Case Study

Policy Options for Coastal Protection: Integrating Inland Water Management with Coastal Management for Greater Community Resilience

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Abstract: Coastal cliff collapse is a problem faced along many shorelines the world over, especially as cliffs tend to be affected by global climate change. Problems of cliff collapse can benefit from interdisciplinary policy responses that synthesize principles of three paradigms: integrated watershed management, integrated coastal zone management, and water-sensitive urban design. This exploratory, largely empirical research looks at how local and national policies address coastal cliff collapse along Israel's Mediterranean seashore, in a way that highlights impediments and opportunities for integrated planning. Findings emphasize the importance of addressing urban runoff to prevent coastal cliff collapse using practices originating based on the three paradigms. Conclusions provide insights about policies that could improve the resilience of coastal communities suffering from coastal cliff collapse in the era of climate change. Particularly, greater cross-scale (regional and national) efforts are needed to coordinate proper drainage of the watershed that along coastal cliffs involves integrating principles of watershed management, coastal management, and urban design practices. These should be aimed at implementing practices that reduce phenomena that lead to cliff destabilization, such as ensuring runoff diversion and implementing building setbacks. The case study research leads to recommendations for policy mechanisms that provide opportunities to implement such practices. **DOI: 10.1061/(ASCE)WR.1943-5452.0000913.** *© 2018 American Society of Civil Engineers.*

Introduction

Erosion and retreat of coastal cliffs (or bluffs) are natural phenomena, exacerbated by global climate change in recent years, but also worsened by cliff-top construction and inappropriate management of surface water runoff (Katz and Mushkin 2013). In general, development along coasts both influences the collapse of cliffs and is influenced by it; in many coastal cities, cliff collapse makes for grave planning and governance dilemmas linked to issues of property rights, jurisdictional authority, and human welfare (Hapke et al. 2009; Semeoshenkova and Newton 2015).

Many countries face such problems. In Europe, high coasts made of soft soil materials are eroding, such as those at the Pas de Calais in France, Dover in the United Kingdom, along the Polish coast, and in southern Europe (Doody et al. 2004; European Environment Agency 2006; Minhea et al. 2006). In the United States, soft erosion-prone seaside bluffs (hereafter *cliffs*) are found along both the nation's eastern and western seaboards (Davis and Fitzgerald 2004; Tanski 2007; Limber et al. 2008). In recent decades, climate change has affected coastal cliffs. These effects often include more frequent and intense storms and sea-level rise (Carlson et al. 2015), effects that have coincided with a rush for development of the coast (Pilkey and Cooper 2004; Douglas et al. 2012). These two phenomena, climate change and extensive coastal development, cause acute situations in places where coastal cliffs make up a dominant element of the urban landscape; here, cliffs are often an integral part of cities because they provide recreation and touristic opportunities, such as for ocean viewing along cliff-top promenades (e.g., Tanski 2007). Furthermore, although quite variable along the Mediterranean Sea, at some locations, recent or expected increases in tide ranges further exacerbate erosion (see Minhea et al. 2006). In less developed areas, cliffs are designated historic and nature parks or are used for agriculture, and their demise is of great concern (Minhea et al. 2006; Katz and Mushkin 2013; Semeoshenkova and Newton 2015). With all this at stake, this paper contends that scientists and professionals working on coastal planning and policy need to look beyond exclusively disciplinary work on the *seaside* causes of cliff collapse, to consider *landside* water management with all its complexity, and to seek links among various disciplinary concepts for improved overall resilience.

The goal of this research has been to gain insights for the interlinking of three water-related management paradigms through the analysis of the historical development of inland water and coastal policies using the case study of Israel's response to coastal cliff collapse. The analysis is directed by the premise that such interlinking can improve coastal community resilience to natural phenomena exacerbated by the effects of climate change.

Water Management and Resilience

Research rarely addresses the effects of landside water management on the nearshore marine environment using the sufficiently broad, interdisciplinary perspective necessary to bring about improved coastal community resilience. When policy research has addressed landside water management in view of coastal issues, the concern is usually with regard to water quality, i.e., how upland water resource management contributes to nearshore marine pollution, eutrophication, and ocean acidification (e.g., Kelly et al. 2011; Hering and Ingold 2012), without regard for the influence of water quantity and flow on coastal structure. Yet the maintenance of coastal structure and stability is a major factor for urban resilience.

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Note. This manuscript was submitted on January 3, 2017; approved on September 27, 2017; published online on January 30, 2018. Discussion period open until June 30, 2018; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Water Resources Planning and Management***, © ASCE, ISSN 0733-9496.

J. Water Resour. Plann. Manage., 2018, 144(4): 05018005

Resilience is roughly defined as the ability to absorb, accommodate, and recover from hazards quickly and efficiently, including through the preservation and restoration of basic community structures and functions (UNISDR 2012). Adapted from studies of how ecological systems cope with disturbances caused by external factors, resilience has recently been applied to understand the response of communities to the effects of climate change, including sea-level rise and increased average return periods of extreme sea state/storm events and high tides, which will significantly affect coasts. Literature reviews reveal an important emerging scholarship on resilience (Olsson et al. 2015), yet most studies on the subject make use of general, vague, and sometimes confusing terminology and they fail to illustrate with reference to practical application how resilience can be achieved.

This exploratory research synthesizes between the fields of coastal and water drainage management to assess the effectiveness of policy responses to coastline change with regard to cliff collapse. It uses a single case study approach and brings three water-related management paradigms—integrated watershed management, integrated coastal zone management, and water-sensitive urban design—to bear on the policy analysis of the response to coastal cliff collapse. Although this research examines policy developments manifested locally, if properly applied, integration of the three paradigms briefly reviewed below can expand the policy toolbox for the planning and managing of urban coastal edges in other, similar contexts.

Integrated Watershed Management

A specific approach aimed at sustainable use of water resources is integrated water resources management (IWRM); it ensures safe, reliable supplies of water for many and varied uses from irrigation to protection of aquatic ecosystems (Hering and Ingold 2012). IWRM is defined as "a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Jønch-Clausen 2004). This broad definition puts emphasis on the process of managing water sources of all types in an integrated manner. Rarely has this approach been directed toward coastal seawater, although rising dependence in some areas of the world on desalination may change that (see Feitelson and Rosenthal 2012).

By contrast, integrated watershed management (IWM) is defined as "the protection, improvement and rational use of water and land and other renewable natural resources in a *watershed*, in order to reach the optimal goals of ecological, economic and social benefits" (Newson 2000). This approach emphasizes a certain (usually large and regional) spatial scale and leads to management of water resources according to the natural geographical unit for water management (Zoltay et al. 2010), rather than according to administrative boundaries (Tefera and Stroosnijder 2007; Carlson et al. 2015). Risks at any point that must be addressed and managed can be understood in relation to the topographical positions of human activities with their corresponding effects on local hydrology.

Taken together, both IWRM and IWM emphasize multiple water sources, i.e., groundwater, surface water, stormwater, and floodwater. When the watershed is a coastal one, the effects of coastal rivers and streams, marshes, tides, and currents can therefore be considered (Beatley et al. 2002; Davis and Fitzgerald 2004; Randolph 2011). As such, IWM, with its emphasis on scale and the spatial extent of the management unit, should be well positioned for consideration with integrated coastal management. However, even where IWM is determined as relevant for the management of coastal watersheds, as one gets closer to the shoreline, policy makers and planners are often greatly challenged by its implementation. This is because administrative (institutional) divisions often hinder the concept's application, for example, when different entities are responsible for different parts of the shore. In addition, whereas coastal management often occurs at a regional and national level (Shipman and Stojanovic 2007; Portman et al. 2012), water resources management is often stuck, or preferably occurs, at the municipal level (Carmon and Shamir 2010; Hammer et al. 2011; Ferguson et al. 2013; Larsen et al. 2016).

Integrated Coastal Zone Management

Integrated coastal zone management (ICZM) is a widely accepted approach to managing resources that has been adopted in response to the well-documented failures in the management of marine fisheries, coastal hazards, mining, and nearshore land use (Cicin-Sain and Knecht 1998). Definitions of ICZM have evolved over time and vary depending on context (Massoud et al. 2004). In general, ICZM is defined as "a continuous and dynamic process by which decisions are taken for the sustainable use, development and protection of coastal and marine areas and resources" (Cicin-Sain and Knecht 1998). The paradigm can be further understood by way of historical context; it developed in answer to sectoral management that plagued both coastal and nearshore resources management, including common shoreline development practices.

In the United States, ICZM has been implemented for many years through the U.S. Coastal Zone Management Act, promulgated in 1972. The European Union (EU) adopted a recommendation for the implementation of Integrated Coastal Zone Management (2002/413/EC) in May 2002. The recommendation formalizes eight principles of ICZM that should be implemented by each member country (see European Parliament 2002; Portman et al. 2012). From the academic literature on ICZM, and from many studies of plans and programs, there are several salient dimensions of integration, from the spatial and temporal to institutional and interdisciplinary (Cicin-Sain and Knecht 1998; Massoud et al. 2004; Portman et al. 2012). The spatial dimension refers to that of physical scale (e.g., local versus regional or international); the temporal dimension refers to concerns of short- versus long-term time frames; institutional dimensions are most closely related to public and private sectoral entities and their operational mechanism (e.g., laws and regulations); and finally, the interdisciplinary dimension seeks integration across fields and professions (see PAP/RAC 2007; Portman et al. 2012).

A current concern of coastal management is that of erosion (European Environment Agency 2006; Ma et al. 2014). Principles of *integrated* CZM relate to the spatial dimensions of erosion in two ways. Firstly, integration calls for the consideration of (positive or negative) effects of an action taken in one place along the shoreline to other areas of the coast. Secondly, integration calls for the consideration of an activity's effect across landscape units. The latter refers to both terrestrial and marine (submerged) areas of the coast and their effects on eroding cliffs (Massoud et al. 2004; Portman 2012). These principles exemplify the previously mentioned spatial dimension of ICZM.

European environmental agencies have invested heavily in solutions to address coastal erosion. The Mediterranean Sea shores make up the longest stretch of coastline of the European continent affected by erosion (reportedly 30% of all erosion-affected shores) with high levels of vulnerability due to intensive development (European Environment Agency 2006). In Israel the situation is particularly acute (Gabbay 2000). For example, a recent study conducted on the fairly continuous 30-km Sharon Escarpment in the

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center of the country found that cliff erosion over the period of a year following a severe winter storm amounted to $12{,}000 \pm 3{,}300\ \mathrm{m}^2$ loss of land area with up to 8 m of cliff-top retreat in some areas (Katz and Mushkin 2013).

Water-Sensitive Urban Planning

A third paradigm, which involves the development and implementation of practices related to watershed management, is water-sensitive urban planning. Commonly referred to as water-sensitive urban design (WSUD), this paradigm is fueled by the interest in sustainable urban development. It integrates best water management practices (many related to stormwater runoff), with mechanisms of urban planning. WSUD, developed in Australia, connects urban planning with stormwater management mainly for protecting groundwater in aquifers. In the United States, planners employ a similar approach, called low-impact development (LID), which focuses on maintaining a steady hydrological response (i.e., stormwater runoff volume and discharge rate leaving the spatial unit before and after development), but also seeks to view stormwater as a benefit to the environment, rather than only as a disturbance (Carlson et al. 2015).

While both LID and WSUD aim to minimize the hydrological effects of urban development on the surrounding environment, based on a review of the literature, WSUD puts more emphasis on maintaining a water balance that considers "waterway erosion" along with the management of "groundwater, stream flows, and flood damage" (see Fletcher et al. 2015, p. 527), and therefore it is used in this analysis. Erosion of "waterways" refers to that occurring along river banks, stream channels, or, as herein, coastal cliffs.

Since the management of runoff and stormwater makes up a major part of WSUD, and coastal cities are now facing problems of flooding, changing (usually eroding and subsiding) shorelines, and more (Hunt and Watkiss 2011; Barbier 2014), WSUD can also be directed toward resilience building in these areas. As mentioned, *resilience* is increasingly applied to situations related to climate change adaptation and preparedness because it refers to the ability to return to or maintain some form of normal condition after a period of stress (Olsson et al. 2015). Despite WSUD addressing water management in the urban environment and sea coasts becoming increasingly urbanized, application of WSUD has not been applied yet to coasts.

Integrating Inland Water and Coastal Management

Since land-based activities are inherently linked with systems of rivers, estuaries, and marine environments, particularly with regard to preventing salt-water incursion, sea-level rise and flooding during extreme sea states, inland water management should be integrated with management of activities in the nearshore marine environment. Yet research addressing the policy aspects of such integration is limited. In a notable exception, Massoud et al. (2004) examined management tools for integration between activities in river basins and coastal zones. The authors posit that the latter emphasizes physical planning, whereas the former lends itself to water supply management, thus equating it closely to integrated water resources management. An impetus for integration being a sought-after norm for inland water management (at the watershed or river basin scale) is the need for holistic management across multiple jurisdictions within a watershed (Rhoads et al. 1999). This is also true for coastal management, where jurisdictional issues hinder holistic management that addresses erosion forces such as longshore currents and sediment transport from one part of the littoral cell to another (Beatley et al. 2002; Portman et al. 2012).

Additional similarities between IWM, ICZM, and WSUD relate to protection of the coastal cliffs and riparian areas from erosion. Furthermore, the coastline, like the urban riverbed, is an environmental asset that contributes to tourism and residents' well-being (Massoud et al. 2004; Semeoshenkova and Newton 2015). However, important differences exist with regard to runoff in the coastal zone and runoff in the watershed, with one difference being that the goal of aquifer recharge within a watershed as part of water-sensitive development would be highly unsuitable at the top of coastal cliffs. Runoff along the shore must be treated in a completely different manner. Since this is the case, how can goals of WSUD such as water retention and infiltration be reconciled with the goals of runoff management near coastal cliffs? A first step in addressing this problem would be to understand policy processes taking place concurrently to address both inland runoff management and coastal cliff stability issues.

The remainder of this paper presents exploratory policy research addressing surface runoff's effect on coastal cliff collapse. The research started by asking: to what extent is surface runoff *recognized* as a factor contributing to coastal cliff collapse? And then, are the three paradigms presented here useful for the prevention of coastal cliff collapse and coastal protection from erosion? How can they be implemented simultaneously? Policy measures taken to address collapse of the cliffs along the Mediterranean shores of Israel are presented and analyzed in view of these questions.

Israel's Cliff Collapse Problem

Israel's 190-km Mediterranean shoreline consists of natural stretches of white sandy beaches along the country's southern shores, low rocky tidal zones north of Haifa, and cliff areas in the country's center (Fig. 1). Around 70% of the country's population is clustered along the 15-km-wide (measured east to west) central section of the country. Coastal zone problems include relentless pressure for urban touristic and residential development, as well as for infrastructure expansion (e.g., power and desalination plants, military bases, and marinas). These activities portend a loss of public access along the coast, a plethora of use conflicts, and exacerbated erosion (Zviely and Klein 2004; Rosen 2010).

Already around 60 km of the coastline is within developed urban areas, with another 40 km slated for development. Only 13 km are designated public bathing beaches, and the pressure continues as plans for desalination plants, energy pipelines, and artificial islands come to fruition (Alfasi 2009; Portman 2012; IMoEP 2016). During the years 1980–2008, the country's population grew from approximately 4 million to 7.4 million inhabitants, while the number of designated bathing beaches decreased by 11 (State Comptroller 2010)

Along approximately 45 km between the cities of Ashkelon in the south and Hadera in the north, coastal cliffs (Fig. 2) consisting of layers of eolianite (or aeolianite) sandstone (locally *kurkar*) and reddish sandy loam (*hamra*) rise to heights of between 10 and 50 m above sea level (Gvirtzman et al. 1983; Zviely and Klein 2004; Rosen 2010; IMoEP 2016). Besides providing aesthetic beauty, these cliffs contain many cultural and recreational amenities and important environmental values based on their unique ecology (Davidovitch 2009). Estimates of cliff erosion rates vary along the coast (Zviely and Klein 2004; Rosen 2010; Katz and Mushkin 2013). The UNEP Mediterranean Action Plan reported the average rate of retreat in the central area of the country as 15–22 cm/year (UNEP 2001), while a more recent estimate sets the rate between

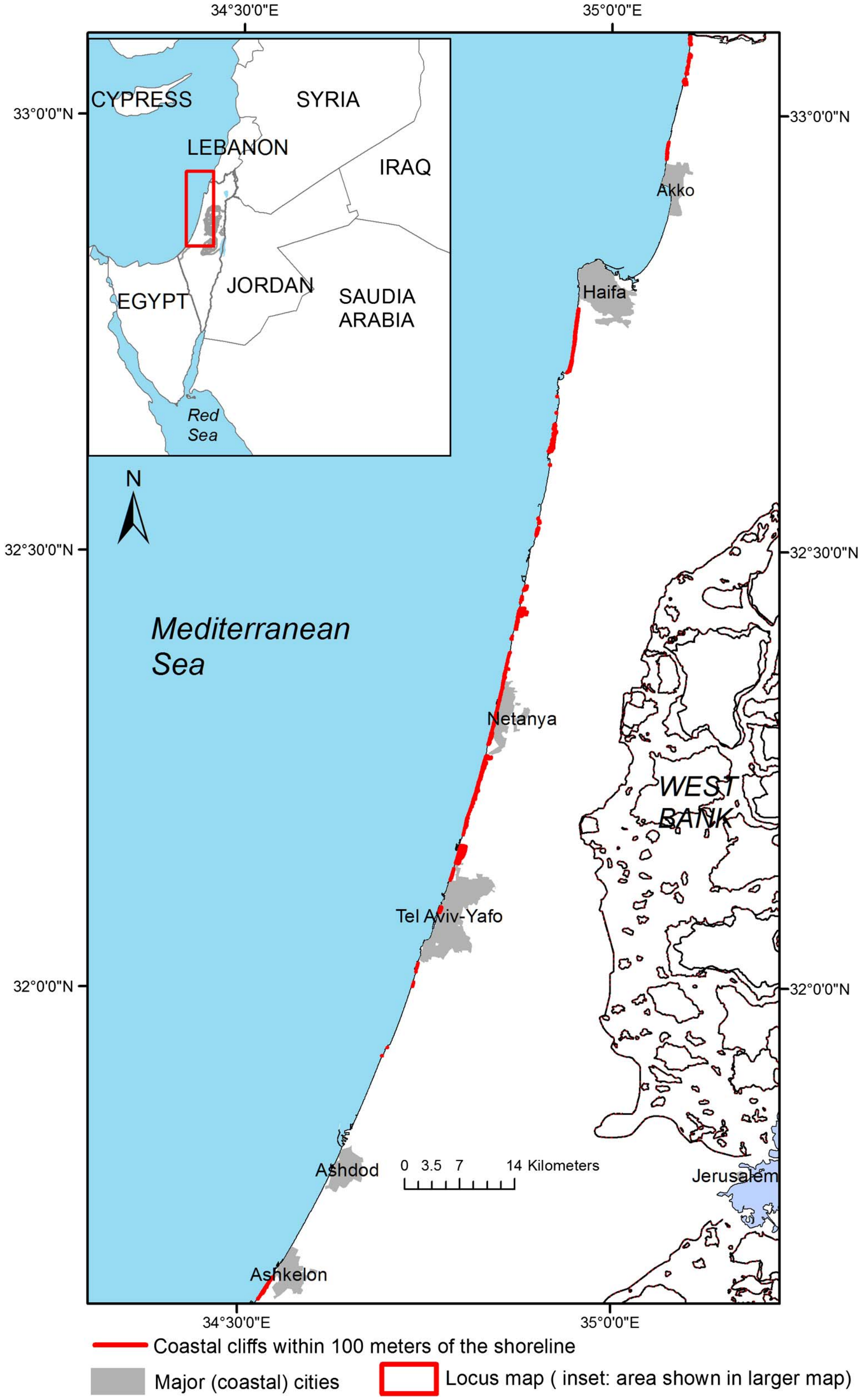

Fig. 1. Coastal cliff areas along Israel's Mediterranean Sea coast

0.5 and 1 m/year (Bein et al. 2010). Sea-level rise along the coast of Israel has occurred at a rate of 5.9 mm/year from 1992 to 2014 (Rosen et al. 2007; Herut et al. 2015).

Causes of accelerated erosion are many. Indirect human interventions through climate change results in sea-level rise and greater storm action that affects the cliff (Melloul and Collin 2009). Narrow beaches expose the base of the cliff to undercutting by waves, which eventually leads to cliff collapse, a known problem in many parts of the world (Davis and Fitzgerald 2004). Past sand mining (until outlawed in 1963) along Israel's shores led to the narrowing of many beaches (Zviely et al. 2007). The blockage of the south-to-north sand transport (from the Nile River delta) by various infrastructure and construction projects jutting into the sea (beginning with the construction of power station cooling basins at

(a)

(b)

Fig. 2. (a) Kurkar cliffs along Israel's Mediterranean Sea between Haifa and Netanya; (b) runoff-related erosion on cliff, City of Netanya [(a and b) images by Michelle E. Portman]

Ashdod and Tel Aviv, then the Port of Ashdod completed in 1965, followed by the Yafo and Tel Aviv marinas in the 1970s, and the Ashkelon, Ashdod, and Herzliya marinas built in the early 1990s) has systematically narrowed beaches north of these structures. Other documented causes of cliff erosion and collapse along the Mediterranean shores of Israel are destabilization from the seepage of surface runoff (including irrigation water), combined with problems of natural foreshore slope and cliff-top development (Rosen et al. 2007; Bein et al. 2010). Cliff collapse is now a national, high-profile problem in Israel with fiscal, social, and legal repercussions (State Comptroller 2010). Three persons have been killed by erosion-related cliff collapse since the late 1970s, with one death as recently as 2009 along the beach of the City of Netanya (Globus-Israel Business Section 2009).

Methods

The issues outlined in the section "Water Management and Resilience" lead to the analysis of policies that could support the application of WSUD principles for the treatment of runoff in the coastal environment in ways that address coastal cliff collapse. Theoretically, such application provides an opportunity to integrate the three paradigms described above: IWM, ICZM, and WSUD. Policy analysis can give an indication of whether or not such integration is occurring and point out impediments, opportunities, and points of intervention for such integration. Thus, this research analyzes coastal and inland water management policies with the goal of arriving at recommendations for future emphases and changes.

The research uses two sources of information, commonly used for exploratory research (see Stebbins 2001): (1) documents including plans, policies, legislation, and protocols and (2) informal interviews with policymakers and regulators. Interviewees were chosen because of their intimate knowledge with coastal cliff collapse issues at either the local level (e.g., the City of Netanya) or the national level [e.g., the Israel Ministry of Environmental Protection (IMoEP)]. Approximately six such in-depth interviews were conducted using an open-ended, unstructured battery of questions posed to municipal or national-level planners and regulators.

Interview answers provided further understanding of laws and policies promulgated at the national level and implemented at local levels and gave an idea of the extent that planners and managers were interested in implementing design principles that follow one of the three paradigms. For example, a research query posed sought to determine the extent to which municipalities were taking measures to stop infiltration of water along the sensitive coastal cliffs or making use of water diverted from the cliff area for other municipal purposes. Researchers asked about the implementation of general water-sensitive design techniques, such as swales, biofilters, or water catchment for reuse (e.g., for recreation or irrigation) in other parts of the city. Along cliff areas themselves, researchers asked about setbacks for new development that considers future cliff retreat (as required by NOS 13).

The review of coastal and water policy documents focused on questions derived from the literature and led to characterization of policies into "waves" since Israel's establishment (Table 1). Their analysis sought to identify the contribution of water-related management principles, if any, to the management of runoff in the coastal environment as it relates to coastal cliff collapse (see Weimer and Vining 2011; Menahem 2001). The analysis led to the identification of factors that hinder or support integration of the three paradigms described above for coastal community resilience in the form of coastal cliff collapse prevention.

Findings and Analysis

Coastal Development Policies

Until recently, coastal management in Israel progressed slowly. Coastal policy was driven largely by land-use conflicts that ignored marine-side development (Sas et al. 2010; Portman 2015) despite the existence of the Territorial Waters Committee, created since passage of Israel's Planning and Building Law in 1965 (Fletcher 2000), specifically to review projects proposed in marine areas extending to the westward limit of the country's territorial waters (to 12 nautical miles from shore). In the 1970s, Israel's obligations to comply with international treaties (e.g., the Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution) did help create some laws and institutions related to the coastal zone, but these focused almost exclusively on the protection of marine water quality (Amir 1987). The National Planning Administration, established by the National Planning and Building Law of 1965, issued guidance on coastal uses as early as 1970 asserting that uses should be determined in accordance with damage that they might cause to the coastal environment (Fletcher 2000). However, despite good intentions, including those aimed at considering both land and sea elements of the coast, these nonstatutory policies had no means for implementation. Coastal regulation began in earnest only with the passage of the National Outline Scheme for the Mediterranean Shore (NOS 13) in 1983 (Alfasi 2009; Sas et al. 2010).

Table 1. Categorization of Coastal Zone Management and Water Resources Management in Israel into Three "Waves" (Since Statehood in 1948)

Management type	First wave [year(s)][a]	Second wave [year(s)][a]	Third wave [year(s)][a]
Coastal zone management	Planning and building law promulgated to allocate land uses (1965)	Coastal water policy paper published (1999)	Ministry of the interior initiates marine spatial planning (2010)
	The National Planning and Building Board issued development guidelines for Israel's coast (1970s)	Intensive private (residential) building along coast (mid 1990s–mid 2000s)	Prime minister's office interministerial committee initiates actions to address cliff collapse (2010)
	UNEP Mediterranean Action Plan (1980s) initiated for improved protection of coasts and nearshore marine environment	Law for the Protection of the Coastal Environment promulgated to protect the shore, access to it and give precedence to water-dependent uses (2004)	Barcelona convention ICZM protocol approved by Israel (2011)
	National Outline Scheme for Mediterranean Coast (NOS 13) approved (1983) to establish land uses along the coast		The Mediterranean Coastal Cliff Preservation Government Company Ltd. established (2013)[b]
Water resources management	Large water diversion infrastructure projects planned and implemented (1960s)	Urban demand takes precedent over agricultural demand (1990s)	Stormwater runoff management reform begins (2010–present)
	Major water resources laws passed, e.g., Drainage and Flood Protection Law of 1957, Water Law of 1959 (1950s and 1960s)	Intensive desalination plant planning and construction begins (2004)	Recognition of riverbed (ecosystem) services (2010)
	Agrarian water demand takes precedent (1950s–1970s)	WSUD principles incorporated in National Outline Scheme for the Water Sector (NOS 34) (2006–2007)	Long-term master plan for the water sector developed (2008)

Note: The first two periods of four described by Menahem (2001), which prioritize allocation of water for agriculture, are combined here. For further detail on the development of Israel's CZM policies (see Fletcher 2000).
[a]Rough approximations.
[b]See Rinat (2012).

NOS 13 stipulated the uses allowed in the nearshore land area (i.e., tourism, agriculture, etc.) and provided some protection from overdevelopment by designating areas as bathing beaches, coastal reserves, and landscape reserves. It also determined a 100-m landward setback line for development, albeit from the ambiguous, high-waterline position that was not clearly delineated. But even NOS 13 was unsuccessful in regulating major development projects that began to take off in the 1990s and early 2000s. Several controversial megaprojects were authorized during this period; they transformed the coastal resource into real estate designed for high-income residential development, while severely reducing access for the public (Tzafrir 2005). Today, the original NOS 13 is outdated, although its amendments provide opportunities for integrated coastal management, especially in regards to the protection of coastal cliffs (explained below).

With burgeoning population, rising standards of living, and intense expansion of the tourist industry, policymakers recognized the need to overcome disjointed management resulting from the Territorial Waters Committee's responsibility for regulating development in submerged areas and the National Planning Administration's responsibility for development on land according to NOS 13 (e.g., State Comptroller 1998). After much controversy in the country about development along the limited and fragile coast, the government passed the Law for the Protection of the Coastal Environment (LPCE) in 2004 (Alfasi 2009; Sas et al. 2010; Portman et al. 2012).

The LPCE became a beacon planning tool, one stating planning policy in primary legislation, unchangeable by local, discretionary plans and thus binding even at the local level (Alfasi 2009). The LPCE defines the "coastal environment" as including the sea to the extent of the territorial waters, over which national sovereignty is clear. This law also regulates the shore and the backshore, both within and without cities up to 300 m from the waterline defined as the position of elevation contour +0.75 m relative to the Israel Land Survey Datum and with its coordinates fixed in the Israel New Grid coordinate system. The rationale for the wider view as described by Alfasi (2009) is that the coastal environment "forms a unified, complex system of land uses, processes and opportunities that cannot be [properly] handled if torn to small pieces."

Despite renewed policy development that pertains to the nearshore environment, including two new marine spatial planning initiatives addressing Israel's territorial (nearshore) sea and beyond (see Portman 2015), the country's limited coastal resources and demographic and development pressures heighten the urgency for improved coastal management policy (Tal 2013). A positive development in this regard has been the recent ratification of the Barcelona Convention's ICZM Protocol by Israel in 2012. However, it remains to be seen what effect, if any, the protocol will have on local and national policy.

Watershed Management Efforts

The Water Law of 1959 vested ownership of all water resources in the State of Israel and centralized systematic production and allocation. The guaranteed supply of water, first and foremost to agriculture, continued until the end of the 1990s, when water policy and resources were considered to be in crisis due to, among other problems, a major depletion of Israel's underground water sources (Menahem 2001). During the 1990s, a huge shift in water management occurred, influenced by general forces taking place in the country, particularly privatization and massive urban development, both of which had huge implications on the agricultural sector (Feitelson and Rosenthal 2012). To meet urban needs, significant changes were called for in laws, regulations, and institutions to improve water management over time and space (Laster et al. 2009).

Attempts in the 1990s to reform the institutional structure of those entities administering the different laws led to the consolidation of 26 drainage authorities responsible for 40% of Israel's land area into 11 dedicated river authorities covering the entire country in 1997. More recently, the Israeli government set out to identify the problems with the existing surface runoff management institutions (Sadan et al. 2011). Significant conflicts were identified related to the administration of three laws: the Rivers' Authorities Law of 1965 (hereafter the *Rivers Law*); the Water Law of 1959; and the Drainage and Flood Law of 1957. Problems stem from the often conflicting goals of water management, particularly those promoted by authorities responsible for river "corridors" established by the River Law and by those responsible for stormwater drainage according to the Drainage and Flood Law. The latter focuses on treating "damaging" surface water in a sweeping manner without distinguishing between various local geographies. These problems illustrate spatial conflicts (i.e., riparian municipalities fail to coordinate runoff management with the responsible river authorities within their city limits) and conflicting goals sought by mandated actions (e.g., drainage versus river ecosystem health).

Other reorganization efforts affecting the scale and scope of runoff and stormwater management policies and practices include amendments to the National Outline Scheme for the Water Sector (NOS 34). NOS 34 was originally approved only in 2003. The most recent two amendments of the original plan, NOS 34/B/3 and NOS 34/B/4, mandate regulations that promote Israel's version of WSUD called *water-sensitive planning* (WSP) (Carmon and Shamir 2011). Like similar water management practices in other countries, WSP emphasizes (among other aspects of management) considering runoff as a benefit rather than a nuisance or harm and seeks to connect water management to land-use planning mechanisms.

The first amendment, NOS 34/B/3, addresses the protection of streams and the drainage of stormwater by requiring that infiltration of surface runoff take precedence to the removal of water by artificial drainage. The second, NOS 34/B/4, requires that major city and neighborhood plans include drainage appendices that encourage stormwater infiltration and retention and prevent groundwater contamination. Such appendices are required to include "to the extent possible" instructions for the use of surface runoff water (e.g., for irrigation, local landscaping, stream replenishment, etc.) and to enable the use of public open space for retention and infiltration of runoff (NOS 34/B/4, Chapter D, §§ 22.1.1 and 22.1.2). In Amendment 4 of NOS34/B, although the term *drainage* was not replaced with *stormwater management* as experts promoting principles of WSP proposed, at least the definition of *drainage* was broadened to include myriad WSP objectives, such as replenishment of underground aquifers and runoff reuse for landscaping.

Another influential policy document is the country's Long Term Master Plan for the Water Sector (hereafter *Water Sector Master Plan*). Principles of WSP have been incorporated in the latest version of this plan, which calls for considering runoff as a resource and not a nuisance; developing watershed master plans that integrate basin-wide runoff management with management of urban runoff; and promoting urban development practices that aim to preserve water, such as green roofs and biofilters. The plan calls for a transfer of responsibility for managing runoff and drainage in urban communities to the municipal water and sewage corporations (Israel Water Authority 2012, p. 9). Yet as a nonstatutory document, the Water Sector Master Plan, unlike laws and regulations, lacks implementation authority.

Therefore, problems remain. Significant decision-making power is still in the hands of the agrarian sector, which results in the problematic division of responsibility between regional drainage authorities and the municipalities (Fischhendler and Heikkila 2010; Sadan et al. 2011; Becker and Ward 2015). Other impediments to WSP include the lack of physical and climatic data that would allow detailed planning and accessible professional training and expertise to support existing national guidelines (Laster et al. 2009). These issues influence how runoff treatment affects coastal cliff collapse, although to date, such effects have been left out of Israeli water management studies and are lacking in the general coastal and water resources management professional and academic literature.

National Policy Efforts to Halt Cliff Collapse

Three significant interrelated actions have been taken since 2010 to try to halt coastal cliff collapse beyond allocation of public funds for study of the problem. Policy recommendations were adopted through a series of government decisions. These led to comprehensive national planning that took place in the form of a dedicated amendment to NOS 13 and a government corporation being established to take charge of some aspects of the issue.

The most important government decision, that of April 2010, declared the problem of coastal cliff collapse as one of national urgency. Subsequently, the prime minister's office led an interministerial committee (including both the Ministry of the Environment and the Ministry of the Interior) charged with preparing recommendations on the subject. The committee proposed adopting responses to cliff collapse according to a commissioned report (Bein et al. 2010), which led to Government Decision 3097 of April 2011. At this time, more than US$100 million were allocated to the cause of coastal protection.

In July 2011, an additional government decision (1) set up the government corporation to address cliff protection, (2) established dedicated positions within the IMoEP to deal with the issue, and (3) earmarked government funding (for the IMoEP) for coastal cliff protection. Policy recommendations adopted at this time included (1) not allowing any further development along the cliff, (2) restricting the issuance of building permits derived from approved plans that pertain to the coastal area until a comprehensive plan is approved for coastal defense, (3) developing new plans that prohibit development in some areas where it was previously allowed, and (4) abandoning and destroying existing buildings as needed using mechanisms of eminent domain.

Comprehensive national planning efforts have led to the preparation of a National Outline Scheme for the Coastal Cliff. Labeled Amendment 9 of NOS 13 (hereafter *NOS 13/9*), this master-level plan implements principles adopted by the government in past decisions. A corresponding detailed plan (NOS 13/9/A) was approved in June 2015 whose main purpose is to establish detailed arrangements for the protection of prioritized segments ("cells") of mostly urban cliff areas. The plan mandates that a "cell analysis plan" be prepared and approved by the subcommittee of the National Planning Board for each designated cell, with cells encompassing between 300 m and 1 km of shoreline. Such cell plans represent an intermediary step between detailed planning and final permitting of construction, and they will determine which solutions from the options detailed in NOS13/9/A are suited to a particular cell. Solutions address four parts of the cliff: base, slope, cliff head and cliff top (or in Hebrew: "cliff roof"). Possible protections include tarps, vegetation, slope regrading, sea walls and revetments, and runoff treatments. Only one such plan has been approved so far for the city of Ashkelon's coast (Fig. 1), where cliff erosion problems are severe. Further, the adopted policy of planning cells contradicts ICZM principles; the mitigation actions in a cell may affect other cells, yet separate, uncoordinated determination of the best local solution is often the result.

The third major action has been the finalizing of the Mediterranean Coastal Cliff Preservation Government Company Ltd. in late 2013 according to government decree. The government-owned company has a mandate to make detailed plans and implement them in cooperation with the local municipalities in order to protect and strengthen the cliffs, as well as to monitor and maintain marine coastal protection structures (IMoEP 2015, 2016). However, the

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company has a limited mandate. It must address cliff protection through actions taken in submerged areas (marine side) of the coast, and because of a dependence on outsourcing, those executing the company's work may lack familiarity with local conditions. Also, submerged areas tend to be favored for action by the Cliff Preservation Company for the simple reason that the company is funded by the national government, whereas landside protections are funded by local authorities.

Discussion

While IWM, ICZM, and WSUD are relevant to the treatment of runoff affecting coastal cliff collapse, existing policies and plans have failed to incorporate the principles they espouse in a systematic or coordinated fashion. Therefore, a discussion of impediments and opportunities for their synthesis follows. Such synthesis could lead to the improvement of resilience for coastal communities by guiding land-use changes and developing building codes and engineering design standards for implementation at the local level. Such guidance is consistent with two of the "reaction modes" recommended by Travis (2009) for reducing underlying exposure and vulnerability to improve coastal community resilience.

From the analysis of the case study, impediments to integration for the purposes of countering cliff erosion along Israel's Mediterranean coast can be characterized as socio-institutional, meaning that they require addressing issues beyond those that are strictly technological and engineering issues. Such characterization coincides with other studies that address both water resources management (Brown and Farelly 2009) and coastal zone management (Sekhar 2005; Portman et al. 2012). In general, scholars have described barriers that impede transitioning to sustainable urban water management as socio-institutional, For example, professional expertise is needed to enhance implementation of regulation and to mediate constituencies with different values and goals related to cultural norms and institutions (see Brown and Farelly 2009; Brennan and Portman 2017). Whereas technical knowledge exists (such as the use of breakwaters to protect beach base width to keep waves from cutting into the bottom of cliffs), competing interests at different levels of government hinder integration. These interests lead to a standoff about coastal cliff collapse prevention between local governments and national-level government, which plays out as a lack of funding, a distinctly socio-institutional barrier.

Impediments to integration can also be characterized as those related to spatial scale (Cash et al. 2006) or as those related to spatially designated institutional mandates that separate coastal cliff protection responses into those designed for either the marine realm or the terrestrial realm, but not both. As for issues of spatial scale, whereas terrestrial problems may be solved at the local scale, because of the characteristics of the marine environment—particularly the fluid nature of the nearshore marine environment and geomorphological dynamics (Beatley et al. 2002)—hazards must be addressed at a district, national, or regional scale. The Government Coastal Cliff Protection Company has a mandate to implement exclusively marine-side coastal cliff protection solutions, such as the construction of submerged breakwaters, for which government financing is assured. For landside treatment solutions, including those involving cliff-top runoff management, burdens fall on the local authorities whose inaction derives, justifiably or not, from a lack of funds.

On a technical level, a major impediment for applying practices of WSUD to the coastal zone is a lack of congruence between physical conditions in different geographic areas. Water infiltration is frequently promoted as a WSUD technique in arid environments (Carmon and Shamir 2010). Israel's coastal plain has relatively high-quality runoff that renders it suitable for reuse or direct recharge into the local aquifer (Goldshleger et al. 2015). In addition to flood protection and stream rehabilitation (Sadan et al. 2011), recharge and use of surface runoff relieves pressure to desalinate. Therefore, WSUD and the localized WSP seek infiltration (Carmon and Shamir 2010), yet this approach conflicts with efforts to redirect water at the top of coastal cliffs, where water infiltration leads to cliff instability (Arkin and Michaeli 1985; Bein et al. 2010). The implication is that WSUD can be applied only if it is tailored to specific local coastal conditions. Perhaps because it is so context specific, WSP is not widely implemented in Israel even when previsions are made for it through statutory plans and regulations (e.g., NOS 34/B/4 requiring 15% pervious surface for areas slated for new development) and compliance is low (A. Hayim, personal communication, 2016b).

The provision of ever-increasing amounts of desalinated water render WSP less urgent in the eyes of local technocrats who see little reason to invest in surface water collection technologies, such as irrigation pools. In some cities, localized infrastructure solutions exist (since before cliff collapse was a problem) that collect runoff from cliff tops and channel it into large underground pipes leading away from the shore. Landward sloping at the cliff top ensures that runoff is channeled into large underground pipes and redirected for discharge at sea. In highly developed urban environments, such as Tel Aviv and Netanya (Fig. 1), tendencies are to enlarge these underground structures to absorb more runoff. For example, Netanya has plans to double the size of the existing 2.5-m-diameter pipe that collects runoff averted from landward graded cliff-top edges for seaward diversion as urban development expands along the coast (A. Akerman, personal communication, 2016a; M. Hayim, personal communication, 2016b). The discharge of this water, without exploitation of it assuming that water desalination will fill the gap, is an erroneous approach. Desalinated water exacts a heavy environmental and economic price (e.g., energy consumption) and desalination plants decrease the already limited land supply along Israel's Mediterranean coast (Feitelson and Rosenthal 2012; Tal 2013).

Planners and managers face myriad challenges in implementing the water management paradigms discussed here, and synthesizing the three is even more challenging. Even so WSUD and the local WSP center on the integration of land-use planning with water resources management, which should include aspects of coastal management. At the same time, since ICZM focuses heavily on nearshore land-use controls, broadening its scope to encompass management of all types of surface runoff management, including those related to cliff protections, should be considered. As mentioned, great care needs to be taken in implementing general principles of WSUD, such as infiltration, which can be highly detrimental in the coastal zone. Therefore, true integrated management practices need to offer context-appropriate localized solutions that are coordinated with comprehensive regional or, in Israel's case, national comprehensive water and coastal planning.

A promising opportunity for a practical solution may be available as part of the effort to consolidate the large number of sectoral National Outline Schemes promulgated over the years into a single Outline Scheme, dubbed NOS 1. This new plan, the first draft version of which was made available in August 2016 (Kaplan 2016), addresses both the coastal environment and the management of runoff, albeit in separate chapters. This is a singular opportunity to coordinate development policies and regulations that apply to each in an integrated manner. Practices described in general terms in NOS 13/9 could be incorporated in further detail, both for the

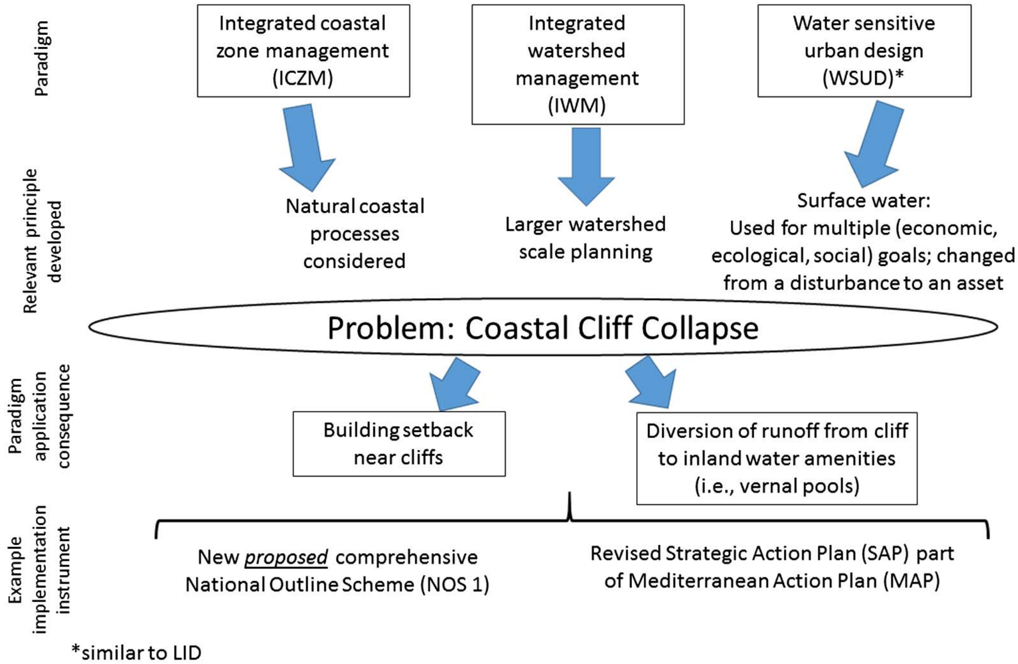

Fig. 3. Diagram illustrating how IWM, ICZM, and WSUD can be synthesized in order to provide solutions to coastal cliff collapse problems using mechanisms particular to the case study

chapter detailing with protected areas and that dealing with water, if sections addressing coastal cliff areas were added.

Another opportunity for integrating the three paradigms in order to address coastal cliff collapse is through the country's Strategic Action Plan (SAP), which is part of its Mediterranean Action Plan (MAP). This plan stipulates Israel's obligations to the Barcelona Convention (State of Israel 2015). Although the newest plan—a revision of the 2005 SAP—focuses mostly on the prevention of pollution to the Mediterranean Sea from land-based sources, its proposed approach to stormwater runoff management could be broadened to include aspects of shoreline change. (In fact, a new MAP Phase II document published April 12, 2017, by the Barcelona Convention Working Group for Assessment of the MAP states, "the focus of MAP gradually shifted from a sectoral approach to pollution control to integrated coastal zone planning and management as the key tool through which solutions are being sought"). Both opportunities, Israel's SAP and its NOS 1, are listed in Fig. 3 as concrete examples of ways to promote planning solutions to protect coastal cliffs originating in the three water resources management paradigms: IWM, ICZM, and WSUD.

Conclusions

Generally, water management paradigms can be broadened and tailored to consider coastal erosion in view of the prominent (and growing) role of urbanized coasts. Three water resource–related management paradigms—IWM, ICZM, and WSUD—can be simultaneously applied and synthesized for planning in urban environments suffering from coastal cliff collapse by improving surface runoff management. Countering effects of urban storm and irrigation runoff that destabilizes cliffs is especially critical as sea-level rise and more frequent and intense storms that lead to shoreline change, reduce urban resilience and leave communities vulnerable. While municipalities may have limited authority to mitigate global and regional effects of climate change that impact shoreline erosion or accretion most (such as sea-level rise and more frequent and intense storm surges), they make and implement significant decisions about the treatment of surface water runoff.

Our findings and analysis lead to the conclusion that WSUD could be expanded to take into account the specific condition of coastal cities and urban coastal development in ways that link the paradigm to coastal zone management efforts and integrated water management. In the case of Israel, one such opportunity is provided by the consolidation of sectoral National Outline Schemes into a single comprehensive plan, and the other is within the framework of the country's Strategic Action Plan addressing inland water influences on the Mediterranean shore. Policymakers in other areas of the world should look for similar opportunities to synthesize the three paradigms discussed here in plans, policies, and other regulatory initiatives.

References

Alfasi, N. (2009). "Can planning protect the public interest? The challenge of coastal planning in Israel." *Geogr. Res. Forum*, 29, 83–102.
Amir, S. (1987). "Classification of coastal resources: A Mediterranean case study." *Landscape Urban Plann.*, 14, 399–414.
Arkin, Y., and Michaeli, L. (1985). "Short- and long-term erosional processes affecting the stability of the Mediterranean coastal cliffs of Israel." *Eng. Geol.*, 21(1–2), 153–174.
Barbier, E. B. (2014). "A global strategy for protecting vulnerable coastal populations." *Science*, 345(6202), 1250–1251.
Beatley, T., Brower, D. J., and Schwab, A. K. (2002). *An introduction to coastal zone management*, Island Press, Washington, DC.
Becker, N., and Ward, F. A. (2015). "Adaptive water management in Israel: Structure and policy options." *Int. J. Water Resour. Dev.*, 31(4), 540–557.
Bein, A., Edelman, A., and Cohen, G. (2010). "Cliff collapse along the coast of Israel—Response, economic, public and environmental impacts." Israel Ministry of Environmental Protection and Jerusalem Institute of Israel Studies, Jerusalem, 48 (in Hebrew).

Brown, R. R., and Farelly, M. A. (2009). "Delivering sustainable urban water management: A review of the hurdles we face." *Water Sci. Technol.*, 59(5), 839–846.

Brennan, R. E., and Portman, M. E. (2017). "Situating Arab-Israeli artisanal fishermen's perceptions of marine litter in a socio-institutional and socio-cultural context." *Mar. Pollut. Bull.*, 115(1–2), 240–251.

Carlson, C., Foltz, K., Kirshen, P., and Barreteau, O. (2015). "Storm water management as a public good provision problem: Survey to understand perspectives of low-impact development for urban storm water management practices under climate change." *J. Water Resour. Plann. Manage.*, 10.1061/(ASCE)WR.1943-5452.0000476, 04014080.

Carmon, N., and Shamir, U. (2010). "Water-sensitive planning: Integrating water considerations into urban and regional planning." *Water Environ. J.*, 24(3), 181–191.

Carmon, N., and Shamir, U. (2011). "Storm water and drainage management: Issues with the framework of the national outline scheme for the water sector." *Water Eng. Israel Water Mag.*, 73(36–45), 1–7 (in Hebrew).

Cash, D. W., et al. (2006). "Scale and cross-scale dynamics: Governance and information in a multilevel world." *Ecol. Soc.*, 11(2), 8–20.

Cicin-Sain, B., and Knecht, R. W. (1998). *Integrated coastal and ocean management: Concepts and practices*, Island Press, Washington, DC.

Davidovitch, F. K. (2009). "Cliff retreat along the shores of Israel: Its causes and agency responses." *Rep. Knesset's Committee of the Interior and Environmental Protection*, The Knesset, Center for Research and Science, Jerusalem, Israel, 11 (in Hebrew).

Davis, R. J., and Fitzgerald, D. (2004). *Beaches and coasts*, Blackwell Science, Malden, MA.

Douglas, E., et al. (2012). "Coastal flooding, climate change and environmental justice: Identifying obstacles and incentives for adaptation in two metropolitan Boston Massachusetts communities." *Mitigation Adaptation Strategies Global Change*, 17(5), 537–562.

Doody, P., et al., eds. (2004). *Living with coastal erosion in Europe: Results from the Eurosion study*, Office for Official Publications of the European Communities, Luxembourg, 21.

European Environment Agency. (2006). *The changing faces of Europe's coastal areas*, Office for Official Publications of the European Communities, Luxembourg, 107.

European Parliament. (2002). "Recommendation of the European parliament and council of 30 May 2002 concerning the implementation of ICZM in Europe (2002/413/EC)." *Official Journal of the European Communities L 148 6.6.2002*, Luxembourg, 24–28.

Feitelson, E., and Rosenthal, D. (2012). "Desalination, space and power: The ramifications of Israel's changing water geography." *Geoforum*, 43(2), 272–284.

Ferguson, B. C., Brown, R. R., Frantzeskaki, N., de Haan, F. J., and Deletic, A. (2013). "The enabling institutional context for integrated water management: Lessons from Melbourne." *Water Res.*, 47(20), 7300–7314.

Fischhendler, I., and Heikkila, T. (2010). "Does integrated water resources management support institutional change? The case of water policy reform in Israel." *Ecol. Soc.*, 15(1), 4.

Fletcher, S. (2000). "The evolution of coastal management policy in the state of Israel." *Mar. Policy*, 24(5), 395–405.

Fletcher, T., et al. (2015). "SUDS, LID, BMPs, WSUD and more—The evolution and application of terminology surrounding urban drainage." *Urban Water J.*, 12(7), 525–542.

Gabbay, S., ed. (2000). "UNEP/MAP/PAP coastal area management programme (CAMP) Israel." *Final Integrated Rep.*, Israel Ministry of the Environment, Jerusalem.

Globus-Israel Business Section. (2009). "Twenty year old killed by Kukar cliff collapse." *Globus-Israel Business Section*, March 30, 2009 (in Hebrew).

Goldshleger, N., Maor, A., Garzuzi, J., and Asaf, L. (2015). "Influence of land use on the quality of runoff along Israel's coastal strip (demonstrated in the cities of Herzliya and Ra′anana)." *Hydrol. Process.*, 29(6), 1289–1300.

Gvirtzman, G., Shachnai, E., Bakler, N., and Hani, S. (1983). "Stratigraphy of the Kurkar Group (Quaternary) of the coastal plain of Israel." Geological Survey of Israel Current Research 1983–1984, Jerusalem, 70–82.

Hammer, M., Balfors, B., Mörtberg, U., Petersson, M., and Quin, A. (2011). "Governance of water resources in the phase of change: A case study of the implementation of the EU water framework directive in Sweden." *AMBIO J. Hum. Environ.*, 40(2), 210–220.

Hapke, C. J., Reid, D., and Richmond, B. (2009). "Rates and trends of coastal change in California and the regional behavior of the beach and cliff system." *J. Coastal Res.*, 25(3), 603–615.

Hering, J., and Ingold, K. (2012). "Water resources management: What should be integrated?" *Science*, 336(6086), 1234–1235.

Hunt, A., and Watkiss, P. (2011). "Climate change impacts and adaptation in cities: A review of the literature." *Clim. Change*, 104(1), 13–49.

IMoEP (Israel Ministry of Environmental Protection). (2015). "Strategic action plan (SAP) to address pollution from land-based activities (English version)." Ministry of the Environment, Israel, 145.

IMoEP (Israel Ministry of Environmental Protection). (2016). "The Mediterranean coastal cliff preservation—Government Company Ltd. (in Hebrew)." ⟨http://www.sviva.gov.il/AboutOffice/authorities-minister/Pages/CoastalCliffs-GovernmentCompany.aspx#GovXParagraphTitle1⟩ (Feb. 24, 2016).

Israel Water Authority. (2012). "The long term master plan for the water sector." The Water Authority, State of Israel, Jerusalem, 102.

Herut, B., All Scientific Group of IOLR, and National Institute of Oceanography. (2015). "The National Monitoring Program of Israel's Mediterranean waters." *Scientific Rep. for 2013/14, IOLR Rep. H21/2015*, Ministry of Environmental Protection, Israel.

Jønch-Clausen, T. (2004). "Integrated water resources management (IWRM) and water efficiency plans by 2005—Why, what and how?" Global Water Partnership, Stockholm, Sweden.

Kaplan, M. (2016). "National outline scheme one." Ministry of Finance, Jerusalem (in Hebrew).

Katz, O., and Mushkin, A. (2013). "Characteristics of sea-cliff erosion induced by a strong winter storm in the eastern Mediterranean." *Quat. Res.*, 80(1), 20–32.

Kelly, R. P., et al. (2011). "Mitigating local causes of ocean acidification with existing laws." *Science*, 332(6033), 1036–1037.

Larsen, T. A., Hoffmann, S., Lüthi, C., Truffer, B., and Maurer, M. (2016). "Emerging solutions to the water challenges of an urbanizing world." *Science*, 352(6288), 928–933.

Laster, R., Almog, R., Livni, D., and Rosenthal, M. (2009). "Examination and adaptation of low impact development (LID) in Israeli conditions." *Rep. to the Ministry of National Infrastructure*, Jerusalem (in Hebrew).

Limber, P. W., Patsch, K. B., and Griggs, G. B. (2008). "Coastal sediment budgets and the littoral cutoff diameter: A gram size threshold for quantifying active sediment inputs." *J. Coastal Res.*, 24(2A), 122–133.

Ma, Z., et al. (2014). "Rethinking China's new great wall." *Science*, 346(6212), 912–914.

Massoud, M. A., Scrimshaw, M. D., and Lester, J. N. (2004). "Integrated coastal zone and river management: A review of the literature, concepts and trends for decision makers." *Water Policy*, 6, 519–548.

Melloul, A., and Collin, M. (2009). "Key natural and anthropogenic parameters enhancing the effect of sea level rise: The case of Israel's Mediterranean coast." *Ocean Coastal Manage.*, 52(1), 39–46.

Menahem, G. (2001). "Water policy in Israel 1948–2000: Policy paradigms, policy networks and public policy." *Israel Affairs*, 7(4), 21–44.

Minhea, R., et al. (2006). "Deliverable 4.2: Assessment of hazards and threats on the coastal zone, arising either from global change or from regional variability due to either natural or anthropogenic forcing." *IASON Project No. 515234*, Hellenic Centre for Marine Research, Athens, Greece, 264.

Newson, M. D. (2000). "Science and sustainability: Addressing the world water 'crisis.'" *Prog. Environ. Sci.*, 2(3), 204–228.

Olsson, L., Jerneck, A., Thoren, H., Persson, J., and O'Byrne, D. (2015). "Why resilience is unappealing to social science: Theoretical and empirical investigations of the scientific use of resilience." *Sci. Adv.*, 1(4), e1400217.

PAP/RAC (Priority Actions Programme/Regional Activity Centre). (2007). "ICZM protocol in the Mediterranean (as signed in Madrid on 21 January 2008)." ⟨http://www.coastday.org/iczm_policy_workshop/documents/ICZM_flyer_en.pdf⟩ (Jan. 21, 2008).

Pilkey, O. H., and Cooper, J. A. G. (2004). “Society and sea level rise.” *Science*, 303(5665), 1781–1782.

Portman, M. E. (2012). “Losing ground: Mediterranean shoreline change from an environmental justice perspective.” *Coastal Manage.*, 40(4), 421–441.

Portman, M. E. (2015). “Marine spatial planning in the Middle East: Crossing the policy-planning divide.” *Mar. Policy*, 61, 8–15.

Portman, M. E., Esteves, L. E., Le, X. Q., and Khan, A. Z. (2012). “Improving integration for integrated coastal zone management: An eight country study.” *Sci. Total Environ.*, 439, 194–201.

Randolph, J. (2011). *Environmental land use planning and management*, Island Press, Washington, DC.

Rhoads, B. L., Wilson, D., Urban, M., and Herricks, E. E. (1999). “Interaction between scientists and nonscientists in community-based watershed management: Emergence of the concept of stream naturalization.” *Environ. Manage.*, 24(3), 297–308.

Rinat, Z. (2012). “A new government company will plan and construct various measures to save sections of the cliffs in danger of collapse, including such solutions as building breakwaters.” *HaAretz*, July 17.

Rosen, D. S., Galanti, B., Golan, A., and Raskin, L. (2007). “Policy document on the collapse of coastal cliffs: Assessment study on the expected changes until 2100 at the beach cliffs of the country under the influence of climate change via marine morpho-dynamic processes.” *Final Rep., IOLR Rep. H6/2007*, Israel Oceanographic and Limnological Research, Haifa, Israel (in Hebrew).

Rosen, S. D. (2010). “Assessing present and future Mediterranean sea level rise impact on Israel’s coast and mitigation ways against beach and cliff erosion.” *32nd Int. Conf. on Coastal Engineering*, Shanghai, China, ASCE, Reston, VA, 12.

Sadan, E., et al. (2011). “Roadmap for the environmental management of surface runoff in rivers of Israel. Part A: Analysis of existing conditions.” Ministry of the Environment, Jerusalem, 148 (in Hebrew).

Sas, E., Fishhendler, I., and Portman, M. E. (2010). “The demarcation of arbitrary boundaries for coastal zone management: The Israeli case.” *J. Environ. Manage.*, 91(11), 2358–2369.

Sekhar, N. U. (2005). “Integrated coastal zone management in Vietnam: Present potentials and future challenges.” *Ocean Coastal Manage.*, 48(9–10), 813–827.

Semeoshenkova, V., and Newton, A. (2015). “Overview of erosion and beach quality issues in three Southern European countries: Portugal, Spain and Italy.” *Ocean Coastal Manage.*, 118, 12–21.

Shipman, B., and Stojanovic, T. (2007). “Facts, fictions and failures of integrated coastal zone management in Europe.” *Coastal Manage.*, 35(2–3), 375–398.

State Comptroller. (1998). “Land use planning along the Mediterranean coast.” *Rep. No. 49*, Office of the State Comptroller, Jerusalem (in Hebrew).

State Comptroller. (2010). “Governing authorities treatment of cliff collapse.” *Rep. for 2009 on the Local Authorities*, State Comptroller, Jerusalem, 365–408 (in Hebrew).

State of Israel. (2015). “2015 Strategic action plan (SAP) to address pollution from land based activities.” Ministry of Environmental Protection, Jerusalem, 145.

Stebbins, R. A. (2001). *Exploratory research in the social sciences*, Sage, London.

Tal, A. (2013). “Shifting sands.” *Harv. Int. Rev.*, 35(2), 37.

Tanski, J. (2007). *Long Island South Shore: A primer on the forces and trends shaping our coast*, New York Sea Grant, Stony Brook, NY, 27.

Tefera, B., and Stroosnijder, L. (2007). “Integrated watershed management: A planning methodology for construction of new dams in Ethiopia.” *Lakes Reservoirs Res. Manage.*, 12(4), 247–259.

Travis, WR. (2009). “Going to extremes: Propositions on the social response to severe climate change.” *Clim. Change*, 98(1), 1–19.

Tzafrir, D. (2005). “The coastal zone act: The social purpose and environmental justice.” *Merkarkeyim*, 4(1), 83–84 (in Hebrew).

UNEP. (2001). “Mediterranean action plan CAMP project “Israel”.” *Final Integrated Rep. and Selected Documents, MAP Technical Rep. Series No. 134*, Athens.

UNISDR (United Nations Institute for Disaster Risk Reduction). (2012). *How to make cities more resilient: A handbook for local government leaders*, Geneva, 102.

Weimer, D. L., and Vining, A. R. (2011). *Policy analysis: Concepts and practice*, Prentice Hall, Upper Saddle River, NJ.

Zoltay, V. I., Vogel, R. M., Kirshen, P. H., and Westphal, K. S. (2010). “Integrated watershed management modeling: Generic optimization model applied to the Ipswich river basin.” *J. Water Resour. Plann. Manage.*, 10.1061/(ASCE)WR.1943-5452.0000083, 566–575.

Zviely, D., and Klein, M. (2004). “Coastal cliff retreat rates at Bait-Yannay, Israel, in the 20th century.” *Earth Surf. Process Landforms*, 29(2), 175–184.

Zviely, D., Kit, E., and Klein, M. (2007). “Longshore sand transport estimates along the Mediterranean coast of Israel in the Holocene.” *Mar. Geol.*, 237, 61–73.

J. Water Resour. Plann. Manage., 2018, 144(4): 05018005