper highlights key vulnerabilities to climate change there – specifically in terms of food security and water security. The context is that of a continuing belligerent occupation by Israel, including the imposition since January 2006 of an economic sanctions and closure regime, as well as the continuing effects of the Israeli military assault in December 2008-January 2009.[2] The general social resilience of the population in Gaza serves little to reduce its overall climate vulnerability. Exploration of the "climate vulnerability pathways" finds a conflict-structured component of vulnerability overwhelming projected climatic risks. The mechanisms of the occupation and siege of Gaza impose constraints on the capacity of residents to cope with, and adapt to, climate-related hazards.

[1] Our use of the term 'occupied Palestinian territory' follows the accepted nomenclature employed by the United Nations in reference to a series of UN Security Council Resolutions on the Israeli-Palestinian conflict, beginning with Resolution 242 in November 1967.

[2] While Israel has stated that, with its unilateral withdrawal from the Gaza Strip in September 2005, its status as an occupying Power there has finished, it still maintains effective control of the Strip and thus remains bound by international humanitarian obligations regarding belligerent occupation (Dinstein, 2009, pp. 276-280).

In this paper we first justify the definition of climate vulnerability employed (Section 2) and provide a brief geographical profile of the Gaza Strip (Section 3). We then discuss the key pathways of climate vulnerability identified by stakeholders in Gaza (Section 4), which conjoined with short-term and long-term response capabilities (Section 5), provide a collective representation of key climate vulnerabilities. We conclude that, under the current conditions of the Israeli blockade and associated security interventions, there is no scope for pro-active climate adaptation in the Gaza Strip. More generally, assessments of climate vulnerability within humanitarian spaces are scientifically incomplete inasmuch as they ignore chronic, non-climatic determinants of human insecurity.

2. Framing climate vulnerability

According to the IPCC, vulnerability to climate change is "the propensity of human and ecological systems to suffer harm and their ability to respond to stresses imposed as a result of climate change effects" (Adger et al., 2007, p. 720). Behind this compact definition lies an attempt to integrate distinctive theoretical perspectives, which have tended to emphasise either biophysical or socio-political dimensions of climate vulnerability. The former is characterised by risk-hazard approaches which focus on exposure to climate perturbations or stresses in the context of biophysical system sensitivities (e.g. Alcamo et al., 2008; Kates et al., 1985; Downing and Patwardhan, 2003). Vulnerability in these terms combines with climate change events to generate potential threats to human and ecological systems. In contrast, "social vulnerability" approaches centre less on biophysical stresses than on the socio-economic and political conditions that determine the capacity of people to respond to these climate events. This perspective derives mainly from research in environmental sciences and human geography, drawing on theories of entitlements and human well-being from development studies (e.g. Bohle and Watts, 1994; Brooks, 2003; Kelly and Adger, 2000).

While early IPCC formulations of vulnerability highlighted biophysical impacts of climate change, it is now recognised that climate vulnerability includes both the "external" exposure of socio-ecological systems and their "internal" susceptibility and adaptive capacity (Adger, 2006; Füssel and Klein, 2006). This integrated understanding of vulnerability is evident in the *Fourth Assessment Report* and the IPCC-sponsored global research project, *Assessment of Impacts and Adaptations to Climate Change* (Leary et al., 2008). In principle, it opens up vulnerability assessments to consider the full range of non-climatic determinants, including socio-political and socio-economic evaluations of climate impacts, although the IPCC has still been charged with neglecting the root causes of vulnerability (Gaillard, 2010, p. 224). Such criticism is misplaced insofar it ignores the role of IPCC Working Group II in identifying the high climate vulnerability of poor and marginalised communities (especially in developing countries), as well as its explicit call for more research on the causal links between development paths and vulnerabilities to climate change (Schneider et al., 2007, p. 804). Nevertheless, the regional and sectoral scope of IPCC assessments can displace scientific and policy attention from, for example, key climate vulnerabilities facing poorer populations in sub-regions or territories exposed to the effects of conflict: the Gaza Strip is one such conflict zone where a more fine-grained treatment is justified.

In its contribution to the *Fourth Assessment Report*, IPCC Working Group II acknowledges that fragile governance systems and conflicts, armed and otherwise, typically heighten the vulnerability of people to climate risks, though only recent conflicts in Africa - within the Greater Horn of Africa and the Great Lakes region - are discussed (Boko et al., 2007, pp. 442-443). More widely, Barnett (2006, pp. 117-125) identifies at least 37 countries facing or recovering from conflict since 1989, arguing that their affected populations are especially vulnerable to climate variability and extremes because of their low capacity to cope with, and

recover from, such stresses. Most of these countries, he notes, have faced significant food shortfalls as natural resource assets and livelihood opportunities have been severely eroded by the effects of conflict. In societies marred by protracted military occupation, as in East Timor (1975-1999) and the occupied Palestinian territory (1967-), the entrenched social vulnerability created by systemic human rights violations is likely to overwhelm the impacts of particular climate hazards (Barnett, 2010, pp. 260-262; Mason, 2011). For Gaza, as argued below in Section 4, the Israeli closure regime significantly weakens the capacity of Palestinians to cope with, and adapt to, key climate risks. We employ the term "enforced coping" to refer to the constrained (and possibly harmful) ways people seek to mitigate or avoid significant climate-related harm under conditions of exceptional vulnerability. The presence of enforced coping questions the view (e.g. Agrawal and Perrin, 2009, p. 354) that governments and other external actors necessarily increase the adaptive capacity of economically marginal communities by strengthening the *existing* coping strategies of households and other social groups (*cf.* Smit and Wandel, 2006, p. 289).

We focus here on a UNDP-facilitated stakeholder assessment of climate vulnerability in Gaza, which took place in three phases between December 2008 and August 2009. This was part of a broader climate change adaptation initiative in support of the Palestinian Authority (UNDP, 2010a), and reflects also a worldwide UNDP Climate Adaptation Programme assisting 75 countries in their responses to climate change. Given pressing humanitarian and development needs in Gaza and the West Bank, the UNDP climate adaptation work for the Palestinians was framed explicitly by the agency's perspective on "human security", defined by its regional bureau as "the liberation of human beings from those intense, extensive, prolonged, and comprehensive threats to which their lives and freedom are vulnerable" (UNDP, 2009, p. 2; see Dalby, 2009, pp. 41-43). UNDP-sponsored human security reports covering the Middle East have paid growing attention to major environmental threats, notably those impacting on water availability and food production; for example, a recent *Arab Human Development Report* highlights potential threats to regional water and agricultural systems from climate change (UNDP, 2009, pp. 47-50), while the latest *Palestinian Human Development Report* pinpoints declining water availability and inadequate wastewater facilities as chronic threats to human security in the oPt (UNDP, 2010b, pp. 89-93). Framing human security in a climate vulnerability context highlights human capacities and freedoms to pursue lives and livelihoods free from threats induced or compounded by climate hazards (Adger, 2010; O'Brien et al., 2007; Pelling, 2010). As noted below (Section 4), initial stakeholder consultations in Gaza identified water insecurity and food insecurity as the key threats to human security in the context of forecasted climate risks.

3. The geography of the Gaza Strip

Gaza's coastline is 41km long, comprising sandy beaches and dunes with occasional outcrops of calcareous sandstone. Its subsoil conditions (consolidated sedimentary rocks, sand and clays) resemble many non-deltaic coastal areas in the Mediterranean Basin and the Middle East. However, the coast is generally more open, without the barrier islands found off the coasts of north Africa or Saudi Arabia (Food and Agriculture Organization, 1997, p. 49). Several jetties, sea walls and shipwrecks provide the only barrier influence on local tidal conditions. The northern coast adjacent to Gaza City is most built-up (see Figure 1), though erosion and ecological degradation is observable along the entire coastline, notably from extensive sand mining for use in construction – including substantial amounts of sand transported out of Gaza by Israel just before its withdrawal in 2005. As noted in a recent UN environmental assessment, for many decades the coastal and marine environment of the Gaza Strip has been significantly impacted by sewage

pollution, waste dumping and over-fishing (UNEP, 2009, p. 63), with additional stresses from the collapse of sewage treatment systems during the 2008-9 Gaza war.

Figure 1: Built-up area in the Gaza Strip (UNEP, 2009: Map 2)

Despite its small area (378km^2) and flat terrain, there are significant variations in the Gaza Strip's temperate climate: the average seasonal rainfall is 422mm in the northern governorate and 225mm in the southern Rafah governorate (Palestinian Water Authority, 2007). The Gaza Strip experiences hot, dry summers and mild winters. There is already some evidence that global warming is affecting the Gaza Strip: an analysis of daily temperature data from 1976 to 1995 has shown an increase in mean temperature of 0.4C, which reflects above all an upward trend in mimimum temperature values (El-Kadi, 2005).

This finding is corroborated by Israeli research demonstrating that average temperatures in the eastern Mediterranean have increased steadily over the last 100 years, with increased inland aridity (Krichak et. Al, 2007; Kafle and Bruins, 2009).

With 1.5 million people (and a population growth rate of 3.4% per annum), it is not surprising that the coast has been comprehensively modified by human activity. Gaza is experiencing rapid urbanisation trends: in 2004 21% of the Strip was urbanised and, if the current population growth rate continues, it has been forecast that 48% of the Strip will be urbanised by 2025 (Applied Research Institute-Jerusalem 2006: 83). Current Israeli restrictions on labour, trade and financial/investment flows into Gaza prevent long-term infrastructure investment and urban planning (Chalmers, 2009, World Bank, 2009).

The human development situation in the Gaza Strip is particularly serious. Even before Israel undertook *Operation Cast Lead* in winter 2008/9, Israeli economic sanctions and the external blockade[3] had triggered a collapse in industrial activity. Aside from the high level of human casualties caused by *Operation Cast Lead*, post-conflict damage assessment indicated a serious threat to food security and water security, as discussed later. The most visible signs of this were the razing of up to 18% of cultivated lands (including the destruction of greenhouses, livestock and poultry farms), serious damage or destruction to 203 registered agricultural groundwater wells and four drinking water wells, as well as damage to over 19,000 metres of water pipes (Palestinian National Authority, 2009).[4] Reconstruction efforts have been seriously hampered by the continuing blockade (UNDP, 2010c, p. 10).

Higher numbers of the population in Gaza are dependent on social and humanitarian assistance: two-thirds are UNRWA-registered refugees. A survey of the latest available household and expenditure data for the Gaza Strip confirms a deepening of poverty, which relates to a deterioration of living conditions since the imposition of the Israeli blockade: in 2007 68% of Palestinians in southern Gaza and 72% in northern Gaza lived below the poverty line (UNRWA, 2009). Between 1995 and 2009. total unemployment rose in Gaza from 29.4% to 39.3% (Palestinian National Authority, 2010, p. 13). The poor general situation of public health levels and services corresponds as would be expected with high levels of poverty and unemployment (Chalmers, 2009; Shomar, 2010).

4. Mapping climate vulnerability pathways in the Gaza Strip

While formally involving the Palestinian Quality Authority (EQA) as lead agency, the impetus for climate adaptation planning in the oPt was driven from external funders, reflecting a global UN agenda for mainstreaming climate adaptation in its human development studies. Informed by the UNDP *Adaptation Policy Frameworks for Climate Change* (Lim et al., 2005), the Palestinian initiative featured stakeholder engagement in both the West Bank and Gaza Strip, including interviews and discussions with key stakeholders, a questionnaire survey of relevant experts, scoping meetings, and feedback meetings on a draft *Climate Change Adaptation Strategy.* In Gaza, the relevant stakeholders included the EQA, Palestinian Water Authority (PWA) and Coastal Municipalities Water Utility (CMWU) officials (attending as independent water experts), UNDP Gaza Strip staff, environmental scientists from universities and NGO representatives (see UNDP 2010a: 25-27, 30-32). UN-imposed restrictions prevented any meetings with Hamas officials.

[3] Economic sanctions against Gaza started with the January 2006 victory of Hamas in the Palestinian Legislative Elections: they were tightened even further in September 2007 following the declaration by Israel that the Gaza Strip was a "hostile entity".

[4] According to a survey conducted by the Palestinian Hydrology Group, in the worst affected areas of Al Attara and Ezbet Abed Rabbo half the water networks were damaged (Palestinian National Authority, 2009, p. 29).

Participatory vulnerability assessments are oriented to identifying risk conditions and anticipated community responses as experienced or judged by affected parties (Delica-Willison, 2004; Smit and Wandel, 2006; Vogel et al., 2007). As noted above (Section 2), the climate vulnerability approach employed by the UNDP in Gaza was framed according to principles of human security, which throws light on those people most susceptible to life and livelihood threats induced or compounded by climate hazards. An initial review of the climate change scenarios for the eastern Mediterranean and stakeholder consultations concluded that vulnerability assessment in the Gaza Strip should focus on human insecurity as it relates to *water resources insecurity* – physically unsustainable withdrawal rates coupled with the lack of access of individuals to sufficient safe water for heath and well-being – and *food insecurity* – the lack of access of individuals to sufficient safe food for health and well-being (UNDP 2010a, p. 2).

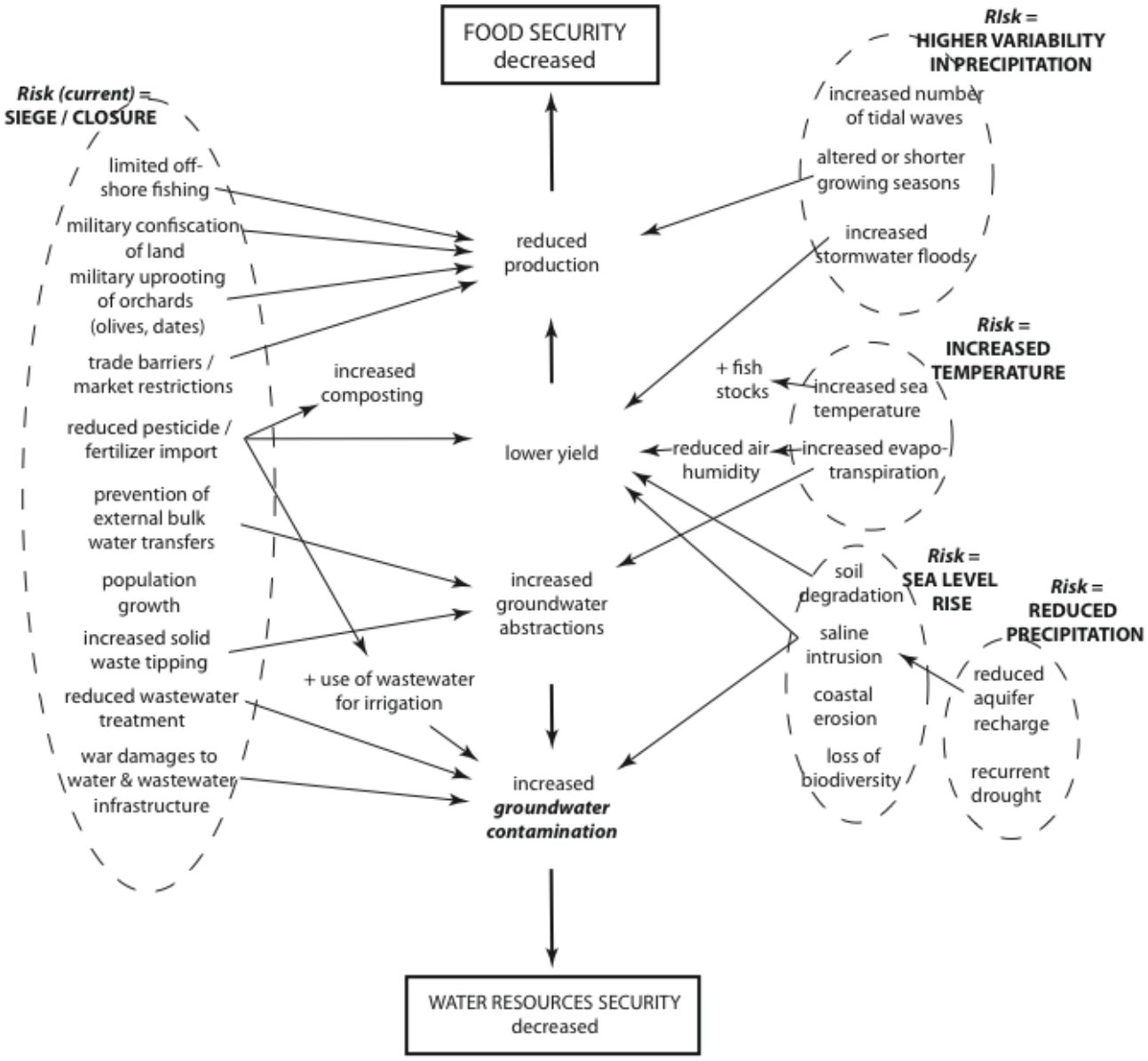
Figure 2 (below) summarises graphically those environmental risks relating to climate vulnerability identified by the Gazan stakeholders during the UNDP consultations in 2008-9. The emphasis here is on the multiple paths that lead to reduced water security (through degraded groundwater quality), and food security (through reduced food production, which is related to groundwater quality).[5] The immediate (socio-economic and political) climate vulnerability of the residents of the Gaza Strip is compounded by the expected longer-term risks of climate change set out on the right-hand side of the figure. A higher variability in precipitation translates into reduced yields for rainfed agriculture, and could also mean a greater frequency of flash floods (e.g. the flooding in January 2010 that destroyed a road bridge in Al Zahra may be evidence of this). Reduced amounts of precipitation will mean greater strain on groundwater resources. Increased temperatures may also lead to greater groundwater pumping because of increased evapotranspiration and desertification (particularly in the south). Finally, any sea level rise will, as well as eroding the coastline, contaminate the coastal soil and increase the saline intrusion already experienced throughout Gaza.[6]

However, the bulk of the vulnerability pathways arise from, or are compounded by, Israeli sanctions on, and blockade of, the Gaza Strip. The negative impacts on water security and food security resulting from current occupational practices can be seen on the left-hand side of the figure. The impact is ultimately felt in a reduction in the ability of individuals and groups to avoid, cope with or adapt to the consequences of climate variability and/or change.

[5] The approach is similar to the 'chains of impacts' analysis employed in Magnan et. al. (Magnan et al., 2009: Fig 7), and elsewhere.

[6] There is much uncertainty over the magnitude of this rise for the eastern Mediterranean by 2100: Israeli scientists have forecast an increase of 0.1m every decade (Office of the Chief Scientist, 2008), which falls within recent global estimates of 0.6-1.6m (e.g. Jevrejeva et al., 2010).

Figure 2: Climate vulnerability pathways in the Gaza Strip (adapted from UNDP 2010a, p. 36)



4.1 *Vulnerability pathways to water resources insecurity*

The broad notion of 'water security' encompasess the literature's focus on water *resources* security,[7] which considers primarily water quality and water quantity issues for the environment and for human use (Cook and Bakker, forthcoming). Palestinians living in the Gaza Strip suffer the effects of water insecurity through both water quantity *and* water quality issues (World Bank, 2009, pp. 27-32). The entire territory of Gaza lies above part of the Coastal Aquifer Basin, which runs from Haifa to northern Egypt through Gaza. Due primarily to its permeable sandy cover, the aquifer itself has "intrinsic vulnerability" to pollution (Almasri,

[7] The broad understanding of water security also comprises related 'security areas' such as energy, food, human, and national security (Zeitoun forthcoming).

2008). Israeli over-pumping of the Israeli portion of the Coastal Aquifer in the 1960s and 1970s led to high rapid salinisation through seawater intrusion. The risk of serious damage to the aquifer was countered by reducing abstractions, and the flows replaced through increased abstractions from other water sources (the Lake of Tiberias or the Western Aquifer Basin, whose recharge zones are transboundary with the West Bank) as well as from artificial recharge of the Israeli portion of the aquifer (Zeitoun*, et al.*, 2009).

Palestinians living in the Gaza Strip are prevented from accessing similar alternative water sources, such as bulk transfers of water from the West Bank. As a result, and in-line with population growth, the Gazan portion of the Coastal Aquifer Basin has been pumped beyond sustainable limits, for decades. The "sustainable limit"[8] of the Coastal Aquifer has been estimated from 299 (HSI, 1999: IV) to 420 million cubic metres/year (MCM/y) (World Bank, 2009, p. 27), of which the Gazan portion is roughly 55 MCM/y (Yacoubi, 2008). Total pumping within the Gaza Strip in 2008 was estimated at 170 MCM/y (UNICEF, 2010, p. 12). Return flows from system leaks, wastewater and irrigation amount to 31-51 MCM/y (Palestinian Water Authority, 2000). Not accounting for "return" flows,[9] this means that the Gazan portion of the aquifer is being over-drawn at a rate up to three times its sustainable limit.

The abstraction rate and lack of alternative water sources leads directly to deteriorating water quality. As has been the case in Israel, the over abstraction induces increased seawater intrusion and up-coning, leading to salinisation of the freshwater. Israeli restrictions on the import of construction materials have immobilised local and donor efforts to treat wastewater, furthermore (UNEP, 2009). Untreated or partially treated wastewater (including sewage infiltrating from the Northern Treatment Plant in Beit Lahiya, and the rapidly growing raw sewage outflows around Khan Younis, Rafah and Wadi Gaza) seeps into the groundwater, further increasing nitrate and chloride levels. An additional source of contamination occurs through natural processes – the Eocene salts migrating under the border from Israel (Vengosh*, et al.*, 2005). Reduced recharge means less dilution of runoff laden with agricultural fertilisers and pesticides (although the potential for contamination can be partially offset by longer flow paths to the water table). It has been estimated that only 5-10% of the portion of the aquifer under Gaza provides acceptable drinking water (Palestinian Water Authority, 2010, p. 27; UNDP, 2010c, p. 40) – a severe case of chronic water resources insecurity.

The biophysical and social causes of the water resources insecurity impact on human well-being in a number of ways. In terms of public health, poor drinking water quality has led to gastro-intestinal diseases, methomoglobinemia, dental fluorsis and diarrhoea (Al-Farra, 2005; Shomar, 2010; World Bank, 2009, p.27). A greater percentage of household income is spent on associated medical bills, as well as for treated water. Roughly 80% of the Gaza population uses desalinated water from the private sector, which is below international drinking water standards and subject to microbiological contamination in transit or when stored at home (GVC/PHG, 2009; UNICEF, 2010, pp. 12-15). Palestinian farmers, whose livelihoods are linked with water resources, feel the impact in terms of reduced yields, as we will see.

[8] The concept of safe yield and sustainable limits of aquifers is highly contested, with Bredehoeft (1997) asserting the irrelevancy of aquifer recharge rate to sustainable pumping rates, in what is known as the *water budget myth*. Here, "sustainable limit" refers to the rough mean recharge rate, i.e. the amount of rainwater flowing into the Gaza portion of the Coastal Aquifer.

[9] "Return" flows refers to water that returns to the aquifer from where it was abstracted, i.e. household wastewater and surplus irrigation. A reliable figure of abstracted volumes is possible as these are mainly metred, but "return" flows are not. Return flows have been roughly estimated at 80 MCM/y. Quality issues must be taken into consideration when assessing the actual capacity of the aquifer, however, as the "return" flows are of very poor quality and serve to contaminate the aquifer further (Vengosh*, et al.*, 2005).

Water quality and sanitation problems accentuated by the Israeli blockade and economic sanctions were further stressed during *Operation Cast Lead* by Israeli military damage to water wells, as well as to the water distribution and sewage network. For example, a direct hit to the embankment wall of the Az Zaitoun wastewater treatment plant led to a wastewater and sludge spillage affecting 55,000 square metres of agricultural land (UNEP, 2009, pp. 33-36).

4.2 *Vulnerability pathways to food insecurity*

The UNDP assessment of the vulnerability of the Gazan population to climate-induced food insecurity corresponded to the Food and Agriculture Organization (FAO) definition of food insecurity as the lack of adequate physical, social or economic access to sufficient, safe and nutritious food (Food and Agriculture Organization, 2009, p. 8). For households in Gaza, FAO defines food insecurity as households with income and consumption below $1.6 US per capita per day and households showing a decrease in total food and non-food expenditures (Food and Agriculture Organization, 2007, p. 58). At this scale of household food security, according to a Joint Rapid Food Security Assessment conducted in 2008, some 56% of citizens of the Gaza Strip were 'food insecure' with 75% receiving food assistance (WFP/FAO/UNRWA, 2008). A year later, with the onset of *Operation Cast Lead*, this had jumped to 61% (973,600 persons) food insecure with a further 16% (218,950 persons) vulnerable to food insecurity (WFP/FAO, 2009).

As shown on Figure 2, stakeholder perceptions of climate risks to food insecurity in the Gaza Strip highlighted *food production* threats, whereby various biophysical changes projected to negatively affect yields are compounded by the multiple effects of the Israeli blockade. Food production is understood in these vulnerability pathways as a combination of physical production factors (e.g. water quantity and quality, agricultural supplements), social conditions of production (e.g. access to agricultural land, demographic growth), and economic variables (e.g. markets for exports, prices and availability of imported food). In these terms, trade barriers and market restrictions are largely responsible for the overall level of food insecurity in the Gaza Strip. Reliant upon Israel (and to a lesser extent, Egypt) for all goods not produced within the confines of Gaza, the population as a whole is dependent on Israeli decisions about the amount of food allowed in. Israeli tightening of the siege has significantly reduced both imports and exports, particularly since September 2007. The Gaza Strip's overall "carrying capacity" – already stretched from the influx of refugees from British Mandate Palestine in 1948 and 1967 – thus cannot be supplemented. For example, food imports lower reliance on limited freshwater supply to produce food locally. When imports are cut, water abstractions for agriculture increase, which sets into motion the previously-described drivers of groundwater contamination and water resources insecurity.

The closure regime also affects the Gaza Strip fishing zone, which has shrunk from 20 nautical miles (negotiated with Israel under the 1994 Gaza-Jericho Agreement) to more restricted limits unilaterally imposed by Israel – 6 nautical miles from October 2006 and 3 nautical miles since December 2008. This has shrunk Palestinian access to maritime areas by 85% (OCHA-WFP, 2010. pp. 10-11). There is continuing evidence of coercive actions by the Israeli Navy against Palestinian fishing vessels: since the end of *Operation Cast Lead* the UN Office for the Coordination of Humanitarian Affairs has reported on several instances in which Israeli Navy vessels have fired on and boarded Palestinian fishing boats. Israeli restrictions of the Gazan fishing zone have significantly reduced the local fish catch from 2845 metric tonnes in 2008 to 1525 tonnes in 2009 (OCHA-WFP, 2010, pp. 24-25; UNDP, 2010c, p. 69).

There are indications that regional warming may stimulate growth of some fisheries of economic value to the Palestinians (e.g. sardines), while at the same time threatening local population extinctions and the proliferation of harmful species (UNEP-MAP-RAC/SPA, 2008,

pp. 38-40). The wider spread of warm-water species in the eastern Mediterranean is projected to have multiple direct and indirect effects, including the introduction of exotic species through the Suez Canal (Bianchi, 2007).

Farming communities in the Gaza Strip are also socially and economically vulnerable to climate hazards. The closure of the Strip limits exports, thereby cutting off a source of income from produce (generally strawberries, oranges and cut flowers) sold in markets in Israel, Egypt or Europe. The closure furthermore reduces imports of regulated fertilisers, which increase yields more efficiently (and safely) than unregulated fertilisers. Yields are also significantly reduced, furthermore, by the previously-discussed groundwater contamination. There are likely to be *compounded* by climate change-induced causes of higher salinity – reductions in precipitation (which can exacerbate groundwater salinity levels through reduced soil flushing and groundwater recharge), reductions in air moisture (which increase the soil water requirement of crops,[10] or reduce fruit production), and the previously-discussed saline intrusion into the aquifer. Increased salinity levels in the groundwater directly reduce the yields of crops which can sustain them at all – e.g. onions and pulses. Other crops – such as oranges, strawberries, cherry tomatoes, and cut flowers – have little tolerance to high salinity levels. The 2009 International Food Policy Research Institute study *Climate Change- Impact on Agriculture and Costs of Adaptation* projects reductions in each of the basic food staples throughout MENA, with a drop of production of about 33% in rice, 7% in wheat, 8% in Maize and 4% in millet (Nelson et al., 2009: Table 3). The drop in production in wheat in MENA is considerably below the projected global drop (of about 25%), due in part to the predicted regional aridity trend. The previously-mentioned climate change-induced altered growing seasons will also affect production, as farmers adapt through trial-and-error (but such reductions are particularly hard to estimate).

Projections of food insecurity suggest it will continue to rise. Since September 2000 Israel has imposed movement restrictions inside the Green Line security barrier marking its border with Gaza, comprising a “no-go zone” of up to 500 metres from the barrier and a “high-risk zone” between 500 to 1000-1500 metres: this restricted area has reduced Gaza’s cultivable land by 35%. In the past five years, Israeli access restrictions and the associated destruction of agricultural assets in this zone have resulted in the loss of 735 hectares of olive trees, almost 1200 hectares of other fruit-bearing trees and 588 hectares of greenhouses: it has been estimated that the total economic value of all agricultural losses (including livestock farms) is US $267 million (OCHA-WFP, 2010, pp. 19-22.).

5. Response capabilities: enforced coping mechanisms and adaptation planning

The vulnerability of individuals and groups to climate-related hazards can be reduced by enhancing both short-term (coping) and long-term (adaptation) response capabilities. In the Gaza Strip the current means of avoiding or moderating such hazards are above all *short-term and reactive*, with little if any opportunity at present to develop longer-term resilience.

5.1 *Household and community coping mechanisms*

The high level of climate vulnerability reported by stakeholders in Gaza is perpetuated by insufficient resources and livelihood opportunities, as well as weak institutional capacities (UNDP, 2010a, pp. 30-32). Coping strategies in the face of water and food insecurity reveal a level of resilience; for example, individual well-digging, rainwater harvesting, purchasing food on credit and decreasing the amount of food consumed. In the midst of a hostile political and

[10] For example, according to CROPWAT simulations conducted by the PWA, an annual average increase in temperature of 1°C will increase crop water requirements in the Gaza Strip by 6-11% (UNDP, 2010a, p. 36).

economic context, where conventional low-cost coping strategies (e.g. use of life savings) have generally been exhausted (WFP/FAO, 2009), *enforced coping mechanisms* are prevalent, with often harmful long-term effects. In the UNDP stakeholder consultations, for example, negative public health impacts were reported as a result of farmers using raw sewage for irrigation (due to reduced wastewater treatment) (UNDP, 2010a, p. 31).

It is not surprising to find that community coping mechanisms responding to water security and food insecurity are related with ways to bypass the Israeli siege. For example, the increased 'smuggling' through the tunnels dug under the border with Egypt, or occasionally (as in February 2008) breaking down the wall separating the people from the markets in Egypt. Coping under such circumstances is an existential affair, and the capacity of Palestinians in Gaza to survive under the Israeli blockade is almost entirely defined by such 'enforced' coping mechanisms. Once ad-hoc, the hundreds of smuggling tunnels under the border with Egypt are now regulated and taxed by the Hamas-administered government. At least some of these face the threat of closure following Egyptian construction of an underground barrier to impede access (Levinson, 2010).

Coping mechanisms developed to deal with the very poor water quality are diverse. The PWA and the CMWU face a dilemma about how to confront the untreated wastewater – let it continue to seep into the freshwater aquifer and pose a grave public health risk, or pump it several kilometres into the sea during an interim period in which a treatment plant would be built. The latter alternative is not an option due to Israeli prohibitions, and the contamination of the freshwater aquifer continues.

The increasingly poor quality of drinking water also necessitates increased purchase of desalinated water from private-sector neighbourhood-level reverse osmosis units, or the purchase of under-the-sink water filtration units, both of which contribute to the ever-greater share of household income spent on basic services (Palestinian Water Authority, 2008a; 2008b). However, much of the water stored in household water tanks remains biologically contaminated for lack of proper maintenance (GVC/PHG, 2009, p. 15). Neighbourhood water vendors have developed to sell treated water (again, through small scale reverse osmosis plants) to people at a more affordable cost. The quality of this water is not regulated, and has not been tested. Contamination is very likely either at the source (because of poor maintenance) or during transportation (contaminants entering the jerry-cans and buckets used to transport the water). The PWA, CMWU and municipalities have adapted their water-supply systems to the situation. In Khan Younis, for example, the CMWU notifies the residents about occasional contamination from wastewater intrusion and when less polluted water may still safely be used for washing. The water authorities have also developed the habit of mixing sources of safe and unsafe water – to increase the amount of water available for drinking, at a marginally safer quality level.

Adaptation to the combined water and food insecurity is becoming evident through selection of less water-intensive and more salt-resistant crops, such as dates. Such agricultural practice is in fact a return to the traditional crops of the Gaza Strip, whereas cultivation of water-intensive citrus production originated as a policy of the Israeli occupation. The non-availability of fertilizers is encouraging farmers to rediscover organic methods, while they have also piloted the use of solar food-drying techniques as a result of the limited availability of cooking gas. Yet if, in a worst-case climate change scenario, an increase in crop water requirements combines with a further decrease in water quality, such coping mechanisms may prove insufficient to sustain farming livelihoods. With that threshold breached, a new set of vulnerabilities may have to be faced, such as prospects for alternative livelihoods in an economy prevented from trading with the world.

5.2 *Climate change adaptation planning for Gaza*

Adaptation to climate change in the oPt encompasses a range of responses to the impacts of this change, focusing on climate events that pose a significant risk. In the case of Gaza, over the next 40-50 years, there is forecast to be a fall in annual average precipitation, an increased incidence of drought, an increase in the frequency of extreme events, and a significant rise in sea-level. The assessment of future climate events is of course limited by various uncertainties regarding the nature and scope of local impacts, but adaptation is justified because the costs of inaction may well be substantial. Climate change impacts are likely to negatively affect human and economic development in Gaza in a number of key areas – agriculture and food security, water resources, coastal zones, and public health. Above all, these impacts will fall on a population already with high social vulnerability and dependent to a large degree on external humanitarian and development assistance. As the vulnerability pathways and discussion of enforced coping mechanisms has shown, t*he ability to develop longer-term adaptive mechanisms to reduce climate vulnerability is severely degraded by the Israeli closure regime*. Without the capacity to move beyond 'enforced coping' noted above, which is often destructive of social capital (e.g. local disputes over water), communities in Gaza face present and future climate hazards with little or no institutional protection.

Adaptation to climate change can involve governmental, civil society and private sector actors. The initial focus of any such adaptation in Gaza should be on state institutions, as they are responsible for setting the general plans and policies by which significant climate change impacts can be addressed by all societal actors. Of course, due to Israeli occupational practices and the current political split between the Hamas-led government in Gaza and the Ramallah-based Palestinian Authority, there is currently little political capacity for managing climate risk in the Gaza Strip. According to harm prevention principles under international humanitarian and environmental law, this situation nevertheless obliges Israel and other external actors to assist the Palestinians in Gaza to reducing their climate vulnerability. This should be done in a way that delivers 'no regrets' and 'low regrets' benefits (i.e. 'do no harm') in terms of disaster risk reduction and human development even if long-term climate trends are less harmful than predicted. The lifting of the Israeli blockade on Gaza which, as a collective punishment of a civilian population, breaches international law (e.g. Article 33 of the Fourth Geneva Convention) is necessary for the implementation of effective climate risk reduction activities in Gaza.

In the UNDP/PAPP climate adaptation consultations, it was noted by stakeholders in Gaza that an existing *Environmental Preparedness Plan* for the Gaza Strip could serve as a vehicle for adaptation planning. It was claimed that this plan could be developed (and integrate water resources management, coastal management, agricultural planning, land-use, etc) to take into account real and potential climate change impacts (Palestinian Water Authority, 2009, p. 14; UNDP/PAPP, 2010a, pp. 30-31). Similarly, there is a *Coastal Area Protection and Management Plan*, which has been awaiting implementation since 2000. This plan addresses observed and expected damages to seawater quality (e.g. from solid waste dumping and wastewater runoff) and the coast (e.g. dune erosion from sand mining) as a result of human activities. It also considers the impacts of sea level rise attributed to climate change and makes specific recommendations to help conserve coastal areas – such as 'set back lines' (beyond which no construction is allowed), improvements in fisheries legislation and habitat conservation efforts. However, the weak regulatory and legal context in the Gaza Strip, accentuated by the consequences of the Israeli blockade, means that that even the most basic of such recommendations are not being implemented. Building accountable and reliable response capacities to climate change in Gaza is also hampered by the substantial drop in international donor support following the election of the Hamas government in January 2006.

In response to the severe water insecurity in Gaza, new bulk-water solutions need to be considered, whether from transportation, importation or desalination. Large-scale (but step-by-step) desalination is a possible long-term solution to the freshwater crisis in the Strip. Increased purchase of water from Israel is currently seen as problematic by Palestinian authorities for reasons of cost, quality, and national security. Imported water from Egypt is another option for mitigating increasing water scarcity in the context of climate change, although this is problematic as well due to Egypt's strained relations with other riparian states sharing the Nile Basin.

6. Conclusions

Climate scientists forecast disruptive biophysical impacts for the eastern Mediterranean region, by the end of this century, as a consequence of climate change. Climate-induced risks to food and water security in the Gaza Strip are expected to include increased droughts and general water scarcity, decreased agricultural productivity, and reduced drinking water quality from greater salinisation of freshwater resources. These impacts will affect neighbouring countries in the eastern Mediterranean and North Africa. There are additional environmental stresses shared by the Palestinians in Gaza with other territories in the region, caused by rising human population density, urbanisation, and invasive species (Underwood et al. 2009). These processes will compound the predicted effects of climate change and highlight the need for regional cooperation on climate change adaptation.

Forecasts of regional sea-level rises caused by climate change have high uncertainties attached, yet this is a serious issue for low-lying coastal areas in the Mediterranean Basin, most obviously the Nile Delta. According to the greenhouse gas emissions scenario, sea levels are forecast by the IPCC to rise at least 18 to 38cm (emissions scenario B1) and as much as 26 to 59cm (emissions scenario A1F1) by 2100. Recent research on polar ice flow processes has indicated that these estimates in the IPCC *Fourth Assessment Report* (2007) may be too conservative (Jevrejeva et al., 2010). More accurate predictions for the Mediterranean Sea are possible only through longer time-series data from satellite altimetry and a more comprehensive in-situ tide-gauge network. Improved data collection and analysis would improve scientific understanding on why, since 1993, the sea levels in the eastern Mediterranean have risen more than in the west of the basin. In any case, the forecast sea-level rises of existing climate models pose a serious threat to the Gaza Strip through coastal erosion and saline intrusion into the Coastal Aquifer. There is the need in the Mediterranean Basin for a systematic inventory of the vulnerability of coastal aquifers to sea-level rise (Food and Agriculture Organization, 1997).

Climate change adaptation options have been proposed for Gaza by UNDP. Those 'no-regrets' and 'low-regrets measures' which are judged to have the highest levels of adaptive capacity and technical feasibility include: the development of flood contingency plans, increased rainfall harvesting, more efficient water distribution (including for irrigation), wastewater treatment, the selection of crops and ruminants for tolerance to heat and drought, and the protection of coastal sand dunes (UNDP 2010a, pp. 41-47). Such proposals, which are designed to be integrated with human development initiatives, are of course relevant to the situation of poor urban and rural populations living in coastal environments in other parts of the Middle East and North Africa.

However, pro-active climate change adaptation in the Gaza Strip is inconceivable in the current context of Israeli occupational practices, notably the protracted economic sanctions and blockade, which have triggered the breakdown of institutions for Palestinian governance.

In June 2010, under international pressure, the Israeli Security Council announced an easing the closure regime, though major restrictions have continued on imports of humanitarian materials, while all exports from Gaza remain banned (International Federation for Human Rights, 2010). The physical and psychological harm the blockade has inflicted on the civilian population has rendered them highly vulnerable to other stresses, including those arising from climate variability and change. The enforced coping mechanisms discussed above indicate that the adaptive capacity of individuals is weak and reactive, lacking wider infrastructural support (e.g. as might be provided by large-scale water desalination). They also demonstrate conditions where biophysical climate impacts significantly *under-determine* human vulnerability to climate change. While Gaza is often identified as an exceptional case, these findings are relevant to other regions where chronic non-climatic threats to human well-being overwhelm climatic stresses.

References

Adger WN (2006) Vulnerability. Glob Environ Change 16(3):269-281.

Adger WN, Agrawala S, Mirza MMQ, Conde C, O'Brien K, Pulhin J, Pulwarty R, Smit B, Takahashi K, (2007) Assessment of adaptation practices, options, constraints and capacity. In: Parry ML, Canziani OF, Palutikof, JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp 717-743.

Adger WN (2010) Climate change, human well-being and insecurity. New Polit Econ, 15 (2): 275-292.

Agrawal A, Perrin N (2009) Climate adaptation, local institutions and rural livelihoods. In: Adger WN, , Lorenzoni I, O'Brien KL (eds) Adapting to climate change: thresholds, values, governance. Cambridge University Press, Cambridge, pp 350-367.

Alcamo J, Acosta-Michlik L, Carius A, Eierdanz F, Klein R, DörtheKrömker D, Tanzler D (2008) A new approach to quantifying and comparing vulnerability to drought. Reg Environ Change 8:137-149.

Al-Farra A (2005) Health effects due to poor wastewater treatments in the Gaza Strip. Water for life in the Middle East: 2nd Israeli-Palestinian International Conference, Antalya, Turkey, 20-12 October 2004, Israel/Palestine Center for Research and Information, Jerusalem.

Almasri MN (2008) Assessment of intrinsic vulnerability to contamination for Gaza coastal aquifer, Palestine. Jnl Environ Manag 88:577 - 593.

Amnesty International UK et al. (2009) Failing Gaza: No rebuilding, no recovery, no more excuses. Crisis Action, London.

Applied Research Institute-Jerusalem (2006) Analysis of urban trends and land use changes in the Gaza Strip. Bethlehem: ARIJ.

Audit Environmental (2008) An audit of the operations and projects in the water sector in Palestine. Norwegian Representative Office, Ramallah.

Barnett J (2006) Climate change, insecurity, and injustice. In: Adger WN, Paavola J, Huq S, Mace MJ (eds) Fairness in adaptation to climate change. MIT Press, Cambridge, MA, pp 115-129.

Barnett J (2010) Human rights and vulnerability to climate change. In Humphreys S (ed) Climate change and human rights. Cambridge University Press, Cambridge, pp 257-271.

Bianchi CN (2007) Biodiversity issues for the forthcoming tropical Mediterranean Sea. Hydrobiologia 580(1):1573-5117.

Bohle HG, Downing TE, Watts MJ (1994) Climate change and social vulnerability: toward a sociology and geography of food security. Glob Environ Change 4(1):37-48.

Boko M, Niang I, Nyong A, Vogel C, Githeko A, Medany M, Osman-Elasha B, Tabo R, Yanda P (2007) Africa. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp 433-467.

Bredehoeft J (1997) Safe yield and the water budget myth. Groundwater 45(6): 929.

Brooks N (2003) Vulnerability, risk and adaptation: a conceptual framework. Tyndall Centre for Climate Change Research Working Paper 38. UEA, Norwich.

Centre on Housing Rights and Evictions (2008) Hostage to politics: the impact of sanctions and the blockade on the human right to water and sanitation in Gaza. COHRE, Geneva.

Chalmers I (2009) Gaza – a symptom of an insufficiently acknowledged cause. The Lancet 373: 197-198.

Cook C, Bakker K (2011). Water security: emerging debates in policy and academia. Water Alternatives 4.

Dalby S (2009) Security and environmental change. Polity Press, Cambridge.

Delica-Willison Z, Willison R (2004) Vulnerability reduction: a task for the vulnerable people themselves. In: Bankoff G, Frerks G, Hilhorst D (eds) Mapping vulnerability: disasters, development and people. Earthscan, London, pp 145-158.

Dinstein Y (2009) The international law of belligerent occupation. Cambridge University Press, Cambridge.

Downing TE, Patwardhan A (2003) Vulnerability assessment for climate adaptation, APF Technical Paper 3. United Nations Development Programme, New York.

El-Kadi A (2005) Global warming: a study of the Gaza temperature variations in the period 1976-1995. Islamic University Magazine 13(2):1-19.

Food and Agriculture Organization (1997) Seawater intrusion in coastal aquifers: guidelines for study, monitoring and control. FAO, Rome.

Food and Agriculture Organization (2007) West Bank and Gaza Strip: comprehensive food security and vulnerability analysis. FAO, Rome.

Food and Agriculture Organization (2009) The state of food insecurity in the world. FAO, Rome. ftp://ftp.fao.org/docrep/fao/012/i0876e/i0876e.pdf

Füssel H-M, Klein RJT (2006) Climate change vulnerability assessments: an evolution of conceptual thinking. Clim Change 75: 301-329.

Gaillard JC (2010) Vulnerability, capacity and resilience: perspectives for climate and development policy. Journal of International Development 22(2):218-232.

GVC/PHG (2009) Water quality monitoring campaigns: middle area of the Gaza Strip. Gruppo di Volotariato Civile/Palestinian Hydrology Group, Gaza City.

HSI (1999) Development of utilisation and status of water resources in Israel [in Hebrew]. Hydrological Service of Israel, Jerusalem.

International Federation for Human Rights (2010) Dashed hopes: continuation of the Gaza blockade. FIDH, Paris. http://www.amnesty.org.uk/uploads/documents/doc_21083.pdf

Jevrejeva S, Moore JC, Grinsted A (2010) How will sea level rise respond to changes in natural and anthropogenic forcings by 2100. Geophys Res Lett. doi:10.1029/2010GL042947.

Kafle HK, Bruins HJ (2009) Climatic trends in Israel 1970-2002: warmer and increasing aridity inland. Clim Change 96(1):63-77.

Kates RW, Ausubel JH, Berberian M (1985) Climate impact assessment: studies of the interaction of climate and society, Chichester: John Wiley.

Kelly PM, Adger WN (2000) Theory and practice in assessing vulnerability to climate change and facilitating adaptation. Clim Change 47:325-352.

Kitoh A, Yatagai A, Alpert P (2008) First super high-resolution model projection that the ancient 'Fertile Crescent' will disappear in this century. Hydrolog Res Lett 2:1-4.

Khatib I (2009) GLOWA-Jordan River Project 3 Final Report: Regional Climate Scenarios. Palestine Academy for Science & Technology, Jerusalem.

Khatib I, Gerstengarbe F-W, Haj-Daoud A (2007) East Mediterranean climate change trends in the last century. Arab Water World 31(4):96-100.

Krichak SO, Alpert P, Bassat K, Kunin P (2007) The surface climatology of the eastern Mediterranean region obtained in a three member ensemble climate change simulation experiment. Adv in Geosci 12:67-80.

Leary N, Conde C, Kulkarni J, Nyong A, Pulhin J (eds) (2008) Climate change and vulnerability. Earthscan, London.

Levinson C (2010) Egypt tightens Gaza barrier to close tunnels. The Wall Street Journal, February 22.

Lim B, Spanger-Siegfried E, Burton I, Malone E, Huq S (eds) (2005) Adaptation policy frameworks for climate change: developing strategies, policies and measures. Cambridge University Press, Cambridge.

Magnan A, Garnaud B, Billé R, Gemenne F, Hallegatte S (2009) The future of the Mediterranean: from Impacts of climate change to adaptation issues. IDDRI Science Po, Paris.

Mason M (2011) The ends of justice: climate vulnerability beyond the pale. In: Held D, Theros M, Fane-Hervey A (eds) The governance of climate change: science, politics, ethics. Polity, Cambridge, pp 162-182.

Mellouki A, Ravishankara AR (eds) (2007) Regional climate variability and its impacts in the Mediterranean area. Springer, Dordrecht.

Ministry of Environmental Affairs (2000) Gaza coastal and marine environmental protection and management action plan. Ministry of Environmental Affairs, Palestinian National Authority, Gaza City.

Nelson GC, Rosengrant MW, Koo J, Robertson R, Sulser T, Zhu T, Ringler C, Msangi S, Palazzo A, Batka M, Marilla M, Valmote-Santos R, Ewing M, Lee D (2009) Climate change: impacts on agriculture and costs of adaptation. International Food Policy Research Institute, Washington, DC.

O'Brien K, Eriksen S, Nygaard LP, Schjolden A (2007) Why different interpretations of vulnerability matter in climate change discourses. Clim Policy 7:73-88.

OCHA-WFP (2010) Between the fence and a hard place: the humanitarian impact of Israeli-imposed restrictions on access to land and sea in the Gaza Strip. Gaza City, OCHA-WFP. http://www.ochaopt.org/documents/ocha_opt_special_focus_2010_08_19_english.pdf

Office of the Chief Scientist (2008) Preparation of Israel for global climate change: the consequences of climate change in Israel and interim recommendations [in Hebrew]. Ministry of Environmental Protection, Tel Aviv.

Palestinian National Authority (2009) The Palestinian national early recovery and reconstruction plan for Gaza 2009-2010. Palestinian National Authority, Ramallah.

Palestinian National Authority (2010) Millennium development goals: progress report. Palestinian National Authority, Ramallah. http://www.undp.ps/en/newsroom/publications/pdf/other/mdg10.pdf

Palestinian Water Authority (2007) Rainfall data in the Gaza Strip. PWA, Ramallah.

Palestinian Water Authority (2008a) The construction of the central sea water desalination plant and the national water carrier in Gaza Strip. PWA, Ramallah.

Palestinian Water Authority (2008b) Water governance programme: building the capacity for institutional reform of the water sector. PWA, Ramallah.

Palestinian Water Authority (2010) Domestic groundwater quality in the Gaza Strip governorates. PWA, Gaza City.

Pelling, M (2010) Adaptation to Climate Change: From Resilience to Transformation. Routledge, London.

Schneider SH, Semenov S, Patwardhan A, Burton I, Magadza CHD, Oppenheimer M, Pittock AB, Rahman A, Smith JB, Suarez A, Yamin F (2007) Assessing key vulnerabilities and the risk from climate change. In Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp 779-810.

Shomar B (2010) Groundwater contaminations and health perspectives in developing world case study: Gaza Strip. Environ Geochem Health doi: 10.1007/s10653-010-9332-8.

Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability. Glob Environ Change 16(3):282-292.

Somot S, Sevault F, Déqué M, Crépon M (2008) 21st century climate scenario for the Mediterranean using a coupled atmosphere-ocean regional climate model. Glob and Planet Change 63(1-2) :112-126.

Turner BL, Kasperson RR, Matson PA, McCarthy JL, Coreell RW, Christensen L, Eckely N, Kasperson JX, Luers A, Martello ML, Polsky C, Pulsipher A, Schiller A (2003) A framework for vulnerability analysis in sustainability science. Proc Natl Acad Sci 100(14):8074-8079.

Underwood EC, Viers JH, Klausmeyer KR, Cox RL, Shaw R (2009) Threats and biodiversity in the Mediterranean biome. Diversity and Distributions 15(2):188-197.

UNDP (2009) Arab human development report: challenges to human security in the Arab countries. UNDP Regional Bureau for Arab States, Beirut. http://www.arabhdr.org/publications/other/ahdr/ahdr2009e.pdf

UNDP (2010a) Climate change adaptation strategy and programme of action for the Palestinian Authority. United Nations Development Programme/Programme of Assistance to the Palestinian People, Jerusalem.

UNDP (2010b) Human development report 2009/10: occupied Palestinian territory. United Nations Development Programme/Programme of Assistance to the Palestinian People, Jerusalem. http://www.undp.ps/en/newsroom/publications/pdf/other/phdreng.pdf

UNDP (2010c) One year after: Gaza early recovery and reconstruction needs assessment. United Nations Development Programme/Programme of Assistance to the Palestinian People, Jerusalem. http://www.undp.ps/en/newsroom/publications/pdf/other/gazaoneyear.pdf

UNEP (2009) Environmental assessment of the Gaza Strip. Geneva: United Nations Environment Programme, Geneva. http://www.unep.org/PDF/dmb/UNEP_Gaza_EA.pdf

UNEP-MAP-RAC/SPA (2008) Impact of climate change on biodiversity in the Mediterranean sea. UNEP Regional Activity Centre for Specially Protected Areas, Tunis.

UNICEF (2010) Protecting children from unsafe water in Gaza. UNICEF, Jerusalem. http://www.unicef.org/oPt/FINAL_C4D_Report_July_2010.pdf

UNRWA (2009) Poverty in the occupied Palestinian territory 2007. United Nations Relief and Works Agency for Palestine Refugees, Gaza City. http://www.unrwa.org/userfiles/20100118142147.pdf

Vengosh A, Klopmann W, Marei A, Livshitz Y, Guttierez A, Banna M, Guerrot C, Pankratov I, Ranaan H (2005) Sources of salinity and boron in the Gaza Strip: Natural contaminant flow in the southern Mediterranean coastal aquifer. Water Resources Research 41(1):1-19.

Vogel C, Moser SC, Kasperson RE, Dalbeko GD (2007) Linking vulnerability, adaptation, and resilience science to practice: pathways, players, and partnerships. Global Environ Change 17:349-364.

Weinthal E, Vengosh A, Marei A, Gutierrez A, Kloppmann W (2005) The water crisis in the Gaza Strip: prospects for resolution. Ground Water 43(5):653-660.

WFP/FAO (2009) Occupied Palestinian territory: food Security and vulnerability analysis report. WFP/FAO, Jerusalem. http://unispal.un.org/UNISPAL.NSF/0/FC44A5D7F00AA567852576960059BEB4

WFP/FAO/UNRWA (2008) Joint rapid food security survey in the occupied Palestinian territory. WFP/FAO/UNRWA, Jerusalem.

World Bank (2009) West Bank and Gaza: Assessment of restrictions on Palestinian water sector Development. Report No. 47657-GZ. World Bank, Jerusalem.

Yacoubi A (2008) Gaza Strip: sustainable yield of the coastal aquifer. Unpublished report. Palestinian Water Authority, Gaza City.

Zeitoun M, Messerschmid C, Attili S (2009) Asymmetric abstraction and allocation: the Israeli-Palestinian water pumping record. Ground Water 47(1):146 - 160.

Zeitoun M (2011) Global water security. Glob Policy 2.