Strengthening innovation-driven inclusive and sustainable development

Asia-Pacific Tech Monitor

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Science Technology and Innovation for Sustainable Ocean Economy

Plus

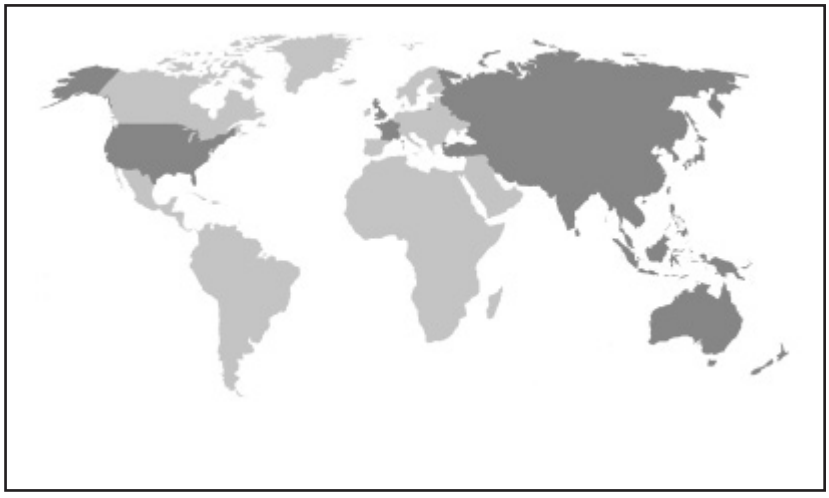
- Technology News and Events
- Tech Ventures & Opportunities
- Business Coach

UNITED NATIONS
ESCAP
Economic and Social Commission for Asia and the Pacific
Asian and Pacific Centre for Transfer of Technology (APCTT)

The **Asian and Pacific Centre for Transfer of Technology** (APCTT), a subsidiary body of ESCAP, was established on 16 July 1977 with the objectives to: assist the members and associate members of ESCAP through strengthening their capabilities to develop and manage national innovation systems; develop, transfer, adapt and apply technology; improve the terms of transfer of technology; and identify and promote the development and transfer of technologies relevant to the region.

The Centre will achieve the above objectives by undertaking such functions as:

- Research and analysis of trends, conditions and opportunities;
- Advisory services;
- Dissemination of information and good practices;
- Networking and partnership with international organizations and key stakeholders; and
- Training of national personnel, particularly national scientists and policy analysts.



The shaded areas of the map indicate ESCAP members and associate members

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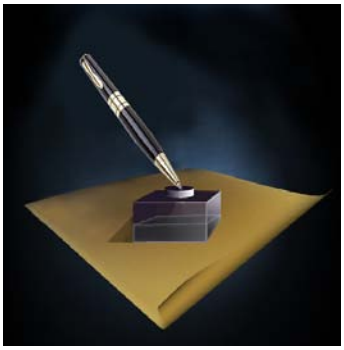

Introductory note

The ocean and its resources are lifelines for billions of people as they depend on oceans for their livelihood and food. The oceans also provide vital support in the form of rainwater, drinking water, weather, climate, the oxygen we breathe and mineral resources. Key economic sectors like trade, fisheries and tourism depend heavily on the oceans. In this context, the Sustainable Development Goal 14 calls upon countries to conserve and sustainably use the oceans, seas and marine resources for sustainable development.

This year's ESCAP theme study "*Changing Sails: Accelerating Regional Actions for Sustainable Oceans in Asia and the Pacific*" calls for enhanced sharing of ocean data, strengthening regional platforms, building partnerships, facilitating knowledge transfer, and enforcing international conventions among others. It points out that the oceans are extremely valuable for the vast Asia-Pacific region, home to more than four billion people, providing food and income for more than 200 million people. Furthermore, shipping accounts for more than 80 per cent of international trade, and two-thirds of global operations are concentrated in the region.

The oceans are becoming more fragile with the impacts of climate change, marine pollution, declining biodiversity and overexploitation. Particularly, the ocean resources are being adversely impacted by overfishing affecting the livelihoods of coastal communities. These challenges would require increased interventions through the means of science, technology and innovation to conserve and sustainably use the ocean resources. Care needs to be taken to increase the sustainability of the ocean economy while harnessing its benefits in which technological innovations play a key role.

In recent years, many enabling technologies promise to improve efficiency and productivity of ocean activities and resource utilization. Key technologies include imaging and physical sensors, satellite technologies, advanced materials, information and communication technology, big data analytics, autonomous systems, biotechnology, nanotechnology and subsea engineering. Innovative technologies in India are seabed crawler-based mining machines for harvesting of minerals, low temperature thermal desalination plants, deep ocean microbial sampling and incubation systems, and data buoys for tsunami early warning. Other examples include fishing vessels installed with Vessel Monitoring System in Thailand, and adoption of Liquefied Natural Gas fueled ship engines to reduce emissions in Singapore. Fourth industrial revolution technologies, such as blockchain, IoT, cloud data, and big data analytics are also offering vital support in administration, logistics, shipping and ports to work together more smoothly.

Technological advancements show many opportunities for sustainable harnessing and utilization of oceanic resources. Many innovative technologies have the potential for greening commercial operations, saving energy and fuel, reducing pollution, generating cost savings and improving efficiencies of marine activities. Utilization of innovative technologies could be enhanced through strengthened regional cooperation, inclusive and action-oriented regional platforms, cross-border technology partnerships, and sharing of experience across stakeholders and countries.

This issue of *Asia-Pacific Tech Monitor* discusses the challenges, opportunities, strategies and good practices to use the tools of science technology and innovation and regional cooperation for sustainable harnessing and utilization of ocean resources in the Asia-Pacific countries.

Michiko Enomoto
Head, APCTT-ESCAP

ASIA-PACIFIC

CHINA

Guideline for enhancing IPR protection

The general offices of the Communist Party of China (CPC) Central Committee and the State Council have jointly issued a directive calling for intensified protection of intellectual property rights (IPR). Titled "The Guideline on Strengthening Intellectual Property Rights Protection," the document aims to implement decisions and plans of the CPC Central Committee and the State Council on stepping up IPR protection and improve related systems and mechanisms. "Strengthening IPR protection is the most important content of improving the IPR protection system and also the biggest incentive to boost China's economic competitiveness," reads the document.

The document said China will make comprehensive use of the law, technology and social governance policies to step up IPR protection. According to the document, by 2022, China will strive to effectively curb IPR infringement, and largely overcome challenges including high costs, low compensation and difficulties in providing evidence for safeguarding intellectual property rights. By 2025, social satisfaction with IPR protection in China will reach and maintain a high level.

Meanwhile, China will strengthen the punishment for infringements and counterfeiting, and improve the protection system for new business forms.

The document calls for speeding up the introduction of a punitive compensation system for infringements of patents and copyrights, and strengthening the protection of trade secrets, confidential business information and their source codes. China will also make greater efforts to step up international cooperation in IPR protection, facilitate communication between domestic and foreign rights holders, and provide support in overseas IPR disputes.

http://www.xinhuanet.com

Patents, royalty income rise

China granted 453,000 invention patents last year, up almost 5% year on year, as the country vows to step up regulations to protect intellectual property. The total import and export of IP fees from January to November 2019 exceeded US$37 billion, already topping the US$35 billion for all of 2018, according to a statement from China's National Intellectual Property Administration (CNIPA), as reported by state-run media *Science and Technology Daily*.

Exports, or the amount foreign companies paid for use of Chinese IP, grew 19.2% year on year to US$6 billion, signaling an improvement in the country's IP quality, according to the CNIPA. Chinese applications for international patents are also on the rise with 61,000 submissions last year, up 10.4% from 2018.

Apart from new inventions, around 1.6 million utility model patents were issued last year for minor improvements on existing products, while 557,000 design patents were granted for ornamental product designs. "China will continue to improve the legal system for intellectual property […] and step up international cooperation in the protection of IP rights as key tasks in 2020," according to a statement from the patent office on Monday.

https://www.techinasia.com

INDIA

Royalty payments for technology transfer

The Government is considering to re-introduce restrictions on royalty payments for technology transfer in view of excessive outflow of such funds to overseas companies, sources said. A proposal in this regard will soon be circulated by the Department for Promotion of Industry and Internal Trade (DPIIT) for inter-ministerial consultation, sources said.

According to the proposal, limits could be imposed on royalty payments in case of technology transfer or collaboration involving foreign entities either directly or indirectly through any firm in India. A similar proposal was mooted by the department last year. That time it had proposed that royalty payments should be capped at 4 percent of domestic sales and 7 percent of exports for the first four years; and for the next three years the limit should be 3 percent of local sales and 6 percent of exports.

Proposing these restrictions, the department had argued that the curbs would help increase the profits of domestic companies, mainly in the automobile sector, prevent depletion of foreign exchange reserves, protect the interest of minority shareholders and increase revenue for the government.

Before 2009, royalty payments were regulated by the government and capped at 8 percent of exports and 5 percent of domestic sales in the case of technology transfer collaborations. They were fixed at 2 percent of exports and 1 percent of domestic sales for use of trademark or brand name. Auto major Maruti Suzuki pays an average royalty of around 5.5 percent of its net sales to its parent Suzuki.

https://www.firstpost.com

Innovative solutions sought to fight Covid-19

The Department for Promotion of Industry and Internal Trade (DPIIT) and Startup India have launched a competition for budding entrepreneurs and companies to come out with innovative solutions to fight against Covid 19 crisis. "Help us fight the Covid 19 hurdle together by participating in the United Against COVID-19-Innovation Challenge," Startup India has said in a tweet. Startup India is an initiative of the DPIIT to promote innovation in the country.

It said that the challenge is open to all start-ups, companies, and innovators - whose innovation can plug the gap between the demand and supply of essential medical items to fight the Covid-19 outbreak. The competition can also innovate technology for applications such as motion tracking, geo-fencing and fake news detection.

"As the world is currently looking at a serious healthcare challenge caused by the pandemic Covid-19, DPIIT with Startup India is scouting for innovative technologies and solutions for precautionary as well as treatment-related interventions. "We are building a one-stop repository of innovative solutions for ready access by the government and the private sector for further development and deployment," Startup India said.

It also said the top solutions will be referred to the government and private stakeholders for further funding and deployment. The solutions will also be published on the Invest India Business Immunity Platform, which is an interactive resource for investors, the business community, and other stakeholders to access all relevant information about India's fight against COVID-19.

Citing examples, it said solutions can be in the areas of low-cost masks which can capture virus from the air and absorb respiratory droplets; cost-effective thermal scanning devices and rapid diagnostic kits, critical-care equipment -- including portable oxygenators and home-based ventilators to monitor and control the spread of the new coronavirus, among others.

https://economictimes.indiatimes.com

INDONESIA

Boosting pharma innovation

The government is planning to relax rules on drug patents in the omnibus bill on job creation to boost the nation›s pharmaceutical industry and encourage patent-sharing, a top minister has said. Coordinating Economic Minister Airlangga Hartarto said that current legislation obliged companies to register their patents in Indonesia in hopes of driving the local pharmaceutical industry, but that the industry had not grown as expected. Instead, the patent rule created difficulties for the industry in providing the needed medication during a health emergency.

"We are pushing [so] companies do not have to register their patents in Indonesia," Airlangga said during a media briefing in Jakarta. Allowing pharmaceutical companies to apply for patents abroad might expedite patent sharing for developing the needed vaccine or antiviral during an outbreak, such as the ongoing COVID-19 outbreak, he said.

Article 20 of the Patent Law stipulates that the patent holder must manufacture its products or process them in Indonesia, which would require technology transfers, investment and/or creating new jobs. The article has been deleted in the omnibus bill on job creation. Instead, the bill stipulates that pharmaceutical companies only need to obtain licenses from the government for operating their business and developing medicines and medical devices.

The government is authorized to revoke the licenses if a company's drugs and medical devices do not meet standards, with further provisions to be regulated in government regulations (PP). Meanwhile, Law No. 36/2009 on health states that medical supplies may be distributed only after a distribution license is granted and must adhere to distribution objectives.

https://www.thejakartapost.com

ADB supports human capital, infrastructure development

The Asian Development Bank (ADB) will provide around US$2.7 billion in loans this year to support Indonesia's human capital, infrastructure and green energy development. ADB president Masatsugu Asakawa said the bank planned to provide Indonesia with more loans this year than the $1.7 billion it provided in 2019. The bank plans to provide Indonesia with $500 million for a competitiveness enhancement program and another $500 million for a financial inclusion program this year.

"This is an increase of $1 billion but it is still a forecast amount," Asakawa said during a news conference in Jakarta on Tuesday after a meeting with President Joko "Jokowi" Widodo. "We want to expand ADB's support for human capital development and infrastructure connectivity."

In his inaugural speech at the beginning of his second term, Jokowi announced that his administration would prioritize human capital and infrastructure development. The administration's goal is to set Indonesia on the path to becoming one of the world's five largest economies by 2045, with a near zero percent poverty rate and an average per person monthly income of Rp 27 million.

After meeting with Jokowi, Asakawa said the bank would focus on providing support in a range of areas including clean energy, higher education and skills development as well as innovative green and blue financing. The ADB has also committed to funding several projects in South Sulawesi including the Mamminasata toll-road project, low-cost apartment developments and a clean water program. The bank plans to finance priority projects of the Indonesian government and the private sector, Asakawa said.

Asakawa added that the bank's proposed Country Partnership Strategy for Indonesia for 2020-2024 would support the government's development priorities and seek to catalyze private sector financing, promote innovation and new technologies. Between 1966 and 2018, the ADB committed $36.68 billion in sovereign and nonsovereign loans, equity investments and guarantees. Furthermore, the ADB provided $460.5 million in technical assistance and $449.98 million in grants to Indonesia.

https://www.thejakartapost.com

PHILIPPINES

Innovation focus on agriculture, water

The Department of Science and Technology (DoST) said its plan to further improve the Philippines' global innovation ranking involves research in key agricultural sectors like coconut and livestock, as well as improving the environment for water resources. Science and Technology Secretary Fortunato T. dela Peña said at a news conference that the Philippines should focus on fields of research like "alternatives to pork meat and… chicken research." The Philippines rose 19 places in the 2019 Global Innovation Index to 54.

He said research resources should also be devoted to biomedical devices, mass transportation systems, machinery design, and energy storage and conservation. "This is the reason why we have modified our monitoring and evaluation system… because we would like to invest in those that will give the best returns," he said.

In addition to the output of university, industry, and research centers, DoST is also looking at the research of senior high school students, drawing in research from experts who have traditionally not

received grants before. He also cited the need to pay more attention to the work of small businesses, including start-ups. "Start-ups… come up with innovations, even without R&D support," he said, noting that the DoST is eager to provide research support at the prototype development stage via business incubators.

The Philippines performed well in indicators related to innovation linkages, high-tech imports, and research talent in the global innovation index. Other bright spots were categories like firms offering formal training, productivity growth, ICT services exports, and creative goods exports.

The identified weaknesses were in ease of starting a business, ease of getting credit, expenditure on education, the presence of global R&D companies, the volume of scientific and technical articles and new businesses.

https://www.bworldonline.com

SINGAPORE

Help for SME retailers

Retailers that are new to e-commerce can have 90 per cent of their costs of selling online covered. The E-Commerce Booster Package was launched to help small and medium-sized enterprise (SME) retailers which are new to, or have little experience in, e-commerce to diversify their revenue streams beyond the traditional bricks-and-mortar model, Enterprise Singapore (ESG) said yesterday. This is especially relevant amid the Covid-19 situation, ESG said.

Retailers can sign up with one of four e-commerce platforms - Amazon, Lazada Singapore, Qoo10 or Shopee - and have 90 per cent of qualifying costs waived. The one-time support is capped at $9,000 and the e-commerce platforms will offset their fees directly. Qualifying costs refer to the services provided by the platforms, including content development services, product listing and advertising.

The platform providers will work with retailers to curate and list products for up to six months, participate in promotional campaigns, fulfil orders and analyse sales data. Those looking to expand their reach overseas can also tap ESG's existing Multichannel E-Commerce Platform Programme and list their products on overseas marketplaces with more qualifying costs covered.

https://www.straitstimes.com

SRI LANKA

Science, technology and innovation

Sri Lanka will lead the Science, Technology and Innovation sector in the Bay of Bengal Initiative for Multi Sectoral Technical and Economic Cooperation (BIMSTEC). The Foreign Relations Ministry said this was agreed during the finalization of areas of cooperation among BIMSTEC Member States during the 20th Session of the Senior Officials' Meeting (SoM) Chaired by Foreign Secretary Ravinatha Aryasinha on 3 March 2020, the BIMSTEC. Accordingly, a BIMSTEC Facility for Technology Transfer is planned to be opened in Sri Lanka in the future. Sri Lanka will also appoint a Director to the BIMSTEC Secretariat in June this year. The SOM was preceded by the 3rd Permanent Working Committee Meeting (BPWC) Chaired by Additional Secretary (Economic Affairs) P.M. Amza, from 1 to 2 March 2020 at the Ministry of Foreign Relations.

Sri Lanka is mandated to lead the sector on Science, Technology and Innovation under which cooperation in Technology, health and human resource development is also included. Bangladesh was mandated to lead Trade, Investment and Development, Bhutan – Environment and Climate Change, Myanmar – Agriculture and Food Security, India – Security (Counter Terrorism and Transnational Crime, Disaster Management & Energy), Nepal – People to people contact (culture, tourism, forums of Think Thanks, Media etc.) and Thailand – Connectivity.

BIMSTEC Charter which is the institutional mechanism to effectively steer the process of regional cooperation under BIMSTEC was also finalized and is expected to be adopted at the 5th BIMSTEC Summit.

http://www.colombopage.com

THAILAND

Aid package for SMEs

To help small and medium-sized enterprises (SMEs) stay afloat as the economy flails, the government is poised to raise the state-owned Thai Credit Guarantee Corporation's (TCG) credit guarantee coverage to 40% from 30%. Deputy Prime Minister Somkid Jatusripitak said a higher credit guarantee ratio will be a key component in the new aid package for SMEs that is scheduled to go before the cabinet today. The higher coverage will help SMEs access credit from banks, said Mr Somkid. "The country's economic slowdown has triggered higher non-performing loans among SMEs. Without any aid measures, these SMEs will eventually be pushed into collapse, which will be a great blow to the economy," he said.

On Aug 20, the cabinet approved an SME stimulus package that included a credit guarantee by TCG and credit lines from state banks worth a combined 100 billion baht. The Office of Small and Medium Enterprises Promotion was also ordered to help SMEs and micro-SMEs access funding sources. According to Mr Somkid, the latest credit guarantee measure would be allotted based on SMEs' characteristics. SMEs will be classified into three groups: those who want to access financial sources but cannot, those whose debts have turned sour, and those who can access financial institution lending but need additional liquidity.

TCG will offer a 10-billion-baht credit guarantee facility to the first group for up to 50,000 SMEs, while a debt restructuring programme will granted for the second group, covering about 20,000 SMEs. For the third group, Krungthai Bank is offering low-rate loans worth 50-60 billion baht to SMEs, while Government Savings Bank is extending 40 billion to boost financial liquidity.

As part of the new package, the Finance Ministry will also propose the cabinet tweak the requirement by extending the debt restructuring negotiation period for SMEs whose loans are guaranteed by TCG to seven years from five years at present.

At present, TCG is required to file lawsuits against SMEs that default and complete debt restructuring talks within five years. An estimated 10,000 SMEs with a combined debt of about 10 billion baht are in this group.

https://www.bangkokpost.com

VIET NAM

Innovative economy index

Viet Nam has moved up on the Bloomberg Innovation Index of the world's 60 most innovative economies, but lags far behind Asian peers. With an overall score 47.64 out of 100, Vietnam has jumped three places from last year to 57th on the annual index released by Bloomberg, the U.S.-based financial, software, data, and media company.

The ranking measures the world's 60 most innovative countries using seven criteria: research and development intensity; productivity; patent activity; concentration of researchers, tertiary efficiency; hi-tech density; and value-added manufacturing.

Vietnam's highest scores were 37th in hi-tech density, 40th in tertiary education efficiency and 42nd in patent activity. It ranked 52nd and 53rd in terms of value-added manufacturing and research and development intensity, respectively. The country did not do well researcher concentration, standing 55th, while productivity ranking was lowest at 60th.

Vietnam's productivity continues to lag behind many of its Southeast Asian neighbors, and use of outdated technology and a low-skilled workforce is widening the productivity gap, said Nguyen Bich Lam, general director of the General Statistics Office.

Based on purchasing power parity (PPP) at 2011 constant prices, the GSO estimateed Vietnam's overall labor productivity in 2018 at $11,142, lower than Singapore, Malaysia, Thailand, Indonesia and the Philippines.

https://e.vnexpress.net

"Youth and Innovation for Ocean" Initiative

UNESCO in partnership with the Coca-ColaFoundation launched the "Youth and Innovation for Ocean" Initiative in Hanoi on June 8 with the aim of empowering students and young professionals to devise solutions to reduce and recycle plastic waste in coastal regions in Vietnam on the occasion of the World Oceans Day.

The initiative will call on young talent and juniorscientists to develop innovative and practical solutions for plastic waste management with the focus on the three"Rs": Reduce, Reuse and Recycle, contributing to the development of a circular economy. Young talent will be provided with technical support from top experts through a mentorship scheme during the framework of the Initiative.

The most innovative ideas will be piloted in UNESCO Biosphere Reserves, specifically the Cu Lao Cham - Hoi An Biosphere Reserve. The initiatives are expected to support communities in coastal regions to deal with plastic waste, improve the environment and enhance their living standards.

In addition, the Youth and Young Professionals on Innovation, Science and Technology Platform for Resiliency (U-INSPIRE) will be launched within the framework of the Initiative which will serve as a national hub for supporting knowledge sharing and innovative ideas from young Vietnamese citizens to address environmental and development issues in the country.

https://en.nhandan.org.vn

Investment incentives for SMEs

As the outbreak of COVID-19 hampers business activity, Vietnam introduced Decree No. 37/2020/ND-CP (Decree 37) on March 30 to update the list of sectors and industries access to investment incentives under Decree 118/2015/ND-CP. The move underlines the government's efforts to support businesses and particularly small and medium-sized enterprises (SMEs) affected by COVID-19.

The regulation expands the list of business lines eligible for investment incentives. This includes four types of SME business lines which are:

- Small and mediums sized enterprises (SMEs) supply chains;
- Business incubators for SMEs,
- Technical support facilities for SMEs; and
- Co-working spaces of SMEs.

The aforementioned businesses will now be eligible for import duty exemptions on fixed assets as well as other exemptions based on location.

SMEs continue to play a major role in Vietnam, accounting for 98 percent of all enterprises, 40 percent of GDP, and 50 percent of employment or 1.2 million jobs. As per the Ministry of Finance, Vietnam has more than 600,000 firms, with nearly 500,000 private and 96 percent being small and micro-enterprises.

Vietnam considers SMEs as an important driving force for its economy While concerns remain, the government introduced the Law on Support for Small and Medium Enterprises No 04/2017/QH14 which took effect in January 2018 which seeks to support SMEs. Later in May 2019, the government issued *Circular No 06/2019/TT/BKHDT* on network consultants for SMEs and *Circular No 05/2019/TT/BKHDT* on subsidies for training courses for women-owned SMEs. There are also several government and private funded programs and organizations lending support to SMEs.

Despite this, SMEs continue to face challenges due to unclear guidelines, vague supporting policies, and implementation of the laws by local authorities. To address these issues the government has proposed a draft to the new Law on Investment, but this is likely in early 2021. *Decree* 37 aims to fill this gap and help SMEs during the pandemic. Decree 37 is also likely to further help startups by attracting more investment including by foreign investors. In *Vietnam's Innovation Ecosystem 2019* report by the Australian Trade and Investment Commission, the report stated that Vietnam has the third-highest rate for startups in Southeast Asia.

The Decree will make it easier to access incentives such as access to land and credit support initiatives. In addition, the regulation will help SMEs aid in recovering the economy as Vietnam looks to restart its economy after COVID-19..

https://www.vietnam-briefing.com

INTERNATIONAL

Wave-energy-driven CO2 reduction system

A team from King Abdullah University of Science and Technology (KAUST), Beijing Institute of Nanoenergy and Nanosystems, and Georgia Tech has developed a wave-energy-driven electrochemical CO_2 reduction system that converts ocean wave energy to chemical energy in the form of formic acid, a liquid fuel.

The system, described in an open-access paper in the RSC journal *Energy & Environmental Science*, mainly consists of a spherical spring-assisted triboelectric nanogenerator (TENG) to convert the mechanical energy of the wave to electrical energy; a power management circuit with a supercapacitor to temporarily store the harvested electrical energy; and a electrochemical setup to reduce carbon dioxide to formic acid.

The team optimized the charging process of the supercapacitor and the operation potential of the electrochemical cells to more effectively utilize the energy harvested from the nanogenerator and maximize the production of formic acid. Under simulated waves, the system can produce 2.798 µmol of formic acid per day via the wave energy harvested from a water's surface area of 0.04 m^2.

They also performed field tests in the Red Sea to demonstrate the practicality of such an electrochemical CO_2 reduction system. According to the field test results, the wave-energy-driven CO_2RR system can produce 0.325 µmol of formic acid per day at 18 knots wind speed. Finally, they present design guidelines for achieving a cost-effective, efficient, and large-scale wave-energy-driven CO_2 reduction system for liquid fuel production.

https://www.greencarcongress.com

AI used to detect ocean pollution

Intel has recently partnered with Accenture and the Sulubaaï Environmental Foundation to create an AI-driven data collection platform aimed at analyzing and protecting vulnerable marine habitats, habitats like coral reefs. A combination of climate change, pollution, and overfishing have been damaging the world's oceans, particularly coral reefs. Coral reefs around the world are experiencing mass die-offs and problems like coral bleaching. Scientists and conservationists are looking for ways to protect coral reefs and help them recover. Designing plans to support coral reefs requires data, and as Engadget reported, Intel has partnered with two environmental foundations to create the CORaiL platform. The purpose of CORaiL will be collecting information on coral reefs and other marine habitats, providing researchers with the data they need to determine what strategies could be effective at protecting vulnerable marine ecosystems. As Jason Michell, managing director of the Communications, Media, and Technology practice at Accenture explained in a blog post: "Artificial intelligence provides unprecedented opportunities to solve some of society's most vexing problems. Our ecosystem of corporate and social partners for this 'AI for social good' project proves that there is strength in numbers to make a positive environmental impact."

In May of last year, the team of researchers and engineers from the three organizations installed concrete structures along reefs found near the Philippines' Pangatalan Island. The concrete chunks contained sections of living coral capable of growing into new habitat for creatures inhabiting coral ecosystems. In addition, the researchers placed video cameras underwater near the structures so they could collect data on the coral and the surrounding environment. The cameras utilized an AI-driven video analytics system developed by Accenture, and the cameras enabled the researchers to gather data on the reefs through minimally invasive methods.

Accenture's AI video analytics system lets researchers collect real-time video data from the coral environments, without needing to be physically present in the water. While many divers collect footage of coral reefs, this incurs travel expenses and presents the possibility that the divers could interfere with wildlife in the area. The AI video platform does much of the data collection and analysis for the research teams, continually monitoring the environment for change, and letting researchers do analysis in more or less real-time.

Over the course of the past year, CORaiL has collected around 40,000 images for analysis, and the images are already helping researchers analyze how coral reefs change in response to shifting environmental conditions. Meanwhile, engineers from the cooperative effort are already working on the next generation of the CORaiL system. The next proptype will include a backup power supply and an optimized series of convolutional neural networks. New versions of CORaiL might be employed for tasks other than studying coral, such as studying how tropical fish migrate through cold waters or monitoring for violators of reef protection orders.

https://www.unite.ai

Solar device converts seawater to drinking water

An international team of scientists has developed a cheap way to provide fresh water to thirsty communities by making seawater drinkable without using electricity. So long as the sun is shining, they say, their device will produce enough high-quality potable water to cover a family's needs, at a cost of around $100. The scientists, from Massachusetts institute of Technology (MIT), U.S. and Shanghai Jiao Tong University, China, believe their brainwave offers a simple solution to thirsty islands and arid coastal areas which lack a reliable electricity supply but have access to seawater. It could even help to prevent some of the mass migrations expected with climate change.

The researchers report their work in the journal *Energy and Environmental Science*. Testing their prototype on a roof at the Massachusetts Institute of Technology, they produced more than 1.5 gallons of

fresh drinking water every hour for every square meter of solar collecting area. Their device is cube-shaped, with multiple layers of solar evaporators and condensers piled one on top of another, surmounted with a layer of transparent insulation. Essentially it is a multi-layer solar still, similar to those used for centuries to make strong liquor and used today in many applications.

A solar still uses flat panels to absorb heat which it then transfers to a layer of water, which begins to evaporate. The vapor condenses on the next panel and the water is collected, while the heat from the vapor condensation is passed to the layer above. Whenever vapor condenses on a surface, it releases heat; in typical condenser systems, that heat is simply lost to the environment. But in this multi-layer version the released heat flows to the next evaporating layer, recycling the solar heat and boosting overall efficiency.

The efficiency comes from using each of the multiple stages to remove salt from the sea water, with the heat released by the previous stage harnessed instead of wasted. In this way, the team's demonstration device achieved an overall efficiency of 385 percent in converting the energy of sunlight into evaporation. Although adding more layers increases the conversion efficiency of the system, each layer also adds cost and bulk. The team settled on a 10-stage system for their proof-of-concept device. It delivered pure water that exceeded city drinking water standards, at a rate of 5.78 liters per square meter (about 1.52 gallons per 11 square feet) of solar collecting area. This is more than twice as much as the record amount previously produced by any such passive solar-powered desalination system, Professor Wang says.

And a big advantage of the system is that it has a self-flushing mechanism which will clean out the accumulation of salt each night and return it to the sea. One possible way of using the system would be with floating panels on a body of saltwater. The panels could deliver constant fresh water through pipes to the shore so long as the sun was shining. Other systems could be designed to serve a single household, perhaps using a flat panel on a large shallow tank of seawater.

The team estimates that a system with a roughly one-square-meter solar collecting area could meet the daily drinking water needs of one person. In production, they think a system built to serve the needs of a family might be built for around $100.

https://www.ecowatch.com

ASIA-PACIFIC

AUSTRALIA

Breaking down marine microplastic pollution

Plastic waste that finds its way into oceans and rivers poses a global environmental threat with damaging health consequences for animals, humans, and ecosystems. Now, using tiny coil-shaped carbon-based magnets, researchers in Australia have developed a new approach to purging water sources of the microplastics that pollute them without harming nearby microorganisms. Their work appears July 31 in the journal *Matter*.

"Microplastics adsorb organic and metal contaminants as they travel through water and release these hazardous substances into aquatic organisms when eaten, causing them to accumulate all the way up the food chain" says senior author Shaobin Wang, a professor of chemical engineering at the University of Adelaide (Australia). "Carbon nanosprings are strong and stable enough to break these microplastics down into compounds that do not pose such a threat to the marine ecosystem."

To decompose the microplastics, the researchers had to generate short-lived chemicals called reactive oxygen species, which trigger chain reactions that chop the various long molecules that make up microplastics into tiny and harmless segments that dissolve in water. However, reactive oxygen species are often produced using heavy metals such as iron or cobalt, which are dangerous pollutants in their own right and thus unsuitable in an environmental context.

To get around this challenge, the researchers found a greener solution in the form of carbon nanotubes laced with nitrogen to help boost generation of reactive oxygen species. Shaped like springs, the carbon nanotube catalysts removed a significant fraction of microplastics in just eight hours while remaining stable themselves in the harsh oxidative conditions needed for microplastics breakdown. The coiled shape increases stability and maximises reactive surface area. As a bonus, by including a small amount of manganese, buried far from the surface of the nanotubes to prevent it from leaching into water, the minute springs became magnetic. "Having magnetic nanotubes is particularly exciting because this makes it easy to collect them from real wastewater streams for repeated use in environmental remediation," says Xiaoguang Duan, a chemical engineering research fellow at Adelaide who also co-led the project.

As no two microplastics are chemically quite the same, the researchers' next steps will center on ensuring that the nanosprings work on microplastics of different compositions, shapes and origins. They also intend to continue to rigorously confirm the non-toxicity of any chemical compounds occurring as intermediates or by-products during microplastics decomposition.

The researchers also say that those intermediates and byproducts could be harnessed as an energy source for microorganisms that the polluting plastics currently plague. "If plastic contaminants can be repurposed as food for algae growth, it will be a triumph for using biotechnology to solve environmental problems in ways that are both green and cost efficient," Wang says. This work was supported by the Australian Research Council, the National Natural Science Foundation of China, and the Science and Technology Program of Guangdong Province.

https://www.sciencedaily.com

Industrial underwater robots to help ocean discoveries

The remotely operated vehicles can be adapted to gather scientific data while being used to inspect and maintain offshore structures. A team of scientists have

published a paper urging for the oil and gas industry to think about how underwater robots -- otherwise commonly referred to as remotely operated vehicles (ROVs) -- could be adapted and used to help researchers gather scientific data about the marine ecosystem.

The team, led by Dianne McLean and Miles Parsons from the Australian Institute of Marine Science (AIMS), published the paper in the journal *Frontiers in Marine Science*, citing how "low-cost engineering and operational tweaks" to ROVs could be used to gather scientific information.

Some of the suggested tweaks included attaching additional cameras, audio transmitters and receivers, and sample collection devices to existing ROVs.

ROVs are typically used by the oil and gas industry to inspect and maintain offshore structures. But McLean believes they can be used, for instance, to collect water samples to analyse environmental DNA, make scientific discoveries, examine the impact structures have on the ocean, and understand how climate change is changing the ocean.

"Scientists have limited access to a lot of the deep oceans just because it is remote and costly to get out there that. The oil and gas industry is doing these surveys with ROVs routinely, we should work with them to get this information," she said, speaking to ZDNet. "Just being able to access some of the imageries these ROVs collect could really provide us with huge insights about marine life down there."

https://www.zdnet.com

CHINA

Supercapacitor to store ocean energy

The system features a supercapacitor to temporarily store the harvested energy and an electrochemical setup able to reduce carbon dioxide to formic acid. A scientific team from the City University of Hong Kong has developed a novel wave energy device that generates electricity while converting carbon dioxide into fuel. Researchers say the new lightweight device can capture ocean wave energy and convert it into formic acid, a liquid fuel.

The electrochemical carbon dioxide reduction system consists of three components – a spherical medusa-like nanogenerator that can convert the energy of the wave into electricity, a power management circuit with a supercapacitor to temporarily store the harvested energy and an electrochemical setup that can reduce carbon dioxide to formic acid.

The research behind this breakthrough highlights the role of the ocean wave energy as an abundant and relatively stable source of renewable energy, which would be highly desirable for the conversion of carbon dioxide to conveniently stored and transported liquid fuels. Professor He Jr-hau from the Department of Materials Science and Engineering said: "Unlike conventional wave energy converters based on electromagnetic generators, the lightweight device, which can float on water surface and causes minimal impact to marine life and the seafloor, is more cost-effective and able to survive storms.

A liquid fuel, in the form of formic acid, is favourable because it can be stored at room temperature and is relatively easy and safe to transport. More importantly, this technology can mitigate carbon dioxide, a major greenhouse gas, during the energy conversion process, and ultimately help combat climate change.

https://www.energylivenews.com

INDIA

Turbines to convert wave energy to electricity

The Indian Institute of Technology (IIT) Madras and National Institute of Ocean Technology (NIOT) researchers are working towards developing better turbines that can harness the power of ocean waves to generate electricity. Their most recent studies on turbine-chamber coupling have been published in the reputed peer-reviewed International Journal of Energy Research.

The research is being headed at IIT Madras by Abdus Samad, Associate Professor, Department of Ocean Engineering, who works towards extracting energy from the ocean waves. The work of Abdus Samad and his research team is aimed at meeting renewable energy and climate change objectives of the Government of India. Recent research by Abdus Samad's group at IIT Madras, in collaboration with National Institute of Ocean Technology (NIOT), is being funded by Ministry of Earth Sciences, Government of India, and focuses on improving the devices and machines used for wave energy harvesting.

The research team comprises of Aravind George, Suchithra Ravikular, R Ananthnarayan, and Abdus Samad from the Department of Ocean Engineering, IIT Madras. George is the first author of the paper, and he is now at the University of Melbourne, Australia, completing his PhD. On the other hand, the scientists, Prasad Dudhgaonkar, Biren Patnaik, and Purnima Jalihal are from NIOT. Jalihal is the head of Energy and Fresh Water group of NIOT.

The aerodynamic performance of the turbine plays a major role in the wave-to-wire conversion efficiency. The coupling between the hydrodynamic process of the wave energy absorption and the turbine's aerodynamic process is affected by the interplay between the pressure in the oscillating water column and the airflow rate through the turbine. This interplay is called the damping effect. The variability of waves induces varying turbine speed, which in turn affects damping. Abdus Samad and his team analyze the running characteristics of a turbine connected to an oscillatory airflow test rig and subjected to varying rotational speeds.

In their recently published paper, the team presents the variations of pressure drop and pressure coefficient along with damping characteristics of the test rig, based on acceleration and deceleration of the turbine. In effect, they present the characteristics of the turbine-chamber coupling. This work by Abdus Samad's team offers a good launchpad for future research in the area of wave power. Such future research would examine the power output of the turbine, the turbine mean efficiency, and the chamber efficiency to relate turbine?chamber coupling in greater detail, which would help in the design of more efficient wave energy harvesting devices.

The turbine is the heart of the wave energy system and a huge amount of research works are done through fluid dynamic analysis, experimental system development, design, and tests. To overcome the challenges coming on the way to develop from scratch to the ocean test took 7 years and more than two dozen of researcher's work on it. The turbines being developed are for the floating and fixed wave devices being developed at NIOT. The hydrodynamics, floating body dynamics, offshore-related aspects and integration of the turbine- generator module with the device are all being done by NIOT.

https://www.indiatoday.in

Hydrogen from sea-water

Researchers from the Indian Institute of Technology (IIT) Madras have developed a technology that can be used to generate hydrogen fuel from seawater, an advance that may contribute to a cleaner energy future. Using this technology, described in the journal *ACS Sustainable Chemistry & Engineering*, hydrogen can be produced on-demand at the point of use, and hence it need not to be stored. This overcomes the storage-related challenges associated with hydrogen as its highly inflammable and may cause an explosion, the researchers said.

The researchers noted that hydrogen is produced at a tunable rate without heat, electricity or sunlight. The starting materials are all eco-friendly. The process is amenable to all scales of production that is relevant for the hydrogen economy — hence sectors such as automotive, aviation etc. would benefit from this technology, they said. The researchers, including Tiju Thomas, Associate Professor at IIT Madras, said they are on the way to customise and design a proper hydrogen system for vehicles.

The technology is used to generate hydrogen from any source of water. However, as seawater covers two-thirds of the surface of the Earth, the researchers are keen on utilising it. The setup, the scientists said, can generate fuel production with the push of a button, which adds water from one compartment to the other.

The researchers noted that the commercial method requires a high temperature of about 1,000 degrees Celsius and nearly 25 bar pressure. However, the new process works at the room temperature, and atmospheric pressure which is 1 bar, they said.

https://www.firstpost.com

JAPAN

New biodegradable plastic in ocean water

Researchers from Osaka University have developed a new kind of plastic that can be used to make watertight containers that are also biodegradable in certain kinds of ocean water. The project was a joint effort from Osaka University and Nippon Shokuhin Kako Company, a Japanese agricultural giant that produces starch-based food products. The team extracted starch from cassava provided by Nippon Shokuhin Kako and combined it with cellulose taken from wood pulp.

The mixture was dissolved in a water solution and spread into a transparent sheet that's just 100 micrometers thick. The sheet was then heated to turn it into a solid plastic, according to a report in the *Asahi Shimbun*. The team says the resulting plastic is twice as strong as conventional plastic made from polyethylene, one of the main components in plastic bags.

To test its biodegradability, they placed samples of the new plastic in several different containers filled with seawater, each of which had varying levels of microorganisms in them. The team found that the plastic fully broke down within 30 days in the seawater sample with the highest concentration of microorganisms. In other containers with lesser amounts of microorganisms the plastic remained in tact after the 30 day observation period.

In comparison, a plastic bag in the ocean takes around 20 years to decompose, while plastic bottles can take as long as 450 years. The team from Osaka University hopes their new kind of plastic could cut down on the harm food containers and other plastic waste causes in the ocean.

https://www.dailymail.co.uk

EUROPE

UK

AI detects plastics in the oceans

An AI system has spotted plastic pollution in the sea by analyzing images from satellites orbiting the earth. The scientists behind the technique claim that it's the first time patches of plastics in coastal waters have been detected via satellites. The system studies images collected by the European Space Agency's Sentinel-2 satellites to spot debris floating in the world's oceans. These objects absorb and reflect light to produce a "spectral signature" in the data that contain clues about what they are.

Researchers from Plymouth Marine Laboratory in the UK then trained an algorithm to classify the different objects by spotting differences in their spectral signatures. They then ran the algorithm over images of seas surrounding Canada, Scotland, Ghana, and Vietnam. On average, the system differentiated between plastics and natural materials such as seaweed with 86% accuracy.

The team now plans to refine the technique to accurately detect floating patches in turbid coastal waters and large river waters. Eventually, they hope the method will be combined with drones to monitor plastic littering and support clean-up operations. But they add that the only way to clean up our polluted oceans is to dramatically reduce the amount of plastic we produce.

https://thenextweb.com

NORTH AMERICA

USA

Battery-free sensor for underwater exploration

MIT researchers have developed a battery-free underwater communication system that uses near-zero power to transmit sensor data. The system could be used to monitor sea temperatures to study climate change and track marine life over long periods — and even sample waters on distant planets. They are presenting the

system at the SIGCOMM conference this week, in a paper that has won the conference's "best paper" award.

The system makes use of two key phenomena. One, called the "piezoelectric effect," occurs when vibrations in certain materials generate an electrical charge. The other is "backscatter," a communication technique commonly used for RFID tags, that transmits data by reflecting modulated wireless signals off a tag and back to a reader.

In the researchers' system, a transmitter sends acoustic waves through water toward a piezoelectric sensor that has stored data. When the wave hits the sensor, the material vibrates and stores the resulting electrical charge. Then the sensor uses the stored energy to reflect a wave back to a receiver — or it doesn't reflect one at all. Alternating between reflection in that way corresponds to the bits in the transmitted data: For a reflected wave, the receiver decodes a 1; for no reflected wave, the receiver decodes a 0.

The researchers demonstrated their Piezo-Acoustic Backscatter System in an MIT pool, using it to collect water temperature and pressure measurements. The system was able to transmit 3 kilobits per second of accurate data from two sensors simultaneously at a distance of 10 meters between sensor and receiver.

The transmitter and receiver must have power but can be planted on ships or buoys, where batteries are easier to replace, or connected to outlets on land. One transmitter and one receiver can gather information from many sensors covering one area or many areas. Next, the researchers aim to demonstrate that the system can work at farther distances and communicate with more sensors simultaneously. They're also hoping to test if the system can transmit sound and low-resolution images. The work is sponsored, in part, by the U.S Office of Naval Research.

http://news.mit.edu

Faster-degrading plastic for cleaner seas

To address plastic pollution plaguing the world's seas and waterways, Cornell University chemists have developed a new polymer that can degrade by ultraviolet radiation, according to research published in the *Journal of the American Chemical Society*. "We have created a new plastic that has the mechanical properties required by commercial fishing gear. If it eventually gets lost in the aquatic environment, this material can degrade on a realistic time scale," said lead researcher Bryce Lipinski, a doctoral candidate in the laboratory of Geoff Coates, professor of chemistry and chemical biology at Cornell University. "This material could reduce persistent plastic accumulation in the environment."

Commercial fishing contributes to about half of all floating plastic waste that ends up in the oceans, Lipinski said. Fishing nets and ropes are primarily made from three kinds of polymers: isotactic polypropylene, high-density polyethylene, and nylon-6,6, none of which readily degrade. "While research of degradable plastics has received much attention in recent years," he said, "obtaining a material with the mechanical strength comparable to commercial plastic remains a difficult challenge."

Coates and his research team have spent the past 15 years developing this plastic called isotactic polypropylene oxide, or iPPO. While its original discovery was in 1949, the mechanical strength and photodegradation of this material was unknown before this recent work. The high isotacticity (enchainment regularity) and polymer chain length of their material makes it distinct from its historic predecessor and provides its mechanical strength. Lipinski noted that while iPPO is stable in ordinary use, it eventually breaks down when exposed to UV light. The change in the plastic's composition is evident in the laboratory, but "visually, it may not appear to have changed much during the process," he said.

The rate of degradation is light intensity-dependent, but under their laboratory conditions, he said, the polymer chain lengths degraded to a quarter of their original length after 30 days of exposure. Ultimately, Lipinski and other scientists want to leave no trace of the polymer in the environment. He notes there is literature precedent for the biodegradation of small chains of iPPO which could effectively make it disappear, but ongoing efforts aim to prove this.

This research was supported by the National Science Foundation's Center for Sustainable Polymers, the NSF-supported NMR Facility at Cornell, and the Cornell Center for Materials Research.

https://www.sciencedaily.com

Catalyst produces hydrogen from seawater

Researchers from the University of Houston have reported a significant breakthrough with a new oxygen evolution reaction catalyst that, combined with a hydrogen evolution reaction catalyst, achieved current densities capable of supporting industrial demands while requiring relatively low voltage to start seawater electrolysis. Researchers say the device, composed of inexpensive non-noble metal nitrides, manages to avoid many of the obstacles that have limited earlier attempts to inexpensively produce hydrogen or safe drinking water from seawater. The work is described in *Nature Communications*.

Zhifeng Ren, director of the Texas Center for Superconductivity at UH and a corresponding author for the paper, said a major obstacle has been the lack of a catalyst that can effectively split seawater to produce hydrogen without also setting free ions of sodium, chlorine, calcium and other components of seawater, which once freed can settle on the catalyst and render it inactive. Chlorine ions are especially problematic, in part because chlorine requires just slightly higher voltage to free than is needed to free hydrogen.

The researchers tested the catalysts with seawater drawn from Galveston Bay off the Texas coast. Ren, M.D. Anderson Chair Professor of physics at UH, said it also would work with wastewater, providing another source of hydrogen from water that is otherwise unusable without costly treatment. To address the challenges, the researchers designed and synthesized a three-dimensional core-shell oxygen evolution reaction catalyst using transition metal-nitride, with nanoparticles made

of a nickle-iron-nitride compound and nickle-molybdenum-nitride nanorods on porous nickle foam.

First author Luo Yu, a postdoctoral researcher at UH who is also affiliated with Central China Normal University, said the new oxygen evolution reaction catalyst was paired with a previously reported hydrogen evolution reaction catalyst of nickle-molybdenum-nitride nanorods.

The catalysts were integrated into a two-electrode alkaline electrolyzer, which can be powered by waste heat via a thermoelectric device or by an AA battery. Cell voltages required to produce a current density of 100 milliamperes per square centimeter (a measure of current density, or mA cm-2) ranged from 1.564 V to 1.581 V. The voltage is significant, Yu said, because while a voltage of at least 1.23 V is required to produce hydrogen, chlorine is produced at a voltage of 1.73 V, meaning the device had to be able to produce meaningful levels of current density with a voltage between the two levels.

https://www.sciencedaily.com

Energy from mixing of freshwater and seawater

Stanford researchers have developed an affordable, durable technology that could harness this so-called blue energy. The paper, recently published in American Chemical Society's *ACS Omega*, describes the battery and suggests using it to make coastal wastewater treatment plants energy-independent.

"Blue energy is an immense and untapped source of renewable energy," said study coauthor Kristian Dubrawski, a postdoctoral scholar in civil and environmental engineering at Stanford. "Our battery is a major step toward practically capturing that energy without membranes, moving parts or energy input." Dubrawski works in the lab of study co-author Craig Criddle, a professor of civil and environmental engineering known for interdisciplinary field projects of energy-efficient technologies. The idea of developing a battery that taps into salt gradients originated with study coauthors Yi Cui, a professor of materials science and engineering, and Mauro Pasta, a postdoctoral scholar in materials science and engineering at the time of the research. Applying that concept to coastal wastewater treatment plants was Criddle's twist, born of his long experience developing technologies for wastewater treatment.

The researchers tested a prototype of the battery, monitoring its energy production while flushing it with alternating hourly exchanges of wastewater effluent from the Palo Alto Regional Water Quality Control Plant and seawater collected nearby from Half Moon Bay. Over 180 cycles, battery materials maintained 97 percent effectiveness in capturing the salinity gradient energy.

The technology could work any place where fresh and saltwater intermix, but wastewater treatment plants offer a particularly valuable case study. Wastewater treatment is energy-intensive, accounting for about three percent of the total U.S. electrical load. The process -- essential to community health -- is also vulnerable to power grid shutdowns. Making wastewater treatment plants energy independent would not only cut electricity use and emissions but also make them immune to blackouts -- a major advantage in places such as California, where recent wildfires have led to large-scale outages.

The Stanford group's battery isn't the first technology to succeed in capturing blue energy, but it's the first to use battery electrochemistry instead of pressure or membranes. If it works at scale, the technology would offer a more simple, robust and cost-effective solution. The process first releases sodium and chloride ions from the battery electrodes into the solution, making the current flow from one electrode to the other. Then, a rapid exchange of wastewater effluent with seawater leads the electrode to reincorporate sodium and chloride ions and reverse the current flow. Energy is recovered during both the freshwater and seawater flushes, with no upfront energy investment and no need for charging. This means that the battery is constantly discharging and recharging without needing any input of energy.

https://www.sciencedaily.com

Measuring bluefin tuna with a drone

Researchers have used an unmanned aerial system (or drone) to gather data on schooling juvenile Atlantic bluefin tuna in the Gulf of Maine. This pilot study tested whether a drone could keep up with the tuna while also taking photographs that captured physical details of this fast-moving fish. The drone was equipped with a high-resolution digital still image camera. Results show that drones can capture images of both individual fish and schools. They may be a useful tool for remotely monitoring behavior and body conditions of the elusive fish.

Individual fish lengths and widths, and the distance between fish near the sea surface, were measured to less than a centimeter of precision. We used an APH-22, a battery-powered, six-rotor drone. The pilot study was conducted in the Atlantic bluefin tuna's foraging grounds northeast of Cape Cod in the southern Gulf of Maine.

Results from the APH-22 study were published in March 2020 in the *Journal of Unmanned Vehicle Systems*. Researchers conducted their work in 2015. They then compared their study results to values in published data collected in the same general area. They also compared it to recreational landings data collected through NOAA Fisheries' Marine Recreational Information Program. Taking precision measurements of animals that are in constant motion near the surface proved easier with a drone that is lightweight, portable, and agile in flight. It can carry a high-quality digital still camera, and be deployed quickly from a small fishing boat. Short flight times limit a drone's ability to survey large areas. However, they can provide two-dimensional images of the shape of a fish school and data to count specific individuals just below the ocean surface.

The APH-22 system has been tested and evaluated for measuring other marine animals. It's been used in a number of environments—from Antarctica to the Pacific Ocean—prior to its use in the northwest Atlantic Ocean. Previous studies estimated the abundance and size of penguins and leopard seals, and the size and identity of individual killer whales.

https://phys.org

Science, Technology and Innovation for a Healthy, Blue Ocean and Sustainable Ocean Economy in the Asia-Pacific

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Abstract

Oceans that cover nearly 70 per cent of the Earth have been exploited by humanity for many decades now. While the oceans have supported these exploits so far, their over-exploitation has brought them to the brink of unsustainability, wherein they are unable to support the humans any further. Realising this quandary and the possible destruction of the human race if business-as-usual continues, world organisations have embarked on 'sustainable oceans' as a goal for all nations of the world.

It is with this understanding that this article aims to look at the various resources provided by the oceans and their possible sustainable exploitation using science, technology, and innovation to achieve sustainable ocean development and a healthy and blue ocean. To strengthen the argument, the article discusses three case studies where science, technology, and innovation have brought about some major changes in the ocean health and have helped in achieving sustainable ocean development.

Introduction

Oceans and seas cover more than 70 per cent of the Earth's surface. They are a major source of regulating climate, food, medicines, clean energy, job creation, inclusive growth, and generation of most of the oxygen we breathe while supporting the global economy through tourism, fisheries, shipping and trade. Despite their importance, the oceans are facing unprecedented threats due to human activities such as pollution, overfishing, climate change, and inadequate governance. If no action is taken 90 per cent of the coral reefs will die by 2052 and all commercially exploitable wild fish stocks will be lost by 2048 in the Asia-Pacific region.[1] In order to safeguard and improve this ecosystem to support the ever-growing need of mankind for these marine resources, there is a need to look at integrated policies that can help conserve natural resources, ecosystems and biodiversity, and support economic productivity and livelihoods to eventually achieve *sustainable ocean development*.

For the Asia-Pacific,[2] the oceans have a diverse biological and productive marine ecosystem[3] due to which there is a high dependency on the marine ecosystem both for income[4] and food. Such over jealousness has supported overfishing using unsustainable methods and illegal fishing gear. As a consequence, coral reefs and fish populations have experienced serious impacts leading to the loss of biodiversity and the ecosystem structure. While countries here are a major source of ocean degradation, they are also the major sufferers of the after-effects of this degradation. In order to achieve a prosperous, inclusive, resilient, and sustainable region, it is essential that we look at *science, technology, and innovation* to achieve the required sustainable ocean development by achieving a healthy and blue ocean that can continue to support the human needs of marine resources.

It is with this thinking that the article will look at the various marine resources it provides to the humans, how these resources are being threatened by human activities and how science, technology and innovation can help bring about sustainable ocean development and a healthy and blue ocean. In order to strengthen the argument, the article would look at three case studies where science, technology, and innovation have brought about major changes in ocean health and have helped in achieving sustainable ocean development.

Background

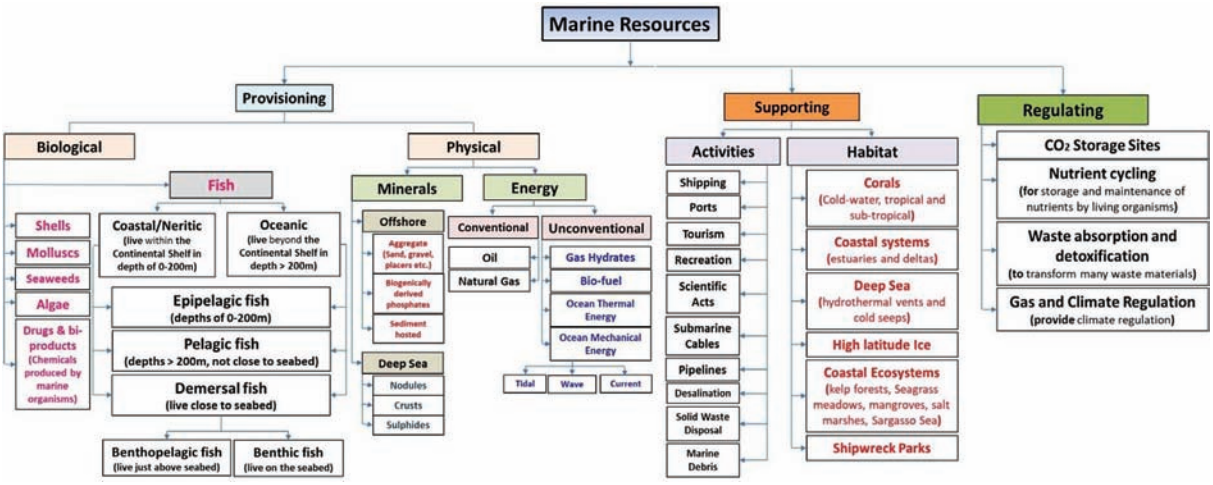
The concept of *sustainable development* was first proposed in 1987 in the

1 ADB, 2018, *The Action Plan for Healthy Oceans and Sustainable Blue Economies*, Flyer, Retrieved from https://www.adb.org/sites/default/files/am-content/484066/action-plan-flyer-20190430.pdf

2 Includes East Asia, South Asia, Southeast Asia, and Oceania

3 The Asia-Pacific region has 17 of the 36 global biodiversity hotspots and 7 of the world's 17 megadiverse countries. It is home to the highest marine biodiversity in the world, with the longest and most diverse coral reef systems, more than half of the world's remaining mangrove areas, and the highest seagrass diversity. *See, Key environment issues, trends and challenges in the Asia-Pacific region,* ESCAP/CED/2018/1, pp. 7-8, Retrieved from https://www.unescap.org/sites/default/files/CED5_1E_0.pdf

4 provides more than 90 per cent of the sea food imported by the US; See, https://www.seafdec-oceanspartnership.org/about/



Source: Author

Figure 1: Taxonomy of marine resources

Brundtland Report.[5] It was further enriched by various development conferences and world summits.[6] Oceans became a part of this drive as a result of the outcome document of the United Nations Conference on Environment and Development of 1992 as Agenda 21.[7] Since then, sustainable development is accepted as a global principle of development with three pillars – environmental protection, economic growth, and social fairness.

Oceans as a continuous source of resources have been exploited and destroyed by humanity by overexploitation and pollution for many years now. Understanding that we do not have a Planet 'B' for ourselves, and keeping the ethos of sustainable development in mind, the United Nations adopted the *Sustainable Development Goals*, that aims to "Conserve and sustainably use oceans, seas and marine resources for sustainable development" as one of its goals under SDG 14 in September 2015. Accordingly, there is a need to manage ocean-related human activities by understanding how humans can interact with the oceans and what impact does this interaction eventually have on the oceans. Such an approach allows prioritisation of sustainable use and conservation, in the same breath, which eventually would lead to equitable outcomes for all and is referred to as a *sustainable ocean economy*. This approach helps different players, policy-makers, industries, businesses, and individuals as a basic minimum, understand their respective parts in the overall pattern thereby avoiding the risk of confusion, contradictory actions, and failure of the entire act. This, therefore, requires a strong need to understand and develop the interaction of humans with the oceans in 'environmental', 'social', and 'economic' ways and hence a need for a multidisciplinary approach.

As discussed, the oceans support humanity in various ways through its rich biodiversity and ecosystem. However, loss of this biodiversity and ecosystem is eminent in the long run.[8] For oceans, the *drivers* that threaten the productivity and health of the ocean are – climate change, habitat change, unsustainable resource extraction, marine pollution, invasive by alien species, and coastal development. In order to ensure a better understanding of these phenomena, understanding the oceans scientifically is essential. It is with this thinking and to ensure that ocean science can fully support countries to achieve the 2030 Agenda for Sustainable Development, the United Nations declared 2021 to 2036 as a 'Decade of Ocean Science for Sustainable Development'.[9]

The taxonomy of the marine resources, as relevant to the ocean, is as seen in Figure 1. In addition to these resources, the ocean is responsible for some critical activities that include regulating the climate by absorbing more than 90 per cent of the excess energy in the climate system, a reservoir and distributor of the global water-cycle, and lowering the atmospheric CO_2 by increasing ocean acidification. To achieve sustainability, a balance is essential as seen in Figure 2. However, climate change, non-sustainable resource extraction, land-based pollution, and habitat degradation are threatening the productivity and health of the ocean.

5 The World Commission on Environment and Development's (WCED) that provided the first formal definition of the concept of sustainable development

6 Three UN Sustainable Development Conferences, the UN Conference on Environment and Development (UNCED) in 1992, the World Summit on Sustainable Development (WSSD) in 2002 and the Conference on Sustainable Development (Rio+20) in 2012

7 United Nations Conference on Environment & Development, June 1992, Retrieved from https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf

8 The Millennium Ecosystem Assessment (MA) identified five major drivers of biodiversity and ecosystem loss. *See*, Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis*. Retrieved from https://www.millenniumassessment.org/documents/document.356.aspx.pdf

9 The Science We Need for the Ocean We Want, May 2019, Retrieved from https://www.oceandecade.org/assets/The_Science_We_Need_For_The_Ocean_We_Want.pdf

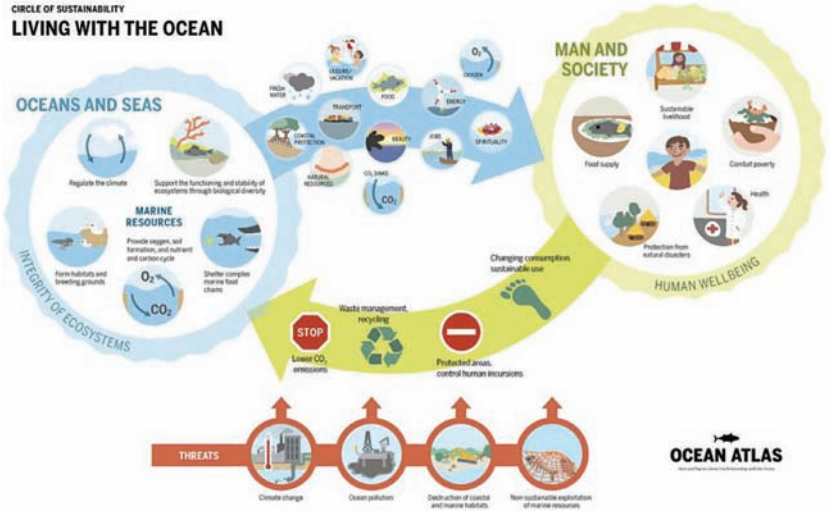
Drivers threatening marine resources

Before we discuss how science, technology, and innovation can help bring about sustainable ocean development and a healthy and blue ocean, it is essential to understand in some detail the threats that are threatening the productivity and health of the ocean so as to focus the science, technology, and innovation in the right direction.

Climate change

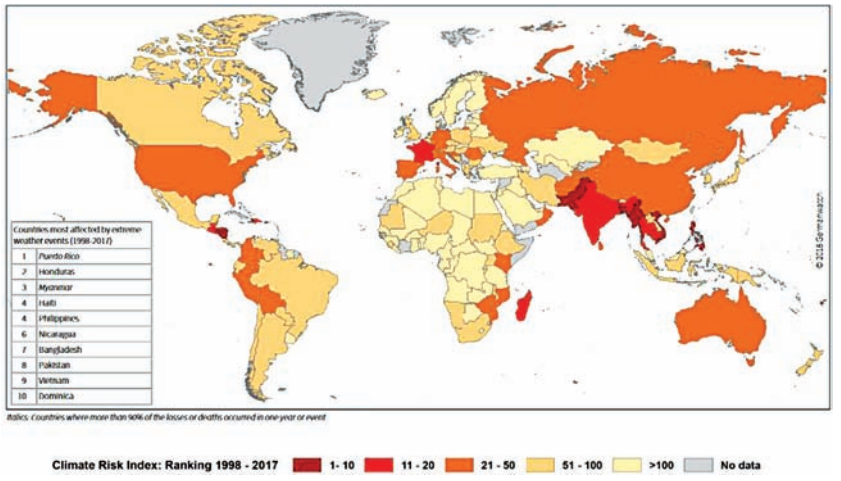
Climate change is an outcome of increased greenhouse gases (GHG) emissions. Even though the poorer communities in the Asia-Pacific contribute little to the GHG emissions, the region is at maximum risk due to climate change (Figure 3) and faces the maximum consequences (Figure 4) more than anywhere else in the world. Such changes cause unpredictable weather patterns that can lead to frequent natural disasters, heat waves, floods, and droughts that result in failing crops, spiking food prices, and spreading diseases.

As a worst-case scenario (also called the business-as-usual scenario (RCP8.5)), it is projected that the Asian summer temperatures over land will increase by 6°C by 2100.[11] This would make Indonesia, Thailand, and Vietnam increasingly drier. Similarly, due to increasing sea-levels much of Maldives would submerge and 18 per cent of Bangladesh's land will get inundated.[12] The mean cost of climate change for these nations could be equivalent to losing 6.7 per cent of combined gross domestic product (GDP) each year by 2100, more than twice the global average loss.[13]



Source: Ocean Atlas, 2017[10]

Figure 2: Human–ocean interactions



Source: Germanwatch, 2019[14]

Figure 3: Climate risk index 1998 – 2017

Such disasters will not allow socio-economic development of the region and would hinder the efforts of sustainable development and poverty in the Asia-Pacific.

Non-sustainable resource extraction

Studies by the UN Environment indicate that resource extraction has more than tripled since 1970. The non-metallic

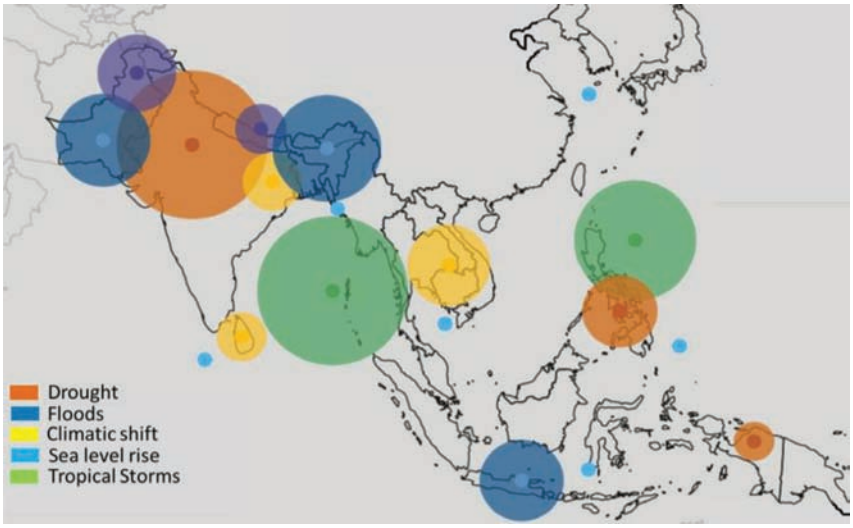
[10] Visbeck, M. et al. 2017, Ocean-Atlas, *Facts and Figures on the Threats to Our Marine Ecosystems*. pp. 42-43, Retrieved from https://meeresatlas.org/wp-content/uploads/2017/06/Ocean-Atlas-Web-EN.pdf

[11] ADB, 2017, *A Region At Risk. The Human Dimensions Of Climate Change In Asia and The Pacific*, Retrieved from https://www.adb.org/sites/default/files/publication/325251/region-risk-climate-change.pdf

[12] *World Development Report 2010 Changing the Climate for Development*, p.6, Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/4387/9780821379875_overview.pdf

[13] Michael J Montesano, Lee Poh Onn, 2010, *Regional Outlook: Southeast Asia 2010-2011*, Institute of Southeast Asian Studies

[14] Eckstein, Marie-Lena Hutfils and Maik Winges, 2019, *Global Climate Risk Index 2019 Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017*, GermanWatch, Retrieved from https://germanwatch.org/sites/germanwatch.org/files/Global%20Climate%20Risk%20Index%202019_2.pdf



Source: Krishnamurthy et. al., 2015[15]

Figure 4: Climate-related risks in Asia

minerals have seen a fivefold increase while fossil fuels a 45 per cent increase with the extraction and processing industry contributing to half of the total GHG emissions and over 90 per cent of biodiversity loss and water stress.[16] Such a resource extraction process is far from sustainable and hence the associated risks and vulnerabilities need to be addressed through recourse efficiency. Similarly, overfishing has resulted in depleted fish stocks. In the Asia Pacific, 64 per cent of the fisheries' resource is at a medium to high risk from overfishing, with Cambodia and the Philippines among the most heavily affected. As competition increases, so does the chances of the collapse of the fisheries industry. If this has to be prevented, countries fishing in this region need to cease all destructive fishing practices and reduce harvest by nearly 50 per cent.[17]

Land-based pollution

As the world population increases, so does the waste generated. In countries with a weak legal and institutional framework to check the disposal of this waste, end up dumping most of it in water bodies that eventually ends into the oceans. It is no wonder that the Asia-Pacific accounts for nearly 80 per cent of all marine pollution with the major portion coming from municipal, industrial, agricultural wastes and run-off. Studies indicate that each year nearly 8 million tons of plastic waste is dumped into the oceans with China, Indonesia, Philippines, Sri Lanka, Egypt, South Africa, Nigeria, Morocco, Thailand, Malaysia, Vietnam, Algeria, Turkey, India, Brazil, Pakistan, North Korea, United States, Myanmar, and Bangladesh, being responsible for 83 per cent of global plastic waste mismanagement.[18] According to the Ocean Atlas, 80 per cent of plastic waste in the oceans comes from dry land, mainly from countries with no or poor waste management.[19]

As the rate of degradation of this solid waste in the ocean is low, it leads to a gradual increase in marine litter found in and under the sea. Since marine litter take a severe toll on human health and the coastal ecosystems and the major contributors are countries of this region it is essential that marine litter – especially marine plastic – is addressed as a priority area for ensuring sustainable development.

Marine habitat degradation

Coastal spaces such as estuaries, swamps, marshes, and wetlands are habitat for nearly all marine species where they breed, nurse, and live. These habitats are disrupted by both natural events[20] and human activities,[21] with the latter being considered more damaging. Such human activities reduce and destroy the coastal habitat and ecosystem and eventually cause loss of inshore coral reefs and coastal mangrove forests, seagrass, birds, and fishes.[22] Add to this, the sea-level rise due to climate change and coastal erosion is ensuring a catastrophic and irreparable marine habitat loss. Since such ecosystems are prevalent along coastlines, as seen in Figure 5, they are naturally of greater significance to the Small Island Developing States in the Indo-Pacific region.[23]

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15 Krishnamurthy, P. K., Lewis, K., Kent, C. and Aggarwal, P. (2015) *Climate Impacts on Food Security and Livelihoods in Asia*. UN World Food Programme, p. 16, Retrieved from https://www.weadapt.org/knowledge-base/vulnerability/climate-impacts-on-food-security-and-livelihoods-in-asia

16 Global Resources Outlook 2019 Natural Resources for the Future We Want, UN Environment, Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/27517/GRO_2019.pdf?sequence=3&isAllowed=y

17 Kim J. DeRidder and Shanti Nindang, (28 March 2018), *Southeast Asia's Fisheries Near Collapse from Overfishing*. Retrieved from https://asiafoundation.org/2018/03/28/southeast-asias-fisheries-near-collapse-overfishing/

18 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., and Law, K. L. (2015). *Plastic waste inputs from land into the ocean. Science, 347(6223), 768–771*. doi:10.1126/science.1260352

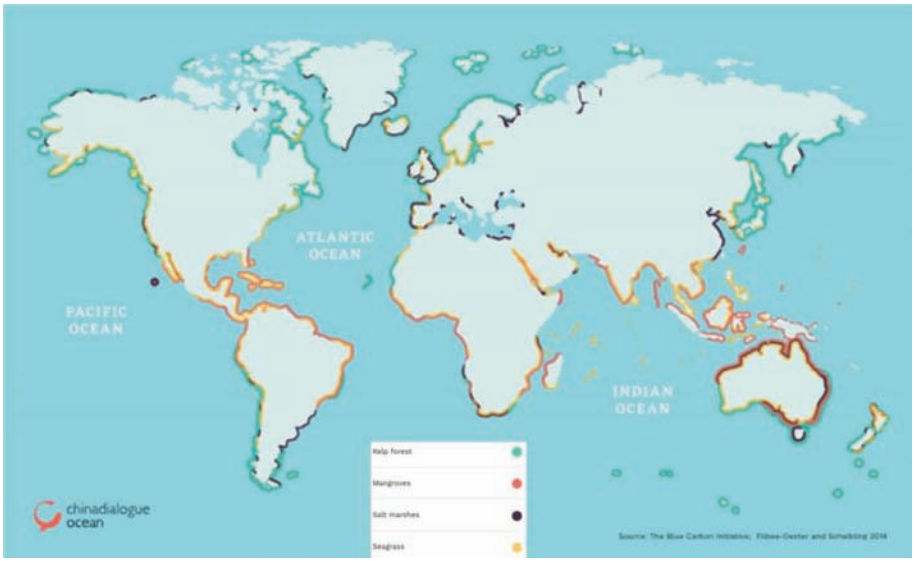
19 Visbeck, M. et al. 2017, Ocean-Atlas, Facts and Figures on the Threats to Our Marine Ecosystems. pp. 16-19, Retrieved from https://meeresatlas.org/wp-content/uploads/2017/06/Ocean-Atlas-Web-EN.pdf

20 Such as hurricanes, typhoons, storm surges, and tsunamis

21 Such as development of wetlands by dredging and filling, pollution by industries, reduced availability of nutrients, increased salinity of coastal water and blocked fish migration routes due to inland dams, oil spills and tourism activities

22 National Geographic, (27 April 2010), *Marine Habitat Destruction*, Retrieved from https://www.nationalgeographic.com/environment/oceans/critical-issues-marine-habitat-destruction/

23 Caribbean (23), Pacific (20), Africa, Indian Ocean, Mediterranean and South China Sea (AIMS) (9), See, https://sustainabledevelopment.un.org/topics/sids/list



Source: chinadialogue Ocean[30]

Figure 5: Distribution of blue carbon ecosystems around the world

These coastal ecosystems help remove carbon dioxide from the air at a rate several times faster than the net rate by mature tropical forests.[24] Estimates[25] suggest that the surviving mangroves absorb from the air around 30 million tonnes of carbon a year, salt marshes as much as 80 million tonnes and seagrasses maybe 100 million tonnes.[26]

These vegetated coastal ecosystems protect the coastline from storms and erosion and help buffer the impacts of sea-level rise. Studies indicate that nearly 340,000 to 980,000 hectares of coastal wetland ecosystems are being lost annually.[27] An IPCC report[28] indicates that nearly 50 per cent of coastal wetlands have been lost over the last 100 years, as a result of the combined effects of localised human activities, sea-level rise, warming, and extreme climate events. With an increasing carbon dioxide production per year from 2 billion tonnes in 1900 to nearly 36.2 billion tonnes in 2017,[29] the need for ensuring a healthy wetland cannot be emphasised more.

Science, technology and innovation to the rescue

Economic activities in the ocean are increasing pressure on ocean resources. Accordingly, various world organisations have initiated programmes to manage ocean-related issues. The UN Environment leads issues related to management and pollution,[31] FAO leads issues related to fisheries[32] and IOC handles the development of scientific solutions.[33] A business-as-usual model for economic activities in the ocean will, however, jeopardise the health of the ocean and hence needs to be avoided. It is hence important that we increase our understanding of the ocean, its resources and the changes occurring in it to ensure a sustainable ocean economy that will eventually help in a healthy ocean. Such a need requires monitoring and studying the oceans.

Over the years, many fixed, submersible, remote, autonomous and drifting systems have been used to gather, store, transfer and process large volumes of ocean observation data. The data derived help in a range of scientific research, support a safe, effective and sustainable use of ocean resources and the ocean environment while helping monitor the development

[24] Usually between 12.5 and 8 tonnes per hectare each year

[25] Negative Emissions Technologies and Reliable Sequestration, A Research Agenda (2019), *Consensus Study Report*, Retrieved from https://www.nap.edu/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda

[26] Fred Pearce, (26 November 2019), *The natural solutions to climate change held in the ocean*, ChinaDialogue Ocean, Retrieved from https://chinadialogueocean.net/11915-coastal-ecosystem-natural-solutions-climate-change/

[27] TheBlueCarbonInitiative.org, *About Blue Carbon*, Retrieved from https://www.thebluecarboninitiative.org/about-blue-carbon

[28] IPCC, 2019,*The Ocean and Cryosphere in a Changing Climate*, A Special Report of the Intergovernmental Panel on Climate Change (IPCC), p. 13, Retrieved from https://www.ipcc.ch/site/assets/uploads/sites/3/2019/12/SROCC_FullReport_FINAL.pdf

[29] Kelly Levin, (05 December 2018), New Global CO2 Emissions Numbers Are In. They're Not Good., Retrieved from https://www.wri.org/blog/2018/12/new-global-co2-emissions-numbers-are-they-re-not-good

[30] Fred Pearce, (26 November 2019), *The natural solutions to climate change held in the ocean*, ChinaDialogue Ocean, Retrieved from https://chinadialogueocean.net/11915-coastal-ecosystem-natural-solutions-climate-change/

[31] *See*, https://www.unenvironment.org/

[32] Through Port State Measures Agreement to eradicate IUU fishing, *See*, http://www.fao.org/fisheries/en/

[33] United Nations Decade of Ocean Science for Sustainable Development (2021-2030), Retrieved from https://en.unesco.org/ocean-decade

of ocean economic activities and improve marine spatial planning.

In spite of this knowledge we realise that we have little know-how about a number of aspects about the oceans (such as marine species and topographical information in waters greater than 3,000 metres) that are disallowing policymakers to take a cost-benefit decision of ocean exploitation. What is even more disturbing is the fact that humanity lacks a detailed scientific understanding of the ocean (properties, behaviour, health, role in climate change, influence on weather etc.) that are considered essential for him to understand and manage ocean ecosystems and sustainable operations of ocean-based industries.

To address these, sustained and systematic ocean observations are considered as a basic minimum to document ocean change and provide critical information for an improved ocean understanding. In addition, integrated research is required to assess the risks associated with the ongoing and future types of ocean pollution, new ideas to promote recycling, improved waste management and to encourage more sustainable production and consumption. While the challenges and requirements are numerous and ever-increasing, let us look at some efforts that have already been put in place or are being addressed to help a sustainable ocean economy.

Globally, in the coming decades every sector of the ocean economy is likely to be affected by technological advances such as innovations in advanced materials, subsea engineering and technology, sensors and imaging, satellite technologies, computerisation and big data analytics, autonomous systems, biotechnology, and nanotechnology. Since these technologies are cross-cutting and not area specific, the discussion here is kept generic.

Even though a variety of *ocean observation* procedures and technologies have been employed over the years,[34] advances in ocean robotics and the combination of remote and in-situ *underwater observatories,*[35] *seafloor observatories,*[36] and the *ocean observatories*[37] offer new opportunities. The data collected in some cases is free and open that allows multi-stakeholder contributions thereby opening exciting new dimensions. By using satellite and remote sensing technology and applying real-time connectivity and analytics to large datasets, a "smart oceans" platform[38] can help forecast sea conditions, improve marine safety and support ocean-based business activities such as shipping, aquaculture, fisheries, algae blooms, port navigation, disaster management and protection of species by altering shipping lanes, to name a few. Yet another form of *dynamic observatories* for marine scientific research being proposed is through the use of "green cables".[39]

Economic activities in shipping, tourism, fishing, and offshore oil and gas (all of which are undergoing changes), is set to change dramatically in the coming decades due to emerging *renewal technologies* that include offshore wind, tidal and wave energy, oil and gas exploration and production from previously inaccessible waters, offshore aquaculture, seabed mining, cruise tourism, and marine biotechnology, among others.[40]

Digital platform technologies (blockchain, IoT, cloud data, and big data analytics) are supporting benefits in administration, logistics, shipping, terminal, and port to work together more smoothly. Such efforts are supporting saving energy, fuel in transport, and limiting pollution.

Today, a wide range of *environmental services* such as oil spill response, wastewater treatment, marine scientific services are available. These services are available to address the respective area so as to support business and decision making while ensuring solutions for environmental problems to nations who lack them. Such services in the long run allow poorer nations to address environmental problems adequately to ensure sustainable use of the ocean economy.

Technology solutions exist for curbing *IUU fishing*. Solutions are available for everything from fishing vessel tracking to law enforcement using mobile technology[41] or dedicated transmitters.[42]

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34 Unmanned untethered vehicles (e.g. gliders, sail drones, wave gliders, Argo Floats, deep ocean buoys, remotely operated/piloted vehicles, and autonomous underwater vehicles, etc.), satellites, and ships, as well as state-of-the-art sensors and more

35 Used as underwater viewing public aquariums. First founded in 1974; *also see*, Coral World Underwater Observatory, Retrieved from https://en.wikipedia.org/wiki/Coral_World_Underwater_Observatory

36 First established off Japan in 1993 and were individual cabled or self-contained observatories that were managed from the sea surface through dedicated remotely controlled tethered vehicle; also see http://www.whoi.edu/oceanus/feature/seeding-the-seafloor-with-observatories

37 Such as the Ocean Observatories Initiative, the Global Ocean Observing System, the Blue Planet initiative of the Group on Earth Observations, the Integrated Ocean Observing System (IOOS), and the European Multidisciplinary Seafloor and Water-Column Observatory (EMSO)

38 One such program, dubbed "Smart Oceans/Smart Industries," has been proposed by the World Ocean Council. *See*, https://www.oceancouncil.org/global-issues-platforms/program-focus/smart-oceans-smart-industries/

39 Nitin Agarwala (2018): *"Green cables" – Development, opportunities and legal challenges: Part I*, Maritime Affairs: Journal of the National Maritime Foundation of India, 14:2, 49-62, DOI: 10.1080/09733159.2018.1562456; Nitin Agarwala (2019): *Green cables – Development, opportunities and legal challenges; Part-II*, Maritime Affairs: Journal of the National Maritime Foundation of India, 15:1, 93-107, DOI:10.1080/09733159.2019.1631538

40 OECD (2018), *OECD Science, Technology and Innovation Outlook 2018: Adapting to Technological and Societal Disruption*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/science-and-technology/oecd-science-technology-and-innovation-outlook-2018_sti_in_outlook-2018-en

41 The United States Agency for International Development (USAID) has partnered with Philippines mobile operator SMART, and the local government in Tawi-Tawi to develop platforms for online fishing vessel registration and community reporting of harmful fishing methods. *See*, Using mobile technology for marine biodiversity conservation, (27 June 2014),Retrieved from https://resonanceglobal.com/using-mobile-technology-marine-biodiversity-conservation/

42 The United States Agency for International Development (USAID) has partnered with Futuristic Aviation and Maritime Enterprise, Inc. (FAME) of the Philippines to track catch data and promote sustainable fisheries. *See*, USAID brings Philippines Small-Scale Fisheries Online in New Traceability Pilot, (June 27, 2018), Retrieved from https://www.usaid.gov/asia-regional/press-releases/jun-27-2018-usaid-brings-philippines-small-scale-fisheries-online

Eco-engineering[43] through the installation of green infrastructure such as artificial floating islands (AFIs)[44] to create habitat for biodiversity is a novel technique that has been employed in the UK.[45]

Geo-engineering schemes aim to tackle climate change by removing CO_2 from the air or limiting the sunlight reaching the planet so as to tackle the effects of climate change directly. Although large-scale geo-engineering is still a concept and is presently treated as a distraction from reducing emissions. It may become a reality if climate change continues.[46]

Advances in science and technology in molecular biology have supported the development of *marine biotechnology*. This has helped improve our understanding of marine life and facilitating access to, and study of, marine organisms, ecosystems, and bioresources that have been largely untapped.[47]

A number of *ocean energy technologies* have been developed over the years. These include ocean energy technologies such as kinetic energy (winds and currents), potential energy (tidal amplitude), mechanical energy (waves), thermal potential (vertical temperature gradients) or even osmotic pressure (horizontal gradients of salinity). Of these, wind, wave, tidal energy and temperature gradient technologies show promise, however most of these technologies are still under development with many economic, technical, governance and environmental problems to be solved[48] while technologies, like wind, are maturing and have already achieved commercial success. Technologies such as Ocean thermal energy conversion (OTEC) promise both freshwater and electricity and hence can be used for dual purposes. For ecologically fragile regions and small islands, a Low-Temperature Thermal-Desalination (LTTD) combined with the OTEC can be used by the SIDS of the Indo-Pacific region.[49]

A number of *enabling technologies* such as advances in materials, ICT, big data analytics, autonomous systems, artificial intelligence, nanotechnology, subsea engineering sensors (physical, remote and satellite based) are available to industries in the ocean economy. Such technologies allow a more coherent response of these industries is more coherent than that of individual sectors.

Similarly, innovation networks try and bring together different players such as research institutes, enterprises, and universities to work together on a range of scientific and technological innovations, in various sectors of the ocean economy such as marine robotics, autonomous vehicles, aquaculture, marine renewable energy, biotechnologies, offshore oil and gas. This is helping many such networks to grow in different parts of the world and leverage their organisational and skill diversity to benefit the ocean economy.

This said, there is an urgent need to build capacity; increase access to affordable innovation and technologies; and ensure that research and innovation are ethically and socially acceptable, environmentally sustainable, and delivering solutions to the problems of the poorest and most marginalised communities and income groups.

Case studies

To strengthen the case of science, technology and innovation usage to support sustainable ocean development, we look at a few case studies that have supported this cause. Many more case studies[50] such as the Coral Triangle Initiative, Micronesia Challenge,[51] Marine Spatial Planning[52] are available and can be reviewed separately.

Limiting Illegal Unreported and Unregulated (IUU) fishing

After being warned by the EU for illegal fish trading in 2015, Thailand has used effective and modern technology to take control and develop one of the most robust and reliable systems for IUU fishing. In order to make the system functional, all fishing vessels above 30 GT have been installed with Vessel Monitoring System (VMS) and the fishing gear is verified with the fishing licence issued. Any vessel caught after 01 April 2018 without a valid licence is prosecuted. This has resulted in locking of 1,098 commercial fishing vessels.[53] Additionally, illegal vessels were purchased by the government and all new registrations were suspended for a period of two years starting July 2018.

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[43] refers to the modification of planned or existing structures to become multifunctional

[44] Typically, 2 m2, they broadly consist of a buoyant mat of non-woven plastic matrix, integrated connection grid and polyurethane foam, planting media and emergent vegetation

[45] Jessica Ware and Ruth Callaway, 2019, *Public perception of coastal habitat loss and habitat creation using artificial floating islands in the UK*, PLoS ONE 14(10): e0224424, Retrieved from https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0224424

[46] The Guardian, (18 February 2011), *What is geoengineering?*, Retrieved from https://www.theguardian.com/environment/2011/feb/18/geo-engineering

[47] OEDC, 2016, *Marine Biotechnology: Enabling Solutions for Ocean Productivity and Sustainability*, Retrieved from https://www.oecd.org/sti/emerging-tech/marine-biotechnology-ocean-productivity-sustainability.htm

[48] Melikoglu, M. (2018). *Current status and future of ocean energy sources: A global review. Ocean Engineering, 148, 563–573.* doi:10.1016/j.oceaneng.2017.11.045

[49] Maitreyee Shilpa Kishor & Nitin Agarwala (2019) *Sustainable desalination technologies: Avenues for cooperation in the Indo-Pacific*, Maritime Affairs: Journal of the National Maritime Foundation of India, 15:1, 78-92, https://www.tandfonline.com/doi/abs/10.1080/09733159.2019.1628335

[50] The Role of Major Groups in Sustainable Oceans and Seas, Retrieved from https://sustainabledevelopment.un.org/content/documents/402bdoc99-6.pdf;

[51] Wright, G., Schmidt, S., Rochette, J., Shackeroff, J., Unger, S., Waweru, Y., Müller, A., (2017), *Partnering for a Sustainable Ocean: The Role of Regional Ocean Governance in Implementing SDG14*, PROG: IDDRI, IASS, TMG & UN Environment, 2017, Retrieved from https://www.prog-ocean.org/wp-content/uploads/2017/03/PROG_Partnering-for-a-Sustainabe-Ocean_Report.pdf

[52] Piyapat Nakornchai, Michael Bordt, Natacha Pitaksereekul, and Teerapong Praphotjanaporn, *Asia-Pacific Marine Spatial Planning Snapshot 2009-2019*, Retrieved from https://communities.unescap.org/system/files/asia-pacific_msp_snapshot_2009-2019_-_final_0.pdf

[53] Claire Starn, (17 July 2018), *Thailand confident to ban illegal fishing, forced labour by end of year, says ambassador*, Euractiv.com, Retrieved from https://www.euractiv.com/section/agriculture-food/news/thailand-confident-to-ban-illegal-fishing-forced-labor-by-end-of-year-says-ambassador/

To ensure that apprehensions result in prosecutions for adherence of rules against IUU fishing, a new law governing the fisheries sector was passed in 2015. In addition, amendments were made to existing legislation and over 100 new implementing regulations have been enacted. Fishing methods deemed highly destructive were prohibited and the validity of licence was redefined based on possible sustainable fishing.

Monitoring, control and surveillance (MCS) have also been improved. Thirty "Port-in-Port-Out" (PIPO) Control Centres have been established with around 4,000 personnel working to ensure a committed, robust and integrated MCS. Various government agencies inspect the vessel when it moves in and out of the PIPO and at sea to check illegal activities. Aircraft and unmanned aerial vehicles are used to conduct air surveillance in conjunction with sea patrols by an undercover vessel.[54]

To ensure transparency, all fish catches are recorded electronically. A new digital PIPO system named ePIPO has been developed that allows all requests to be submitted electronically[55] and records workers employed in a boat through facial recognition. This system draws together the historical paper-based documentation and 'FishingInfo2' database into a 'single gateway' system to check a PI or PO request automatically. The database also allows risk analysis and action to be taken by agencies such as the Marine Department, the Command Centre for Combating Illegal Fishing, the Ministry of Labour and the Royal Thai Police against offenders.

Technology has made the difference in Thailand's fight against IUU fishing and human rights abuse at sea and helped sustainable fishing. This has allowed the marine ecosystem around Thailand to slowly recover and artisanal fishermen to earn a livelihood and can be used as a template for encouraging sustainable economy from fishing while eradicating IUU fishing.

The Maritime Singapore Green Initiative (MSGI)

The MSGI was launched in 2011 by the Maritime and Port Authority of Singapore (MPA) to reduce the environmental impact of shipping and related activities and to promote clean and green shipping in Singapore. The initiative comprises of the Green Ship Program (GSP), the Green Port Program (GPP), Green Technology Program (GTP) and the Green Awareness Programme (GAP). These are voluntary programs to encourage maritime companies to adopt clean and green shipping practices and fulfil the mandated environmental sustainability requirements. The GSP encourages Singapore-flagged ships to reduce CO_2 and sulfur oxide (SOx) emissions and receive up to 75 per cent discounts on the Initial Registration Fees and 50 per cent discounts on Annual Tonnage Tax. The GPP encourages ocean-going ships calling at the Port of Singapore to reduce the emission of pollutants. Conforming ships can enjoy a 15 per cent reduction in port dues, while ships that do so throughout their entire port stay within the port limits can enjoy a 25 per cent reduction. The GTP aims to encourage local maritime companies to develop and adopt green technologies or develop green technologies that reduce emissions of SOx, NOx, and CO_2. GTP has supported more than 20 projects involving over 60 vessels. The GAP focuses of creating awareness on possible avenues towards sustainable shipping.

To date, MSGI has benefited 21 maritime companies in the shipping, port and harbour craft sectors, with the projects yielding an estimated direct reduction of 285,000 tons of CO_2 per year.[56] With 436 registered ships and 40 enrolled companies and benefiting from the initiative,[57] the MSGI has been extended two times since its inception till 2024[58] while encouraging the adoption of engines using alternative fuels such as LNG, to reduce emissions.[59] This initiative of Singapore is supporting the reduction of pollution from ships not only within their harbours but also by making a larger number of ships Energy Efficiency Design (EED) matrix compliant.[60] It encourages the development of green technology through scientific collaboration for much reduced environmental pollution, leading to reduced ocean acidification that will eventually permit sustainable ocean development.[61]

Use of LTTD for freshwater supply

Given the ecologically fragile marine environment of the Lakshadweep Islands and the need to ensure freshwater availability in these Islands, the National Institute of Ocean Technology (NIOT) redesigned the OTEC process on independent parameters to develop a new process,[62] now known as LTTD,[63] and then went ahead to success-

54 MFA, Thailand, (15 October 2018), *Illegal fishing clampdown*, Retrieved from https://www.reuters.com/sponsored/article/turning-the-tide/illegal-fishing-clampdown

55 EJF, 2019, *Thailand's progress in combating IUU, forced labour & human trafficking, Observations and Recommendations*, Vol. 7, Retrieved from https://ejfoundation.org/resources/downloads/EJF-PIPO-Technical-Report-update-spring-2019.pdf

56 GreenPort, (04 Mar 2014), *Singapore Green Initiative*, Retrieved from https://www.greenport.com/news101/asia/singapore-green-initiative

57 TAN Suan Jow, (21 March 2018), *MPA Green Initiatives*, Retrieved from http://www.ppcac.org/Panel%204-B-Suan%20Jow%20Tan.pdf

58 World Maritime News, (08 November 2019), *Maritime Singapore Green Initiative Extended Until 2024*, Retrieved from https://www.offshore-energy.biz/maritime-singapore-green-initiative-extended-until-2024/

59 MOT, *Big steps towards environmentally-friendly shipping*, Retrieved from https://www.mot.gov.sg/Transport-Matters/sea/detail/big-steps-towards-environmentally-friendly-shipping

60 Becqué Freda Fung Zhixi Zhu, January 2018, Discussion Paper, *Incentive Schemes For Promoting Green Shipping*, NRDC, Retrieved from https://www.nrdc.org/sites/default/files/incentive-schemes-promoting-green-shipping-ip.pdf

61 World Ocean Council, 2018, *Ocean/Maritime Clusters: Leadership and Collaboration for Ocean Sustainable Development and Implementing the Sustainable Development Goals*, Retrieved from https://www.oceancouncil.org/wp-content/uploads/2018/03/Ocean-Maritime-Clusters-and-Sustainable-Development-WHITE-PAPER-FINAL-2018-logo_edited.pdf

62 Muthunayagam A E, Ramamurthi K and Paden J R (2005), *Low Temperature Flash Vaporization for Desalination*, Desalination, Vol. 180, Nos. 1-3, pp. 25-32

fully develop a land-based LTTD plant after experimenting with the technology on a floating barge off Tamil Nadu.

This desalination technology has been extensively employed in the Lakshadweep islands. Being isolated from the mainland, access to freshwater is a major problem here. Since the islands are made of corals and porous limestone, adequate groundwater is not retained and the little that is, frequently gets contaminated by seawater due to tidal action. Rooftop rainwater harvesting, and desalination of ocean water were attempted, but could not be sustained due to difficulty in its maintenance[64] and the accruing detrimental environmental effect on coral structures.

Using LTTD that is 'indigenous, robust, environmentally-friendly, and requires a minimum operating and maintenance efforts',[65] the Earth System Science Organisation (ESSO) and NIOT set up an LTTD plant at Kavaratti Island, in May 2005, with a capacity of 100 m^3/day (0.1 MLD). Two more plants were set up, one each in Agatti Island and Minicoy Island, in April 2011 and July 2011, respectively, each with a capacity of 1 lakh litres per day. These plants are being maintained by the islanders since their installation. While executing these plants in two distinct islands, ESSO-NIOT has evolved site-specific techniques in the design and installation of marine structure and deep-sea cold-water pipe.[66]

Since an LTTD plant needs electricity to run the pumps and condensers, it uses fossil fuel. To make the technology self-sustaining, NIOT has proposed to install a self-powered desalination plant using OTEC in Kavaratti, where the electricity produced from OTEC will be used to power the desalination plant. The pilot project is expected to be commissioned soon.[67] This project, which has been a priority status project for the NITI Aayog, will "put India at the forefront of developing OTEC globally and pave way for large-scale self-powered desalination and development of standalone OTEC plants."[68]

Way forwrd

As discussed in the preceding paragraphs, the ocean resources are under serious stress from human activities and hence there is a serious and urgent need to ensure sustainable ocean development and that life continues to exist. With the development of technology, one realises that such a development is possible if science, technology, and innovation are used in the appropriate mix. There is hence an urgent need to build capacity; increase access to affordable innovation and technologies; and ensure that research and innovation are ethically and socially acceptable, environmentally sustainable, and delivers solutions to the problems of the poorest and most marginalised communities and income groups.

Such an effort will support halting the losses and help protect, restore, and enhance ocean assets. While science, technology, and innovation can be tools, however, to achieve marine sustainable development improvements in the following areas are essential.

(a) *Regional cooperation*, to address the complex and trans-boundary nature of ocean and coastal issues and challenges.
(b) Utilising existing *best practices* of ecosystem-based management to proactively govern ocean resources and uses across multiple jurisdictions, and protecting and sustaining marine and coastal ecosystems and their functions.
(c) *Integrating fisheries and marine resources* as part of food security would provide a better understanding of the link between fisheries, food security and food safety thereby promoting healthier practices in fisheries management; combating IUU fishing; and sustainable mariculture practices.
(d) Encourage *knowledge dissemination* on the role of coastal and marine ecosystems in natural disasters to reduce environmental degradation by human efforts and increase resilience due to likely destruction due to climate change in this region.

Conclusion

The need for sustainability of oceans for a safe and prosperous future of humanity needs no further emphasis. Humanity has been dependent on the oceans for many centuries now and continues to exploit and in some cases over-exploit these oceans. While the oceans have been providing the required resources so long, however, the unsustainable methods of humans have brought the oceans to a point where they can no more support the excesses of humans.

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63 Low Temperature Thermal Distillations is a process similar to OTEC where the temperature difference between the warm surface water and cooler deep water is used to produce freshwater but no electricity. Water at low pressures (27 millibar) and condense the resultant vapour using colder water to obtain freshwater. Warm ocean water is evaporated at low pressure using the high temperature surface water and condensed using the deep cold water to produce freshwater as condensate. The process of LTTD requires a lower thermal gradient of 16°C as compared a 20°C gradient required for OTEC and a lesser minimum depth of 600 m as compared to 1000 m for OTEC making it feasible in more areas of the world than OTEC.

64 *Implementation of Desalination Plants in Agatti and Minicoy*. 2017. National Institute of Ocean Technology. https://www.niot.res.in/index.php/node/index/213/.

65 National Institute of Ocean Technology. 2017. *Annual Report 2016-2017*. Chennai: National Institute of Ocean Technology. https://www.niot.res.in/documents/admin_annual_report/Annual%20Report%202016-17.pdf.

66 *Implementation of Desalination Plants in Agatti and Minicoy*. 2017. National Institute of Ocean Technology. https://www.niot.res.in/index.php/node/index/213/.

67 *World's first self-powered desalination plant by NIOT coming up in Lakshadweep*, 23 October 2018, IndianExpress, Available at https://www.newindianexpress.com/nation/2018/oct/23/worlds-first-self-powered-desalination-plant-by-niot-coming-up-in-lakshadweep-1888841.html

68 *India's first ocean power generation project coming up in Kavaratti, Lakshadweep*, 22 September 2016, ANI, Business Standard, Available at https://www.business-standard.com/article/news-ani/india-s-first-ocean-power-generation-project-coming-up-in-kavaratti-lakshadweep-116092200284_1.html (accessed 03 September 2018)

Realising this, various international organisations have focused on the need for a sustainable ocean economy model with different organisations working on different aspects of ocean sustainability. As science and technology develop and find ways of involvement in the various facets of human life, they have made their mark in efforts to achieve ocean sustainability. There is hence a need to have new research to develop and flesh out sustainable blue-green growth agendas and link it to efforts in ecosystem protection and that which can provide a clean, resilient, productive, safe, well-observed, documented, and predicted ocean.

However, one should not forget that such a realisation cannot be achieved by science, technology, and innovation alone, as they are only facilitators. The need of the hour is political will that can help strengthen policy and regulatory frameworks, sharing knowledge on lessons learned and support regional cooperation on transboundary issues. This said, the involvement of the 'person on the ground' cannot be overlooked, for all starts with him/ her.

The involvement of science and technology would help reduce ocean pressures, increase ocean resilience, and promote ocean prosperity for generations to come by providing some solutions for implementation. All in all, the success of achieving a sustainable ocean economy lies in the hand of science and technology as a facilitator and the policy-makers as the implementors.

Disclaimer

The views expressed in the paper are those of the author and do not reflect the views or policies of the Government of India, the Indian Navy or the NMF. The author can be reached at nitindu@yahoo.com. ■

Nine principles for healthy oceans launched

During UN's Climate Action Summit in New York, the UN Global Compact launched the UN Sustainable Ocean Principles, providing a base for responsible business practices across sectors, in line with the Ten Principles of the UN Global Compact on human rights, labour, environment and anti-corruption.

The newly launched Sustainable Ocean Principles highlight the urgency on tackling climate change which severely impacts on the oceans, resulting to high temperatures, acidification, and pollution from land and sea.

#1 Ocean health and Productivity

- ***Principle 1***: Assess the short- and long-term impact of their activities on ocean health and incorporate such impacts into their strategy and policies.
- ***Principle 2:*** Consider sustainable business opportunities that promote or contribute to restoring, protecting or maintaining ocean health and productivity and livelihoods dependent on the ocean.
- ***Principle 3:*** Take action to prevent pollution affecting the ocean, reduce greenhouse gas emissions in their operations to prevent ocean warming and acidification, and work towards a circular economy.
- ***Principle 4:*** Plan and manage their use of and impact on marine resources and space in a manner that ensures long-term sustainability and take precautionary measures where their activities may impact vulnerable marine and coastal areas and the communities that are dependent upon them.

#2 Governance and engagement

- ***Principle 5:*** Engage responsibly with relevant regulatory or enforcement bodies on ocean-related laws, regulations and other frameworks.
- ***Principle 6:*** Follow and support the development of standards and best practices that are recognized in the relevant sector or market contributing to a healthy and productive ocean and secure livelihoods.
- ***Principle 7:*** Respect human-, labour- and indigenous peoples' rights in the company's oceanrelated activities, including exercise appropriate due diligence in their supply-chain, consult and engage with relevant stakeholders and communities in a timely, transparent and inclusive manner, and address identified impacts.

#3 Data and transparency

- ***Principle 8:*** Where appropriate, share relevant scientific data to support research on and mapping of relevance to the ocean.
- ***Principle 9:*** Be transparent about their ocean-related activities, impacts and dependencies in line with relevant reporting frameworks.

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Science, Technology and Innovation for Sustainable Ocean Economy

A South Asian Perspective

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Abstract

Countries all over the world are now becoming more interested in the ocean economy and looking for sustainable ways of exploring and utilizing them. The South Asian countries are looking to use the potential of the ocean available to them. To harness the vast resources of oceans while preserving its environment, the advancement of science, technology and innovation is key. This is particularly true for South Asian countries that are among the worst victims of climate change. However, the countries are not yet that much advanced in terms of ocean technology. The paper tries to gauge the existing state of oceanic research and technology in South Asia and provide some useful recommendations for future steps. In doing so it explores the different avenues of science, technology and ocean. It also looks into the cases of Australia, China and the European Union to see how they are advancing the agenda of oceanic research and development. The paper concludes by providing some ways ahead for the countries of the region.

Introduction

In the 21st century, seas and oceans provide new frontier for mankind to venture in. Oceans have also been labelled as "economic frontier" as the expanding global population looks for new sources of livelihood and prosperity. Development of the ocean economy, which includes more than 80 per cent of global trade, marine and coastal environments is a major resource for the overall economic development of humankind (IORA, 2020).[1] All over the world countries are trying to find ways to efficiently enhance the use of the ocean for trade, commerce and economic activities. While it is important to explore the oceanic resources for economic purposes, it is equally important to keep in mind that the ocean is home to a vulnerable ecosystem that can be destroyed with reckless endeavours.

The increasing impact of climate change has heightened the need to be more careful about the environmental impact of our economic activity. The commitment to ensuring that development of today does not hamper the ability of the future generations to develop themselves is further enhanced due to the adoption of the sustainable development goals (SDGs) by world leaders at the UN General Assembly in 2015. Goal Number 14 of the SDGs, titled 'Life Below Water', encompasses many important aims for the better use of the oceans. Some of the key goals of the SDG 14 include: enhancing conservation and the sustainable use of ocean-based resources, wise management of resources, and the protection of marine and coastal ecosystems from pollution, including the impacts of ocean acidification (UN, 2015).[2] All of those goals are incorporated into the concept of the sustainable ocean economy.

Two-thirds of the earth's surface is covered by Oceans and it is estimated that over three billion people either directly or indirectly depended on marine and coastal systems for their livelihoods (Senaratne, 2017).[3] The importance of harnessing ocean economy is, therefore, cannot be stressed enough. But sustainable ocean economy has to be based on clean technologies which will ensure the economic and social needs of the people without damaging the planet. The traditional economic activities often do not take into account environmental factors. Side effects of unchecked economic activities such as overfishing, pollution and ocean acidification are causing significant damages to the ocean and its environment. Thus, it is only through new technologies and innovation that the world can find ways to properly utilize the resources available at the sea, without causing damage to the environment. Science and technology will have to search for new sources of growth, while innovative advances will make new resources and spaces accessible for development.

The South Asian subcontinent is located at the bank of the Indian Ocean, with plenty of the territory for them to explore. It is one of the most populous regions of the world, but at the same time, it is also the fastest-growing sub-region in terms of

[1] Indian Ocean Rim Association (2020), " Blue Economy", available at https://www.iora.int/en/priorities-focus-areas/blue-economy, accessed on January 1, 2020.

[2] United Nations (2015), "Transforming the World: The 2030 Agenda for Sustainable Development". A/RES/70/1.

[3] Senaratne, A. (2017), "Oceans and Sri Lanka's future: Towards a blue economy", *The Daily FT*, available at http://www.ft.lk/article/620407/Oceans-and-Sri-Lanka-s-future--Towards-a-blue-economy, accessed on December 27, 2019/

economy. Since, 2014, with an average growth rate of 7% (Song, 2019).[4] With the exploration of their maritime territories, the countries are standing on the verge of opening new avenues for their economies that can take their countries to the next stage of development, ensuring the rights of their people and community. There is a significant interest among the nations to deal with sustainable ocean economy/ blue economy and the term is often used in government policy papers. However, the vast oceanic resources of the Indian ocean and the Bay of Bengal can only be explored if the countries find technological methods to do so, which remains a significant challenge for the countries of the region.

It is in this backdrop, this paper tries to understand what initiatives the South Asian countries need to initiate in order to achieve a sustainable ocean economy, particularly to boost innovation in ocean technology. The paper begins by linking science and technology with the ocean economy to see what kind of technologies is needed for sustainable ocean economy. The next section looks into the existing initiatives for ocean economy and technological advancement taken by countries and regional organizations in South Asia. The following section looks into the initiatives taken by other countries/ institutions around the world to find out the best practices in oceanic research and innovation, here the paper takes Australia, China and the European Union as case studies. The following section provides recommendations as to how to initiate advancement in the field of science and technology. The last chapter concludes the paper.

Sustainable ocean economy: What technologies we need?

The ocean is often termed as mankind's final frontier in the earth that is still largely unexplored. Exploring the huge grounds of oceans and seas will require mankind to find a new science, technology and innovation that will help them to harness the vast resources of the ocean economy. Additionally, new technology is also required to make the existing economic activities in the ocean more cost-effective and environmentally friendly. The challenges of the ocean economy are to use the resources available at the ocean while maintaining environmental sustainability. In this area too, science and technology will help mankind to find ways to do that successfully. In this regard, The Organisation for Economic Co-operation and Development (OECD), in its website links a number of ways that the science, technology is required and will be useful for a sustainable ocean economy.

The first requirement for successfully exploring the oceans is to know about it more thoroughly, for which there is need for data about the oceans. This calls for more ocean observation and scientific missions. Ocean observations and scientific missions can provide new evidence and data which increases the understanding of the ocean. The countries need to invest more in equipment that will acquire and generate data about oceans. The data collected from those pieces of equipment can be used for research by scientific communities as well as by other public and commercial parties. Scientific exploration is needed for doing the stock take of existing oceanic resources and find out previously unknown resources. More scientific research will strengthen the countries capacity to use its ocean resources in a safe, effective and sustainable way. This will protect the ocean environment and can even find out more commercial uses of the ocean. Furthermore, in recent times the oceanic observations are also being used to monitor the development of ocean economic activities and to improve marine spatial planning.

Another major use of science and technology in regards to the ocean economy is using them to stimulate improvements in efficiency, productivity and cost structures in the ongoing oceanic activities. Whether it is shipping, port facilities, energy or tourism, scientific research is required to make them more cost-effective. Technologies such as imaging and physical sensors, satellite technologies, advanced information and communication technology (ICT), big data analytics, biotechnology, nanotechnology and subsea engineering etc. For example, many OECD countries are starting to use Blockchain and big data analytics applications in their port facilities and maritime supply chains. This will help them to provide more integrated services for shipping companies, port operators and marine transport stakeholders while saving cost by deploying a more efficient system, all while improving the overall quality of service (OECD, 2019).[4]

Perhaps the most popular area where technology is used in the ocean economy is the marine or blue biotechnology. It is deemed so important that the Indian Ocean Rim Association (IORA) included marine biotechnology besearch and Development as one of the six priority areas. Marine biotechnology has an important role in the extraction of marine species, which are then applied to a number of sectors including biotechnologies, nanotechnology, biomaterials and the introduction of genetically modified fish, which can yield high economic returns (Ninawe and Indulkar, 2019).[5] The ocean environment is still a largely unexplored area where new compounds can be found with potential to be used in novel drugs, health, nutraceuticals and personal care products. Further, the blue biotechnology can help in environmental issues. For example, bioremediation can be used for breaking down ocean pollutants and it can also help in developing cost-effective and non-toxic antifouling technologies (IORA, 2020).[6]

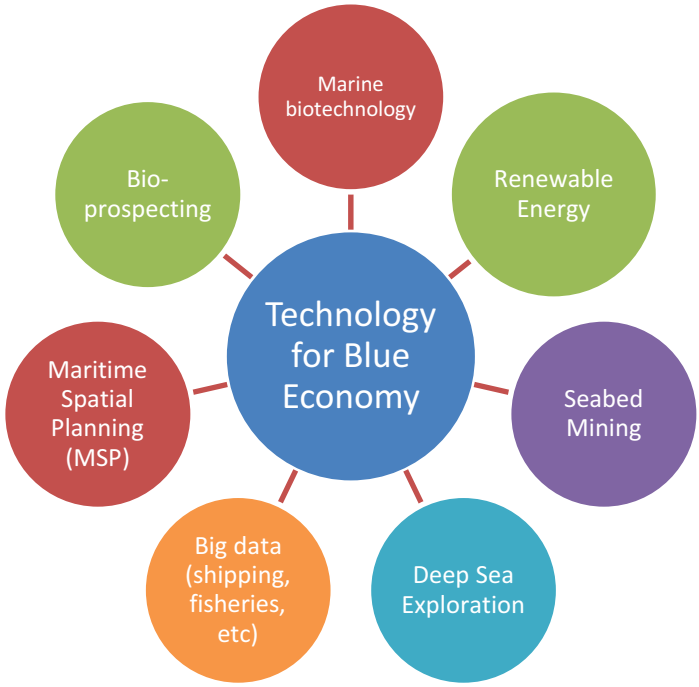
[4] Song, L. L. (2019), "How South Asia can continue as world's fastest growing subregion", available at adb.org/news/op-ed/how-south-asia-can-continue-world-s-fastest-growing-subregion-lei-lei-song, accessed on 3 January, 2020.

[5] OECD (2019), "Innovation for a sustainable ocean economy", available at http://www.oecd.org/innovation/inno/ocean-economy/, accessed on January 2, 2020.

[6] Ninawe, A. and Indulkar, S.T.(2019), "Blue Economy Mission: India's Focus", *Journal of Aquaculture & Fisheries*, Vol. 3, No.017.

There is also the renewable energy sector where new technology and innovation is largely required. As the world tries to combat the adverse impacts of climate change, technologies for renewable energy from the ocean will become increasingly important. At present, renewable energy technologies are in various stages of commercialization in the ocean economy. The type of energy that is being used includes the widely established offshore wind industry, the harnessing of the wave, current, and tidal energy, and the capture of ocean thermal and salinity gradient energy (Patil et al., 2018).[7] The amount of tidal and wave energy that is being generated is still quite low. The biggest wave energy farm which is under construction in Lewis coast in the North-western Scottish province will generate 40 Megawatt upon compilation.[8] However, with its environmentally friendly features and vast oceanic resource, the wave and tidal energy can be the future for energy of this planet.

Figure 1 shows some of the areas where technology is extremely important for the exploration of sustainable ocean economy.



Source: compiled by the author

Figure 1: Areas where technology extremely important for the exploration of sustainable ocean economy

Ocean and technology: Current situation in South Asia

The countries of the South Asian sub-region have a huge potential in the ocean economy. There has been plenty of talk regarding ocean economy/ blue economy in the policy spaces; however, there are still not many concrete policy initiatives in the countries regarding the ocean economy. One area that the countries are particularly lagging behind is the science, technology and innovation. The sub-region is not particularly advanced in science and innovation, with only India holding a distinctive Global Innovation Index ranking in 2019 (ranked 52).[9] The lack of specific blue economy strategy in the countries has also contributed to lack of scientific research and innovation in regards to the ocean economy.

India

For India, ocean economy initiatives have mostly consisted with port facilities and building partnership with many of its neighbours. So far, the country has blue economy cooperation initiatives with Seychelles, Mauritius, Sri Lanka and Bangladesh among other countries and ocean technology is one of the areas of cooperation among others (Islam and Mostaque, 2019).[10] When it comes to ocean technologies, the country has generated significant revenue for marine biology and biotechnology. It has been projected that the country will generate USD 100 Million by 2025 through biological and bio-technology industrial growth. The Indian Department of Biotechnology has taken initiative to explore the potentials. The department is setting up an institute on ocean biology and bio-technology for research and development of oceanic resources. On the other hand, the Indian Ministry of Shipping is also becoming more tech-savvy. It has started using IT enabled services extensively for its port-led development programmes (Ninawe, and Indulkar, 2019).[11] Additionally, under the "sagar-mala" initiative, it is assisting in increasing Africa's maritime capabilities, which includes development of maritime capacity building in, among other areas: coastal area development, port infrastructure buildings,

[7] Iindian Ocean Rim Association. (2020), " Blue Economy", *op. cit.*.

[8] Patil, P.G; Virdin, J.; Colgan, C. S; Hussain, M.G.; Failler, P. andVegh, T. (2018). Toward a Blue Economy: A Pathway for Sustainable Growth in Bangladesh. Washington, DC: The World Bank Group.

[9] Marine Insight (2019) , "The World's Largest Wave Farm", available at https://www.marineinsight.com/offshore/the-worlds-largest-wave-farm/, accessed on January 23, 2020.

[10] WIPO (2019), "Global Innovation Index 2019: India Makes Major Gains as Switzerland, Sweden, U.S., Netherlands, U.K. Top Ranking; Trade Protectionism Poses Risks for Future Innovation", available at https://www.wipo.int/pressroom/en/articles/2019/article_0008.html.

[11] Ninawe, A. and Indulkar, S.T.(2019), *op. cit.*

marine sciences, renewable energy and hydrography.[12]

Bangladesh

Bangladesh, on the other hand, has also been very enthusiastic regarding the exploring its ocean, especially after the demarcation of its maritime boundary in the area of the Bay of Bengal. Bangladesh's Seventh Five Year Plan, the national plan for Bangladesh's economy has mentioned the blue economy in it. The plan calls for twelve actions to be undertaken for maintaining a prosperous and sustainable Blue Economy.[13] In 2017, the Government of Bangladesh established the "Blue Economy Cell' with the mandate to coordinate Blue Economy initiatives across sectoral ministries (Islam and Mostaque, 2019).[14] Additionally, the Blue Economy sector of the country's Ministry of Foreign Affairs has identified 26 potential Blue Economy sectors (MoFA, 2018).[15] Among these 26 sectors, marine biotechnology is identified as one of the key sectors. It also identifies the lack of sound technology and technical-technological capacity as one of the main challenges for the development of sustainable ocean economy in Bangladesh. However, the country has established Bangabandhu Sheikh Mujibur Rahman Maritime University and an Oceanographic Research Institute in order to promote education and research about the ocean and maritime resources.

Sri Lanka

Sri Lanka, another of the countries with vast access to ocean has also been venturing in the ocean economy development. The Government of Sri Lanka has promoted a Blue Economy initiative under the 'Sri Lanka NEXT' program in October 2016 (Senaratne, 2017).[16] The country is an important link for sea lanes through its ports and has tremendous tourism prospects as well. The Government of Sri Lanka, through the "Report on Sustainable Sri Lanka 2030 Vision and Strategic Path" published in January 2019, has once more emphasised the importance of development in oceans that will decouple socio-economic development from environmental and ecosystem degradation. The report highlights several areas of sustainable ocean economy including new technologies, business models and innovations for promoting or restoring ocean health and states that the ocean is "a huge laboratory" and source for blue biotechnology. Additionally, the report acknowledges the lack of marine knowledge and research capacity and recommends building a national institution for ocean exploration and innovations. That institute will collaborate with other similar national and regional institutes. The plan also includes a recommendation for establishing a supra-ministerial task force supported by a lean management team to implement a focused "Experiment Nation" initiative. It should also be mentioned that considerable progress has been made in the development a Marine Environmental Baseline Information Network (MEBIN), which has be initiated by the Petroleum Resources Development Secretariat of the Sri Lankan Government (PEC, 2019).[17]

Regional Organizations

As for the regional organizations, SAARC and BIMSTEC have started venturing area of the ocean economy. The 18th SAARC Summit Declaration recognized the vast prospects of the blue economy in the South Asia region (Rahman, 2017).[18] Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) also has been looking into the blue economy sector; its interest in the area was discussed during the 4th Summit of BIMSTEC.[19] However, there has not been any significant progress in regards to this area, especially cooperation in science and technology. The counties and regional organisations, in general, are not very advanced in regards to the ocean technology initiatives. However, the countries are identifying this gap and are starting to take action in this area, which is a welcome initiative.

Case Studies: Australia, China and the European Union

As mentioned before, exploring the ocean economy is one of the most trending policy discussions of this century. Many countries have already taken the initiative to explore and harness their oceanic resources. However, the priority for the countries in the ocean economy is not the same for every country. Some countries are prioritising economic benefits, while others are more focused on conserving the environment (Islam and Mostaque, 2019). Only a handful of countries are employing innovative methods to balance between both. Here, the paper has includes the case study of Australia and China, both of the countries are investing in the science and technology aspect of the ocean economy. In addition, the paper also examines the efforts made by the European Union (EU), because they have also made significant efforts in developing science and technology in the ocean economy for the perspective of a regional organisation.

Australia

The Australian Government has chosen to term sustainable ocean economy as blue economy and it defines it as "a Blue Economy is one in which our ocean ecosystems bring economic and social

[12] Attri, V. N. , (2016), "An Emerging New Development Paradigm of the Blue Economy in IORA; A Policy Framework for the Future", University of Mauritius, available at https://www.iora.int/media/23838/the-blue-economy-and-iora-2016.pdf, accessed on 26 February 2020.

[13] General Economics Division, (2015), *Seventh Five Year Plan (FY2016 – 2020): Accelerating Growth, Empowering Citizens*, Dhaka, Bangladesh: Planning Commission, Government of the People's Republic of Bangladesh.

[14] Islam, M. and Mostaque, L. (2018), "Blue Economy and Bangladesh: Lessons and Policy Implications", BIISS Journal, Vol. 39, No. 2, pp.135-162.

[15] Ministry of Foreign Affairs (MoFA), Bangladesh, Official Website (2018), "Blue Economy National Co-ordination Workshop", available at https://mofa.gov.bd/site/press_release/bb5cd232-1529-46db-aa8c-d0c8bc4c0e47, accessed on 10 January 2020.

[16] Senaratne, A. (2017), *op. cit.*

[17] Presidential Expert Committee, (2019), "Sustainable Sri Lanka 2030 Vision and Strategic Path", Presidential Secretariat: Columbo, Sri Lanka.

[18] Rahman, M. R. (2017). "Blue Economy and Maritime Cooperation in the Bay of Bengal: Role of Bangladesh",*Procedia Engineering,* 194, pp. 356 – 361.

[19] "BIMSTEC focuses on blue economy" ,*The Independent,* September 1, 2018.

benefits that are efficient, equitable and sustainable" (CSIRO, 2015).[20] The actions of the Government of Australia regarding the development of the ocean economy have been mostly concerned with promoting scientific, technological and other innovations. Additionally, they have been proactive in establishing regional cooperation among the neighbouring countries regarding ocean economy and environment. The Australian government has published its 'National Framework for Marine Research and Innovation' in 2013. In the plan, it has highlighted the critical areas of marine science that offer opportunities for experimentation and investments. The Framework also included many schemes for improving the quality of marine science research in Australia, including creations of marine infrastructure in terms of observing technologies, observe vessels, etc; reorganization of existing institutions for marine research for better coordination and effective execution (OPSAG, 2015).[21] Additionally, the Government of Australia has also declared a 'National Marine Science Plan 2015-2025'. This Plan has been made by drawing together the knowledge and experience of more than 24 marine research organisations, universities and government departments and more than 500 scientists. The plan outlines the science, technology and innovation needed for growing Australia's sustainable ocean economy and identifies a number of areas for future investments which include (1) National Blue Economy Innovation Fund, (2) National Marine Research Infrastructure, (3) National Marine Baselines and Monitoring Program, (4) National Integrated Marine Experimental Facility, (5) National Ocean Modelling Program, and (6) Marine Science Capability Development Fund.[22] Additionally, the Australian Government also has the Australian Ocean Data Network (AODN), which an interoperable online network of marine and climate data resources for Australia.[23]

China

China has been initiating a number of initiatives to forward its scientific innovation for the marine industry and ocean economy. Most of the initiatives by China is aimed at forwarding the economic agenda of the country. However, those efforts are quite advanced compared to many of the other countries. For example, China has established six national marine economic innovation and development demonstration areas and seven national industrial demonstration bases for rejuvenating marine industry with science and technology. These include Shandong Peninsula Blue Economic Zone, Blue Silicon Valley and the strategic cooperation among marine parks and bases in the Yangtze River Delta region. The Shandong Peninsula Blue Economic Zone was established back in 2011 and by 2020, it is planned that the Shandong Peninsula Blue Economic Zone will develop into a blue economic zone that features optimized industrial structure for an ocean economy that promotes harmonious coexistence between human and nature. The Blue Silicon Valley in Qingdao endeavours to establish world-leading centres for marine scientific and technological research and developments and become an innovation platform that enables China to scientifically develop and utilize marine resources and links global marine scientific research resources (Wenhai, 2019).[24]

European Union

The European Union has been very active in Blue Economy. The first effort in Blue Economy by the European Commission was in 2012 when they formulated "Blue Growth Strategy". The strategy was aimed at harnessing the possibilities of Europe's oceans, seas and coasts for growth and job. It identified five focus areas for blue growth, i.e., blue energy, aquaculture, maritime, coastal and cruise tourism, marine mineral resources and blue biotechnology.[25] In 2014, EU launched its Blue Economy Innovation Plan, highlighting three aspects: (I) sustainable jobs and growth, (II) knowledge, legal certainty and security in the blue economy, and (III) Sea basin strategies to ensure to foster cooperation between countries.[26] Research and innovation in the ocean economy has been a key focus of the EU. During the 2014-2016 period, a total of US$ 911.68 million allocated to marine and maritime research and innovation projects. In order to highlight the results of its research and innovation in Blue Economy, EU published another report in 2017. The report demonstrated how the EU funded research and innovation projects were helping in meeting the main challenges in sustainable Blue Economy development. The report also talked about Coastal and Marine Spatial Planning (CMSP).[27] The organisation has also done studies on specific seas to explore its Blue Economy potential. One of those studies was the western Mediterranean. The European Union has also been very active in protecting the environment. It has put in place the EU Marine Strategy Framework Directive (MSFD) to protect the marine ecosystem and biodiversity.[28] Moreover, the EU has also been focusing

[20] Commonwealth Scientific and Industrial Research Organisation (2015), *Innovation for the Blue Economy: Workshop Summary*, Canberra: CSIRO, p. iii.

[21] Oceans Policy Science Advisory Group (2013), "Marine Nation 2025: Marine Science to Support Australia's Blue Economy", Canberra: Government of Australia,

[22] National Marine Science Committee, *National Marine Science Plan 2015-2025: Driving the Development of Australia's Blue Economy,* Canberra: Government of Australia, 2015.

[23] "The National Marine Science Plan: The Plan, Challenges & Recommendations", available at http://www.marinescience.net.au/national-marine-science-plan/implementing-the-plan/, accessed on 20 December 2019.

[24] Wenhai, L, et al. (2019), "Successful Blue Economy Examples with an Emphasis on International Perspectives", *Frontiers in Marine Science.*

[25] European Commission (2012).*Blue Growth: Opportunities for Marine and Maritime Sustainable Growth*, Brussels: European Commission,

[26] Wenhai, L, et al. (2019), op.cit.

[27] European Commission (2017), *Report on the Blue Growth Strategy: Towards a More Sustainable Growth and Jobs in the Blue Economy,* Brussels: European Commission.

[28] European Commission, "Environment", 18 May 2017, available at http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm, accessed on 15 October 2018.

on sustainable marine energy and blue biotechnology; both of which require a high level of technological innovation (European Commission, 2017).[29] Most recently in 2018, it has funded an expert study on sustainable Blue Economy that will suggest pathways for the development of Blue Economy in Europe while conserving of marine and coastal ecosystem (Pantzar and Kettunen, 2018).[30]

Scope for advancement

The countries of South Asia also have to involve themselves in the area of the sustainable ocean economy in order to not fall behind from the rest of the world. It is evident that the countries have considerable desire to engage in the oceanic economy; however there is still a lack of coordinated action on their behalf for the advancement of this area. As science, technology and innovation hold great importance in the investment of sustainable ocean economy; the countries need to invest in this area for future needs. The countries of the region can, therefore, take the following actions.

Countries need to invest more in the scientific exploration of the sea; these explorations will provide the countries data regarding their available resources in the ocean. They should also invest in the satellite and imaging systems, which will help them in improving their sea routes and port facilities among other things. The ports should use big data analysis to improve their service delivery and efficiency. This has the potential to have an impact not only the ocean economy but the economy of the country as a whole, as improved port facility will boost trade and commerce.

More investment should be made in the area of biotechnology, in order to find new resources for pharmacy, beauty industry and other products. Investment is also required to improve technology in fishing and marine aquaculture. The World Bank is already investing in a fisheries and aquaculture fund called "PROFISH", which is a multi-donor trust fund housed at the Bank. To date, PROFISH has investments of US$ 4.5 million in research, analysis and technical support.[31] Countries can seek assistance from that fund in order to develop their own technologies.

Countries can also follow the example of China and develop dedicated marine economic innovation and development demonstration areas. In addition, they can also establish marine silicon valley, Blue Economic Zone and marine industrial parks. These initiatives are likely to boost the research and development in the ocean economy and boost their economies.

Countries also need to increase cooperation between them for improving research in the ocean economy. More agreements need to be taken place between countries for bilateral cooperation between them for research on areas of mutual interest. For example, Bangladesh and India can cooperate on maritime aquaculture, in particular to the species Hilsa, which is of the great demand from both countries consumers.

As for the regional organizations, IORA, SAARC and BIMSTEC can all invest more attention to the scientific research on sustainable ocean economy, particularly on technological advancement and innovation. Specially IORA, which already focuses on the blue economy, can follow EU's example and develop a plan for science, technology and innovation which will dictate goals for countries in regards to ocean research. In addition, regional organisations can also have specific funds for scientific research on ocean economy.

The vast resources required for research in the ocean also calls for private-public partnership (PPP) in this area. Since scientific oceanic research helps both government and private companies looking to venture in the ocean economy, this can be a good place for PPP. Not only in investments, but cooperation can also be in terms of data collection, where sharing each other's inventory will bring greater benefit for all.

Lastly, the SMEs are some of the key agents who will bring the benefits of the ocean economy to the people and the local community, then they also need to be involved in the process. The government can think about providing funds for SMEs who are involved in sustainable ocean practices. Further, "Marine innovation award" may be introduced for SMEs who bring sustainable and innovative ideas in acquiring marine resources.

Conclusion

The ocean provides great opportunities for economic endeavours and can open a great window for the development of humankind. But at the same time, any exploration of the ocean has to be done in a manner that does not harm the fragile ecosystem and environment of the ocean. Otherwise, the results can be catastrophic and can further intensify the impacts of climate change. Here new technology and innovation can help to find out ways for sustainable ocean economic activities. It can also help in modifying the existing economic endeavours to become more efficient and environmentally friendly. The South Asian sub-region is still lagging far behind in scientific research and development in regards to the ocean economy. However, learning from the experience of the more advanced nations in this area and by extending the hand of cooperation with each other, they can venture further in the area of science, technology and innovation in the sustainable ocean economy.

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Technological Developments for India's Strategic Blue Frontier

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Abstract

With the depleting land-based resources, effective exploration and sustained harvesting of the ocean resources is essential. The emerging blue economy paradigm insists on innovative approaches required to conserve the oceans, while reaping their benefits in an equitable and sustainable way. Thus the blue economy is based on resilient systems, persistent innovation and advances in achieving integrated ecological, economic and social well-being. India with a 7600 km long coastline and an exclusive economic zone of 2.3 million km^2 and spearheading the blue economic growth and security of all the countries in the Indian Ocean region have initiated policies for leveraging the growth of the Indian economy through blue economy. The article discusses the strategic technology developments undertaken in India by the National Institute of Ocean Technology-Ministry of Earth Sciences (MoES), Government of India for the harvesting of the living and non-living blue economic resources, and for protecting the ocean ecosystems.

Introduction

Oceans with an estimated asset value of US$24 trillion commands the seventh position among the global economies. With their annual value of goods and services of about US$2.5 trillion, oceans are a promising strategic frontier for the economic growth, water and food security for the global population which will require 30% more water, 40% more energy and 50% more food by 2030. The pillars essential for transforming the traditional "Ocean and marine economy" to a "Blue" or "Sustainable" economy requires appropriate governance in the sustained utilization of the ocean, coastal and marine economies, vision, technology, management, monitoring and time-bound regulatory reforms (World Bank Group 2017).

India with about 7,600 km coastline provides sustained livelihood to more than 250 million people. Subsequent to the foundations of the 2012 Rio United Nations Conference on sustainable development, Goal 14 towards sustainable development of the ocean resources was announced in 2015. The blue economies of the United States, China and the European Union are estimated to be about US$1.5, 0.1, and 0.5 trillion, respectively, and policies are being enacted for the sustained exploitation of the blue resources for augmenting their economic growth (FICCI Task Force, 2017).

Considering the strategic importance of the blue frontier, the Government of India has enacted policies and programs through the Deep Ocean Mission (DOM) for the use of oceans, seas and marine resources to achieve sustained economic growth. The DOM is among the seven priority technology missions of India among quantum frontier, artificial Intelligence, bio-diversity, electric vehicles, bio-science for human health, waste to wealth and the Accelerating Growth for New India Innovation (AGNi) mission (https://www.investindia.gov.in). Driven by the huge resource potential and enacted policies, India is currently seeking extension to its Exclusive Economic Zone (EEZ) to 350 miles, by which the total EEZ area will equal its land area. India is a key member of the Indian Ocean Rim Association (IORA) that aims to strength the regional cooperation and sustainable development in the Indian Ocean region. Over the past 25 years, the National Institute of Ocean Technology (NIOT), under the mandate of the Ministry of Earth Sciences has undertaken various technology programs in blue economy with persistent innovation to achieve integrated ecological, economic and social well-being, underlined by the United Nations Sustainable Development Goal 14. The activities of NIOT include development of eco-friendly technologies for harvesting deep ocean minerals, unconventional hydrocarbons, renewable energy, desalination and bio-prospecting; and to monitor the health of the ocean environment and coastal ecosystems including coastline protection, cyclone and tsunami early warning systems, coral habitat observations, sustainable fishing, and the Polar Ocean monitoring (Vedachalam et.al. 2018; Atmanand 2019).

Harvesting non-living and living resources

Economic security

About 247, 2, 10 and 9.5 million tons of manganese, cobalt, nickel and copper are located in waters depths ranging 5000-6000m as poly-metallic nodules in the Central Indian Ocean Basin, hydrothermal sulphides in the southern Indian Ocean and cobalt crusts in the Afanacy Nikitin sea mount area (Fig.1a) . As developments in offshore mineral resources could compliment industrial and economic growth, India has been allocated an area of 75,000 and 10,000 km^2 by the International Seabed authority in the polymetallic nodule and hydrothermal sulphide sites in the central and southern Indian Ocean, respectively. In order to

leverage the exploration activities, NIOT has developed seabed crawler based mining machine, work-class deep water remotely operated vehicles and in-situ soil tester. After carrying out field demonstration using crawler-based mining machine at about 500m water depth, the development of a 6000m depth-rated demonstrative polymetallic nodule mining machine is underway (Fig.1.b).

The crawler powered and controlled through the electro-optic umbilical shall be capable of crawling in the soft deep seabed, collecting the polymetallic nodules, crushing and pumping them to the mother ship in the form of slurry through a 6000 m vertical flexible riser (Varshney et.al. 2015). A 6000m depth-rated in-situ soil tester is developed and being used to carry out in-situ shear and bearing strength measurements of the seabed locations of scientific interest (Fig.1.c) (Muthukrishna et.al. 2014). Studies such as environmental impact assessment studies, deep ocean moorings for environmental monitoring during demonstrative mining, and the upstream metallurgical processes and water disposal methodologies are being undertaken in association with other ministries. For enabling deep ocean mineral exploration, a 6000m depth-rated electric work-class Remotely Operated Vehicle (ROSUB 6000) with real time visual web cast to the shore is developed and is being used in the potential mineral sites of interest, including the gas hydrate site in the Krishna-Godavari basin in the east coast of India, polymetallic nodule site in the central Indian Ocean basin and in the hydrothermal sulphides site at the Rodriguez Triple Junction in the Central Indian Ridge (Fig.1.d) (Ramadass et al 2015). To further augment the exploration capabilities through direct human intervention and to empower the nation capacity building in the strategic deep ocean human missions, development of a 6000m depth-rated battery-powered manned scientific submersible capable of carrying three crew for 12h mission endurance is being developed.

Figure 1: (a) Location of mineral resources (b) 500m mining machine (c) Soil tester (d) Work class ROV

Energy security

Understanding the importance of the sustainable marine energy and its importance in the energy security, economic development and climate adaptation, NIOT is working on renewable energy technologies including offshore wind, marine current, wave power and ocean thermal energy conversion technologies and technologies for exploring unconventional marine gas hydrates. For accelerating the growth of the offshore wind energy installations, the National Offshore Wind Energy Authority is established to carry out resource assessment in the EEZ of India. The installed capacity of the offshore wind energy sector is forecasted to reach 5GW in 2032 and 20GW by 2047. For enabling offshore wind resource assessment, that has a potential of about 350GW, LIDAR-based data collection platforms are established by NIOT and Ministry of New and Renewable Energy (MNRE) in the Gulf of Kutch and the Gulf of Khambhat (Fig.2a) (Satya et.al. 2017). NIOT has successfully demonstrated wave energy devices and off-grid hydrokinetic turbines in the open sea (Fig.2b). For some locations in the Andaman Islands where high water current potential exist, hydrokinetic turbines of required capacities are being developed. India recently became a member of the International Energy Agency-Ocean Energy Systems technology collaboration program and this is expected to accelerate the development of ocean energy technology. A range of floating wave powered systems including a Backward Bent Ducted Buoy and a navigational buoy suitable for port and harbors have also been developed (Ashwani and Nitinesh 2018).

The unconventional hydrocarbons are expected to contribute more than 10% of the national natural gas demand after 2030. About 1874 TCM of natural gas is sequestrated as gas hydrates in the continental margins of India, preferably in the east coast. For supporting the national efforts undertaken by the government in bringing the gas hydrates from the prospective to a contingent state, NIOT is developing a 3000m depth-rated sea bed based wireline autonomous coring system (Fig.2c) capable of taking *in-situ* gas hydrate core samples from beneath the sea floor. The system shall be used for ground truth validation and to carry out spatial quantification of the deep seated gas hydrate resource. Numerical models are developed for techno-economic evaluation of potential hydrate bearing reservoirs (Vedachalam et al, 2020).

Water security

As on date, about 19,000 desalination plants in 150 countries serve 95 million m^3 of potable water to about 4 % of the global population. About 600 million or 48% of India's population face high to extreme water stresses. Coastal communities are increasingly turning to the sea to meet their drinking-water needs, while inland there is a tendency for groundwater to become

increasingly brackish over time. The indigenous, robust and eco-friendly, Low Temperature Thermal Desalination (LTTD) technology developed by NIOT requires warm sea surface water and the cold water from water depth around 300m drawn using high density polyethylene pipe. NIOT has installed LTTD plants of 100 m^3/day capacities in the three Islands in the Union Territory of Lakshadweep (Fig.3a), where people predominantly rely on rain water and highly contaminated ground water.

The plants that are operating over a decade have proven multiple socio-economic advantages including health of the island community. The water-bound medical complaints dropped from 198 over a period of 7 months before the installation of the LTTD plants to less than 10 complaints over the same period. Efforts are underway for installing LTTD-based desalination plants in six more islands of India (Fig.3b). This concept is also being used in coastal thermal power plants to cool the condenser reject water and co-generate fresh water. After demonstrating this technology in the coastal North Chennai thermal power station, this is being extended to similar plant in Tuticorin Thermal Power Station (Vengatesan et.al. 2019; Atmanand, 2020). To make the LTTD plants in islands independent of diesel generators, an Ocean Thermal Energy Conversion (OTEC) powered desalination plant is currently being planned which will power the desalination unit with energy generated from the ocean thermal gradient thus leading to clean water and green energy.

Food security

The world bank's active Blue Economy portfolio worth ~ US$4.1 billion is targeted to realize an improved integrated management of fisheries, aquaculture, marine and coastal ecosystem so as to deliver increased and long-lasting benefits. Technologically improved and integrated management of fisheries, aquaculture, marine and coastal ecosystems deliver increased and sustained benefits. It is identified that sustained fish production in India could be increased up to 8.4 million tons, a 30% increase from the current production level. To identify effective fish aggregation methods, NIOT has developed and demonstrated multi-point moored open sea cages made of high density polyethylene of diameters > 9 m capable of withstanding turbulent sea states (Fig.4a). Culturing commercially important marine fin-fishes were demonstrated in the Andaman Islands, Tamilnadu and Andhra Pradesh. For fostering the studies on the applications of the deep sea piezophilic micro-organisms in the health and medical sectors, NIOT has established a deep ocean microbial sampling and incubation system capable of bringing the deep-ocean micro bio-resources to the surface and incubating them by maintaining their ambient pressure (Fig.4b). The marine-derived enzymes and algae, which are key for the food, nutritional, cosmetic, pharma and bio-fuel industries, are studied at NIOT using large scale cultivation systems, such as bubble column photo-bioreactor, tubular photo-bioreactor and raceway pond systems (Fig.4c) (https://www.niot.res.in; Dharani et.al. 2019).

Response to ocean health challenges

Coastal ecosystem protection

Coastal ecosystems including beaches, fish stocks, coral reefs, and mangrove forests are recognized as natural capital assets. The ~ 0.5 million km long global coastline yields ~ 90% of the global fish production. Coasts undergo constant changes as rivers, near-

Figure 2: (a) Offshore wind assessment station, (b) Marine current turbine, (c) Autonomous coring system

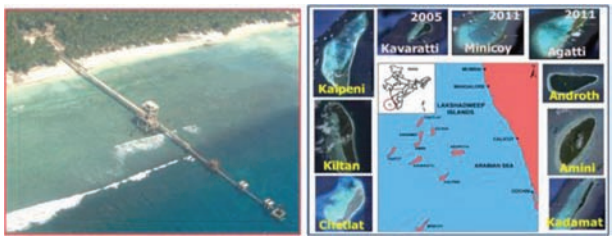

Figure 3: Desalination plants under operations and under construction

shore currents and waves move sediments inside, outside and within the near-shore zone. Coastline-specific solutions based on the sedimentation process and littoral drift are undertaken by NIOT in various sensitive coastal zones for effective erosion control and resilience. In Kadalur-Periyakuppam village, near Chennai, which was affected during tropical cyclones, submerged shore parallel offshore dikes of 200m lengths made of geo-synthetic material filled with fine sand have been installed over 1.2 km to protect the beach from severe erosion. The coastline of historical Puducherry (formally Pondicherry) in the east coast of India suffered severe coastal erosion due to natural causes and reorientation of the coast due to the port breakwaters. To identify a long term solution, a pilot beach nourishment project supported by numerical studies was executed based on the long-term shoreline changes using satellite data and measurements taken during various seasons. The efforts resulted in the formation of a wide beach near New Pier (Satya et.al 2017; Ramanamurthy et.al. 2019).

The corals of the Andaman Islands, which has the richest coral diversity among the Indian reef were victims of the thermal stress due to the elevated temperatures, which resulted in the coral bleaching during 1998, 2002, 2005 and 2010. Coral reef surveys were conducted in five islands of the south Andaman district using the shallow water remotely operated vehicle (PROVe) which was developed by NIOT under the unmanned underwater vehicle program (Fig.5b). The observations revealed that most of the coral ecosystems are in the resilient stage after major events such as the 2004 devastating tsunami and the bleaching events during 2005 and 2010 (Ramesh et.al. 2017).

Coastal natural hazard advance warning

The Indian maritime zone is dominated by a range of economic activities including port operations, conventional fishing, hydrocarbon exploration, transportation, marine research, and defence activities. Sustained real-time ocean observations are vital to understand the ocean dynamics and variability required for improving weather prediction, ocean state forecast, climate change studies and other oceanographic services. The incidence of the tropical cyclones is higher in the northern Indian Ocean because of the unique geography. Although, it is not possible to completely avoid natural disasters, their effects can be minimized by undertaking some long-term and short-term mitigation measures and improved response mechanism. Hence continuous ocean observation and timely dissemination of information to various end users is essential.

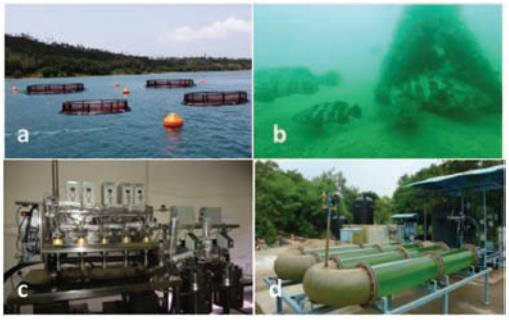

Figure 4. Activities under marine bio-technologies

Figure 5: Beach restoration in Puducherry and ROV-based coral reef survey in Andaman Islands

The Indian Ocean Oobservation Network (OON) includes the NIOT-operated Research Moored Array for African-Asian-Australian Monsoon Analysis and prediction mooring network (RAMA), the Ocean Moored buoy Network for northern Indian Ocean (OMNI) buoys networks and the Indian Coastal Ocean Radar Network. The subsurface mooring system can measure temperature and salinity profiles from the surface down to 500 m depth and the surface meteorological variables. Over the past two decades, the moored data buoys are deployed in more than 650 locations ranging from the coastal waters to the deep oceans spanning between 63°E to 93°E and 6°N to 20°N for collecting the meteorological, water surface and subsurface parameters (Fig.6a) (Hermes et.al. 2019; Venkatesan 2017). During a tsunami, the sea level inputs from the tsunami buoys serve as critical inputs to the Indian Tsunami Early Warning Center (ITEWC) for numerically computing tsunami travel times and wave run-up wave heights, which are essential for the timely generation and dissemination of the tsunami advisories (Fig.6b). The ITEWC is the primary source of the tsunami advisory for India and as a tsunami service provider for the entire Indian Ocean region (Srinivasa et.al. 2016). The data acquired during various events serve as important inputs to various agencies including the Indian Meteorological Department (IMD) and for understanding the Indian Ocean dynamics which is essential for improved modeling of the evolution of the seasonal monsoons and cyclones.

The interactions between the global oceans, atmosphere and cryosphere influence the climate, biogeochemical cycles, biological productivity and the climate change on a global scale. NIOT, along with its sister organizations has installed the first Indian multi-sensor moored observatory, IndArc, for enabling long-term *in-situ* data collection comprising physio-chemical and oceanographic sensor suite NPOR in Kongsfjorden in Arctic waters (Noufal et.al.

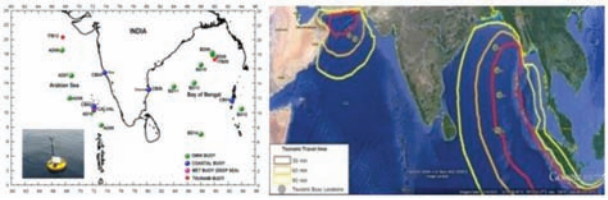

Figure 6: Indian data buoy network and location of tsunami buoys

2017). Long term data collection shall help to understand the influence of cryosphere on the bio-geochemical cycles, biological productivity, ice shelf dynamics, paleo-climate and sea level rise on the global oceans.

Conclusion

Sustained harnessing of the ocean resources shall help to leverage the robust US $2.5 trillion Indian economy targeted for a growth rate of 7%. The technologies developed in India by the National Institute of Ocean Technology for the sustained utilization of the vast Indian blue living and non-living economic resources, hazard mitigation, monitoring the coastal and ocean ecosystems are essential to keep the blue economic activities in balance with the long-term capacity of the Indian Ocean ecosystems are detailed. The vessel fleet comprising of coastal research vessels, deep ocean technology demonstration vessels, infrastructure for hyperbaric testing, environmental chambers help in seamless qualification of the developed technologies. The matured technologies including remotely operated vehicles, deep-ocean moorings, autonomous underwater profiler-cum-drifter, marine biotechnology products and processes and marine electronic systems have already been transferred to Indian industries to spur blue growth. India being a key member of the Indian Ocean Regional Association is willing to cooperate with other countries to share the technology products so as to ensure economic growth and security of all the countries in the Asia-Pacific region.

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SEA circular

SEA circular is an initiative from the UN Environment Programme and the Coordinating Body on the Seas of East Asia (COBSEA) to inspire market-based solutions and encourage enabling policies to solve marine plastic pollution at source.

Plastic waste is choking our rivers and seas, threatening ecosystems and livelihoods in South East Asia. Striving for cleaner seas, less plastic wasted and a more circular economy requires fundamental changes throughout the plastic value chain.

It is estimated that just four Asian countries — China, Indonesia, the Philippines and Vietnam — account for about half the plastic waste that flows from land into the ocean. This is due to rapid growth in plastic production, and inadequate management of solid waste – resulting in overflowing landfill sites and plastic leakage.

At the third United Nations Environment Assembly (UNEA-3) in December 2017, Heads of State and Ministers of the Environment from over 140 countries declared that:

"Any threat to our environment is a threat to our health, our society, our ecosystems, our economy, our security, our well-being and our very survival."

Plastic pollution has wide-ranging environmental, social and economic impacts, damaging marine ecosystems and biodiversity and ultimately impacting human health.

SEA circular is a working in six countries in South East Asia: Cambodia, Indonesia, Malaysia, the Philippines, Thailand and Vietnam, from 2019-2023. The project is supported by the Government of Sweden.

The focus is on several points along the plastic value chain. Interventions are designed and implemented with an understanding of land-sea interactions, and towards a circular economy. SEA circular works with national and provincial governments, private sector corporations, civil society groups and NGOs – and many other stakeholders – to support good governance and policy making, and promote circular economy principles.

SEA circular focusses interventions on supporting market-based solutions, enhancing the science-basis for decision making, generating outreach to support awareness and behaviour change, and promoting a regional approach through collaboration and networking.

For more information, access:

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Transforming to Sustainable Ocean Economy

Green Ports and Shipping in the Asia-Pacific

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Abstract

Ocean economy is the sum of economic activities from ocean-based industries, together with assets, goods and services provided by the marine ecosystem. The port and shipping industry is considered an ocean-based industry; an industry facilitating the growth of global trade and economy in the Asia-Pacific. A sustainable ocean economy is a strategy that supports economic development and ocean health as compatible propositions, by balancing between economic benefits and the environment in ocean-based industries. For the port and shipping industry to achieve a sustainable ocean economy, innovative technological advancements such as green ports and ships can be a feasible method. However, the development of green ports and shipping will have cost and operational implications. Policy formulation is considered a key measure to reap the benefits and tackle the challenges of green ports and shipping for a sustainable ocean economy.

Introduction

The ocean's relationship with the economy is evolving in important ways, as the ocean is the primary medium upon which global trade takes place. The Organisation for Economic Co-operation and Development (OECD) defined ocean economy as the sum of economic activities by ocean-based industries, together with the assets, goods, and services provided by marine ecosystems (OECD, 2016). These ocean-based industries include fishing, oil and gas, ports and shipping, marine tourism, and offshore renewable energy. It was reported that recent ocean economic activity accounts for approximately USD1.5 trillion gross value-added (GVA) globally. The report also projected that ocean economic activities will reach more than USD3.0 trillion global GVA by 2030.

Economic growth is closely linked to maritime transport activities, as 90% of world trade is carried out by the shipping industry. Seaborne trade is further expanding by raising cost-effectiveness, transporting raw materials and manufactured goods *en masse* across the globe. According to the International Chamber of Shipping (2018), there are approximately 50,000 merchant ships from 150 countries involved in international trading. These ships are sophisticated and deemed as high-value assets whose operations are expected to generate an average annual profit of USD0.5 trillion. The prospect of seaborne trading remains bright, especially as the world population continues to expand and become more reliant on shipping as the main mode of transportation for raw materials and manufactured goods. In this context, optimum development of ports into capital-intensive infrastructures is extremely vital to boost seaborne trading. The Asia-Pacific region requires optimum development of ports rather than competition, to ensure sustainability.

The Economist Intelligence Unit (2015) mentioned that a sustainable ocean economy views economic development and ocean health as compatible propositions. To support sustainable economic growth from ocean-based industries, it would require a long-term strategy. The concept is relevant to all countries especially in the Asia-Pacific region, due to the importance of the ocean to the area. For a sustainable ocean economy, particularly in the port and shipping industry, it must be supported by innovative technological advancements such as green ports and green ships. The purpose of this article is to examine the eco-friendly technological characteristics of both green ports and green ships. Furthermore, this paper will focus on the prospects and challenges of green ports and shipping in the Asia-Pacific. Finally, policy recommendations will be proposed as a way forward to transform the port and shipping industry.

Eco-friendly technological characteristics of green ports

A green port, or an ecological port, is a sustainably-developed and environmentally-friendly port that fulfils specific environmental requirements in port activities, including port development, operation, and management. According to Pavlic *et al.* (2014), a green port is recognised as a new ideology to realise sustainable development at ports through harmonising the balance between economic benefits and environmental effects. Green ports were previously referred to as ports proactive in addressing negative environmental externalities between the 1990s and the late 2000s. Later in the 2010s, the term has been widely linked to ports that possess active initiatives and projects promoting the use of eco-friendly technological advancements, such as renewable energy for port operations. Anastasopouos *et al.* (2011) mentioned that the concept of a

green port highlights sustainable and efficient usage of its resources in order to reduce the negative impacts on the ocean environment resulting from port activities. The concept deals with the protection of the ocean environment through constructive approaches, such as technical infrastructures, pricing and access, and integrated management approaches.

Technical infrastructures

A green port is well-equipped with technical infrastructures capable of solving specific environmental problems such as energy efficiency, ship waste, and air quality. According to Tseng and Pilcher (2015), cold ironing, or commonly known as Onshore Power Supply (OPS), is a technology that could supply electricity to ships from ports. In this method, electricity is generated from natural resources like hydroelectricity. Ships could switch off their diesel-powered generators when docked at ports that provide hydroelectricity. As a result, greenhouse gas emissions at ports from these ships could be eliminated, thus reducing the negative environmental impacts of port activities.

The development of a waste reception infrastructure at ports was also identified as a key measure to reduce the negative impacts of port activities. Puig *et al.* (2014) reported that the development of a waste reception infrastructure at ports allows for port authorities to collect and manage all types of waste including solid, liquid, and gaseous waste discharged by ships. For instance, ships routinely discharge ballast water, which could ideally be collected and treated at the waste reception infrastructure in order to prevent the introduction of invasive species in the area.

According to Rigot-Muller *et al.* (2013), the Greenhouse Gas Emissions Inventory could assist port authorities to monitor and analyse port activities that produce greenhouse gas emissions. The tool is useful in identifying trends and reduction measures of greenhouse gas emissions at ports, besides supporting socio-economic and political claims of port authorities, especially in cross-boundary emissions. However, the development of the aforementioned inventory is very complex and costly as it requires an all-inclusive baseline data and highly-skilled operators.

Pricing and access

A green port has a number of tools for pricing and access that are mainly focused on ships' access and shipping lines to port terminals, as well as shipping companies operating at ports. The Environmental Shipping Index (ESI) is one such tool, mentioned by Lister *et al.* (2015), a web-based tool that provides assistance in improving the environmental performance of ships visiting the ports. ESI requires a cooperative online submission of fuel receipts and the provision of incentives for ships with low greenhouse gas emissions by ship operators and port authorities, respectively. The aforementioned tool was collectively designed by port authorities in the World Ports Climate Initiative that was officially launched on 24 November 2008 in Los Angeles, California.

The concession agreement is another crucial tool that could be adopted to address port activities' impact on the ocean environment. In this case, environmental sustainability could be set as one of the topmost requirements for granting concession agreements to shipping companies that intend to operate at ports, as stated by Notteboom and Lam (2018). This tool may be legally effective in urging shipping companies to adhere to environmental objectives, such as reducing greenhouse gas emissions set by port authorities.

Acciaro *et al.* (2014) suggested that incentive pricing and penalty pricing could be used as a 'carrot and stick approach' to improve the environmental performance of ports. Both the 'sustainability and polluter pays' principle could be applied in port activities, whereby incentive pricing and penalty pricing are issued accordingly based on the performance of shipping and port operators. For example, port authorities could issue penalty pricing to shipping operators involved in oil spills. This tool may be practical in encouraging shipping companies to meet the environmental requirements as part of their responsibility.

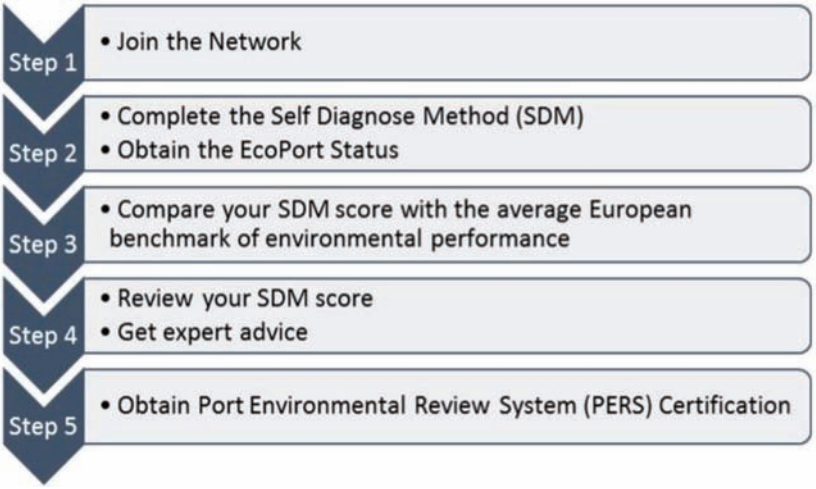
Integrated management approach

Apart from technical infrastructures, pricing, and access, the Environmental Management Systems (EMS) is also promoted as a green port tool, based on an internationally-recognised environmental management standard as reported by Lam and Notteboom (2014). Meanwhile, the Ports Environmental Review System (PERS) (Figure 1) and Eco-Management and Audit Scheme (EMAS) are examples of internationally-recognised environmental management standards that ports could adopt in EMS to maintain sustainability that fulfils specific environmental requirements. These mentioned standards are useful to port authorities in planning their port activities, including port development, operations, and management. In addition, the EMS could be used to monitor, document, evaluate, and improve the environmental performance of the port on a timely basis.

Eco-friendly technological characteristics of green ships

A green ship or an ecological ship is a vessel that serves as a significant enabler for green shipping. It is an environmentally-friendly ship that fulfils specific environmental requirements aided by the development of green technologies. According to Im *et al.* (2005), green shipping is a marine transport activity focusing on the balance between economic benefits and environmental effects by referring to the use of environmentally-friendly resources and energy to transport people and goods by ships. Compliance with specific environmental requirements regulated by the International Maritime Organisation (IMO) is made compulsory for green ships. For green ships, the International Convention for the Prevention of Pollution from Ships (MARPOL) is the main convention with provisions from six technical annexes that prevent both operational and accidental environmental pollution caused by ships. The six technical annexes with specific areas of regulations are as follows:

Annex 1: Regulations for the prevention of pollution by oil



Source: Yahya (2019)

Figure 1: The Ports Environmental Review System (PERS)

Annex 2: Regulations for the prevention of pollution by noxious liquid substances in bulk

Annex 3: Regulations for the prevention of pollution by harmful substances carried by sea in packaged form

Annex 4: Regulations for the prevention of pollution by sewage from ships

Annex 5: Regulations for the prevention of pollution by garbage from ships

Annex 6: Regulations for the prevention of air pollution from ships

Green ship technologies

The introduction of green ships is recognised as a competitive advantage in order to meet the environmental regulations of IMO, as stated by Yang (2012). These ships are well-equipped with the latest green technology and could play a role as strategic vessels for green shipping. A few benchmark technologies have been developed to build green ships that could ultimately protect the ocean environment, besides competing advantageously in terms of cost and efficiency in the shipping industry. A tri-fuel engine is one of the technologies installed in ships whereby Liquefied Natural Gas (LNG) is used with Marine Diesel Oil (MDO) and Heavy Fuel Oil (HFO) as marine fuels. LNG is a colourless and non-toxic natural gas that comprises mainly of methane. It is considered a cheaper and greener fuel compared to conventional diesel fuels such as MDO and HFO. In the tri-fuel system, conventional diesel fuel will generate power during the normal voyage, then the engine will switch to the consumption of LNG to generate power at ports, as mentioned by Karan (2019). The tri-fuel technology was initially introduced in gas carrier ships and later adopted in container ships to reduce greenhouse gas emissions and the cost of OPS. This green technology is adopted by shipping operators as one of the recent key technologies to collectively meet the global 0.5% sulphur cap in 2020, as required by MARPOL.

The application of anti-fouling paint on the hull of ships could enhance shipping performance as reported by Mohit (2019). Anti-fouling paints are formulated with copper compounds and biocides, which prevents marine fouling by retarding the growth of marine organisms such as algae and barnacles on the hull. Moreover, the anti-fouling property of the paint is effective in facilitating the detachment of marine organisms, thus resulting in a clear and smooth hull devoid of marine fouling. Ships with clear and smooth hulls could reduce the consumption of marine fuels during voyage due to the reduced resistance from friction caused by oceanic currents. As a result, these ships are able to reach their destinations with minimum usage of marine fuels, which could decrease the cost of ship operations. However, the application of anti-fouling paints containing tributyltin was banned by IMO on account of its toxicity to marine ecology in the 1970s. The chemical properties of anti-fouling paints applied to hulls must be environmentally-friendly in order to meet IMO's strict environmental regulations.

The development of ECO Voyage is another remarkable green technology to enhance shipping performance in a sustainable manner. ECO Voyage is a maritime software developed by Maersk Maritime Technology with the assistance of a number of shipping operators, as mentioned by Anish (2019). The software is used to reduce the cost of ship operations through passage and voyage planning. Several factors need to be taken into account for passage and voyage planning, such as the estimated time of arrival and economical speed of the ship, together with the expected waves and currents of the ocean. The sophisticated software will provide optional passages and voyage plans for shipping operators to reach their destination with the least usage of marine fuels, directly decreasing the cost of ship operations. These passage and voyage plans will be recorded and stored in the central server system for future reference, for other shipping operators. In short, the ECO Voyage is a green technology for shipping operators to plan an ecological voyage with minimum operational cost and environmental impact.

Prospects and challenges of green ports and shipping in the Asia-Pacific

In recent years, there has been a wave of environmentally-driven regulations pushing the transformation of ports and shipping industries in the Asia-Pacific towards a sustainable ocean economy. Ports are infrastructural assets that play important roles as points of ocean-land convergence and gateways of international seaborne trading. In line with the positive growth of port traffic over the years, these infrastructures are expected to align their key

performance index by taking environmental sustainability into account. Despite the development of ports through technological approaches such as technical infrastructures, pricing, and access, as well as integrated management approaches, it will still have cost implications, such as further funding requirements. Nevertheless, it is still considered a vital strategy to improve the attractiveness of ports of call for shipping companies in the Asia-Pacific.

Clarksons Research (2019) stated that an average ship call has a turnaround time of 0.97 days at ports. The average turnaround time of ships at ports is the measurement of the efficiency and trade competitiveness of the respective ports. In the Asia-Pacific, ports with the shortest turnaround times are mostly found in technologically advanced ports such as Port of Shanghai and Port of Singapore, located in China and Singapore, respectively. Port authorities could implement port call optimisation as a measure to reduce the turnaround time of ships at ports. This measure will ensure that the arrival of ships and the operation of ports are in accordance with the schedule. In this case, additional charges will be imposed on the early or late arrival of ships at ports. Besides that, ports that fail to perform clearance (either in loading or unloading operations) on time will also be penalised. A port call optimisation aimed at improving the efficiency of ports with optimum port traffic could eventually improve the efficiency of the economy.

Ports that are built adjacent to the ocean is exposed to changes in oceanic currents, ocean-level rise, and flooding. Jevrejeva *et al.* (2018) estimated that the global damage due to extreme phenomena such as ocean-level rise accounts for approximately USD10.8 trillion per year, with a rise of average temperature of 1.5 °C, indicating global warming by the year 2100. The ports are expected to perform sustainably – protecting the ocean environment while increasing the efficiency of the economy. The environmental management standards such as PERS and EMAS should be adopted by port authorities to reduce negative environmental impact, specifically greenhouse gas emissions, which is responsible for global warming and ocean-level rise. The concept of a green port is comprehensive in driving the transformation towards a sustainable ocean economy, as both environmental and economic benefits resulting from port activities are closely related to each other.

The implementation of the IMO regulation on reducing the content of sulphur in marine fuels from 3.5% to 0.5% effective 1 January 2020 is expected to bring significant benefits to the environment. The regulation was initiated to reduce greenhouse gas emissions from ships, specifically sulphur oxide, that escapes into the atmosphere and ultimately contribute to global warming. The implementation and enforcement of the new 0.5% sulphur cap is the responsibility of every state party to MARPOL. Meanwhile, port authorities are fully responsible for detaining ships that do not comply with the regulation at ports. Furthermore, a penalty will be imposed on shipping operators accordingly for their violation of the regulations. In addition, an amendment to MARPOL further prohibits the carriage of non-compliant marine fuels on the ship during the voyage. This amendment will be effective 1 March 2020 onwards to further reduce the negative environmental impacts of shipping activities.

UNCTAD (2019) reported that compliance with the 2020 IMO regulation will bring challenges, particularly on cost implications to the shipping industry. This is because compliance with the regulation requires huge investments in the development of certification schemes and technological advancements for green ships. For instance, entry into force of certification schemes for the green ships will have a direct cost implication on the shipbuilding and ship repair sector to incorporate the new standards required by the regulation. Furthermore, the installation and maintenance of a tri-fuel engine powered by LNG in green ships will be cost-consuming compared to a normal engine powered by conventional diesel fuel. Consequently, additional costs will unavoidably be absorbed by shipping operators and then dispersed to consumers across the supply chain as increments on the cost of shipping and price of goods.

Apart from cost implication, the supply of ships could be disrupted by the 2020 IMO regulation. The transition period from the development of certification schemes and technological advancements for green ships will greatly reduce the availability of ships for seaborne trading. In addition, older ships that cannot be upgraded into green ships will be permanently delisted from the industry. The supply of ships will not be able to support the demand for direct port calls, thus increasing the demand for trans-shipment, as mentioned in World Maritime News (2019). In short, the 2020 IMO regulation is undoubtedly a practical test to transform the shipping industry towards a sustainable ocean economy by adjusting the balance between economic benefits and environmental impacts.

Way forward for the port and shipping industry

A sustainable ocean economy is a collaborative model that emphasises joint consultations, cooperation, and mutual benefits through ocean-based industries. In the context of a sustainable ocean economy, the port and shipping industry is expected to deliver economic gains with minimum negative environmental impact. While the prospect of seaborne trading remains bright, the feasibility of transforming the port and shipping industry towards a sustainable ocean economy in the Asia-Pacific is being questioned by industry players. From the perspective of industry players, the full implementation of the 2020 IMO regulations will bring uncertainties in relation to the standardisation of certification schemes and technological advancements for green ports and shipping. Besides that, the cost and availability of alternative green fuels, namely LNG, to support green ports and shipping are the emerging concerns of industry players since it directly affects the cost of shipping. There is an urgent need to adopt an immediate and systematic approach in order to support the transformation of the port and shipping industry towards a sustainable ocean economy in the

Asia-Pacific. Risks from the transformation of the industry can be mitigated through the standardisation of laws and rules governing industrial investments and operations. For example, the National Shipping and Port Council (NSPC) was established by the Ministry of Transport Malaysia to address environmental and economic disputes emerging from the transformation of the port and shipping industry to a sustainable ocean economy.

An international maritime cooperation could be initiated to realise the transformation of the port and shipping industry to a sustainable ocean economy in the Asia-Pacific. Maritime cooperation, specifically on environmental and economic aspects, could be promoted via the establishment of an international platform for cross-border maritime information sharing. For example, respective stakeholders could take collaborative efforts to accelerate joint research on green technology that may reduce cost and development risks in the port and shipping industry. Moreover, human capacity development inclusive of technical training and academic exchange via cross-border seminars and workshops can be another important measure in transforming the industry. These collaborative efforts for international maritime cooperation at different levels and scales in the Asia-Pacific will eventually stimulate a sustainable ocean economy.

The transformation of the port and shipping industry towards a sustainable ocean economy could be facilitated by a national policy focused on a proactive long-term vision. An overarching national policy focusing on environmental and economic development is useful in establishing essential standards and principles for industry players to translate their green strategies into their business reality. A sustainable ocean economy relating to green ports and shipping is inevitably affected by institutional and situational factors such as national priorities and interests. These priorities and interests that will be timely highlighted in the policy may constructively ensure industry players will be able to selectively adopt green strategies that fit the institutional and situational contexts of the nation. In this case, industry players could adopt different combinations of strategies at different time periods based on the environmental, economic, and regulatory priorities highlighted by the national policy, in reaching a sustainable ocean economy.

To leverage the opportunities and address environmental and economic challenges in transforming the port and shipping industry, appropriate risk and benefit assessments on a regular basis would be vital. In Malaysia's case, industry players are incentivised by the government to conduct comprehensive risk and benefit assessments for optimum development of the port and shipping industry, in order to promote competitiveness and connectivity while tackling environmental challenges. In addition, extensive stakeholder consultations should be undertaken as another key measure to minimise risk factors associated with potential challenges resulting from the transformation of the industry towards a sustainable ocean economy. In this instance, the additional cost of shipping is considered as one of the potential challenges that will exert a significant impact on the cost and supply of ships. Industry players involved should develop visionary operational plans that include far-reaching economic impact studies to ensure that the ultimate objective of a sustainable ocean economy can be achieved.

Conclusion

A sustainable ocean economy views economic development and ocean health as compatible propositions, requiring a long-term strategy from all countries, especially in the Asia-Pacific region. Of the various ocean-based economies, a sustainable ocean economy for the port and shipping industry can be achieved via innovative technological advancements such as green port and ships that meet the environmental regulations set by IMO. However, it is important not to view a sustainable ocean economy solely in environmental terms, as the potential economic prospects and challenges should be considered in order to meet the objectives of the strategy. In this case, an international maritime cooperation of the countries in the Asia-Pacific region should be initiated to realise the transformation of the port and shipping industry towards a sustainable ocean economy. Then, the establishment of essential standards and principles through policies focusing on environmental and economic development would guide the industry players to translate green strategies into their business reality. The policies should include a focus on results towards realising the goal of shared environmental and economic prosperity through a sustainable ocean economy.

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Action Plan for Healthy Oceans, Sustainable Blue Economies

The Asian Development Bank (ADB) has launched the Action Plan for Healthy Oceans and Sustainable Blue Economies for the Asia and Pacific region at the 52nd Annual Meeting of ADB's Board of Governors in Fiji. The action plan will support the efforts of ADB's developing member countries to achieve the Sustainable Development Goals (SDGs), including SDG 14 Life Below Water.

The Action Plan for Healthy Oceans and Sustainable Blue Economies will expand financing and technical assistance for ocean health and marine economy projects to $5 billion from 2019 to 2024, including cofinancing from partners. It will focus on four areas: creating inclusive livelihoods and business opportunities in sustainable tourism and fisheries; protecting and restoring coastal and marine ecosystems and key rivers; reducing land-based sources of marine pollution, including plastics, wastewater, and agricultural runoff; and improving sustainability in port and coastal infrastructure development.

As a part of the action plan, ADB will launch the Oceans Financing Initiative to create opportunities for the private sector to invest in bankable projects that will help improve ocean health. The initiative will provide technical assistance grants and funding from ADB and other donors to reduce the technical and financial risks of projects. This will be done through instruments such as credit risk guarantees and capital market "blue bonds".

The Oceans Financing Initiative will be piloted in Southeast Asia in collaboration with the ASEAN Infrastructure Fund and the Republic of Korea. The World Wide Fund for Nature, a longtime partner of ADB, will support the design and implementation of the financing initiative.

For more information, access:

https://www.adb.org/news/adb-launches-5-billion-healthy-oceans-action-plan

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9th Asia-Pacific Forum on Renewable Energy (AFORE 2019)
Contact: Secretariat, 05836 Room B515,
H Business Park, 25, Beobwon-ro 11-gil,
Songpa-gu, Seoul, Republic of Korea
Tel: +82-2-883-8051; Fax: +82-2-883-8042
E-mail: ksnre@ksnre.or.kr
Web: http://afore2019.org/afore2019/

Nov 18–19
Singapore
GREEN WORLD ASIA
Contact: Angie Eng
Director of Marketing & Partnerships
Tel: +65 6817 5811
Mob: +65 8163 2109
E-mail: a.eng@closerstillmedia.com
Web: https://www.greenworldasia.com/

Nov 30–Dec 02
Kuala Lumpur, Malaysia
ASIAWATER EXPO & FORUM 2020
Contact: United Business Media (M) Sdn Bhd
Suite 5-01, Level 5, Sunway VISIO Tower
Lingkaran SV, Sunway Velocity
55100 Kuala Lumpur, Malaysia
Tel: +603 9771 2688
Fax: +603 9771 2799
Web: https://www.asiawater.org/

Dec 15–17
Mumbai, India
INTERSOLAR INDIA 2020
Contact: MMI India Pvt.Ltd.
Inizio 507 & 508, 5th floor
Cardinal Gracias Road, Opp. P&G building
Chakala, Andheri (E), Mumbai – 400 099, India
Tel: +91 22-4255 4700
Fax: +91 22-4255 4719
Web: http://www.mm-india

Tech Ventures & Opportunities

Business Coach

Tech Opportunities

Design and implementation of business strategy

Small Industries Development Bank of India (SIDBI)
https://sidbi.in

Diagnosis

Before designing a strategy, one should be aware/understand the elements that surround the business. Be it designing a strategy for start-up or existing business, one has to undergo an analysis of the business environment in which an enterprise operates/is going to operate. Some important tools for business diagnosis are given below. The tools given below can be used by the MSME manager to understand the external (PESTLE) and internal (SWOT) business environment.

Designing

Strategy formulation is the process of determining appropriate courses of action for achieving organizational objectives and thereby accomplishing organizational purpose. It is the second phase in the strategic management process that leads to the establishment of the organization's goals and of a specific strategic plan.

1) Corporate Strategy

Corporate strategy is concerned with broad decisions regarding overall scope and direction of the organisation.Basically, corporate strategy pertains to determination of the growth objective and strategy for achieving it, the lines of business, and how these lines of business fit together. It is useful to think of three components of corporate level strategy:

- Growth or directional strategy -what should be the growth strategy, ranging from retrenchment through stability to varying degrees of growth - and how to accomplish it.
- Portfolio strategy - what should be the portfolio of lines of business, which implicitly requires reconsidering the degree of concentration or diversification.
- Parenting strategy - how to allocate resources and manage capabilities and activities across the portfolio -- where to put special emphasis, and how much to integrate the various lines of business.

2) Competitive Strategy (also known as Business Level Strategy)

This involves deciding how the company will compete within each line of business (LOB) or strategic business unit (SBU). One of the most authoritative works on competitive strategy is the Porter's five forces analysis.

3) Functional Strategy:

Functional strategies are relatively short-term activities that each functional area (Marketing, Human resources, finance etc.) within a company will carry out to implement the broader, longer-term corporate level and business level strategies. Each functional area has a number of strategy choices that interact with and must be consistent with the overall company strategies.

- Marketing strategy deals with product/service choices and features, pricing strategy, markets to be targeted, distribution, and promotion considerations.
- Financial strategy includes decisions about capital acquisition, capital allocation, dividend policy, and investment and working capital management. (to read more download "Financial Strategy" document provided at bottom of this webpage)
- The production or operations functional strategies address choices about how and where the products or services will be manufactured or delivered, technology to be used, management of resources, plus purchasing and relationships with suppliers. For firms in high-tech industries, R&D strategy may be so central that many of the decisions will be made at the business or even corporate level, for example the role of technology in the company's competitive strategy, including choices between being a technology leader or follower.
- Human resources functional strategy includes many topics, typically recommended by the human resources department, but many requiring top management approval. Examples are job categories and descriptions; pay and benefits; recruiting, selection, and orientation; career development and training; evaluation and incentive systems; policies and discipline; and management/executive selection processes.
- IT Strategy pertains to organization›s overall objectives relating to the technology infrastructure it is going to utilise. To read on efficient use of ICT, click here .

Implementation

Developing a good strategy on paper is a job only half done. The capability to continually implement strategy is the key to long-term success. The challenge is to perform strategy processes, turn the strategy into business improvements and implement these changes in the operative business to improve results. Organizations successful at strategy implementation effectively manage six key supporting factors:

- Action Planning
- Organization Structure
- Human Resources
- The Annual Business Plan
- Monitoring and Control
- Linkage

Investment climate in Bangladesh

Bangladesh Investment Development Authority, Bangladesh
http://bida.gov.bd

Ease of doing business

Doing Business, a World Bank Group flagship publication, is a series of annual reports which measures the regulations that enhance a country's business activities and those that constrain it. Doing Business presents quantitative indicators on business regulations and the protection of property rights that can be compared across 190 economies. A high Ease of Doing Business ranking indicates a more favorable regulatory environment for starting and operating business in that particular country. Doing Business captures several important dimensions of the regulatory environment as it applies to business enterprises, providing quantitative indicators on regulation for the following: starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts, resolving insolvency.

To promote a more sustainable and inclusive investment environment, Bangladesh Investment Development Authority (BIDA) has undertaken steps for massive reforms to ensure:

- Creation of a true one-stop service for the investors.
- Facilitate the development of entrepreneurs.
- Aid the creation of necessary skills to match the needs of higher value production chains.
- Efforts to improve the ratings of Bangladesh in various indicators such 'Doing Business report of World Bank', 'Global Competitive Index' of the World Economic Forum and others.

Entrepreneurship development

The Government has taken many steps for investment promotion that include building infrastructure, undertaking mega projects, making available energy and power, enhancing access to finance, reforming policies, re-designing various programs, improving tax and regulatory regime, arranging better services, improving incentive structure, creating ancillary facilities and developing institutions like BIDA.

To realize the full potential of the Bangladesh economy double digit growth is required from the current 7% per annum. The tools to attaining this is to bridge missing links one of which is 'entrepreneurship development' to sustain and to create entrepreneurs in a number of leading sectors like RMG, Power, transportation, pharmaceuticals etc and also in new frontiers including those in 'sun-rise1 industries like IT, biotech, health care, financial services etc in other news sectors. The rear the new entrepreneurs mentoring and financial support is of utmost important. Financing through Venture Capital or other mechanism can be endeavored.

An exhaustive entrepreneurship development program (with sector specific variation as needed) aiming at developing 300,000 entrepreneurs over a period of three years with 100,000 every year on average.

Economic corridor development

The concept of Economic Corridor in Bangladesh is a recent phenomenon. Economic Corridor is an infrastructure that helps to facilitated economic activities along a defined geography by linking economic nodes or hubs usually centered on urban landscapes, in which large amount of economic resources concentrated.

The Seventh Five-Year Plan of Bangladesh envisages an integrated development strategy for the southwest region. Given its strategic locational advantage, Bangladesh's southwest region is a strong claimant to becoming domestic and regional industrial, trade, and investment hub. The experience of economic corridor in other developing countries like Malaysia, India, Vietnam, Thailand and South Korea, inspired Bangladesh to undertake a programme to establish economic corridor in the south western part of the country.

Privatization

Privatization in Bangladesh started in mid-seventies. Later on it got an institutional shape by creation of the Privatization Board in the year1993. Privatization Board was transformed in to the Privatization Commission under the provision of the Privatization Act, 2000. In the backdrop of sickness and continual decaying condition of State Own Enterprises (SOEs), government was committed to quickly privatize such SOEs and commercial enterprises to strengthen the role of private Sector and to stabilize it as an instrument of development. Since the establishment of Privatization Board and thereafter Privatization Commission a total of 74 SOEs have been privatized of which 54 were privatized through outright sale and 20 through offloading of government shares. There were 12 methods of privatization of SOEs, but Privatization Commission generally followed the method of sale through tender.

Finance and banking

The financial sector in Bangladesh is continuously evolving towards a more modern and efficient system of finance which is supportive of greater investment and inclusive economic growth. The financial system of Bangladesh consists of The Bangladesh Bank, scheduled banks, non-bank financial institutions, micro finance institutions, insurance companies, co-operative banks, credit rating agencies and stock exchange.

Registration of technology transfer agreements in the Philippines

Board of Investments, Philippines
http://boi.gov.ph

Royalties and similar fees

Royalties and similar fees can be charged to operations provided payments for said fees are covered by a technology transfer agreement (TTA) which conforms with the mandatory and restrictive provisions of the Intellectual Property Code (IPC). Compliance of the TTA with the IPC requirements will not require the registration of the TTA with the Documentation, Information and Technology Transfer Bureau (DITTB) of the Intellectual Property Office (IPO).

The non-conformity of the TTA with the IPC shall generally render the TTA unenforceable. However, in certain exceptional and meritorious cases provided under the IPC, non-compliance with the IPC is allowed subject to prior approval of the TTA by the IPO. The IPC provides certain restrictions in the terms and conditions of the TTA particularly those that will adversely affect free competition and trade. It also prescribes certain mandatory provisions that should be included in the TTA.

Royalties and similar fees are generally subject to 30% gross income tax and 12% value added tax when payable to a non-resident foreign corporation. However, the tax rates for the royalties payable to residents of foreign countries with which the Philippines has a tax treaty vary according to the terms of the respective treaties.

Reimbursements of actual cost

Reimbursements of actual cost incurred abroad for operations such as maintaining offices, advertising, commission, etc. are allowed provided they are duly supported by documents and that these costs are incurred in connection with the regular course of trade or business of the local paying company.

Technology transfer arrangements

Technology transfer arrangements refer to contracts or agreements involving the following: transfer of systematic knowledge for the manufacture of a product or the application of a process; rendering of a service, including management contracts; and the transfer, assignment, or licensing of all forms of intellectual property rights, including licensing of computer software, except computer software developed for mass market.

Government approval

Within ten days from the filing of the request for certification of compliance, the DITTB conducts a summary evaluation of the TTA. If the TTA conforms with the Prohibited Clauses and Mandatory Provisions of the IPC, the DITTB issues a Certificate of Compliance. Otherwise, the DITTB notifies the parties of any violation and requires them to comply with the IPC if they wish to obtain a Certificate of Compliance.

Documentary support

With the liberalization of foreign exchange rules, remittance of royalties, fees, or similar payments to a foreign company, net of the applicable taxes, may be made through AABs without need of BSP approval. The following documents may be required by the AABs to prove the legitimacy of the transaction: (a) copy of contract/agreement; (b) statement/computation of the royalty/copyright/patent/licensing fee; and (c) proof of payment of withholding tax or tax exemption or entitlement to preferential tax treatment, as the case may be.

Registration of transfer of patent and petty patent in Thailand

Department of Intellectual Property, Thailand
http://www.ipthailand.go.th

Consideration criteria

The patent transferring contract is a contract with which the assignor grants the right to the assignee right (assignment of patent/petty patent). In this regard, the right transferring shall not exceed the protection period as follows;

* The protection period of invention patent lasts 20 years.
* The protection period of petty patent lasts 6 years, or upon the petty patent renewal application according to Article 65 paragraph 2 the laws.

Conditions of application submission

1. To register a transfer of the patent/petty patent, the applicant shall submit the form as determined by the Director-General, together with the transferring contract of the invention patent/petty patent.
2. Authorization
   2.1 In case the applicant of the patent does not reside in the Kingdom of Thailand, he shall authorize the patent agent/patent attorney registered with the Director-General of the Department of Intellectual Property to act on his behalf. In this regard, the power of attorney shall be presented to the Director-General in accordance with the following regulations;
   (1) If the authorization is done outside the Kingdom of Thailand, the signatures in the authorization letter or power of attorney shall be certified by the authorized official of the Thai embassy or consulate or Director of the office of the Ministry of Commerce located in the country where the principal or power grantor resides, or the person authorized to act on behalf of the said officials or the person authorized to certify the signature according to the law in that country, or
   (2) In case the authorization is done in the Kingdom of Thailand, the applicant shall submit a copy of passport or temporary residence certificate of the principal or power grantor, or any evidence indicating that at the time the authorization was made, the principal or power grantor was in Thailand.
   2.2 The Power of Attorney shall be attached with the revenue stamp of 30 Baht/patent agent/patent attorney/application.

Proceeding according to the official's instruction

1. In case that the official finds a correctable defect in the application, the official shall notify the applicant or his patent agent/patent attorney for the correction. The applicant shall finish the correction within 90 days of the notification reception date. After such period, without the correction, the applicant shall be deemed to have abandoned the application, except the Director-General extends the period for correction as deemed appropriate due to any necessity.
2. After the applicant corrected the application, the applicant shall submit the correction application and the fee to the Department of Intellectual Property or the provincial office of the Ministry of Commerce. The corrected application shall enter the consideration and initial inspection processes respectively, similarly to the re-submission of the application.
3. In case of application submission via the website of the Department of Intellectual Property, the inspecting official shall check the completeness of information and details in the patent/petty patent application, request or other applications based on information and details appearing in the e-patent filing system. In this regard, the applicant shall present the application and supporting documents to the Department of Intellectual Property within 15 days of application number reception date and patent/petty patent application filing date via internet. The inspection of application submitted via internet shall be in accordance with the Notification of the Department of Intellectual Property Re: Principles and conditions for submission of patent/petty patent application, requests or other applications via internet.

Relevant laws

- The Ministerial Regulation No.25 (B.E. 2542) issued by virtue of the Patent Act B.E. 2522 (Dated 24 September 1999).
- The Patent Act B.E. 2522 as amended by the Patent Act (No. 2) B.E. 2535 and the Patent Act (No. 3) B.E. 2542

Stages of startups and sources of funding

Startup India Hub, Government of India
https://www.startupindia.gov.in

There are multiple sources of funding available for startups. However, the source of funding should typically match the stage of operations of the startup. Please note that raising funds from external sources is a time-consuming process and can easily take over 6 months to convert.

Ideation/Pre-Seed Stage

This the stage where you, the entrepreneur, has an idea and are working on bringing it to life. At this stage, the amount of funds needed is usually small.

Given the fact that you are at such an initial stage in the startup lifecycle, there are very limited and mostly informal channels available for raising funds. Common funding sources utilized by startups in this stage are:

- **Bootstrapping/Self-financing:** Bootstrapping a startup means growing your business with little or no venture capital or outside investment. It means relying on your own savings and revenue to operate and expand. This is the first recourse for most entrepreneurs as there is no pressure to pay back the funds or dilute control of your startup.
- **Friends and Family:** This is also a commonly utilized channel of funding by entrepreneurs still in the early stages. The major benefit of this source of investment is that there is an inherent level of trust between the entrepreneurs and the investors
- **Business Plan/Pitching Events:** This is the prize money/grants/financial benefits that is provided by institutes or organizations that conduct business plan competitions and challenges. Even though the quantum of money is not generally large, it is usually enough at idea stage.

Validation/Seed Stage

This is the stage where your startup has a prototype ready and you need to validate the potential demand for your startup's product/service. This is called conducting a 'Proof of Concept (PoC)', after which comes the big market launch.

- **Incubators:** Incubators are organizations set-up with the specific goal of assisting entrepreneurs with building and launching their startups. Not only do incubators offer a lot of value-added services (office space, utilities, admin & legal assistance, etc.), they often also make grants/debt/equity investments
- **Government Loan Schemes:** The government has initiated a few loan schemes to provide collateral-free debt to aspiring entrepreneurs and help them gain access to low-cost capital. Some such schemes include CGTMSE, MUDRA, and Stand-up India.
- **Angel Investors:** Angel investors are individuals who invest their money into high potential startups in return for equity. Reach out to angel networks such as Indian Angel Network, Mumbai Angels, Lead Angels, Chennai Angels, etc. or relevant industrialists for this.
- **Crowd funding:** Crowdfunding refers to raising money from a large number of people who each contribute a relatively small amount. This is typically done via online crowdfunding platforms.

Early Traction/Series A Stage

This is the stage where your startup's products or services have been launched in the market. Key performance indicators such as customer base, revenue, app downloads, etc. become important at this stage. Funds are raised at this stage to further grow user base, product offerings, expand to new geographies, etc. Common funding sources utilized by startups in this stage are:

- **Venture Capital Funds:** Venture capital (VC) funds are professionally managed investment funds that invest exclusively in high-growth startups. Each VC fund has its own investment thesis – preferred sectors, stage of startup, and funding amount – which should align with your startup. VCs take startup equity in return for their investments and actively engage in mentorship of their investee startups.
- **Banks/NBFCs:** Formal debt can be raised from banks and NBFCs at this stage as the startup can show market traction and revenue to validate their ability to finance interest payment obligations. This is especially applicable for working capital. Some entrepreneurs might prefer debt over equity as they debt funding does not dilute equity stake
- **Venture Debt Funds:** Venture Debt funds are private investment funds that invest money in startups primarily in the form of debt. Debt funds typically invest along with an angel or VC round.
- **TReDs:** To decrease the financing concerns faced by MSMEs in India, RBI introduced the concept of TReDS in 2014, an institutional mechanism for financing trade receivables on a secure digital platform. Trade Receivable Exchanges such as M1xchange, standardizes the process of funding MSMEs via Invoice Discounting. TReDS addresses the gaps in MSME industry as enterprises face challenges in getting their payments on time, thus creating working capital discrepancies.

Guidelines on equity policy and foreign investment in Malaysia

Malaysian Investment Development Authority (MIDA), Malaysia
http://www.mida.gov.my

Equity policy in the manufacturing sector

Malaysia has always welcomed investments in its manufacturing sector. Desirous of increasing local participation in this activity, the government encourages joint-ventures between Malaysian and foreign investors.

Equity policy for new, expansion, or diversification projects

Since June 2003, foreign investors could hold 100% of the equity in all investments in new projects, as well as investments in expansion/diversification projects by existing companies, irrespective of the level of exports and without excluding any product or activity.

The equity policy also applies to:

- Companies previously exempted from obtaining a manufacturing licence but whose shareholders' funds have now reached RM2.5 million or have now engaged 75 or more full-time employees and are thus required to be licensed.
- Existing licensed companies previously exempted from complying with equity conditions, but are now required to comply due to their shareholders' funds having reached RM2.5 million.

Equity policy applicable for existing companies

- Equity and export conditions imposed on companies prior to 17 June 2003 will be maintained. However, companies can request for these conditions to be removed and approval will be given based on the merits of each case.

Protection of foreign investment

Malaysia's commitment in creating a safe investment environment has attracted more than 8,000 international companies from over 40 countries to make Malaysia their offshore base.

Equity ownership

A company whose equity participation has been approved will not be required to restructure its equity at any time as long as the company continues to comply with the original conditions of approval and retain the original features of the project.

Investment guarantee agreements

Malaysia's readiness to conclude Investment Guarantee Agreements (IGAs) is a testimony of the government's desire to increase foreign investor confidence in Malaysia. IGAs will:

- Protect against nationalisation and expropriation
- Ensure prompt and adequate compensation in the event of nationalisation or expropriation
- Provide free transfer of profits, capital and other fees
- Ensure settlement of investment disputes under the Convention on the Settlement of Investment Disputes of which Malaysia has been a member since 1966.

Malaysia has concluded IGAs with the following groupings:

- Association of South-East Asian Nations (ASEAN)
- Organisation of Islamic Countries (OIC)

Convention on the settlement of investment disputes

In the interest of promoting and protecting foreign investment, the Malaysian government ratified the provisions of the Convention on the Settlement of Investment Disputes in 1966. The Convention, established under the auspices of the International Bank for Reconstruction and Development (IBRD), provides international conciliation or arbitration through the International Centre for Settlement of Investment Disputes located at IBRD's principal office in Washington.

Kuala Lumpur Regional Centre of Arbitration

The Kuala Lumpur Regional Centre for Arbitration was established in 1978 under the auspices of the Asian-African Legal Consultative Organisation (AALCO) - an inter-governmental organisation cooperating with and assisted by the Malaysian government.

A non-profit organisation, the Centre serves the Asia Pacific region. It aims to provide a system to settle disputes for the benefit of parties engaged in trade, commerce and investments with and within the region.

Any dispute, controversy or claim arising out of or relating to a contract, or the breach, termination or invalidity shall be decided by arbitration in accordance with the Rules for Arbitration of the Kuala Lumpur Regional Centre for Arbitration.

Grassroots innovation in India

National Innovation Foundation, India

http://nif.org.in/initiatives

The National Innovation Foundation (NIF) - India was set up in March 2000 with the assistance of Department of Science and Technology, Government of India. It is India's national initiative to strengthen the grassroots technological innovations and outstanding traditional knowledge. Its mission is to help India become a creative and knowledge-based society by expanding policy and institutional space for grassroots technological innovators.

NIF scouts, supports and spawns' grassroots innovations developed by individuals and local communities in any technological field, helping in human survival without any help from formal sector. NIF helps grassroots innovators and outstanding traditional knowledge holders get due recognition, respect and reward for their innovations. It also tries to ensure that such innovations diffuse widely through commercial and/or non-commercial channels, generating material or non-material incentives for them and others involved in the value chain.

NIF has pooled a database of over 310,000 technological ideas, innovations and traditional knowledge practices (not all unique, not all distinct) from over 608 districts of the country. NIF has till date recognised 847 grassroots innovators and school students at the national level in its various National Biennial Grassroots Innovation Award Functions and annual Dr A P J Abdul Kalam Ignite Children Award functions. In collaboration with various research & development (R&D) and academic institutions, agricultural & veterinary universities and others institutions, NIF has helped in getting several hundred grassroots technologies validated and/or value added.

NIF has also set up an augmented Fabrication Laboratory (Fab Lab) with the help of Massachusetts Institute of Technology (MIT), Boston, for product development and strengthening in-house research. Pro bono arrangement with intellectual property firms has helped NIF file over 1040 patents, including eight filed in the USA and 28 Patent Cooperation Treaty (PCT) applications, on behalf of the innovators and outstanding traditional knowledge holders. Of these, 72 patents have been granted in India and 5 in the USA. In the same time period NIF has filed 21 Design registrations for innovations of the grassroots and student innovators.In addition to this 10 trade mark applications have also been filed.

NIF has also filed applications for 71 plant varieties developed by farmers at the Protection of Plant Varieties & Farmers' Rights Authority. Of these, 9 have successfully been registered.

Micro Venture Innovation Fund (MVIF) at NIF, with support from Small Industries Development Bank of India (SIDBI), has provided risk capital to 230 innovation based enterprise projects, some of which are at different stages of incubation.

NIF has received over 1500 product inquiries from 110 countries for various technologies. It has also succeeded in commercialising products across countries in six continents, apart from being successful in materialising 109 cases of technology licensing.

Selected initiatives

Grassroots Innovations Design Studio (GRIDS): Grassroots Innovation Design Studio (GRIDS) facilitates formal design inputs to the grassroots innovations at premier institutes viz National Institute of Design (NID) - Ahmedabad, Indian Institute of Technology (IIT) - Gandhinagar, National Institute of Technology (NIT) - Srinagarand Srishti School of Arts, Design & Technology, Bengaluru.

Students' Club for Augmenting Innovations (SCAI): A nationwide student movement, comprising students from India›s best management and technology institutes,SCAI provides product development, mentoring and monitoring support to innovators and traditional knowledge holders at the grassroots.

Micro Venture Innovation Fund (MVIF): One of its kind of dedicated risk fund in the world, setup with the support of SIDBI in October 2003 and operationalised in January 2004, MVIF provides financial support to grassroots innovators. It is extended under a single signature on a simple agreement of understanding without any collateral or a guarantor.

Grassroots Technological Innovations Acquisition Fund (GTIAF): Sanctioned in 2011 and operationalised in 2012, GTIAF obtains the rights of technologies from innovators after compensating them for the same, with the purpose of disseminating and diffusing them at low or no cost for the larger benefit of the society.

Gandhian Inclusive Innovation Challenge Awards: The Award aim towards developing new solutions for three challenges -- paddy transplanter, wood stove and tea leaf-plucking machine.

Grassroots to Global (G2G): NIF has proved that Indian innovators can match anyone in the world when it comes to solving problems creatively. They perform better than others in generating greater sustainable alternatives by using local resources frugally. Those who see poor only as the consumers of cheap goods, miss the richness of knowledge at grassroots level. The G2G model propagated by NIF is all set to change the way the world looks at creativity and innovations at grassroots.

In situ incubation: NIF provides in situ incubation of grassroots technologies to the innovator at his/her place. All incubation facilities (financial or technical support, mentoring, etc.) are extended to the innovator at his place where he continues to work on his/her ideas or innovations.

Inverted model of innovation: The inverted model of innovation implies that children invent, engineers & designers fabricate and companies commercialise.

Catalyzing digital innovation ecosystems in Malaysia

Malaysia Digital Economy Corporation Sdn Bhd, Malaysia
https://www.mdec.my

The future lies in innovation, and at Malaysia Digital Economy Corporation (MDEC), we believe that being ahead of the technology curve is the way to future-proof businesses. Big Data Analytics (BDA), the Internet of Things (IoT), E-Commerce, and Data Centre & Cloud are our key focus areas that have been identified as catalysts that will kickstart and sustain an ecosystem of digital innovation, keeping us at the forefront of technology.

Big Data Analytics (BDA)

Malaysia is one of the few countries with a structured Big Data Analytics (BDA) roadmap to untap the value of big data. At the turning point of digital revolution, the powers of big data can be used to describe a problem, assess a situation, forecast results, and prepare solutions. Business owners, government, and citizens all stand to gain from Malaysia's vision as ASEAN's leading BDA solution hub.

To make this vision a reality, MDEC is spearheading this platform to lead efforts and create conversations. MDEC works to encourage and increase BDA adoption across all sectors by developing talent in the field of data science and enabling strategic partnerships, while introducing upskilling efforts and spurring integrated initiatives.

Our strategic initiatives are:

- Generating (Increasing) the usage of BDA in private sectors.
- Catalysing the adoption and usage of BDA in public sectors.
- Building the BDA industry in Malaysia.

To propel MDEC forward as an industry leader in ASEAN, we have set up the ASEAN Data Analytics eXchange (ADAX), a regional platform that brings together innovative talent development models and showcase the latest BDA technologies. A national initiative to benefit Malaysia, ADAX has the unique opportunity to serve a greater national agenda. This aspiration can only take flight by building a Big Data community through shared values, skills building and collaboration around a robust data analytic ecosystem.

By piloting advanced data analytics use cases for the ASEAN region and providing a co-working location for BDA start-ups and accelerators, ADAX has a unique opportunity to catalyse the migration of traditional organisations to become Data Driven Organisations.

Data centre & cloud

Malaysia's Data Centre & Cloud industry is marked by broad trends of expansion, efficiency, and consolidation. Rising above comparisons like China, Indonesia, and India, Malaysia holds the advantage in attracting potential clients and investors thanks to a climate of politcal stability, location that is free from natural disasters, and competitive real estate market. With a year-over-year growth of over 20% in the last five years in Malaysia, the field of digital data management has never been more ripe for the picking.

The main strategy for the proliferation of data centre and cloud is to cement Malaysia's position as the epicentre for technology-driven delivery of digital content and services in the region, with centres spanning 5 million sq ft by 2020. MDEC works to position Malaysia as a regional hub for data centre and cloud services by leveraging on various factors such as cost efficiency, availability of skilled workers, and a strong foundation of data governance laws.

Local data cloud players are strengthened through MDEC's initiatives by priming their high-value services to be regionally competitive. This is done by facilitating the growth of data centre parks in strategic locations through world-class physical and soft infrastructure.

International businesses also stand to gain from MDEC's FDI policy as it offers an attractive portfolio of incentives for Cloud/Internet Giants to invest and set up facilities in Malaysia.

E-commerce

We live in a time where half the population are digital buyers, which is why e-commerce is an important stepping block to 'future proof' existing businesses while opening up market access. However, the eCommerce ecosystem development in Malaysia is still at an early stage.

According to A.T. Kearney findings under the National E-Commerce Strategic Roadmap, Malaysia is at a turning point of e-commerce growth which must be sped up through government involvement. Issues that need to be resolved are lack of offerings, poor fulfilment experience, low adoption and awareness and lack of supporting ecosystem.

For Malaysia to move beyond the early stage, it needs a strong support and focused government intervention to drive it forward to the growth stage. Through efforts such as #MYCYBERSALE which started in 2014, we have achieved RM67 million Gross Merchandise Value (GMV) in 2014 and RM117 million in 2015.

Greening manufacturing in Philippines

Department of Trade and Industry, Philippines

http://industry.gov.ph

Greening the Philippine Manufacturing Industry Roadmap

The manufacturing sector of the Philippines is challenged to significantly strengthen its competitiveness in order to be prepared for the challenges lying ahead. Seeing the worldwide dynamics of industrial development and the integration process of the ASEAN Economic Community, it becomes obvious that the manufacturing industry needs to successfully position itself as a globally competitive industry on domestic, regional and global markets.

Asia's economies and their businesses are increasingly becoming main drivers for Green Economic Development (GED) worldwide. It is obvious that the manufacturing industry of the Philippines is challenged to be responsive and proactive to this worldwide trend. Already today, the business community sees in the overuse of natural resources and the impacts of climate change a key challenge to do business successfully and to ensure its long-term economic growth perspective.

In a common effort, industry and government in the Philippines have launched an initiative, in which sectoral road maps have been elaborated and submitted to the Department of Trade and Industry and the Board of Investments. The so-called Road Map Process is a unique opportunity to define a well-focused stimulation and promotion for an industry driven GED that is integral part of a modernization and innovation process of the economy of the Philippines. Within the industry sectors, each company have to elaborate and implement their own strategy to unleash the specific market potential for products and service delivery.

Public policies on regulation, subsidies, incentives and information have a central role to play for the green modernization of the industry. Green investment from both the public side and the private side is an investment for immediate returns and for the future.

Worldwide experiences show that without a forceful and coordinated set of actions that removes barriers and sets favorable framework conditions, it is unlikely that even the most economically beneficial options would overcome a short-term sighted "Buy-the-Cheapest" or "Business-as-Usual" attitude. In cooperation with other government entities, the BOI and DTI should contribute to setting framework conditions and to building up capacities that support a paradigm shift towards an innovation process that results in competitiveness, good environmental performance, climate change resilience and job creation.

Promotion of Green Economic Development (ProGED) Project

ProGED is a project of the Department of Trade and Industry (DTI) with the Federal Republic of Germany through the Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ). It is primarily aimed at improving the competitiveness of MSMEs while coping with climate change adaptation and mitigation requirements through the adoption of environment-friendly, climate-smart, and inclusive strategies and measures.

Interventions are implemented at the operational level through the Regional and Provincial offices of DTI (to support the enterprises in greening their operations), as well as at the policy level through the Regional Operations Group (ROG), where the green perspective is integrated into the programs and projects of DTI. A Green Growth Core Group has likewise been established within ROG to steer their initiatives on greening MSMEs within the Department.

ProGED promotes a green economy strategy founded on the five pillars of mitigation, adaptation, competitiveness, green jobs, and preserving or even improving nature's capital. The project focuses initially on the tourism sector with its high potential for investment, employment, and poverty reduction due to its linkages with upstream and downstream industries in other economic sectors.

The project is implemented from 2013 to 2016, and piloted its approach in the Provinces of Cebu and Bohol. Since 2014, it has expanded to include fourteen replication provinces in seven regions, namely: Pampanga and Tarlac (Region 3) Laguna and Cavite (Region 4A), Palawan and Occidental Mindoro (Region 4B), Albay and Camarines Sur (Region 5), Negros Occidental and Capiz (Region 6), Negros Oriental and Siquijor (Region 7), and Agusan del Norte and Surigao del Norte (Region 13). Aside from tourism, additional priority sectors are taken up according to the location's competitive advantages.

In relation to its efforts to support the greening of enterprises and upon the request by DTI, ProGED also supported the Greening the Manufacturing Industry Roadmaps process, which aims at integrating green economic development elements in selected industry roadmaps and the overall manufacturing roadmap. This will create climate smart, environment friendly, and globally competitive manufacturing industries in the Philippines.

Green technology in Malaysia

Malaysian Investment Development Authority, Malaysia
http://www.mida.gov.my

In line with Malaysia's aim to become an inclusive and sustainable advanced nation by 2020, Green Technology (GT) has been identified as one of the drivers of the future economy for the nation that would contribute to the overall Green Growth and Sustainable Development. Under the National Green Technology Policy, the cross-sectoral GT focuses on four sectors namely energy, building, waste management and transportation.

Renewable energy

Malaysia is emphasizing greater importance for Renewable Energy (RE) generation through specifically formulated policies and initiatives to spur the growth of the sector as a major step towards green economy. Other than the Feed-in-Tariff (FiT) mechanism, the Net Energy Metering (NEM) and Large Scale Solar (LSS) Photovoltaic plant schemes were introduced in 2016 to boost RE generation. NEM benefits users in terms of savings in electricity bill through lower electricity usage and energy credit from solar power generation while LSS allows developers to produce renewable energy in larger capacities.

In 2016, a total of 111 projects in renewable energy with total investments of RM1.9 billion were approved incentives. Out of the total, RM1.7 billion (88%) were from domestic sources and RM233.8 million (12%) were from foreign sources. These projects are expected to create 615 employment opportunities in this sub-sector.

The approved investments include 81 projects (RM588.8 million) that will generate energy from solar power, 12 projects (RM145.7 million) from biogas, 10 projects (RM806.6 million) from mini-hydro and six (6) projects (RM343.6 million) from biomass as the sources of energy generation.

Energy efficiency

As price of energy steadily increases over the years, there is a need to adopt energy efficiency measures to ensure productive use of energy and minimize waste. The use and adoption of energy efficiency systems and technology is encouraged through introduction of incentives and import duty exemptions on qualified machines and components. Consecutively, energy efficiency activities also open up opportunities for energy service companies (ESCOs) to provide energy efficiency services to potential clients.

In 2016, a total of 19 projects in energy efficiency with total investments of RM248.5 million were approved incentives. Investments were mainly from domestic sources i.e. RM235.6 million (95%) meanwhile RM12.9 million (5%) were from foreign sources. These investments are expected to provide 142 employment opportunities in the sub-sector.

Green technology incentive

Under the provision of Budget 2014, tax incentives for Green Technology in the form of Green Investment Tax Allowance (ITA) for the purchase of green technology assets and Income Tax Exemption (ITE) on the use of green technology services and system were introduced to further strengthen the development of green technology.

Application for incentive is to be submitted to MIDA for green technology projects and services, and to Malaysian Green Technology Corporation (MGTC) for purchase of green technology assets as listed in MyHijau Directory, by 31 December 2020. Projects which qualify for this incentive are renewable energy; energy efficiency; integrated waste management and green building / green data centre. In addition, eligible services activities include system integration of renewable energy; energy services; services related to green building / green data centre; green certification of products, equipment & building; and green township.

Artificial Intelligence-Based Image Search Tool for Brands

The World Intellectual Property Organization (WIPO) has launched a new artificial intelligence (AI)-powered image search technology that makes it faster and easier to establish the distinctiveness of a trademark in a target market. The new search functionality covers the national collections of 45 trademark offices already participating in the project - even if they have not been using a classification system for figurative elements. This represents a total number of almost 38 million trademarks to date. WIPO periodically adds new collections from around the world to the database.

For more information, contact:

Media Relations Section
World Intellectual Property Organization
Tel: (+41 22) 338 81 61 / 338 72 24
Fax: (+41 22) 338 81 40
Web: https://www.wipo.int

Technology Offers

CHINA

Cleaner chromium tanning

A Chinese firm is offering technology of cleaner chromium tanning method, closed pickle tan loop system. The technology involves continous recycling of spent liquors from a suitably standardized less-chrome, high exhaustion chrome tanning in pickling such that there is no discharge of exhaust liquors containing chrome tanning processes, preventing pollution due to these substances on the one hand and avoiding material loss on the other. Compared to conventional chrome tanning process, this new pickle-tan closed loop system ensures near zero discharge of potential pollutants such as chrome and neutral salts viz. sodium chloride and sodium sulphate.

Area of Application

Chemical industry, Tanning industry, Leather industry

Advantages

Cleaner production: near zero discharge of chrome and neutral salts in pickle and chrome tanning processes thus preventing pollution due to these substances Avoids material loss Water consumption in pickle-tan stage is considerably minimized.

Technical specifications

- Cleaner chromium tanning method
- Closed pickle tan loop system

Contact

Polytex Chemical Engg Co.
No.317 Wenhuidong Rd, Yangzhou city, Jiangsu,
China
Zip/Pin Code:225009

Fogger sprayer and high-range sprayer

6HY series fogger sprayers and 6HW series high-range sprayers, which are successfully developed by Nanjing Forestry University in collaboration with Nantong Guangyi Mechanical & Electrical Co. Ltd, are the achievements of the national science and technology projects in the 8th-Five-Year-Plan and the State 948 Project. These are mainly used in sanitation and epidemic prevention, pests and diseases control in forests and rubber plants in agriculture. They have the features of high efficiency, low consumption of pesticide, low cost, good droplet penetration. The 6HW series high-range sprayers have widely used in pests and disease control in farmland shelter-forests, plantation along freeways. The vertical range can reach 25-30m, so they are suitable machines for pests and disease control of high trees.

Area of Application

- The 6HY series fogger sprayers are mainly used in sanitation and epidemic prevention, pests and diseases control in forests and rubber plants in agriculture.
- 6HW series high-range sprayers are widely used in pests and disease control in farmland shelter-forests, plantation along freeways.

Advantages

- 6HY series fogger sprayers have the features of high efficiency, low consumption of pesticide, low cost, good droplet penetration.
- For 6HW series high-range sprayers, the vertical range can reach 25-30m, so they are suitable machines for pests and disease control of high trees.

Environmental aspects

Energy efficiency

Development Status

Fully commercialized

Legal Protection

Patent

Transfer Terms

Equipment Supply

Contact

Nanjing International Technology Transfer Center (NITTC)
No.11 Baochang North Road, Libao Town, Haian County, Jiangsu Province, Nantong, China
Zip/Pin Code: 226631

HUNGARY

Device for eliminating smoke

Our partner has developed a new efficient device for eliminating smoke. This invention uses high-frequency circuits and fly-back transformers to generate high voltage electric field arc. This arc plasma impinges upon a smoke particle, and zaps it away. The client is interested in finding license partners.

Area of Application

- Part of a fire alarm system that eliminates presence of smoke to allow time for escape for civilians, or as a portable system to enhance the firefighters' visibility when on the firefighting task;
- Self-contained household device for same purpose;
- May be portable or permanently installed for office building or public area.

Advantages

- Usability: User-friendly interface. Once switched on, the smoke zapper will start eliminating smoke instantly.
- Mobility: Smoke zapper is a portable device as big as a volleyball. Light and easy to carry. Also, it could be thrown into fire by rolling.
- Sustainability: Smoke zapper is not only fire-proof but also crash-proof. It is able to keep operating over 2 hours in fire.
- Pollution-free: Smoke releases no pollutant while functioning. Moreover, it is made of eco-friendly materials.
- Flexibility: Smoke zapper could be manufactured in different dimensions, and integrated into other fire-fighting equipment.

Development Status

Laboratory model

Legal Protection

Patent

Technical specifications

The invention uses high-frequency circuits and fly-back transformers to generate high voltage electric field, and eventually electric arc within air.

Transfer Terms

Technology licensing

Target Countries
Worldwide

Central venous catheter system

A Hungarian medical research institute has developed a central venous catheter system for subclavial or jugular vein puncture. The kit contains the following items: insertion needle with the patented two-way valve system, syringe to check if the catheter is in place, the catheter itself, wrapped in sterile package and plastic adaptor to lock the catheter securely after the removal of the needle. The patented "HunCath" catheter system is a novel alternative to a safer catheter which can be widely used in techniques, such as pacemaker electrodes.

Area of Application
Medical technologies

Advantages
Among all catheters currently used this product bears with the lowest risk for the patient and the easiest use for the physician.

Development Status
Commercial prototype

Legal Protection
Patent

Technical specifications

- Requires fewer changes of grip during introduction of the catheter into the vein; therefore, accidental withdrawal of the catheter is less likely.
- The "HunCath" can be inserted into the vein

Transfer Terms
- Subcontracting
- Technology licensing

For the above two offers, Contact

Laser Consult Ltd
H-6701 PO Box 1191.
Szeged, Hungary

INDIA

Tea catechins as anti-aging compounds

The present invention relates to the preparation of consumable composition for oral administration that contains tea catechins. The composition prepared by the process of this invention is useful in providing controlled release of catechins contained therein.

Area of Application
Application includes antiaging agents

Environmental aspects
Environment friendly

Development Status
Laboratory model

Legal Protection
Patent

Transfer Terms
- Consultancy
- Technical services
- Technology licensing

Solvent tolerant bacterial lipase

We could offer a technology to sysntheize bacterial lipase that has potential applications in the food industry. Brief description of the process / product / technology developed- se to various polar and non-polar organic solvents for 2 h elucidates that the enzyme was stable to all organic solvents tested. The highest relative activity was achieved with chloroform (400%) followed by toluene (250%) and 1-The present invention provides an extra cellular bacterial lipase from Pseudomonas mendocina M-37 (MTCC 7054) with high stability and substrate specificity. The bacteria were isolated from oil industry effluent showing high activity on olive oil. The substrate specificity of Pseudomonas mendocina M-37 lipase shows that the lipase was especially more active towards the synthetic triglycerides and fatty acids esters that possesses butyryl group like benzyl butyrate (1120% relative activity), tributyrin (744%) and amyl butyrate (550%) respectively. The stability of lipase in organic solvents offers advantages for ester synthesis. Exposure of M-37 lipaoctanol (215%).

Area of Application
The bacterial lipase showing high activity in organic solvents and substrate specificity for butyrated esters has possible significant applications in food industry for ester synthesis. The esterification reactions in food industry are carried out in organic solvents and uses butyrated substrates. *Pseudomonas mendocina lipase* has possible applications in synthesis of flavour and fragrance esters; for organic synthesis and modification of fats and oils

Advantages
Pseudomonas mendocina lipase possessing high stability in organic solvents, high substrate specificity mainly for butyrated esters has possible significant applications in food industry for ester synthesis.

Environmental aspects
Environment friendly

Development Status
Laboratory model

Legal Protection
Patent

Transfer Terms
- Consultancy
- Technical services
- Technology licensing

A novel compound with leishmanicidal activity

One new unsaturated amide named as Piplamide, N-isobutyl-19-(3',4'-methylenedioxyphenyl)-2E,4E-nonadecadienamide, was isolated from the fruits of the Indian medicinal plant Piper longum by bioassay guided fractionation and isolation, using an in vitro promastigotes assay against of Leishmania donovani. The

structure was elucidated on the basis of spectroscopic analysis. a) piplamide shows a very good antileishmanial activity against Leishmania donovani promastigotes

Area of Application

- Piplamide could be evaluated as prospective enzyme inhibitor and could provide lead structure for further optimization of activity for use in antileshmanial drug developement.
- Piperlongimin A and piperlongimin B could provide lead structures for the development of novel anticancer therapeutics.

Environmental aspects

Environment friendly

Development Status

Laboratory model

Legal Protection

Patent

Transfer Terms

- Consultancy
- Technical services
- Technology licensing
- Research partnerships

For the above three offers, Contact

Amity University
Sector-125, Noida, Distt Gautam Buddha Nagar 201303
Uttar Pradesh, India

Retort pouch technology

The technology relates to a ready-to-serve fish curry in retortable pouch. The technology provides a method for preparing the ready-to-serve fish curry in retortable pouch with excellent storage stability and quality with a shelf life of more than one year at ambient temperature.

Area of Application

Food, meat, fish processing

Advantages

- The technology provides a method for preparing the ready-to-serve fish curry in retortable pouch with excellent storage stability and quality
- The ready-to-serve fish curry is thermal processed and do not require any further processing before consumption.
- The thermal processing conditions have been standardized for this product in order to make it safe for consumers

Environmental Aspects

Energy efficiency

Development Status

- Pilot plant
- Fully commercialized

Transfer Terms

- Consultancy
- Technical services
- Technology licensing

Chitin and chitosan

Chitin and chitosan are important byproducts form the shell of shellfishes. Chitin is the most important organic constituent of the exoskeletal material of invertebrates and theimportant economical source of this material is the shrimp processing industry. Chitin and its derivatives, chitosan find various industrial applications like, biotechnology, food processing, pharmacy and medicine.

Area of Application

Various industrial applications like biotechnology, food processing, pharmacy and medicine.

Advantages

Chitin and its derivatives, particularly chitosan find industrial application in various fields namely flocculation, paper making, textile printing and sizing, ion exchangechromatography, removal of metal ions from industrial effluents, manufacture ofpharmaceuticals and cosmetics and as an additive in food industry.

Environmental Aspects

Waste utilization

Development Status

- Pilot plant
- Fully commercialized

Transfer Terms

- Consultancy
- Technology licensing

For the above two offers, contact

Central Institute of Fisheries Technology
CIFT Junction, Matsyapuri, Willingdon Island
Cochin - 682029, India

Brightness of LEDs

A device for compensating the effect of temperature variation on the brightness of LEDs has been developed. We invite interested parties to contact us for exploring the possibilities of licensing this technology.

Area of Application

- Camera calibration
- Color printer application
- Automobile applications e.g. traffic light, signal light etc.
- LED displays in different instruments

Advantages

- The LED driver circuit will provide bias to the LEDs to provide temperature compensated brightness without using any temperature sensors.
- No temperature sensor is required, since properties of the diodes themselves are used to achieve the temperature compensation performance.
- The temperature controlled bias voltage/current generated according to the junction temperature of the LEDs themselves, thus any temperature gradient will not affect the temperature compensation.
- Temperature changes induced by power dissipated within the diodes are also compensated.

- No trial and error method is involved to optimize the circuit performance.

Development Status
Fully commercialized

Legal Protection
Patent

Transfer Terms
Technology licensing

Target Countries
India

Contact

Space Applications Centre (ISRO)
33 22 / TTID / PPG, Space Applications Centre (ISRO), Jodhpur Tekra, Ahmedabad 380 015, India

Oral care products

Scientists have developed a process for constructing nanoparticle-polymer complex forsustained release of active agents for oral care (for applications in toothpastes and oral rinses). Polymer multilayers are built up layer by layer on nanoparticles of 5-50 nm, consisting of a water repelling (hydrophobic) shell around a core of multiply (polyanion and polycation) charged material (the core can be of inorganics as silica, titania and/or clay) and encompassing outer layer with an affinity to the tooth enamel.

Area of Application
Oral hygiene application- sustained release of antimicrobial/ flavour compounds

Advantages
- Precisely controlled polymer multilayers can be built on nanoparticles without therequirement of the cumbersome separation step after each coating of the polymer layers
- Active compounds localised as per the requirement by fine tuning the outer layer ofthe complexes- retained in the complex despite extensive rinsing with water
- Enables designing systems that can anchor and retain on the surface enamel of the teeth for extended periods by adjusting the ionic strengths

Development Status
- Laboratory model
- Commercial prototype

Legal Protection
Patent

Transfer Terms
Technology licensing

Contact

National Chemical Laboratory, CSIR
A208, PAML Building,, National Chemical Laboratory
Dr Homi Bhabha Road,, Pune 411007, India

PHILIPPINES

Micro-hydro power for villages

Save the Ifugao Terraces Movement (SITMo) has worked closely with local communities to develop and install thirteen micro-hydro systems in remote villages in the Ifugao province of the Philippines. The systems provide electric light and power to 190 families, bringing a better standard of living and making it more attractive for people to stay on the farms.

Area of Application
Hydro power generation

Development Status
Commercial prototype

Transfer Terms
- Consultancy
- Technical services
- Others

Contact

Esther Nalliw-Licnachan, Save the Ifugao Terraces Movement (SITMo), Ifugao Heritage and Community Education Centre, Sitio Dinapugan Tuplac, Kiangan, Ifugao, Philippines 3604
Tel: +63 9209 108253
E-mail: savetheterraces@hotmail.com

THAILAND

Kitozan biofertilizer

We have five years' experience to produce Kitozan which we helped people to save environment and produce organic friuts and vegetable to feed people. which Low cost and fast result. We had more than3 million user in Thailand.

Area of Application
Biotechnology

Advantages
- It can use with any chemical and fertilizer.
- It can mix with water and feed for animal.

Environmental Aspects
- Cleaner Production
- Waste utilization
- Energy efficiency
- Systems integration
- Not Applicable

Development Status
Fully commercialized

Legal Protection
- Trade Mark
- Copy right

Transfer Terms
- Turnkey
- Others

Target Countries
Worldwide

Contact

Aloe Life Co.,ltd Thailand, 24/548 Vibhawadee Road Donmuang Bangkok 10210, Thailand

Asia-Pacific Tech Monitor

Readers are requested to complete the Response Form to the best of their knowledge/opinion and return it to APCTT by fax or email. We look forward to your cooperation to serve you better.

Technology Intelligence
Asian and Pacific Centre for Transfer of Technology (APCTT)
C-2 Qutab Institutional Area, New Delhi -110016, India
Fax: +91) (11) 26856274, Email: sahus@un.org, dasm@un.org

I read Tech Monitor

☐ Always ☐ Often ☐ Sometimes ☐ Never

1. **I find the design and layout of the Tech Monitor**

   ☐ Excellent ☐ Very Good ☐ Good ☐ Not Good

2. **I find the language used in the Tech Monitor**

   ☐ Easy to understand ☐ Little difficult to understand ☐ Difficult to understand

3. **I find the Tech Monitor**

   ☐ Very valuable ☐ Generally valuable/interesting ☐ Somewhat valuable/ interesting

   ☐ Little value ☐ No value

   I read Tech Monitor because I appreciate

   ☐ Technology Market Scan ☐Technology Scan ☐ Special Feature (articles)

   ☐Tech Events ☐Technology Opportunities ☐Business Coach

4. **I find the following sections**

	Very useful	**Useful**	**Less useful**	**No use**
Technology Market Scan	☐	☐	☐	☐
Technology Scan	☐	☐	☐	☐
Special Feature (articles)	☐	☐	☐	☐
Tech Events	☐	☐	☐	☐
Technology Opportunities	☐	☐	☐	☐
Business Coach	☐	☐	☐	☐

5. **Tech Monitor facilitated/contributed to:**

☐ Understand issues related to technology development and transfer
☐ Enhance my knowledge on latest technological developments and events
☐ Identity technology/business partners
☐ Negotiate technology/business transactions
☐ Establish contact with institutions/authors/experts
☐ Conclude a technology transfer
☐ Acquire a technology
☐ Selling a technology
☐ (Any other, please specify)

6. **To get similar information, I read other periodicals like:**

7. **I would like Tech Monitor to cover the following:**

About Myself

Name:

Gender: ☐Female ☐Male

Nationality:

Profession:

☐ Policy Maker ☐ Small and Medium-sized Enterprise (SME)

☐ Consultant ☐ Financier ☐ Researcher

☐ Professor/ Teacher ☐ Student ☐ Others (Please specify)

Contact details:

Organization:

Designation:

Street Address:

P.O Box:

Country:

Telephone:

Fax:

E-mail:

Website:

Note: *The survey results would be used for APCTT's internal purposes only.*

Selected Analytical Reports and Technology Platforms & Databases of APCTT

Analytical Reports (available online)

1. National Assessment Framework on Enabling Environment, Technology Innovation Ecosystem for Making Sustainable Energy Options Affordable and Accessible (For Indonesia and Lao People's Democratic Republic), January 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/National-assessment-framework_-final_ESCAP.pdf

2. Report on the National Assessment Framework of Enabling Environment and Technology Innovation Eco-system for Making Sustainable Energy Options Affordable and Accessible – Indonesia, May 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/Indonesia_Report-on-National-Assessment-of-Sustainable-Energy_optimized.pdf

3. Indonesia National Sustainable Energy Strategy Report on Enabling Environment and Technology Innovation Ecosystem for Affordable Sustainable Energy Options, May 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/Indonesia-National-Strategy-Report_final.pdf

4. Report on the National Assessment Framework of Enabling Environment and Technology Innovation Ecosystem for Making Sustainable Energy Options Affordable and Accessible - LAO PDR, May 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/Lao_Report-on-National-Assessment-of-Sustainable-Energy.pdf

5. Lao People's Democratic Republic National Sustainable Energy Strategy Report on Enabling Environment and Technology Innovation Ecosystem for Affordable Sustainable Energy Options, May 2014

   http://apctt.org/nis/sites/all/themes/nis/pdf/Lao-National-Strategy-Report_final.pdf

6. National Innovation System (NIS) training manual - "NIS Diagnosis and STI Strategy Development to Achieve National Sustainable Development Goals", 2016

   http://apctt.org/nis/sites/all/themes/nis/pdf/NIS%20Training%20Manual.pdf

Technology Platforms and Databases

1. APCTT's Technology4SME Database

   The Technology4SME Database serves as an online platform for information exchange on the availability and sourcing of technologies for small and medium enterprises in countries in the Asia Pacific region.

   http://apctt.org/technology-transfer

2. Renewable Energy Technology Bank

   The primary objective of the Renewable Energy Cooperation-Network for the Asia Pacific (RECAP) established by APCTT is to facilitate technology transfer cooperation among countries in the Asia-Pacific region in the area of renewable energy. RET-Bank provides tested and proven renewable energy technologies (RETs) initially in the areas of solar, biomass, wind, mini-hydro power and geo-thermal energy.

   http://apctt.org/recap/renewable-energy-technology-bank

3. Global Technology Databases

   APCTT has compiled a list of global as well as country-wise technology databases that deal with the technology transfer related services for SMEs and entrepreneurs.

   http://apctt.org/aptitude/