Climate Change and Maritime Security in the Indian Ocean Region

Abhijit Singh*

Climate change is likely to influence maritime security in the Indian Ocean Region (IOR). The growing unpredictability in climate and weather patterns is having a disproportionate impact over the region. Not only is the IOR predicted to bear the brunt of future climatic changes, it is also likely to face strong constraints in meeting the coming threats. The effect of climate change on human security in the IOR is only likely to be matched by the impact of extreme weather conditions on naval operations and the security of maritime assets. This article argues that changing climate could take the form of a structural challenge that regional maritime forces will need to prepare systematically to tackle effectively.

Introduction

In October 2014, India's east coast suffered a calamity of catastrophic proportions. Cyclone Hudhud, a Category 4 storm, struck the coastal city of Vishakhapatnam—an important industrial base and home to Indian Navy's Eastern Command—with brutal force, bringing everyday life in the bustling city of over 2 million people to a virtual halt.[2] With winds exceeding 200 kmph pounding the city, entire settlements and structures were blown away—some as large as the roof of the city airport. Days after the cyclone, Vishakhapatnam looked like a war-ravaged zone, with uprooted trees on the roads, electricity poles and debris littered on the streets, and facades and rooftops of buildings missing.[3]

* The author is a Research Fellow with the IDSA, New Delhi.

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Hudhud's impact was also felt at the naval base in Vishakhapatnam, where the airfield and other installations suffered extensive damage.[4] In its aftermath, weather experts wondered whether the cyclone was a manifestation of climate change over the Bay of Bengal. Their suspicions were aroused by the fact that Hudhud came less than a year after another devastating cyclone, Phailin, struck the east coast.[5] With no convincing explanation available, opinions remained divided on the subject. But it was apparent that the frequency and intensity of extreme weather events had significantly increased on India's east coast.

That global climate has been in the throes of a dramatic transformation has been evident for some time. Recent studies and surveys show that the last decade has been the warmest and climatologically most active since weather was first recorded nearly a century ago.[6] Since 2011, the world is said to have witnessed some of the most extreme weather in the past 500 years—each successive year setting a new record of extreme rainfall and heat waves, even as the frequency of extreme climatic events has risen exponentially. The year 2013, by itself, was one of the hottest years in recent memory and witnessed more storms than any other year in the modern satellite era.[7]

In November 2014, the Intergovernmental Panel on Climate Change (IPCC) released its fifth assessment report. The report states, with a conviction not seen in any previous report, that human activity has not only been the most dominant cause of warming since the mid-20th century, it is also impacting the global climate system in ways more complex than previously feared.[8] The earth, it affirmed, has entered an era of irreversible climate change that is resulting in a drastic rise in ocean temperatures and severe ecological instability.[9] This, the report claimed, was most likely to hit coastal regions where people could soon be grappling with extreme events and food and water shortages.

While many of the report's findings remain contested,[10] there appears to be a developing consensus among experts about the impact of worsening weather on coastal communities.[11] There is now clear evidence that suggests a pernicious link between changing climate, ocean security and human security, and the serious risks mankind faces as a result of climate-induced crises—in particular, extreme weather events.[12]

The threat of deteriorating climate is likely to have profound implications for maritime security in the Indian Ocean. It is gradually becoming clear that changing weather patterns in IOR have been influencing the operational maritime environment. As climatic conditions

worsen and the need for maritime assistance to ailing coastal populations in crises-hit regions grows, the success of naval missions will depend entirely on how well individual forces adjust their functional regimes to the demands of an altered operating environment.

This article attempts to outline the impact of climate change on the maritime security in the IOR. Its aim is not to investigate climate change as a valid scientific phenomenon, but rather to delve into its potentially grave consequences in a nautical context. While explaining the impending ill-effects of rapidly worsening climate on the Indian Ocean, the article also seeks to establish structural imperatives for maritime forces in the Indian Ocean Region (IOR). More crucially, it attempts to outline a new operations philosophy where regional navies can account for the need to mitigate the adverse effects of climate-induced crises, and adapt doctrines and procedures to meet the coming challenges.

Changing Climate in the IOR

In general, experts agree that climate is changing rapidly; but 'how much' and 'how fast', no one seems sure about. The ambivalence stems from a lack of understanding about the exact nature of the phenomenon of climate change and its downstream effects on human security. On two accounts, however, there is considerable agreement: one, Africa, Asia and the wider IOR are facing a disproportionate burden of changing climate; two, as climate in the IOR changes, it has a direct impact on ocean security.

Recent studies show that IOR States are most vulnerable to changing climate. According to a global ranking of the vulnerability of countries to the impacts of climate change over the next 30 years, the South Asian littorals are likely to be one of the worst affected regions.[13] This is attributable, mainly, to the high levels of poverty, dense populations, exposure to climate-related events, and the absence of institutional systems to mitigate their ill-effects.

The rising seas in the IOR present an especially grave challenge. A study in 2010 found that Indian Ocean sea levels were rising unevenly and threatening densely populated areas and islands.[14] The key player in the process was, apparently, the Indo-Pacific warm pool—an enormous, bathtub-shaped area spanning a region of the tropical oceans from the east coast of Africa to the International Date Line in the Pacific. The warm pool has heated by about 1 degree Fahrenheit, or 0.5 degree Celsius, in the past 50 years, primarily because of human-generated emissions of

greenhouse gases.[15] These findings seem to match those in the IPCC's fourth assessment report (AR 4, 2007) that estimated a sealevel rise of 0.18 to 0.59 metre by the end of the 21st century.[16] The UN report also brought out that the icecaps and glaciers were in serious danger of melting, and were likely to be accompanied by frequent and intense weather events. The combined effects, the report held, would be a loss of arable land and severe shortage of fresh water and food.[17]

Climate change may also render the Indian Ocean nations vulnerable to stronger and more frequent and higher storm surges. Recent studies suggest that tropical cyclones in the Indian Ocean will grow more intense. Meanwhile, the dangers posed by storm surges are increasing.[18] A World Bank paper concluded in 2009 that five of the 10 countries with the greatest percentage of coastal population at risk, four of the 10 countries with the highest percentage of coastal Gross Domestic Product (GDP) at risk, and six of the 10 countries with the highest proportion of coastal urban areas at risk, were all located around the Indian Ocean basin.[19]

From a regional maritime perspective, the threat that extreme climatic events pose to coastal cities and critical infrastructure in South and South East Asia is deeply disconcerting—particularly when some of these nations are most ill-prepared to meet the threat. Climate experts say that the damage caused by future extreme weather could be extensive, placing a considerable burden on government resources.[20] This is because coastal zones are home to a significant proportion of the regional population. Most people here live in big coastal cities with large supporting infrastructure such as port facilities and oil refineries. Many of these cities are prone to natural disasters and sea level rise. In the event of a severe climate crisis, the risk of damage to coastal infrastructure—including naval docking and shore facilities—is very high.

Climate Crises and Migration

Equally serious is the large-scale migration that climate change could potentially trigger in the IOR. Studies suggest that desertification in coastal African and South Asian states could setoff a vicious circle of environment degradation, migration and conflict. As per a recent United Nations (UN) estimate, there will be nearly 50 million 'environmental' refugees by 2020—a majority in Asia and Africa.[21] Within the IOR, the most vulnerable countries are likely to be in South Asia.

A seminal study in 2003 showed that migration in an abrupt climate-change scenario had the potential to impact international security.[22]

Climatic events, the study held, could result in mass migration, affecting the weak states by over-stretching the already limited capacity of governments to effectively respond to the challenges they face—a scenario already playing out in the IOR.

Evidently, climate-induced migration in susceptible regions is taking place in three distinct ways: movement in response to a fast-deteriorating environment; increasing short-term population dislocations due to particular climate stimuli, such as severe cyclones or major flooding; and larger-scale population movements slowly building in momentum with the interaction of other migration drivers, such as political disturbances, military conflict, and ecological stress, among others.[23] Increased migration leads to higher risk of conflict in coastal communities. This, in turn, could lead to greater use of maritime forces in preventing refugee influx from the seas as well as their deployment insupport of local operations to defuse developing conflicts (see Table 1).

Reports point out that migration has the potential to cause greater conflict, particularly in the IOR where an environmental anomaly is exacerbating the impact of changing climate on local communities. In September 2014, researchers found evidence of a major inconsistency in the warming of the Indian Ocean that was altering the strength of the south-west monsoon. With the western tropical Indian Ocean registering

Table 1 Forecasted Population at Risk from Sea-level Rise in 2050, Top 10 Countries Globally (in millions)

India	37.2
Bangladesh	27.0
China, People's Republic of	22.3
Indonesia	20.9
Philippines	13.6
Nigeria	9.7
Viet Nam	9.5
Japan	9.1
USA	8.3
Egypt	6.3
Other Asian countries in the top 20: Republic of Korea (12), Myanmar (13), Malaysia (16), Thailand (20)	

Source: 'Climate Change and Migration in Asia and the Pacific', *The Asian Development Bank Report*, 2009, p. 25.

a rate of heating faster than any other region of the tropical oceans, a 'warm pool' was formed in the Indian Ocean that was causing weather abnormalities and extreme weather events.[24]

Climate Change and Maritime Security

Climate change has a disruptive potential and is best understood as a global threat multiplier. Its inherent ability to destabilize regions, causing conflict and strife, however, makes it an international security challenge.[25] Climate-induced crises tend to alter the balance of the mix of strategic interest, by creating new imperatives, many of which manifest in the maritime domain. These include protection measures from sea rise, humanitarian relief efforts in coastal areas, prevention of trans-regional migration, etc.

Indian Ocean states, unfortunately, don't seem to have taken the implications of changing climate as seriously as the developed West.[26] In the United States (US), for instance, three policy documents—National Security Strategy, National Defence Strategy, and Quadrennial Defence Review—have all sought to address environmental security and climate change, and advocated a multifaceted and multilateral approach. Independent studies have concluded that even though diplomacy and development is not the Armed Forces' primary mission, they must widen and strengthen their capabilities in these areas.

Interestingly, within the US defence establishment, it is the United States Navy (USN) that has contributed the most to strategic thinking on climate change and its implications for maritime strategy, policy and plans. The USN's 'Climate Change Roadmap' articulates climate goals with great clarity, also identifying conditions of particular naval interest, such as sea level rise, the frequency and intensity of tropical storms, rainfall patterns, and concentrations of greenhouse gases.[27]

Alive to the demands that the new conditions place on maritime operations, America's naval leadership has been gearing up for tasks such as humanitarian assistance and disaster relief, defence support of civil authorities, maritime domain awareness, search and rescue, and strategic sealift. The US Department of Defence's 'Climate Change Adaptation Roadmap', unveiled in October 2014, details how the US military will prepare and respond to the fallout from global warming, and the different types of seaborne and airborne assets it has been procuring to complete the mission.[28] Like the USN, other modern navies like the Royal Navy and the Royal Australian Navy have also been developing doctrines that

account for climate crises and recognize the need for contribution by maritime forces.[29]

In a classic maritime security context, changing climate in the IOR has two important implications. First, it could act as a major catalyst for maritime disputes. The rising seas threaten low-lying islands in the Indian Ocean, leading to disputes over Exclusive Economic Zones (EEZs) and seabed resources. Since low-lying features are commonly used to delineate maritime boundaries, their submergence would invalidate claims by coastal states on parts of the sea that would otherwise fall outside their EEZs. In the event of a dramatic sea level rise, the low-water marks—critical in measuring EEZs of nations—would shift, resetting baselines and raising the real possibility of new maritime disputes.[30]

The more damaging impact of climate change, however, is on the ocean environment, which in turn is likely to affect maritime operations. Scientists now agree that the warming of ocean water and melting of land ice is raising sea levels, changing the salinity index and altering ocean water temperatures. What is more, the absorption of CO_2 in seawater is increasing ocean acidity levels and also appears to be altering the flow of ocean currents.[31] As the sea environment changes, maritime forces are now acknowledging the need to revise their operational regimes. There is, in fact, greater recognition of the fact that the changing environment may have a bearing on aspects of maritime operations: from navigation and pilotage to operational exercises, and maintenance of ships, engines and other equipments.[32] If the environment continues on its present steep trajectory, regional maritime forces will need to seriously study technologies, procedures and skills to deal with the changes in the aquatic environment.

Climate events have the unique ability to disrupt maritime commercial activity and adversely impact port infrastructures. From a commercial operations point of view, even minor disturbances in major national ports like Mumbai and global ports like Colombo or Singapore could cause substantial damage.[33] Disruptions to global shipping and commercial ports resulting from climate change will present strong challenges. The threat to maritime trade and potential port disruptions could draw in the maritime forces, which would then have to coordinate responses.

A Threat to Naval Operations and Infrastructure

While changing climate is likely to have a serious impact on naval operations, its sub-processes are hard to define or predict. Experts posit

that a global ice melt could cause a drastic change in water densities that might infuse a great amount of fresh water into the oceanic system. This could potentially lower the density of waters in the northern latitudes, while increased evaporation from a warmer atmosphere will increase the density of tropical waters. The attendant change in the salinity of seawater might cause a shift in the buoyancy of submarines and the performance of underwater weapons.[34]

As the density of seawater changes, it may alter the underwater acoustic properties, adversely affecting sonar performance. A recent study concluded that future fossil fuel CO_2 emissions could lead to increased acidification and a significant fall in low frequency sound absorption by mid-century.[35] Naval operations may also be influenced by changing thermoclines that might result in a significant shift in the flow pattern of hot and cold water currents.[36] Indian Ocean currents, for instance, could be affected by changing patterns in the monsoons.[37] Maritime forces need to conduct further research to better determine density, salinity and acidity thresholds at which climate change may impact sub-surface operations.

The impact of climate change on surface operations too is more discernable than earlier. There is growing evidence that naval surface operational deployments is likely to be hindered by extreme weather events in the future. Inclement weather does take a toll on aship's crew's physical and mental well-being. For instance, in warmer climates surface temperatures on the decks of aircraft carriers can reach high temperatures, putting great strain on the deck crew's ability to launch planes. High temperatures can also have negative repercussions on the crew's ability to sustain high tempo operations. Maritime forces do train sailors for a variety of inclement weather conditions, but there is a need to reassess this training for more persistent high-heat conditions and other new considerations associated with climate change, such as the presence of cyclonic storms.

Lastly, changing climate may adversely affect the performance parameters of on-board combat systems, sensors and munitions (both life and accuracy).[38] Navies need to develop and validate the components of a munitions preservation system and a decision support system (DSS) that will help achieve optimal discrimination performance of sensors and systems at lowest attainable cost (for both surface and sub-surface operations).[39]

Extreme climate events and rising sea levels are likely to threaten, to some degree, the naval installations and other maritime infrastructure

necessary for naval operations.[40] With the weather conditions in the Indian Ocean getting worse with time, there is an increased possibility of storms and associated storm surge that might inundate key coastal and island bases (along with airfields). This could even result in the loss of key low-lying bases.

The threat that extreme climatic events pose to maritime infrastructure is exemplified by the typhoon Haiyan—a super-cyclone that struck south-central islands in the Philippines in November 2013—wreaking havoc not just in terms of death and destruction of people and property, but also damaging the Philippine Navy's Tacloban naval station.[41] The scale of devastation at the station was so severe that for many hours after the winds had subsided, ships refused to enter the harbour, delaying the rescue effort.[42] The extent of destruction at Tacloban showed how unprepared Philippine authorities were in dealing with extreme weather events. But this is true of many other Asian countries as well. As with the Philippines Navy, other maritime forces too appear ill-prepared to face the impact of climate change on their coastal infrastructure and maritime operations.

To counter the threat posed by climate change, the highest priority task for maritime forces is to identify and secure the shore facilities vulnerable to storm surges and extreme climate events. Here, a recent study on climate change and natural disasters focusing attention on two climate 'hotspots'—Goa and Visakhapatnam—could prove instructive.[43] These two sites host some prominent Indian naval shore establishments, airfields and docking facilities, and are uniquely susceptible to climate events. The study delves in detail into the vulnerability of urban infrastructure to climate change, and gives sector-specific recommendations on planning and implementation of climate-resilient measures. The template that it posits for remedial measures could also be useful in drawing plans to secure maritime facilities and infrastructure in other vulnerable centres near the seas.

An Evolving Role for Maritime Forces

From a maritime perspective, climate change policy decisions are most informed by the rigour and cost involved in the two recommended approaches to tackle climate effects: adaptation and mitigation. These must be understood as two different concepts that ameliorate the impact of changing climate in different ways. As climate conditions gradually worsen, maritime forces need to adapt to a new emerging environment.

This means focusing attention and resources on learning how climate change is affecting the maritime operating environment and must be done to adapt to the changing conditions. In practical terms, it entails taking the following measures:

1. *Conducting vulnerability assessments*: To deal with the effects of climate change on maritime safety, there is a need for a comprehensive vulnerability assessment of maritime facilities to storm surges and flooding. Such assessments help in undertaking a cost-benefit analysis that is essential in determining the risk-potential of installations.
2. *Implementing cost-effective measures*: Boosting the ability of maritime forces to respond to extreme weather events could generate long-term cost savings. This may need significant upfront investments to sustain operations in a world of rising sea levels. But building more robust new naval facilities or redesigning older ones is usually cheaper than paying for the eventual costs of a severe climatic 'event'.
3. *Creating local response plans*: Naval stations need these plans when they are rendered inoperable in storms or rising tides. These must incorporate pier-readiness in terms of shore cables, hotel services, crane services, and other infrastructure, such as electric power plants that are all necessary for repair missions. The plan must also take into consideration industries surrounding coastal bases and identify other higher or more inland areas to serve as alternative sites if a naval station is damaged.
4. *Auditing of basing locations*: In a rapidly changing environment, evaluating basing locations and assessing vulnerability to climate change has become a rank imperative. For instance, in the case of Indian Navy, the loss of or significant damage to bases at locations in the Andaman and Nicobar Islands could be a significant blow.
5. *Improving climate prediction capability*: Having an efficient and reliable meteorological department is critical, not only for the inputs in initiating action but for the 'benchmark' it provides to properly evaluate the threats of changing weather patterns. Maritime forces need to acquire advanced meteorological equipments and develop systems and procedures that help understand the changing weather much better.

Climate Mitigation and Naval Policy

Climate mitigation essentially refers to efforts to reduce or prevent emission of greenhouse gases. It could mean using new technologies and renewable energies, making older equipment more energy efficient or changing management practices. In practical terms, however, mitigation is about switching to a low-energy consumption model by reducing dependence on traditional fuels like diesel and exploring other alternate energy options such as bio-fuels.

While each nation has its own policy on fuel quality and consumption, the incentive for navies—as responsible sub-national entities—to reduce hydro-carbon fuel consumption is considerable. Here, the example of the USN is instructive. About a decade ago, a Task Force constituted to examine the US Department of Defense (DOD)'s energy strategy found that the USN's dependence on fossil fuels was increasing the Navy's life-cycle operations and support costs.[44] To remedy the adverse situation it recommended switching to more fuel-efficient hybrid-electric engine, where a ship needed to make fewer trips away from the shore to refuel.[45]

In 2009, the USN announced its plans for a 'Great Green Fleet'—a carrier strike group comprising an aircraft carrier, two guided-missile destroyers, a guided-missile cruiser, and an oil tanker.[46] The Fleet, the Navy's planners declared, would use a fuel blend of 50 percent petroleum and a 50 percent mix of waste food oil and algae bio-fuel. This soon became the centrepiece of the USN's commitment to get 50 percent of its energy from alternative sources by 2020.[47] Consequently, the Navy began the process of developing different types of feed-stocks to function as alternative fuel in conjunction with algae and waste food oil. The aim was to reduce the Navy's dependence on traditional fuels.

While the USN's experimental programme was criticized for being hugely expensive (costing over $500 million over three years), there was a broad recognition of the fact that an alternative for fossil fuels needed to be found. From a larger maritime operations perspective, it highlighted the challenges of implementing mitigation measures even when there is clarity and consensus on remedial action.

In an IOR security context, one agency that seems to have made an apt (albeit belated) determination of the coming challenges of climate change is the Indian Navy. As part of an energy conservation drive, the Indian Navy adopted some green initiatives in October 2014. This was initiated apparently in view of the 'diminishing energy resources, price volatility and the need to minimise the impact of fossil fuels on the

environment'.[48] More encouragingly, a set of exhaustive guidelines were released in the form of an 'Energy Conservation Roadmap' to implement the 'Green Initiatives' and its formations.[49]

Fuel conservation, however, is only one part of mitigation; the other important aspect is the ability to provide expeditious humanitarian assistance to disaster-hit areas. Unfortunately, the larger maritime space where the Indian Navy operates is one where national governance is weak and most people affected by climate crises live in poor and deprived conditions. The impacts of the December 2004 tsunami on Sri Lanka, and the May 2008 Cyclone Nargis on Myanmar are just two examples of how the tragic consequences of severe natural events are exacerbated by thecollapse of local governance. The challenge for regional navies is to mitigate climate threats even in situations when the civilian administration has been rendered ineffective.

Importantly, 'adaptation' and 'migration' are two different forms of climate countermeasures that must be employed in tandemto deal with climate-related contingencies. Experts opine that a prudent strategy is one of 'iterative risk management' that includes aspects of both mitigation and adaptation.[50] This would entail adopting flexible policies that can be suitably modified with new and improved information over time.

Operational Planning for Climate Change

Unfortunately, the overall maritime response to climate change has been lacking in conviction. This appears to be driven, mainly, by an inherent reluctance of maritime forces to expand their operational charter beyond the confines of traditional security roles. Navies, it seems, have an inherent reluctance to undertake non-traditional missions, which they believe dilute the core naval war-fighting skills by diverting precious resources and appropriating vital operational focus.[51] The notion is a fallacy as modern maritime operations do reveal a human security dimension, increasingly embraced by naval planners.

To reconfigure their strategy for an energy–climate era, maritime forces need strategic guidance and a sound operations plan that takes into account both traditional and irregular challenges. In objective terms this implies doing the following tasks:

1. Developing a revamped operational strategy and new and evolved policies to meet the contingencies of climate change.

2. Rethinking 'maritime operations' in areas vulnerable to climate change and training naval personnel to operate in those regions.
3. Investing in capability and infrastructure, including boats, hovercrafts and amphibious equipments.
4. Acquiring a capacity for strategic communications and working on an outreach programme.
5. Undertaking a comprehensive environmental assessment.

These challenges, onerous as they are, can best be met by working on a near-term and a long-term plan separately, that individually define their respective subtasks and acquisition processes. In the near-term, maritime forces need to reconfigure their energy-use patterns and operational schedules, to make them consistent with the changing national legislation and international measures. This will also entail safety audits of present naval bases to ascertain their vulnerability to climate events, and corrective measures must be taken to make them safe.

The most crucial requirement in the near future is to prepare for the impact of climate changes on operations, installations, missions, and strategy. Specific procedures will need to be developed and Standard Operating Procedures (SOPs) modified to take climate change into account. Over the long-term, maritime forces would have to consider auditing the locations of future installations and focus on building climate-resistant/corrected capabilities in new infrastructure and on-board operational systems.

In the long-term, maritime forces will need to equip in a way that makes them fully mission-capable across a range of changing climatic conditions. The future naval force structure and infrastructure will have to be made capable of meeting combatant commander requirements in all probable climatic contingencies over the next two decades.

As a first step to address maritime challenges, navies and coastguards would need to build a knowledge base on the climatic changes and commensurate response options. This must be followed by creating a 'blue-print' for action. Response mechanisms will need to be developed and procedures put in place to meet any contingencies. Most importantly, financial implications for such responses would have to be identified and catered for in the navy budgets. The overall impact of climate change on maritime security forces is likely to be gradual rather than abrupt, leaving time for maritime security forces to invest in basic scientific research and marine environmental assessment, the development of new technological solutions to emissions reductions

and better national and regional security risk assessments. The strategic implications of climate change, however, must be comprehensivelyassessed.

Implications for the Indian Navy

As the principal maritime force in the IOR, the Indian Navy has been playing a significant role in combating non-traditional threats in the South Asian littorals. The Indian Navy defined its benign role in the wake of the 2004 Tsunami in which it played a significant part in disaster relief operations. Since then, the Indian Navy has participated in other humanitarian operations such as the relief effort following the cyclones Sidr (Bangladesh, 2008) and Nargis (Myanmar, 2008).[52]

As climate change in the Indian Ocean becomes more pronounced overtime, the Indian Navy must adapt its equipment, systems, operations, and doctrines to the altered maritime operations environment. Its central imperative is to restructure its force-architecture to meet the demands of relief and rescue missions, in particular the ability to move rapidly and land large volumes of supplies at short notice. With climate events affecting the use and availability of amphibious landing sites, the Navy needs to acquire shallow draught ships capable of landing in disaster areas and heavy-lift helicopters for ship-to-shore transport. While air-cushion vehicles and hovercrafts offer an attractive option, the thrust of the Indian Navy's efforts would likely be on replacing brown-water platforms with multi-role expeditionary capability warships.[53]

Significant in equal measure is the need to procure equipment and stores for humanitarian missions. This includes materials for relief and rescue operations, as well as equipment pertaining to construction, sanitation, fuel, medical supplies, and power generation. Here the Indian Navy has already made an encouraging start. Increasingly, the Indian Navy ships have been carrying stores such as disaster relief bricks, as well as relief materials and medical and communication stores.[54]

But even as the Indian Navy improves its disaster response capability, it must recognize the need for cooperative action. The threats that climate change poses to the Indian Ocean need a collaborative and coordinated effort, for which the Navy needs to deepen cooperation with other maritime forces. It also needs to improve coordination with relevant civilian agencies to track climatic conditions and provide relief on ground.[55]

What is then needed is a compendium of climate 'Lessons Learned' and a framework of best practices to sustain operations. These must clearly

bring out expected changes in the undersea and surface environments, as also the implications of rising sea levels for naval operations. Beyond best practices, however, maritime forces need to improve the ability to share meteorological, seismic, radar, communications, and other data that can help anticipate and deal with severe events. Furthermore, maritime forces will need a climate-operations doctrine, and will have to train their cadres to operate in different ocean and climate conditions.

Conclusions

The costs and consequences of climate change will define the 21st century. As the global weather in the IOR becomes less predictable and stable, it is likely to lead to a series of humanitarian crises. The severity of these crises, exacerbated by weakened state structures and institutions, will strain the existing security structures in the maritime domain, rendering the question of the future use of maritime forces centrally relevant. As navies and coastguards in the IOR grapple with the implications of changing climate, they will need to re-evaluate threats, re-prioritize missions and re-tool operational kits. To surmount these challenges, maritime forces will have to come up with innovative solutions.

Even so, the traditional approach of mitigating climatic ill-effects and adapting to the demands of the changing environment would continue to play a critical role. Alongside reorienting their posture and profile, navies will have to find new ways to protect maritime assets and optimize operations in rapidly altering climate conditions. This is likely to entail a re-consideration of operational schedules and doctrines, even as climate calculations become an essential consideration in naval planning and operations.

In the coming years, climate change will affect maritime readiness, strain base resilience, and create impediments in the performance of operational tasks. It is also likely to increase the maritime deployments for subsidiary tasks and humanitarian missions. An integrated response to climate change willbe the most desirable option, but maritime forces will have to provide urgent relief to vulnerable coastal communities in standalone mode. For contingency operations, procedures, plans and doctrines will need to be put in place and a comprehensive framework developed that takes into account both material and human security dimensions.

Confronted with an expanding swath of morphing challenges, maritime forces find themselves in a situation where they need an imaginative and flexible approach to security—one that provides the

space to innovate and improvise, tailoring assets and operations to meet climate challenges. Only a proactive posture and a coordinated approach will beget the desired results.

Notes

1. 'Climate Change Like "100-year War" Says US Army Expert', available at http://www.rtcc.org/2014/03/18/climate-change-like-100-year-war-says-us-army-expert, accessed on 30 October 2014.
2. 'Cyclone Hudhud: Vizag Slips Into Dark Age', *The Times of India*, 16 October 2014, available at http://timesofindia.indiatimes.com/india/Cyclone-Hudhud-Vizag-slips-into-dark-age/articleshow/44830890.cms, accessed on 30 October 2014.
3. Ibid.
4. 'Vizag Naval Base Takes a Battering', *The Times of India*, 13 October 2014, available at http://timesofindia.indiatimes.com/india/Cyclone-Hudhud-Visakhapatnams-naval-base-takes-a-battering/articleshow/44796539.cms, accessed on 25 October 2014.
5. Padma, T.V., 'Early Days, But Fierce Cyclones Could Be Climate Pointer', *India Climate Dialogue*, 20 October 2014, available at http://indiaclimatedialogue.net/2014/10/20/early-days-fierce-cyclones-climate-change-pointer/, accessed on 20 October 2014.
6. Hansen, James, Makiko Sato and Reto Ruedy, *Perceptions of Climate Change: The New Climate Dice*, New York: Goddard Institute for Space Studies and Columbia University Earth Institute, Sigma Space Partners, 2010.
7. 'WMO Statement on the Status of the Global Climate in 2013', *World Meteorological Organization*, WMO No. 1130, 2014, available at http://www.met.hu/downloads.php?fn=/doc/WMO_allasfoglalas/WMO_allasfoglalas2013.pdf, accessed on 10 October 2014.
8. IPCC, Climate Change 2014: *Impacts, Adaptation, and Vulnerability*, Summary for Policymakers, IPCC Fifth Assessment Report, 2014, p. 3, available at http://www.met.hu/downloads.php?fn=/doc/WMO_allasfoglalas/WMO_allasfoglalas2013.pdf, accessed on 10 November 2014.
9. Ibid., p. 6.
10. Despite clear evidence that the earth is warming, many experts contest the science of climate change, disagreeing with those who claim it is linked to human activity. The sceptics oppose the popular narrative about changing climate, calling for a deeper analysis of the phenomenon. See Luigi Jorio, 'Climate Sceptics Continue to Dismiss Scientific "Farce"', *SWI Info.ch*, 30 October 2014, available at http://www.swissinfo.ch/eng/multimedia/climate-sceptics-continue-to-dismiss-scientific--farce-/41087144, accessed on 10 November 2014.

11. Vinik, Danny, 'Climate Change will Force us to Abandon Coastal Cities', *The New Republic*, available at http://www.newrepublic.com/article/117799/climate-change-will-force-us-abandon-cities-if-we-dont-prepare-now, accessed on 10 November 2014.
12. Werz, Michael, and Laura Conley, 'Climate Change, Migration and Conflict: Addressing Complex Crisis Scenarios in the 21st Century', Centre for American Progress, January 2012, available at http://cdn.americanprogress.org/wp-content/uploads/issues/2012/01/pdf/climate_migration.pdf, accessed on 10 October 2014.
13. Climate Change Vulnerability Index (CCVI), 2014, Maplecroft. http://maplecroft.com/portfolio/new-analysis/2014/10/29/climate-change-and-lack-food-security-multiply-risks-conflict-and-civil-unrest-32-countries-maplecroft/, accessed on 30 October 2014.
14. Han, Weiqing, Gerald Meehl, Balaji Rajagopalan, John T. Fascutto, Ai Xua Huo, Jialin Lin and William G. Large, 'Indian Ocean Sea Level Change in a Warming Climate', *Nature Geo-science*, Vol. 3, July 2010, pp. 546–50.
15. Ibid.
16. IPCC, 'Climate Change 2007: Synthesis Report', Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2008, Geneva: IPCC, available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf, accessed on 21 December 2014.
17. Yanda, Pius, and Salomé Bronkhorst, Paper on 'Climate Change and Conflict: Conflict-sensitive Climate Change Adaptation in Africa', http://www.accord.org.za/downloads/brief/policy_practice14.pdf, accessed on 12 October 2014.
18. Yu, Jinhua, and Yuqing Wang, 'Response of Tropical Cyclone Potential Intensity over the North Indian Ocean to Global Warming', *Geophysical Research Letters*,Vol. 36, 2009; Thomas R. Knutson, 'Tropical Cyclones and Climate Change', *Nature Geoscience*, Vol. 3, No. 157, 2010.
19. Dasgupta, Susmita, Benoit Laplante, Siobhan Murray and Dan I. Wheeler, 'Sea-Level Rise and Storm Surges: A Comparative Analysis of Impacts in Developing Countries', Policy Research Working Paper No. 4901, *The World Bank*, April 2009.
20. Ibid.
21. 'Experts Predict 50 Million Environmental Refugees By 2020', available athttp://www.huffingtonpost.com/2011/02/22/environmental-refugees-50_n_826488.html, accessed on 5 October 2014.
22. Schwartz, Peter, and Doug Randall, 'An Abrupt Climate Change Scenario and its Implications for United States National Security', October 2003, available at http://www.ems.org/climate/pentagon_climatechange.pdf, accessed on 15 October 2014.

23. McLeman, Robert and Barry Smit, 'Climate Change, Migration and Security', Canadian Security Intelligence Service, 2 March 2004, available at http://www.csis-scrs.gc.ca/en/publications/commentary/com86.asp, accessed on 15 October 2014.
24. Roxy, M.K., Ritika Kapoor, Terray Pascal and Masson Sabastien, 'The Curious Case of Indian Ocean Warming', *Climate Journal*, American Meteorological Society, 2014; see also Suryachandra A. Rao, Hemantkumar S. Chaudhari, Samir Pokhrel and B.N. Goswami, 'Unusual Central Indian Drought of Summer Monsoon 2008: Role of Southern Tropical Indian Ocean Warming', *Journal of Climate*, Vol. 23, 2010, pp. 5163–74.
25. 'Ban Ki-Moon Makes Climate Plea at Dhaka Summit', available at http://www.bbc.co.uk/news/world-asia-15722382, accessed on 10 October 2014.
26. Ackbarally, Nasseem, 'Indian Ocean Islands Unprepared for Climate Change', *All Africa News*, 3 July 2014, available at http://allafrica.com/stories/201407040887.html, accessed on 30 October 2014.
27. 'US Navy Climate Change Roadmap', US Department of Navy, May 2010, available athttp://www.navy.mil/navydata/documents/CCR.pdf, accessed on 8 October 2014.
28. US Department of Defence, '2014 Climate Change Adaptation Roadmap', June 2014, available at www.acq.osd.mil/ie/download/CCARprint.pdf, accessed on 25 October 2014.
29. The UK MoD has identified climate change as one of the 'Ring Road issues'—primary drivers of global change in that period; see MoD's *Global Strategic Trends—Out to 2040*, Development, Concepts and Doctrine Centre (DCDC), December 2010, available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/33717/GST4_v9_Feb10.pdf, accessed on 8 October 2014.
30. Pascal, Cleo, *Global Warring*, Washington DC: Macmillan, 2010, pp. 78–83.
31. Riebeek, Holli, 'The Ocean's Carbon Balance', *NASA Earth Observatory*, 30 June 2008, available at http://earthobservatory.nasa.gov/Features/OceanCarbon/, accessed on 10 November 2014.
32. US Department of Defence, '2014 Climate Change Adaptation Roadmap'; also see Sharon Burke, Jay Gulledge, Michael Horowitz, Christine Parthemore and Nirav Patel, 'Uncharted Waters: The U.S. Navy and Navigating Climate Change', Working Paper for the Centre for New American Security, December 2008, pp. 17–20, available at www.cnas.org/files/documents/publications/CNAS_Working%2520Paper_CNO_ClimateChange_BurkePatel_Dec2008.pdf, accessed on 10 November 2014.
33. Pandya, Amit A., Rupert Herbert-Burns and Junko Kobayashi, *Maritime Commerce and Security: The Indian Ocean*, Washington DC: Stimson Centre Report, 2011, pp. 18–24.

34. For instance, torpedo operation could be affected by the changing salinity and its impact on sound absorption. See National Development Council, 'National Security Implications of Climate Change for U.S. Naval Forces', Washington DC: National Academies Press, 2011, pp. 107–10.
35. Hester, Keith C., Edward T. Peltzer, William J. Kirkwood and Peter G. Brewer, 'Unanticipated Consequences of Ocean Acidification: A Noisier Ocean at Lower pH', *Geophysical Research Letters*, Vol. 35, 2008.
36. Mcdonagh, Elaine L., Harry L. Bryden, Brain A. King, Richard J. Sanders, Stuart A. Cunningham and Robert Marsh, 'Decadal Changes in the South Indian Ocean Thermocline', *Journal of Climate*, Vol. 18, 2005, available at http://journals.ametsoc.org/doi/pdf/10.1175/JCLI3350, accessed on12 October 2014.
37. Indian Ocean currents are affected by differences caused principally by the monsoons, the limited extent of water in the Northern Hemisphere, and by limited contact with the Pacific Ocean along the eastern boundary.
38. The effects of weather, hot temperatures, direct solar radiation, daily temperature changes, and high humidity may rapidly degrade the performance and safety of explosives. Ammunition is designed for use under stated climatic conditions, and its service life will significantly reduce if it is not stored under specific conditions. In some cases the ammunition may become unserviceable and dangerous to use.
39. Burke et al., 'Uncharted Waters', n. 32.
40 A 2011 National Research Council report found that 128 U.S. military sites could be impacted by sea-level rise of 3 feet or more. Out of these 56 are Navy facilities valued at $100 billion, according to the report.
41. 'Typhoon Haiyan: Tacloban Worst H, *First Post World*, 11 November 2013, available at http://www.firstpost.com/world/typhoon-haiyan-tacloban-worst-hit-philippines-pleads-for-aid-1223257.html, accessed on 10 October 2014.
42. Pacio, Gilbert, 'The Truth That Many Didn't Know About Haiyan', *Philippines Navy News*, 9 December 2013, available at http://www.navy.mil.ph/news.php?news_id=1248, accessed on 30 October 2014.
43. Sharma, Divya and A. Raina Singh, 'Planning Climate Resilient Coastal Cities: Learnings from Panaji and Visakhapatnam', The Energy Research Institute, Working Paper, October 2014, available at www.teriin.org/eventdocs/files/Working-Paper-climate-resilient.pdf, accessed on 20 October 2014.
44. 'More Fight—Less Fuel', Report of the Defense Science Board Task Force on DoD Energy Strategy, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Washington DC, February 2008, available at www.dtic.mil/cgi-bin/GetTRDoc%3FAD%3DADA477619+&cd=1&hl=en&ct=clnk&gl=in, accessed on 10 October 2014.

45. Ibid.
46. Chambers, Alaina M. and Steve A. Yetiv, 'The Great Green Fleet—The US Navy and Fossil-Fuel Alternatives', *Naval War College Review*,Vol. 64, No. 3, Summer 2011.
47. Haber, Sharon, 'U.S. Navy Pushes to Use Advanced Biofuels', *Truman National Security Project*, 20 March 2013, available at http://trumanproject.org/doctrine-blog/u-s-navy-pushes-to-use-advanced-biofuels/, accessed on 12 October 2014.
48. 'Swachh Bharat Campaign and Green Initiatives Launched by Indian Navy', Press Release, Government of India, Ministry of Defence, 2 October 2014, available at http://pib.nic.in/newsite/PrintRelease.aspx?relid=110257, accessed on 15 October 2014.
49. Ibid.
50. Field, Christopher B., *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, Special Report of the IPCC, Delhi: Cambridge University Press, 2012, pp. 27–28.
51. Barnett, Roger W., *Navy Strategic Culture: Why the Navy Thinks Differently*, Annapolis: Naval Institute Press, 2009, pp. 104–8. In this interesting book, the author explores the psychology of maritime operations.
52. *Net Security Provider: India's Out-of-Area Contingency Operations*, New Delhi: Institute of Defence Studies and Analyses (IDSA) Report, October 2012, pp. 35–40, available at http://www.idsa.in/book/NetSecurityProviderIndiasOutofAreaContingencyOperations.html.
53. Chauhan, Sunil, P.K. Gautam and Ajey Lele, 'Impact on War Fighting Capability of the Indian Military', in *Security Implications of Climate Change in India*, Report of the IDSA Working Group, 2009.
54. Parmar, Rahul, 'HADR in the IOR & the Indian Navy', Paper presented during High Availability Disaster Recovery (HADR) Indian Ocean Naval Symposium Workshop in Bangladesh, 2010, available at http://ions.gov.in/sites/default/files/Papers%20presented%20during%20seminar%205.pdf, accessed on 12 October 2014.
55. Balakrishnan, Sunil, 'HADR Operations: Lessons Learnt by the Indian Navy', in Pradeep Kaushiva and Abhijit Singh (eds), *Indian Ocean Challenges: A Quest for Cooperative Solutions*, New Delhi: KW Publishers and National Maritime Foundation, 2012, pp. 119–26.