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Detached islands: Artificial islands as adaptation challenges in the making

Michelle E. Portman

Associate Professor, Faculty of Architecture and Town Planning, Technion – Israel Institute of Technology, Kiryat HaTechnion, Haifa, Israel, 32000
mep@technion.ac.il

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Abstract

There is surprisingly little information and concern within academic literature in the field of coastal or marine planning and management related to the issue of artificial islands. This is particularly noteworthy considering the climate change phenomenon, vis á vis sea-level rise, the urgent need for adaptation, efforts aiming for sustainable use of coastal areas, and the recent focus in academic circles on marine spatial planning. Most literature (including grey literature) on artificial islands appears in the engineering and geology disciplines and is focused on energy extraction, i.e., oil and gas. Yet some coastal nations are intent on solving problems of lack of space and other resource shortages through construction of near-shore artificial islands for myriad uses, including commercial, residential and transportation infrastructure. This paper presents a limited review of the policy literature about planning and construction of artificial islands. It reflects what repercussions artificial islands portend for marine conservation, sustainability and, most importantly, how climate change adaptation is highlighted or neglected in spatial solutions addressed by the building of nearshore artificial islands. The Israeli situation, where tenders have been recently published calling for planning and building of islands in the Mediterranean Sea, serves as an example.

Zusammenfassung

In der Literatur zur Küsten- oder Meeresplanung gibt es überraschend wenig Informationen über künstlich aufgeschüttete Inseln. Dies ist insbesondere bemerkenswert im Kontext eines sich wandelnden Klimas, dem einhergehenden Meeresspiegelanstieg und der dringenden Notwendigkeit der Anpassung, sowie der Bemühungen um eine nachhaltige Nutzung der Küstengebiete und der jüngsten Konzentration in akademischen Kreisen auf maritime Raumordnung. Der überwiegende Teil der Literatur (einschließlich grauer Literatur) über künstlich aufgeschüttete Inseln erscheint in den Gebieten Ingenieurswesen und Geologie und konzentriert sich auf die Energiegewinnung von beispielsweise Öl und Gas. Weiterhin gibt es einige Küstenstaaten, die entschlossen sind, Probleme wie Platzmangel und Ressourcenknappheit durch den Bau und die Nutzung (Handel-, Wohn- und Verkehrsinfrastruktur) von küstennahen, künstlich aufgeschütteten Inseln zu lösen. Diese Studie gibt einen Überblick über die einschlägige Fachliteratur zur Planung und Realisierung von künstlichen Inseln. Es werden die Auswirkungen von künstlichen Inseln auf die Nachhaltigkeit von marinen Ökosystemen diskutiert und analysiert, ob Klimaanpassungen in räumlichen Lösungen beim Bau der Inseln integriert werden. Ein aktuelles Fallbeispiel ist Israel, wo kürzlich die Planung und der Bau von Inseln im Mittelmeer ausgeschrieben wurde.

Keywords ocean sprawl, artificial islands, Mediterranean Sea, sea reclamation, offshore islands

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1. Introduction

Despite significant research on sea level rise (SLR) and other coastal shoreline change phenomena (e.g., accelerated erosion) related to the effects of climate change, there seems to be surprisingly little concern and interest in how these effects might be connected to the topic of artificial offshore islands. In general, within the academic literature (as opposed to professional "grey" literature), there is a dearth of publications on the subject of artificial islands. A cursory search in EBSCOhost ("Environment complete") database conducted on 16 August 2018 using the words "artificial islands" searched for within abstracts, resulted in 141 publications, many from the engineering field; a same-date search using the terms "artificial islands" together with "environmental impacts" in abstracts, resulted in only three sources.

Within the growing body of literature on climate change, many publications focus on increasing problems of loss of land area by erosion and inundation (*Douglas* et al. 2012; *Katz* and *Mushkin* 2013*; Semeoshenkova* and *Newton* 2015) and solving those problems (e.g. *Lister* and *Muk-Pavic* 2015; *Zviely* et al. 2015). It seems that these same issues should be of concern when considering the construction of offshore artificial islands. Yet there is a disconnect in the public discourse about offshore islands in the current era punctuated by climate change. Problems to be encountered during the construction and maintenance of offshore islands (e.g., rising sea levels, frequent and intense sea storms, etc.) seem to be missing from the climate change research and literature, therefore, both literally from their attendant mainland, and figuratively, based on the discourse, such islands are "detached".

One of these examples involves discussions among planners in Israel about the potential of offshore islands to serve as a solution for increasing building and population densities in the country. While there is a significant amount of interest in constructing offshore artificial islands in Israel's Mediterranean ocean space, such as a recommendation to consider the building of nearshore islands for solving infrastructure needs as mentioned in the Technion's Israel Marine Plan (*Technion Marine Plan Integrating Team* 2015), rarely is any connection made to the effects of climate change in this regard.

Certainly there are reasons for concern about how islands might be effected by climate change and also about how they affect ecosystems services related to climate change mitigation. The latter is a type of feedback effect, described by *Harte* (2010) whereas rising temperatures bring about the need for actions that intensify and accelerate heating of the globe even further. With regard to changes in the coastal zone, because erosion and rising sea levels have reduced available shorelines, new shorelines are constructed on new offshore islands – a type of artificial production of space. However, at the same time the areas constructed do away with the ocean-water resources that would otherwise serve as sinks of carbon sequestration, through for example, absorption of CO_2 by carbon sequestration.

Thus a clarifying of the potential detrimental effects of detached islands is in order. From an urban planning or environmental planning perspective, such a review needs to go well beyond impacts on the ecological function and the importance of the seas for climate regulation and stabilization. It needs to include the impacts on society resulting from the maintenance of such structures, the financial strain on budgets, as well as impacts on existing spatial conditions such as urban edges, accepted jurisdictional boundaries, and impacts on stable oceanographic conditions (e.g., currents, temperature and salinity gradients, upwelling, etc.), even regardless of climate change trends.

The detrimental possibilities related to constructed offshore structures have led to the use of new term: "ocean sprawl" (*Bishop* et al. 2017). Like urban sprawl on land, with its negative consequences and connotations (*Randolph* 2011), short- and long-term impacts of artificial islands as well as proximate and distanced spatial effects, must be weighed in relation to any possible advantages. Other issues are cost, financial and otherwise. Due to changing conditions and other challenges that are part and parcel of the dynamic nearshore environment, construction costs would likely be lower than maintenance costs over time especially under the current changing, uncertain and more erratic climate regime.

This paper first of all describes and clarifies what is meant by "artificial islands". Once the term is clear, the scope of such islands is addressed. These effects are viewed in relation to work on adaptation to climate change, highlighting a dissonance. The second part of this paper focuses on the Israeli case; it covers recent initiatives that strongly advocate the building of artificial islands along Israel's Mediterranean shoreline. By bringing the two parts of the paper together in the discussion, we see that on the one hand, proponents are pushing ahead with islands to solve planning problems. On the other hand, challenges, including those related to climate change adaptation measures could be significant (see *Zviely* et al. 2015). This paper concludes with some speculation as to why there is such a "disconnect" between efforts to build offshore artificial islands and efforts to adapt to climate change along coasts in the Israeli context.

2. Artificial islands

2.1 What are "artificial islands"?

The term "artificial island" can be ambiguous. For centuries, coastal development has included filling and land reclamation for human purposes. As far back as during pre-historic times, hunter-gathers constructed "gardens" in the low intertidal areas of coasts, expanding and maintaining the area for clams to live and be harvested that consisted of human-made partially submerged rock-walls and terraces (*Rick* and *Erlandson* 2009). Could these be called islands? They were areas designed for human use but it is unclear whether these early ancient activities constituted islands per se. As other examples, are today's detached breakwaters types of islands? Are polders, built centuries ago, but still maintained today in the Netherlands (*Diamond* 2005: 519), also types of artificial "islands" of human activity in what used to be sea?

Certainly over the course of human history, protective structures, from barrier islands to rock piles, are in essence artificial structures promoted and constructed as a means of generating space, protecting shorelines from wave and storm damage and supporting human access to the deeper areas of the sea. *Chee* et al.'s (2017) informative paper describes the massive land reclamation efforts around Penang, Malaysia as an example of what is common now in Asia and the Middle East and what the authors depict as a "global conservation issue". The study includes many different types of "ocean sprawl" as they call it, from the building of seawalls, rock armouring, breakwaters and marinas, to the "construction of whole new islands". So, how can the construction of artificial islands be distinguished from varied types of age-old practices designed to enable humans to use the sea area?

The most logical place to start with for a definition of what constitutes an island, is the UN Convention on the Law of the Sea (UNCLOS). According to UNCLOS (*UN General Assembly* 1982), an island is: "a naturally formed area of land, surrounded by water, which is above water at high tide." If one adds "artificial" to this definition: "caused or produced by a human" (*Merriam-Webster* 2003), many structures, masses and even objects, could be included. The first place "artificial islands" is mentioned in UNCLOS relates to ports (Part II, §2, Article 11): Off-shore installations and artificial islands shall not be considered as permanent "harbour" works. Most importantly, UNCLOS establishes in Article 56, rights, jurisdiction and duties of the coastal State in the exclusive economic zone (EEZ) with regards to the establishment and use of artificial islands, installations and structures.

While UNCLOS (Article 60) establishes clearly that coastal states have the exclusive right to construct, authorize and regulate the construction, operation and use of artificial islands, such artificial features do not have the status of islands (e.g., for example affecting the delimitation of the territorial sea, the EEZ or the continental shelf). However, this has not stopped China from claiming that massive land reclamation projects in the Spratly Islands area of South China Sea[1] around rocky outcrops (previously used only to shelter fishermen) are sufficient to change the status of features for extending Chinese jurisdiction and access to important resources, including usable space. China's claims *vis á vis* the Philippines, the adjacent coastal state, were decided by the International Tribunal on the Law of the Sea. In any case, China's massive island-building project, which began after the Philippines' initiation of UNCLOS Annex VII proceedings against China in January 2013, created more than 12.8 million square meters of new land around what the Tribunal determined to be "low-tide elevations", an action that has engendered international attention far beyond the maritime community (*Davenport* 2018).

2.2 What are the environmental effects of such islands?

Generally speaking, effects of artificial islands on the marine environment encompass just about every impact imaginable. They will, in many cases, adversely affect humans and flora and fauna of the marine and terrestrial environments (*Holon* et al. 2018). Most of what is known regarding expected impacts to the marine environment before a detached island is built, is based on modelling. As an example, *Wang* et al.'s (2013) study used a two-dimensional hydrodynamic model applied on the basis of the characteristics of the tides, currents, waves, and sediments in the Jinzhou Bay, China. The purpose was to compare layouts for an insular (detached) artificial island to be used as an airport compared to a peninsular scheme. Expected effects were registered on hydrodynamics, morphological evolution of the coastline, water pollution, and biological resource loss, thus giving an indication of what can be expected for most island layouts.

In addition, aesthetics will also be involved, such as those that have determined the fate of offshore wind farm construction (see *Portman* et al. 2009), although it is debatable whether aesthetic impacts are environmental or more socio-economic. They do fall under the category of ecosystem services, as aesthetics are cultural services valued by humans, just as are bathing beaches and other shore area amenities.

Offshore current flow will change. Temperature and salinity, which are the main determinates of environmental conditions in submerged coastal environments, will change as a result and this is to say nothing yet about the physical impact of anything that is constructed on the sea floor. Even if the islands are more like floating platforms, there will be effects from shading within the water column and of course, any human activities on these platforms (or islands) will likely generate waste adding to the existing debacle of marine litter and pollution. Some of these effects can, of course, be mitigated, but at significant cost.

The construction of artificial islands has already resulted in devastating environmental consequences in the semi-enclosed sea of the Persian Gulf, part of a semi-enclosed sea along the coasts of Dubai. The dredging of sand has led to the restriction and change of currents, turbidity and extreme damage to marine habitats (*Moussavi* and *Aghaei* 2013). Some effects are known, or can be estimated, from work done on tracking land reclamation efforts using remote sensing, such as those conducted to determine the extent of jurisdictional claims, whether these be legal or sanctioned internationally or not (*Davenport* 2018). Turbidity caused by island construction and measured using satellite imagery that shows the appearance of plumes, signifies extreme threats to coral reef communities (*Barnes* and *Hu* 2016).

Chee et al. (2017) claim that eco-engineering and adaptation management can offset some of these impacts. However, in the same study, it is pointed out that not only the decimation of seagrass beds will occur in Penang, Malaysia therefore leading to reduction of habitat for a large variety of marine organisms that are essential to ecosystem function, but livelihoods will be negatively affected as tourism and education values are damaged. The seagrass beds provide habitat, feeding and breeding areas for myriad species including fan shells, sea cucumbers, razor clams, sponges, seas anemones, octopuses and cockles. *Chee* et al. (2017) advocates applying eco-engineering solutions used for shorelines (for example, those promoted by *Firth* et al. (2016)), to larger-scale artificial islands or adopting a "hybrid approach", that includes the building of shellfish reefs in combination with other valuable habitats like mangroves on the edges of artificial islands. Policies that accompany approvals of artificial island construction could require rehabilitation of destroyed sea grass beds, the addition of reef balls and oyster castles that enhance fisheries, using artificial wetlands (presumably on and around the islands) that can treat anthropogenic discharge. The problem is that we know that implementation of environmentally friendly practices often lags behind intentions, especially in developing nations and those where capacity, including adaptive capacity to deal with climate change, is challenged.

At a time when so much effort is being put into improving the marine environment, and in protecting marine ecosystem function and biodiversity, the building of artificial islands seems counterproductive, at least from a strictly environmental perspective. Yet, in countries trying to meet the demand of burgeoning population growth and dwindling resources, especially sources of energy (*Pisacane* et al. 2018; *Portman* 2014), the idea of building artificial islands is always on the table.

2.3 Artificial islands in Israel

Michael Bort, a professor of architecture and urban planning, has been a recent outspoken advocate of building offshore islands in Israel's Mediterranean Sea. In an article published in a prominent geographic journal (in Hebrew), he laid out his plan, dubbed "the Blue Corridor Vision", for such islands. He claims that Israel's burgeoning population, limited land area and growing infrastructure needs, leads planners not to doubt whether such islands *should* be constructed, but rather to ponder the questions of *when* they should be constructed. He contends that all types of urban land uses should be built on islands. For the marine area around the seaside city of Haifa alone, he posits that as much as 25 square kilometers is needed for "urban development" purposes including housing, with approximately 18 square kilometers additional area needed for infrastructure and industry (*Bort* 2009).

Although Bort's article was written a decade ago, and he has been promoting his ideas with considerable success ever since, the idea of building artificial islands in Israel has been around for quite some time. Artificial islands were first considered in the 1970s with conceptual planning ideas being extensively evaluated in the 1990s. At that time around 6 million NIS (equal to approximately 1.4 million Euros today) were allocated by the government to research different options that would be relevant for the Israeli context.

During the years 2005-2007, the Israeli National Planning Authority called for the preparation of a policy document on the subject that addressed the planning of such islands. From among the recommendations presented by the experts hired by the government following this call, the National Planning Authority adopted the following points: 1) land uses on islands should be restricted to infrastructure alone; 2) extensive evaluation, focusing on environmental and economic issues should proceed any detailed planning; 3) an intergovernmental task force would be created to lead the evaluation process; and 4) recommendations from the evaluation would be brought before the National Planning Authority for discussion and approval.

The recently completed Technion Israel Marine Plan (TIMP) (*Technion Marine Plan Integrating Team* 2015: 34-36) addresses the idea of artificial islands with caution and concern, yet with underlying support for the concept. Without identification of particular locations for these islands, the TIMP recommends that artificial islands be considered for the siting of infrastructures to serve the burgeoning population in an attempt to solve the lack of such areas on land. Some caveats mentioned in the TIMP are that such infrastructure centers, whose detailed makeup (floating platforms, or pile supported, etc.) and proposed location is unspecified by the plan, could be approved only if they do not require constructed connections to land via causeways or bridges. Also specified is a required minimal distance from the shore (> 7 km) mostly to avoid aesthetic impacts on views from land.

Perhaps more importantly, the TIMP (*Technion Marine Plan Integrating Team* 2015: 7-8) comes across as reiterating past conclusions that had been arrived at by the Israeli government, and planning community.A policy paper on artificial islands adopted by the National Planning and Building Board in 2007 pointed to a strong preference for the creation of small islands, several thousand square meters in size, for infrastructure facility clusters – power stations, a liquified natural gas terminal and desalination plants. National Outline Plan 37H, approved about the time the TIMP was completed, designated for the first time two large offshore infrastructure areas at distances of 7-10 km from the shore. These areas would be designed to receive and treat natural gas from nearby drilling/extraction sites and their siting would include accompanying pipeline corridors from the facilities to the shore.

Although recommending the consideration of such offshore islands, the TIMP lists various nefarious impacts of construction of islands at distances of less than 7 km from the shore: e.g., the blockage of the northwards transport of sediments and sand along the coast; shortages of fill material in addition to great uncertainty regarding impacts and even seismic instabilities that may impact, and be impacted by, such islands. In addition to listing these impacts, and raising questions with regard to the viability of constructing offshore islands, the TIMP suggests that they be sensitively and sustainably developed. However, beyond declaring that "tools for effective social-environmental-economic assessment of the balance between terrestrial and marine development" be developed, the operational meaning of such conditions is not clear. At the same time, the Israel Marine Plan being developed by the government of Israel's Planning Authority, currently under the auspices of the Ministry of Finance, has been more supportive of the idea of constructing offshore artificial islands in Israel's Mediterranean marine space than the TIMP.

While the Technion's Israel Marine Plan clearly does not recommend considering development of the marine space for general urban land uses beyond infrastructure, at least "in the near future" and the Ministry of Finance's Planning Authority supports their consideration, Israel's environmental community has articulated an adversarial position to them. As a precursor to a workshop (with approximately 100 attendees) held on 1 July 2018 on the subject of artificial offshore islands, a number of environmental organizations published a position paper against the development of offshore artificial islands (although they are willing to support some forms of offshore platforms). Since this time, numerous forums have presented, discussed, considered and adopted resolutions regarding the construction of offshore islands, most recently in the Fall 2018 at a workshop organized by the Economic Committee of the Israel Parliament (Knesset). This followed the Ministry of Transport and Road Safety publication of tenders for the feasibility study for construction of artificial islands in Israel's Mediterranean marine space for an airport and "other uses" (Ministry of Transport and Road Safety 2017). The publication of the environmental NGOs' position paper was headed by the Society for the Protection of the Nature in Israel (SPNI), the Israel Union of Environmental Defense (in Hebrew: Adam, Teva v' Din) and Tzalul; the latter organization focuses almost exclusively on environmental advocacy related to marine, coastal and water policy issues. Their position paper voices concerns about the need for excessive amounts of sand (causing shortages) and distributional challenges of sand use, islands becoming vectors of invasive and alien species (both the islands themselves and sand sources), negative effects on the aesthetics of the coastal and marine landscape, decreasing marine water quality between the islands and the mainland, acceleration of coastal erosion due to the blockage of natural sediment transport and associated beach-narrowing and coastal cliff collapse (see also P*ortman* 2018). While the position paper points out these derogative effects, the paper also offers some solutions (or rather recommends conditions) for constructing islands in a way that would be least impactful to the sea; for example, through the use of preferred floating platforms or filled floating cartridges.[2] Therefore, the document, while clearly opposing many aspects of artificial islands construction, comes across as compromising.

In addition to numerous undesirable impacts articulated by marine and environmental conservation NGOs, the international engineering community has pointed out the detrimental impacts (and challenges) of offshore artificial islands. In general, islands create "shadow zones" where wave and current action would be reduced with the associated impacts on water quality (i.e., stagnation), sediment transport (i.e., deposition) and marine and benthic habitat and organisms. There would also be impacts during the construction phase, including elevated turbidity and noise levels among others (personal communication[3]). Other general news articles have also sounded the alarm regarding impacts to the health of marine and coastal ecosystems from the existence of new artificial islands off the coasts of Dubai and in the South China Sea (e.g. *Cressey* 2011; *Ives* 2016; *Poole* 2009).

For the most part, the possibility of constructing artificial islands off the Mediterranean Sea coast of Israel has been addressed conceptually, even though as time goes on more and more effort is being put into feasibility assessment of such projects by various entities. These include, for the most part, various government ministries, academic institutions and the business sector. Even though most efforts are aimed at building infrastructure on such islands, for example for energy production or for desalination and for storage of substances needed to be stored at some distance from the populated coast, Israel's housing shortage fueled by high reproduction rates and immigration are factors leading to the country's general "turning to the sea" (*Teff-Seker* et al. 2019). By 2035 the country's population is expected to reach 11.4 million people, a 25% growth in population from 2015 (*CBS* 2018); there is no doubt that population growth rates will be a factor in the consideration of offshore artificial island planning.

3. Discussion – Why is there a dissonance?

The final theoretical contribution of this paper suggests a dissonance, and reasons for it, between artificial islands and adaptation strategies. While it is clear that rising sea levels will have overwhelmingly negative impacts on coastal communities and much research has looked at these effects, especially at how SLR affects storm-induced flooding and erosion (e.g. for Israel: *Zviely* et al. 2015; *Bitan* and *Zviely* 2018). There is even new evidence that SLR increases both the frequency and the intensity of *tsunami-induced* flooding (*Li* et al. 2018). Intuitively these impacts affecting coastal infrastructures and communities will be severe on artificial islands, yet the connection is rarely made.

There are, therefore, basically two ways to look at the relationship between artificial islands and climate change. One more unique view, considers the contribution of such islands to the acceleration of climate change. Artificial islands do away with areas of the sea that could serve as carbon sinks and climate regulators and they have great potential to become additional elements that heat the globe's surface. The second view considers the adaptation challenge of artificial islands; they increase human vulnerability in the face of climate change. Here, I focus on the second aspect of the relationship. Risks from climate change effects will be intensified as human elements, whether devoid of human presence or not, are put in climate-vulnerable locations, i.e., directly in harm's way.

From this view, the Mediterranean area, in particular, is quite vulnerable to climate change effects. Under current emission scenarios, the Mediterranean is and will be increasingly affected by climate change in the course of the twenty first century, with severe impacts on the environment and human welfare (*IPCC* 2014). The traditional economic activities that have been guaranteeing the livelihood of coastal communities for centuries are all at risk, in particular agriculture, fisheries and tourism (*Pisacane* et al. 2018).

The area of Alexandria, Egypt, relatively close to the shores of Israel and part of the Nile Delta littoral cell, was used as a coastal case study for an important assessment of the effects of climate change in the Mediterranean Sea conducted as part of the Integrated Research Project – Climate Change and Impact Research (CIRCE): Mediterranean Environment. Since the building of the Aswan High Dam in 1964 there has been a rapid reduction in the amount of sediment accreted, leading to significant and rapid changes along the northern shoreline at the delta's mouth. The most vulnerable areas in the West Nile Delta are the low lying districts of Alexandria, the Behaira governorates, and between Abu Qir Bay and the Rosetta promontory (*Navarra* and *Tubiana* 2013c), however, ultimately, as part of the same littoral cell, Israel's coastline is also affected (*Portman* 2012; *Portman* 2018). These areas are highly vulnerable to the combined hazards of sea-level rise and heat extremes which increase the risk of saline intrusion, flooding and inundation of prime agricultural land and industrial facilities, and insurance losses due to storm damage and coastal flooding. For example, the low-lying deltaic areas of the Nile and Ebro rivers (two of the CIRCE coastal case-study locations) are subject to rapid rates of subsidence and are particularly vulnerable to changes in mean sea level or wave storminess (*Navarra* and *Tubiana* 2013c).

So far, there are no artificial islands built in the Mediterranean and Israel's conceptual plans for them embody a serious precedent. With regard to islands in the Mediterranean, of which there are many[4], only very specific (mostly case study) research has been conducted as part of climate change assessments either on the vulnerability of islands (e.g. *Navarra* and *Tubiana* 2013b) or on the contributions to greenhouse gas emissions. With regard to the latter, one of the few studies connecting Mediterranean islands and climate change in general, were sensitivity runs performed by *Kallos* et al. (2007). The study revealed the role of the Aegean Sea islands as chimneys transferring polluted air masses from the marine boundary layer to the free troposphere (*Navarra* and *Tubiana* 2013a). Effects of SLR on well-being and sustainability of coastal area economies of both islands (*Tzoraki* et al. 2018) and mainland, including Israel (e.g. *Bitan* and *Zviely* 2018), have been conducted, showing significant impacts.

So why is there this disconnect? On the one hand, there is significant literature and knowledge about what changes are likely to occur in Israel from climate change and these have been known for some time (*Paz* and *Kidar* 2007); on the other hand, the planning community and the government seems to be working full-steam-ahead to allow artificial islands to serve as a solution for many resource shortages experienced in the country, particularly that of space. Clearly the building of offshore artificial islands has philosophical, social and environmental health and well-being implications that require more research, discussion and public debate, yet planning is underway. Two potential hypotheses for the lack of caution and hesitation can be conjectured. The first is that the private professional planning community lacks strong connections to the environmental scientific community. The second is that it is well known that short-term fixes are the purview of politicians who in many cases lead the professional community down a risky path of short-term planning.

Integration would be a solution to the first issue – that related to the challenge of linking policy to science. Much has been written about the advantages to integration of this kind (see Fig. 1). The second issue must be addressed through managing risk within the framework of adaptation strategies (see *CRC-URI* 2009). The Israeli government published Decision No. 4079 on 29 July 2018 entitled "Israel's Preparedness for Climate Change: Implementation of the Recommendations to the Government for National Strategy and Action Plan". This decision follows up on two previous government decisions (nos. 474 and 1504 dated 25 June 2009 and 14 March 2010, respectively) that both called for the preparation of such a national strategy and plan. Unfortunately, it has taken almost a decade for the follow up to materialize.

On the upside, the Decision 4079 calls for specific actions that will achieve five goals, the first of which is "Reduction of vulnerability...". A pragmatic step called for by the decision is the establishment of a directorate – The Directorate for Climate Change Preparedness – responsible for coordinating between the many government ministries (almost 20) what will each be required to plan and implement actions supporting the five goals. Since this new decision represents a revival of actions that have been slow in materializing, it is difficult to predict how the national strategy and plan will influence (or not) planning and construction of offshore islands. Of note, is that the Ministry leading the effort towards preparedness for climate change is the Israel Ministry of Environmental Protection (MoEP), known to be underfunded and understaffed. In any case, the MoEP has been instrumental in bringing science to bear on policy in the past and as such, the current government decision is a hopeful one, provided the connection between increasing vulnerability and the development of offshore artificial islands is made.

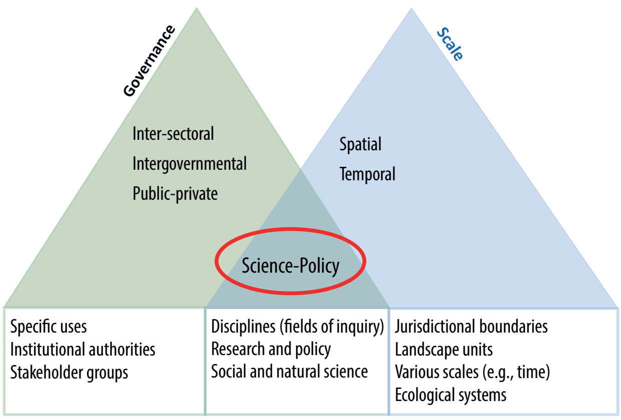

Fig. 1 Dimensions of integration generally and for marine spatial planning purposes with an emphasis on integrating science and policy. Source: adapted from Portman (2011)

The first step in the development of climate adaptation strategies is the assessment of vulnerability (*CRC-URI* 2009; *Portman* 2016) and these must make use of academic work that has already made this connection (e.g. *Zviely* et al. 2015). The level of vulnerability can and should be assessed. This means gaining full knowledge about the exposure of a community to hazards and the consequence of that hazard if it occurs will lead to various perceptions of risk. Yet it is known that risk perception is limited by various characteristics inherent to the issue of climate change (i.e., global, long-term, uncertain) and social-psychological processes (i.e., media framing, perceptions of communicators, dissonance, denial) (*Upham* et al. 2009). In short, these factors have undoubtedly led to a dissonance, or disconnect, between thinking about resource shortage solutions and adaptive strategies simultaneously. Further research and public policy analysis is needed to address what can be done to surmount these obstacles.

4. Conclusions

The IPCC specifically states regarding islands that the "High ratio of coastal area to land mass will make adaptation a significant financial and resource challenge" (*IPCC* 2014: 24). Yet some countries, experiencing resource shortages exacerbated by high rates of population growth and high standards of living, seek to build artificial islands for myriad human uses in the coastal zones. Israel is one of these countries. Since risk is a multiple of vulnerability and the severity of danger, the construction of artificial islands seems to be detached from the realities of climate change and therefore a highly risky endeavor.

Despite these issues, when we look at the agendas promoting artificial island construction along the Mediterranean coast of Israel, it seems likely that the construction of some type of offshore islands will take place in the future. In keeping with what is known about climate change and its associated risks, much more research is needed before implementing such solutions to resource shortages. Ultimately the connection of artificial island planning to what is known (and what will soon be discovered) about climate change must be made with the understanding that the coastal zones of today are not the coastal zones of tomorrow.

Notes

[1] There was uncertainty as to the South China Sea features, namely, whether they are *islands* above water at high tide (Article 121(1)) or *low-tide elevations* submerged at high

tide but above water at low tide (Article 13), and whether the islands are entitled to the full suite of maritime zones under UNCLOS or are rocks only entitled to a 12 nm territorial sea under Article 121 (for explanation of the decision, see *Davenport* (2018).

[2] Examples are modular giant triangles that tied together make floating mega islands, such as those developed by researchers at the Maritime Research Institute Netherlands (MARIN). – A video showing a model of a floating mega-island tested in 15m waves is online available at: https://www.digitaltrends.com/cool-tech/marin-artificial-island/Accessed 16/9/2019

[3] Personal communication via email on 23 July 2018 with D. Anglin, M.Sc., P. Eng., Baird and Associates Coastal Engineers Ltd.

[4] The length of the Mediterranean coastline totals about 46,000 km, of which 19,000 km represent island coastlines.

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