Strengthening innovation-driven inclusive and sustainable development

Asia-Pacific Tech Monitor

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Innovation, technology transfer and management for safe and sustainable water

Plus

- Technology News and Events
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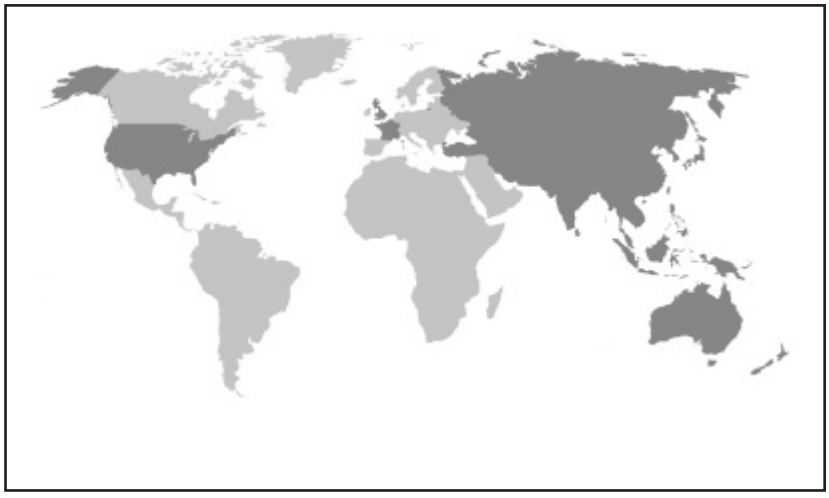
APCTT
Asian and Pacific Centre for Transfer of Technology

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

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

Sustainability of water has been a major global concern, with critical implications for human health and wellbeing. The United Nations, in September 2015, adopted the 2030 Sustainable Development Agenda which is composed of 17 goals and 169 targets to end poverty by 2030 and pursue a sustainable future for the world over the next 15 years. In particular, the Sustainable Development Goal (SDG) - 6 aims at ensuring access to water and sanitation for all by the year 2030 and covers the entire water cycle, including the management of water, wastewater and ecosystem resources. In this context, the availability, accessibility, quality and sustainability of water are some of the key challenges for countries to address.

Rapidly growing population, urbanization and industrialization have led to sharp rise not only in the global water demand but also the volume of wastewater generation. According to the United Nations World Water Development Report 2017, over 80% of the world's wastewater – and over 95% in some least developed countries – is released to the environment without treatment. On average, high-income countries treat about 70% of the wastewater they generate, while that ratio drops to 38% in upper middle-income countries and to 28% in lower middle-income countries.

Sustainable water management is critical for countries in many ways. It can ensure agricultural productivity, provide access to safe and affordable drinking water to meet the growing needs of the population, help in reducing over exploitation of water resources, and facilitate recycling and reuse of water to meet diverse developmental demands of countries. Appropriate policies and strategies for innovation and technology transfer can play a significant role in providing safe and affordable water to the population.

The Governments of many Asia-Pacific countries, have taken proactive measures to support research and development (R&D) and deployment of safe water technologies, as well as increasing public investment in the water sector. Research institutions have developed many water purification and treatment technologies to address contamination problems. Some of these technological innovations may seem to offer promising solutions to address critical water problems like arsenic and fluoride contamination, salinity, water quality monitoring, wastewater treatment. However, the affordability, commercial availability and wide scale deployment of these technologies for the needy population remain a challenge for the countries. It is also important to mention that while Governments focus on safe water technologies, efforts should be made towards preventing water pollution and ensuring sustainable management of water resources.

This issue of *Asia-Pacific Tech Monitor* discusses the innovation policies and frameworks, technology transfer mechanisms and institutional support systems for ensuring safe and sustainable water in Asia-Pacific countries. Successful case studies on using technological innovations for water resource management, purification and desalination from Malaysia, India, Pakistan and the UK are also featured in this issue of Tech Monitor.

Michiko Enomoto
Head, APCTT-ESCAP

Technology Market Scan

INTERNATIONAL

Public investment for research and innovation

A new *Science Business* report, based on a review of economic studies around the world, finds wide variation in how economists estimate the impact of public R&D investment – ranging from a dead loss in some cases to 14,000 per cent in others, depending on the type of technology, the nature of the programme, and the way the impact is measured. But over the past decade, the report finds, a preponderance of broad economic analyses has pegged the long-term return on one euro of public investment in the area of 20 cents a year. This compares to a 6.8 per cent annual return for the past 10 years of the US stock market (S&P 500) or 3.1 per cent for 10-year Euro Area Government Bonds.

Around the world, governments spend more than $1.7 trillion a year on research and development – but often have difficulty tracking the impact. Some investments have had profound impact, such as the US Human Genome Project in the 1990s which, by one estimate, for every dollar invested paid back $141 in new medicines, products, services and employment. Likewise, the European Union's investment over 30 years in mobile technologies – funding more than 380 research projects, and in the 1980s and 1990s leading the charge for cross-border technology standards – catalysed the growth of mobile phone markets around the world.

The report, by Science Business policy analyst Philip Hines, was released on 27 June in Brussels, at the annual meeting of the Science Business Network. It brings together 58 companies, universities, and public-sector organisations dedicated to research and innovation. The group also released a report on international cooperation in research and innovation, urging changes in the EU's Framework Programme to boost global participation. As with all Science Business policy and news reports, the opinions expressed are those of Science Business itself and do not necessarily reflect the views of Network members.

http://sciencebusiness.net

Global Innovation Index 2017

Released jointly by World Intellectual Property Organization (WIPO), Cornell University, INSEAD and the 2017 GII Knowledge Partners, the Confederation of Indian Industry, PwC's Strategy& and the National Confederation of Industry (CNI) and Brazilian Micro and Small Business Support Service (Sebrae).

Switzerland, Sweden, the Netherlands, the USA and the UK are the world's most-innovative countries, while a group of nations including India, Kenya, and Viet Nam are outperforming their development-level peers, according to the Global Innovation Index 2017 co-authored by Cornell University, INSEAD and WIPO. Key findings show the rise of India as an emerging innovation center in Asia, high innovation performance in Sub-Saharan Africa relative to development and an opportunity to improve innovation capacity in Latin America and the Caribbean.

Each year, the GII surveys some 130 economies using dozens of metrics, from patent filings to education spending providing decision makers a high-level look at the innovative activity that increasingly drives economic and social growth. In a new feature for the GII, a special section looks at "invention hotspots" around the globe that show the highest density of inventors listed in international patent applications. Now in its tenth edition, the GII 2017 notes a continued gap in innovative capacity between developed and developing nations and lackluster growth rates for research and development (R&D) activities, both at the government and corporate levels.

http://www.wipo.int

ASIA-PACIFIC

CHINA

Artificial intelligence revolution

A new AI development plan calls for China to become the world leader in the field by 2030. On July 20, China's State Council issued the "Next Generation Artificial Intelligence Development Plan" which articulates an ambitious agenda for China to lead the world in AI. China intends to pursue a "first-mover advantage" to become the "premier global AI innovation center" by 2030. Through this new strategic framework, China will advance a "three in one" agenda in AI: tackling key problems in research and development, pursuing a range of products and applications, and cultivating an AI industry. The Chinese leadership thus seeks to seize a "major strategic opportunity" to advance its development of AI, potentially surpassing the United States in the process.

This new plan, which will be implemented by a new AI Plan Promotion Office within the Ministry of Science and Technology, outlines China's objectives for advances in AI in three stages. First, by 2020, China's overall progress in technology and applications of AI should keep pace with the world's advanced level, while its AI industry becomes an important economic growth point. By this time, China hopes to have achieved important progress in next generation AI technologies, including big data, swarm intelligence, hybrid enhanced intelligence, and autonomous intelligent systems. At that point, the value of China's core AI industry is targeted to exceed 150 billion RMB (over $22 billion) in value, with AI-related fields valued at 1 trillion RMB (nearly $148 billion). Concurrently, China should have advanced in gathering top talent and establishing initial frameworks for laws, regulations, ethics, and policy.

Next, by 2025, China should have achieved major breakthroughs in AI to reach a leading level, with AI becoming a primary driver for China's industrial advances and economic transformation. At that point, China intends to have become a leading player in research and development, while widely using AI in fields ranging from manufacturing to medicine to national defense. China's core AI industry should have surpassed 400 billion RMB (about $59 billion), with AI-related fields exceeding 5 trillion RMB (about $740 billion). In addition, China plans to have achieved progress in the creation of laws and regulations, as well as ethical norms and policies, along with the establishment of mechanisms for AI safety assessment.

Ultimately, by 2030, China intends to have become the world's premier AI innovation center. At that point, China believes it can achieve major breakthroughs in research and development to "occupy the commanding heights of AI technology." In addition, AI should have been expanded and its use deepened within multiple domains, including social governance and national defense. By then, China's AI industry is targeted to exceed 1 trillion RMB ($148 billion), with AI-related fields totaling $10 trillion ($1.48 trillion). To support its continued primacy in AI, China plans to create leading AI innovation and personnel training bases, while constructing more comprehensive for legal, regulatory, ethical, and policy frameworks.

http://thediplomat.com

Tax incentives for tech SMEs

China has announced measures to encourage research and development (R&D) by tech firms through favorable tax terms, the Ministry of Finance (MOF) said in a statement. Small and medium sized-enterprises (SME) in the technological sector can deduct an additional 75 percent of the R&D costs that occurred before paying taxes, effectively lowering their taxable income, according to the statement.

Tech SMEs that chose alternatively to capitalize the R&D costs as intangible assets in the current accounting period can amortize the assets at 175 percent of the original costs. The new tax term will be in effect from the beginning of 2017 to the end of 2019, the statement said.

China has been offering tax incentives to spur corporate dynamism and competitiveness, offering tailored measures to firms of different types. The MOF also announced tax incentives for venture capital firms, allowing them to deduct a certain amount of taxable income for investing in startups. The value added tax (VAT) system will also be streamlined, with four VAT brackets reduced to three, the MOF said.

http://www.chinadaily.com.cn

Promoting innovation, entrepreneurship

China will go further on innovation-driven development and entrepreneurship, with more policy incentives to entrepreneurship from overseas. A guideline is approved at a State Council executive meeting chaired by Premier Li Keqiang to further enhance the support for innovation and entrepreneurship.

China will establish an integrated digital business license registry, and enable one-stop registration for foreign enterprises and their domestic counterparts within a given timeframe for due procedures. The government will simplify procedures of work and residential permit application for high-calibre foreign talents, and pilot integrated service in housing, schooling and medical care. Overseas students in China who start new businesses can also apply for residential permit with their diplomas.

Statistics by the State Administration for Industry and Commerce shows that the country saw the registration of more than 13 million new enterprises between March 2014 and February 2017, 94.6 percent of which are in the private sector, adding an average of 15,600 new enterprises on a daily basis in the first five months of this year, giving employment a major boost.

The country will also put in place programs to support Chinese students overseas to return for business startups and innovation, and enable overseas Chinese entrepreneurs, including those from Hong Kong and Macao special administrative regions, enjoy the same public services as local residents, according to the guideline. More efforts will go to the protection of intellectual property rights, while invigorating technology markets and explore a mechanism that can ensure timely commercialization of research findings with fiscal support in some areas.

The country will also expand the funding channels for enterprises, including measures to enhance the credit support and relevant services and reform on rules for state capital to take part in venture capital investment, according to the guideline. The upgrading of the real economy will get a boost from enhancing the development of innovation and entrepreneurship platforms, the sharing economy and the development of digital economy.

http://www.shanghaidaily.com

INDIA

Innovation lab to promote water and sanitation

Start-ups in Kerala will work closely with the Innovation lab to build products addressing water, sanitation, mobility and agriculture. The Kerala Government and UN's Office of Information and Communication Technology will join hands to set up the country's first UN Technology Innovation Lab in Thiruvananthapuram, it was announced recently.

The Kerala Startup Mission will be spearheading this initiative on behalf of Kerala government and water, sanitation, mobility and agriculture are areas the state government have identified as best suited for this innovation centre, as it would not only address the needs of the state but also can be a collaboration lever with other UN member states experiencing similar issues, said an official. The start-ups in the state will be working closely with the Innovation lab to build products addressing these issues.

The proposed centre would be a United Nations technology project led by the Office of Information and Communication Technology and staffed with members from both the technology and substantive programme areas of the UN.

http://www.thenewsminute.com

Intellectual property exchange

India will soon have an Intellectual Property (IP) Exchange, joining the league of countries like Hong Kong and United Kingdom, where individuals and commercial entities both in India and overseas will be able to buy and sell intellectual property rights across various sectors. The exchange will be developed under the ministry of science and technology through the National Research Development Corporation (NRDC). The idea of setting up a

patent exchange similar to those in Hong Kong and the UK was floated in the ministry around two months ago. The project has already got in-principle approval from the science and technology ministry.

"We have been mandated with the task of creation of the proposed IP exchange and the process will take around 8–9 months for collecting data and setting up the exchange. We are already undertaking exercise of collecting necessary data and information on patents filed worldwide on multiple technologies, predominantly on agriculture and allied sectors," said NRDC chairman and managing director H. Purushotham.

In India, IP rights are given by Controller General of Patents, Designs and Trademarks (CGPDTM). According to its annual report of 2015–16, India witnessed about 30% increase in filing of intellectual property applications compared to previous years. In 2015–16, 3,41,086 applications were filed for IP rights as against 2,35,306 in 2011–12.

According to India Brand Equity Foundation's Innovation and Patents report released in June, India's research and development spend is estimated to reach $71.5 billion by 2016 from $66.49 billion in 2015. In 2015, India became the world's sixth largest annual research and development spending country, accounting for 3.53% of global R&D expenditure. R&D spending in India is anticipated to grow from 0.9% to 2.4% of the country's GDP from 2014 to 2034 respectively.

The number of multinational corporations with R&D centres in India has grown at a CAGR of 4.57% from 721 in 2010 to 943 in 2016. During 2010–16, the workforce in MNC R&D centres increased at a CAGR of 10.08% and reached 363,000, which is estimated to further increase to 387,000 by 2017 in India.

http://www.livemint.com

Mission for ultra-supercritical technologies

India will launch a national mission on advanced ultra-supercritical technologies for cleaner coal utilisation at a total cost of $ 238 million and setting up of two centres of excellence on clean coal technologies at $ 5 million each. "In its quest for cleaner fuels, a national mission on methanol and di-methyl ether is being mounted. A new centre on solar photovoltaic, thermal storage and solar fuels research has been approved at approximately $ 5 million. Funding opportunities have been announced in the area of energy storage, clean coal, waste water treatment amounting to $ 10 million," said the Government of India in a statement at the 2nd Mission Innovation (MI) Ministerial and 8th Clean Energy Ministerial at Beijing, China.

India also announced two MI-centric funding opportunities in smart grid and offgrid access at $ 5 million each. Joint virtual Clean Energy Centre with UK and Indian Government funding of £ 5 million each has been initiated. Under the Indo-US Joint Clean Energy Research (PACE – R) the new collaborative public-private programme on smart grids & energy storage has been approved. India has also embarked upon a joint programme on renewable energy with Norway.

Eighteen months ago on November 30, 2015, leaders of 20 countries came together to launch Mission Innovation (MI), a landmark 5-year commitment to accelerate the pace of innovation and make clean energy widely affordable and accessible worldwide. MI now comprises 22 economies and the European Commission, representing the European Union, and collectively accounts for more than 80 percent of the world's total public financing of clean energy R&D.

http://www.business-standard.com

INDONESIA

Spending on tech start–up incubation

Indonesia has nearly doubled its public spending on incubating tech-based businesses from Rp 190 billion ($14.1 million) to Rp 370 billion ($27.6 million), a government official said. The number seems minuscule still when compared to the funds the archipelago's neighbouring countries are setting aside. Malaysia has budgeted for RM200 million ($46 million) to support its local startups, and Singapore recently introduced a new S$200 million ($146 million) startup building programme. Thailand, too, recently announced a Digital Economy Fund worth $147 million.

Jumain Appe, directorate general of innovation at the Indonesian technology and higher education ministry, told reporters in Jakarta that the increased budget shows the government's commitment to push innovation and entrepreneurship. "We are targeting about 60 incubation units from which 500 startups are expected to be created," he explained.

The government had funded 45 incubators with last year's budget. Jokowi's administration continues to look for pockets of funding to catch up with the private sector that has dominated the budding industry. It has said that it is looking at converting a part of the government's credit facilities for micro, small and medium enterprises (SMEs), labelled people's business credit (KUR), into venture capital funds to be deployed in startups.

https://www.dealstreetasia.com

ISLAMIC REPUBLIC OF IRAN

Patent office supports inventors

An Iranian science official says the country's Vice Presidency for Science and Technology Affairs supports Iranian inventors who seek to obtain patent protection for their inventions and innovations from international centres and commercialize them. The director of Iran Patent Office, Mehdi Zaghimi, says Iranian inventors can envoy the support of the Vice-Presidency for Science and Technology Affairs to take out patent for their scientific and industrial achievements and commercialize them, which is a costly and difficult process.

Zaghimi added over the past two years, the Iranian industrial and scientific society has witnessed an almost 100-percent growth in the number of patents issued by leading international centres for its inventions. In 2015, only 48 patents had been granted to Iranian inventions, he said, adding, however, that in 2016, the figure rose to 94.

"Among the services Iran Patent Office provides domestic knowledge-based companies with is offering a 90-percnt support [to them] in the process of obtaining patent protection from leading international centres. This is because the process of taking out international patent rights is quite costly and time taking. Over the past few years, Iran Patent Office has shored up more than 30 percent of the Iranian inventions in the process of getting patent rights."

He added Iran Patent Office has set up a number of [invention] commercialization and intellectual property offices in Iranian universities which hold specialized workshops on the process of obtaining patent protection for inventions. Zaghimi put the number of these offices at 41, adding they have been established with the cooperation of Iran's Ministry of Science, Research and Technology and domestic universities. In 2015, he said, some 160 patent applications were submitted to Iran Patent Office. "In 2016, the figure rose to 300, of which only 30 percent are processed."

http://ifpnews.com

Incentives for export of knowledge-based products

The Iranian Fund for Innovation and Prosperity (NSFund) has approved a 2% cut in the interest rate of export loans in a renewed effort to help boost Iran-made knowledge-based products in the international market. Knowledge-based firms can now receive export loans at 9%, Behzad Soltani, head of the fund said in a press release. "Knowledge-based companies may apply for loans once they finalize an export deal with foreign companies. They will receive loans on par with the value of their contracts," he added.

The firms would be obliged to start production for exports after they receive the loans, Soltani said and noted that repayment would start after a negotiated grace period. Firms can also apply for loans after exports. Such companies can take loans on par with the value of their exports at [an extra] 1% interest.

Launched in 2008 as an independent entity, the fund is in charge of offering financial services to knowledge-based companies. However, firms need to be licensed by the Vice-Presidential Office for Science and Technology. The fund started operation in 2013, NSFund's loans and investments amounted to 14.9 trillion rials ($397 million) over the past two years (March 2015–17).

So far 3,037 knowledge-based companies are registered with the vice presidency including 1,751 startups, 867 firms active in production sector and 419 industrial knowledge-based firms. Firms involved in biotech, medicine and medical equipment accounted for the largest portion of the revenue earned–3.6 trillion rials ($96 million) in the past two years.

https://financialtribune.com

MALAYSIA

Training facility to develop skilled workforce

MIMOS Berhad and the Northern Corridor Implementation Authority (NCIA) jointly launched a human capital development centre, called MIMOS-NCIA Advanced Competency Development Centre (MIMOS-NCIA ACDC). MIMOS, an agency under the Ministry of Science, Technology and Innovation (MOSTI), is Malaysia's premier Applied Research and Development Centre in ICT, Industrial Electronics Technology and Nano-Semiconductor Technology. NCIA is the authority responsible for the socio-economic development in the Northern Corridor Economic Region (Koridor Utara), which encompasses 25 districts in northern Peninsular Malaysia in the states of Kedah, Perak, Perlis and Penang.

MIMOS-NCIA ACDC offers an end-to-end, world-class, high-technology industry training facility aimed at fostering hands-on experience needed to produce highly-skilled workforce in the Electrical & Electronics (E&E) sector. The local E&E industry is being encouraged to take advantage of the MIMOS-NCIA ACDC to build a workforce with the high-level skills required for Industry 4.0. The E&E sector is key driver for Malaysia's industry, contributing RM288 billion (USD 67.2 billion) or 36.7 per cent of total national exports in 2016.

The Centre is expected to produce 2,000 high-impact E&E professional over five years, meeting the demand from all E&E companies operating in the country presently. The advanced shared service facilities, which form a large part of MIMOS-NCIA ACDC, are internationally certified with ISO9001: 2008 and ISO/IEC17025. The facilities support NanoVerify programme, a joint programme between NanoMalaysia Berhad and SIRIM QAS.

http://www.opengovasia.com

PHILIPPINES

Bill to boost scientific innovations, inventions

The House Committee on Science and Technology has approved House Bill 4581 filed by Albay Rep. Joey Sarte Salceda, which aims to boost the country's scientific innovations and inventions, research and development towards social progress and global competitiveness. Titled "Science for Change Program (S4CP) Act" with the theme of "Science for the People," and a budget that could reach PHP672 billion by 2022, HB 4581 is designed to help accelerate science, technology and innovation (STI) developments and enable the country to keep up with current global technology and innovation trends.

S4CP was launched by the house committee on science and technology chaired by Bohol Rep. Erico Aristotle Aumentado. When enacted, it will be implemented by the Department of Science and Technology (DOST). It was hailed by legislators as a key towards higher standards of STI and global competitiveness. The total R&D budget for 2017 is PHP5.8 billion. The bill proposes an estimated R&D budget which starts at PHP21 billion next year, more or less doubling yearly over the next five-year period, and could reach PHP672 billion in 2022.

S4CP focuses on four core concerns: 1) Program Expansion, 2) New Programs, 3) S&T Human Resource Development, and 4) Accelerated R&D Program for Capacity Building of Research and Development (R&D) Institutions and Industrial Competitiveness. S4CP target areas for R&D include health, food and nutrition; human security; agricultural and aquatic productivity; creative industries, tourism

and services industries; nuclear science for health, agriculture and energy; and agriculture; renewable energy; Biotechnology for agriculture, health and environment; Space Technology and ICT development; Artificial Intelligence, and climate and environmental sciences, among others.

It gives special focus on "S&T education, training, and services" and supports "indigenous, appropriate, and self-reliant scientific and technological capabilities, and their application to the country's productive systems and national life."

https://www.update.ph

REPUBLIC OF KOREA

New technology committee

To promote the development of so-called fourth industrial revolution technologies, the government is creating a committee headed by a person from the private sector - a contrast to other presidential committees that President Moon Jae-in is personally chairing. According to the Presidential Advisory Committee for State Affairs Planning, Moon's de facto transition team, preparations for the forming of the committee will begin next month and its launch will be in August. Moon is directly supervising the plan.

The de facto transition team said the person who heads the committee will come from the private sector and be higher in status than government ministers. The second-in-command positions will be shared by the Minister of Science, ICT and Future Planning and the Blue House policy chief. "The committee will be setting the nation's policy directions in regard to the fourth industrial revolution," said Park Kwang-on, the de facto transition team spokesman. "It will be in charge of fine-tuning the policies of different [government] departments while also gauging public opinion and evaluating performances."

The government intends fourth industrial revolution technologies to enter industrial fields and also the daily lives of the public, the spokesman said. While the Ministry of Strategy and Finance has played a central role in developing technology policies, that role will be taken by the Science and ICT Ministry, which has a more direct connection to evolving technologies and related businesses.

The decision to invite an expert from the private sector to head the fourth industrial revolution committee is seen as the government's attempt to encourage innovative technology changes led by the private sector. Past administrations' concepts of new growth engine projects were mostly led by the government.

http://koreajoongangdaily.joins.com

Road map to upgrade robot technology

The Republic of Korean government has unveiled a road map to develop robot technologies and utilize them in various industrial sectors, the industry ministry said. The plan was a follow-up of the government-led project to upgrade the country's robotics sector set up in November last year, according to the Ministry of Trade, Industry and Energy. The ministry and state-run research centers, including the Korea Institute of Science and Technology and the Korea Institute of Robot and Convergence, have participated in mapping out the road map for the past six months.

Under the plan, related technologies have been categorized into eight core sectors, such as manufacturing, agriculture, medical services, safety and software, which can allow for a more efficient research and development process, the ministry said.

Earlier, the government said it would invest 500 billion won ($445 million) in the coming five years to foster the domestic robot industry as a new growth engine for Asia's fourth-largest economy. (Yonhap)

http://www.koreaherald.com

SINGAPORE

Single point of access to government grants for business

The Government Digital Services (GDS) team at the Government Technology Agency of Singapore (GovTech) is currently developing the Business Grants Portal (BGP), which is designed as a single point of access for companies to find and apply for suitable grants from the government.

The Singapore government offers over 25 grants to Small & Medium enterprises (SMEs). Examples of areas where the SMEs can seek support include technology adoption, building in-house R&D capabilities, efficiency improvement, expansion to international markets and workforce training. A number of different agencies are involved, such as Spring Singapore, IE Singapore, the Infocomm Media Development Authority (IMDA), Building and Construction Authority (BCA), Singapore Tourism Board (STB), Agency for Science, Technology and Research (A*STAR) and more.

The BGP seeks to bring the different government grants for businesses into one portal, making it significantly more convenient for businesses to find and apply for the grants they need. Previously they would have needed to visit multiple websites to find the right grant meeting their requirement.

Users need a CorpPass account to log in to the portal. CorpPass is a single corporate digital identity for businesses and other entities (such as non-profit organisations and associations) to transact with Government agencies online. It was introduced by GovTech last year to remove the need for users to handle multiple login IDs. By December 2017, CorpPass will be the required login for over 100 government digital services.

Access to BGP is divided into three tiers, Viewer, Preparer and Acceptor. While a Viewer can only view and monitor, the Preparer can view, edit and submit the grant applications. In addition to the above rights, the Acceptor can accept the terms and conditions of the Letter of Offer on behalf of the company.

http://www.opengovasia.com

Smart Nation and Digital Government

Since the Smart Nation initiative was launched in late 2014, progress has been made in applying digital and smart solutions to provide better services for our citizens and businesses. Companies have also

responded with innovative products. To enable the Government to be more integrated and responsive in our strategy and processes for Smart Nation and Digital Government (SNDG), the following organisational changes will take effect from 1 May 2017.

The Smart Nation and Digital Government Office (SNDGO) will be formed under the Prime Minister's Office (PMO) comprising staff from the Digital Government Directorate of the Ministry of Finance (MOF), the Government Technology Policy department in the Ministry of Communications and Information (MCI), and the Smart Nation Programme Office (SNPO) in the PMO. The Government Technology Agency (GovTech), a statutory board under MCI, will be placed under the PMO as the implementing agency of SNDGO. Collectively, the SNDGO and GovTech will form the Smart Nation and Digital Government Group (SNDGG) in the Prime Minister's Office.

https://www.tech.gov.sg

SRI LANKA

Hybrid solar and wind energy park

Sri Lanka's Cabinet of Ministers has approved plans to build a hybrid renewable energy park including 240MW of wind and 800MW of solar at Punarin. The approval is in line with the government's plans to add significant amounts of new electricity capacity via renewable energy sources. The Sri Lanka Sustainable Energy Authority (SLSEA) has identified the northern regions of the country as a suitable area to build wind power and solar power plants.

In March, the Cabinet announced Sri Lanka would also go ahead with an international tender to set up a 100MW floating solar plant on the Maduru Oya Reservoir in the eastern part of the island. Since then, it has approved an amendment proposal relating to grant relief on loan interests for residential solar PV, and elected to allocate LKR350 million (US$2.29 million) in the 2017 budget to implement a green building policy. Before March this year, the island's solar progress had been more or less muted, but today's announcement shows clear intent to push forward with renewables infrastructure.

https://www.pv-tech.org

VIET NAM

Tax breaks for high-tech transfers

Firms engaged in technology transfer in Viet Nam are expected to receive tax incentives according to a recent draft amendment of the Law on Technological Transfer. Tax incentives will be applicable on the import of machinery, equipment, materials, and means of transport that are not manufactured in Viet Nam, and used for research and development (R&D) activities, technological innovations, and technology transfer within Viet Nam. The amendment is expected to take effect on July 1, 2017.

High technology is defined as technology, which is beneficial in R&D and can create high-quality products with high added value. It can also be applicable for production or service sectors in terms of modernizing the existing sectors. Proposal includes that items mentioned will be exempted from import taxes to increase transfer. Businesses will also receive tax incentives in cases where production is expanded with the introduction of new technology. Individuals and entities investing in high technology in Vietnam or supporting firms involved in innovations are also eligible for tax incentives. The government has also proposed support in the form of capital and loans from the National Technological Innovation Fund and other credit institutions.

http://www.vietnam-briefing.com

SME support law approved

More than 83 per cent of members in Vietnam's National Assembly voted to approve a Law on Support for small and medium-sized enterprises (SMEs). The support will include access to credit, tax incentives, production space, technology application and transfer, market expansion, provision of information, consultancy and legal aid, and personnel development.

The law sets out SME principles, contents and resources, as well as the responsibilities of related agencies, organizations and individuals. It also covers micro-enterprises and operations with fewer than 200 salaried employees. To be covered, they must show total investment capital not exceeding 100 billion dong (Bt149 million) or total revenue from the previous year not exceeding 300 billion dong.

The law requires that support provided respects market rules and is in line with international treaties to which Vietnam is a signatory. The support given must be transparent in terms of content. The law will take effect next January 1. SMEs account for around 97 per cent of the firms in Vietnam.

http://www.nationmultimedia.com

Vietnam Innovation Golden Book 2017

The book was published by the Vietnam Fatherland Front (VFF) Central Committee, the Ministry of Science and Technology, and the Vietnam Union of Science and Technology Associations (VUSTA). It is a collection of 72 outstanding science-technology projects and solutions selected from 141 works recommended by ministries, localities and VUSTA member organisations.

President of the VFF Central Committee Tran Thanh Man said the book includes valuable initiatives to support the community, dealing with healthcare improvement, environmental protection, and socio-economic development in disadvantaged border, sea and island areas. Also at the ceremony, the VFF leader launched an emulation movement to promote innovation, enhance productivity, product quality for international integration among society, especially intellectuals, entrepreneurs, and workers at home and abroad.

Addressing the event, PM Nguyen Xuan Phuc affirmed that the Vietnamese Party and State always encourage reforms and innovations, particularly in scientific and technological development. The Government has made due investment in science and technology and creates the best possible conditions for scientists to uphold their talents and creativity, he said.

http://english.vietnamnet.vn

ASIA PACIFIC

CHINA

Nanoparticles for water treatment

Magnetic nanoparticle clusters have the power to punch through biofilms to reach bacteria that can foul water treatment systems, according to scientists at Rice University, USA, and the University of Science and Technology of China. The nanoclusters developed through Rice's Nanotechnology-Enabled Water Treatment (NEWT) Engineering Research Center carry bacteriophages—viruses that infect and propagate in bacteria—and deliver them to targets that generally resist chemical disinfection. Without the pull of a magnetic host, these "phages" disperse in solution, largely fail to penetrate biofilms and allow bacteria to grow in solution and even corrode metal, a costly problem for water distribution systems.

The Rice lab of environmental engineer Pedro Alvarez and colleagues in China developed and tested clusters that immobilize the phages. A weak magnetic field draws them into biofilms to their targets. The research is detailed in the Royal Society of Chemistry's *Environmental Science: Nano*. "This novel approach, which arises from the convergence of nanotechnology and virology, has a great potential to treat difficult-to-eradicate biofilms in an effective manner that does not generate harmful disinfection byproducts," Alvarez said.

Biofilms can be beneficial in some wastewater treatment or industrial fermentation reactors owing to their enhanced reaction rates and resistance to exogenous stresses, said Rice graduate student and co-lead author Pingfeng Yu. "However, biofilms can be very harmful in water distribution and storage systems since they can shelter pathogenic microorganisms that pose significant public health concerns and may also contribute to corrosion and associated economic losses," he said.

The lab used phages that are polyvalent—able to attack more than one type of bacteria—to target lab-grown films that contained strains of Escherichia coli associated with infectious diseases and Pseudomonas aeruginosa, which is prone to antibiotic resistance.

The phages were combined with nanoclusters of carbon, sulfur and iron oxide that were further modified with amino groups. The amino coating prompted the phages to bond with the clusters headfirst, which left their infectious tails exposed and able to infect bacteria.

The researchers used a relatively weak magnetic field to push the nanoclusters into the film and disrupt it. Images showed they effectively killed *E. coli* and *P. aeruginosa* over around 90 percent of the film in a test 96-well plate versus less than 40 percent in a plate with phages alone. The researchers noted bacteria may still develop resistance to phages, but the ability to quickly disrupt biofilms would make that more difficult. Alvarez said the lab is working on phage "cocktails" that would combine multiple types of phages and/or antibiotics with the particles to inhibit resistance.

https://www.cemag.us

INDIA

Water purification membrane

A team of researchers from Indian Institute of Science (IISc) Bangalore has improved upon the water purification membrane they developed in 2014. The membrane allows higher flow rate across it and kills nearly 99 per cent of *E. coli* present in water. The results of the study were published recently in the journal Nanoscale. Instead of creating a membrane with sub-micron pore size, a team led by Prof. Suryasarathi Bose, the corresponding author of the paper from the Department of Materials Engineering, IISc produced a more permeable structure by creating pores that are bigger in size and more interconnected.

Bigger and more tortuous pores were produced by mixing equal amounts of two polymers — polyethylene (PE) and polyethylene oxide (PEO). Since PEO is soluble in water unlike PE, pores tend to form when the membrane containing PEO is dipped in water. Earlier, the researchers used tiny amount of PEO and sheared it at high speed to produce tiny droplets of PEO to create smaller pores. "We took equal amounts of PE and PEO so we get more tortuous pores upon removal of PEO. This is not possible if we take tiny amounts of PEO," says Prof. Bose.

Besides being tortuous, the pores are also asymmetrical — the pore dimensions are not uniform throughout. At some places, the pores get so narrow that they tend to be as small as the micro holes that the team produced two years ago. Explaining the logic behind having asymmetrical pores, Prof. Bose says: "If the pores are asymmetrical then bacteria and other contaminants will have a tougher path to pass through, so they will get trapped." The pores are also well connected thereby increasing the ability of water to pass through the membrane. When two polymers are mixed and subjected to post processing application like hot pressing the initial PEO droplets tend to become bigger. The bigger droplets of PEO tend to leave bigger pores. "To prevent this and control the morphology we added maleated polyethylene. The maleated polyethylene does not allow the droplets to get bigger," Prof. Bose says. "Maleated polyethylene basically interacts with PE (polyethylene) on the one hand and reacts with PEO on the other hand. So it is a kind of interfacial stabilising agent and doesn't allow the morphology to coarsen."

Antibacterial studies through direct contact of E. coli with graphene oxide resulted in 100-fold reduction in E. coli colony forming units at the end of 12 hours of contact with the membrane. According to him, graphene oxide has very sharp edges and this helps in piercing and destroying the bacterial cell wall. Also, the amine group of graphene interacts with the phosphate group of the lipids present in the cell and generates reactive oxygen species that eventually destroys the cell membrane. Since polyethylene is inert, the researchers had to render suitable surface modification to anchor graphene oxide on to it, which otherwise would have been very difficult. Lab studies have revealed that there is unimpeded permeation of water across the membrane suggesting that anchoring the graphene oxide on the surface does not clog the pores.

http://www.thehindu.com

Water treatment system and analysis kits

Indian Institute of Technology (IIT) Madras signed a Memorandum of Understanding (MoU) with TANSTIA-FNF Service Centre on Monday (March 20) for the technology transfer of 'Point of use Water Treatment System and Water Analysis Kits'. The T-FNF Service Centre will take this technology to small industries. IIT – Madras has not patented the technology and is giving it away almost free of cost. Prof. Krishnan Balasubramaniam said, "IIT professors are committed to societal development at various levels. This is a grassroots level project that benefits day-to-day entrepreneurs who make a living. While the institutions can develop new technologies, it is organizations such as TANSTIA that can take it from the laboratories to the grassroots."

Prof. Ligy Philip of the Department of Civil Engineering, along with her students Dr. R. Elangovan and Mr. D. Kumaran, developed two water testing kits, one for 14 parameters and another for 24 parameters. The 14 parameters test kit can be used for (i) pH, (ii) total hardness, (iii) chlorides, (iv) dissolved solids, (v) calcium, (vi) sulphate, (vii) nitrate, (viii) fluoride, (ix) alkalinity, (x) magnesium, (xi) acidity, (xii) phosphate, (xiii) residual chlorine and (xiv) bacteriological quality.

The kits have already been tested extensively in the field. United Nations International Children's Emergency Fund or UNICEF sponsored several training programs in Krishnagiri district where the testing kits were distributed to 176 panchayats.

A simple, easy-to-make and easy-to-use domestic water filter has also been developed. The research project was funded by International Development Research Centre (IDRC), a public corporation created by the Canadian Government. The 'Point of Use' water treatment system will remove turbidity, organic matter, colour and odour besides most bacteriological contamination. The filtered water is collected in a container with proper lid, tap and chlorine tablet is added to remove microbes. The maintenance of the system is very simple. 'Point of Use' systems are installed at a single water connection like under kitchen counters or bathroom sinks.

https://indiaeducationdiary.in

Reverse osmosis-based water purifier

Concerned over wastage of water from the RO water systems, two ex-students of Indian Institute of Technology (IIT)-BHU were successful in developing cost and energy efficient water purifier called 'Aquvio'. The patentable technology was developed two years ago. In Aquvio's cost and energy saving Reverse Osmosis-based water purifier, only 30% of water is rejected and 70% is available for drinking purposes. Recognising the potential of Aquvio, IIT-Kanpur granted a seed funding of Rs 20 lakh to the company run by these ex-IIT-BHU students.

The duo--Naveen Kumar and Rohit Kumar Mittal--who had developed Aquvio in just two years, were successful in getting 60 Aquvio water purifiers installed across schools and colleges in Varanasi. Four such water purifiers were also installed at an Army unit in the holy city. Naveen said, "Aquvio's water filters significantly reduce the amount of water wasted as compared to modern RO water systems. In water purifiers available in the market, 70% of the water is drained out, which is nothing but a wastage in the current scenario of water crisis in our country. In Aquvio's cost and energy saving Reverse Osmosis-based water purifier, only 30% of the water is rejected and 70% is available for drinking purpose. Aquvio water purifiers also consume less power". He said, "The technology used in Aquvio has already been patented. This patented technology only ensures that out of four litre of water only one litre gets drained and the remaining water is available for drinking purpose. It significantly helps in saving water", he further said.

Aquvio has two water purifiers that can filter huge quantities of water (100 litre per hour and 50 litre per hour) and are fit for use in corporate offices or schools/colleges. Aquvio has been recognised by Startup India Standup India, a Government of India initiative, Naveen said.

http://timesofindia.indiatimes.com

RUSSIA

Hybrid nuclear desalination technique

Scientists from the National Research Nuclear University have developed a new technology and technological schemes for a pretreatment unit taking into account data on the composition of pollutants, salinity and performance of water treatment systems. It is based on the reagent methods with hydrodynamic activation of the process of pollutant withdrawal in coagulation, flocculation and adsorption, which reduces the unit's size and cost. Moreover, the majority of the sparingly soluble salts can be removed in the pretreatment unit, which increases the efficiency of the system as a whole.

From the pre-water treatment unit, salt water flows into the desalination unit, a very energy-intensive process. Hybrid desalination schemes are proposed to reduce the energy consumption of the desalination process. These schemes use distillation and membrane methods in combination, to produce both drinking water and process water. In addition, the project proposes the development of an integrated technological system of water recycling and desalination systems to reduce environmental burdens and improve the energy efficiency of the system as a whole. The results are intended to be used in complex projects of the State Corporation Rosatom, in particular, in relation to nuclear power plants in Egypt, where it is planned to realize a nuclear desalination technology.

https://phys.org

SINGAPORE

Algae treatment of wastewater

Researchers at the National University of Singapore (NUS) believe they can harness that very growth to treat wastewater, and cut the energy used in treatment by as much as 80 per cent. That is because wastewater treatment takes a lot of energy, most of it to bubble air through, or aerate, sludge ponds so bacteria can eat the waste.

Prof Loh and Prof Tong, of NUS' chemical and bioengineering department, started devising their system about two years ago. They were inspired by a previous government grant call asking for research to

improve the energy efficiency of wastewater treatment. They did not get the grant, but kept plugging away at the system.

Now, they have got as far as a lab-bench experimental setup - a 250ml flask full of algae and an identical flask full of bacteria. The liquids in the twin flasks never mix, meeting only in a reactor where a membrane made of plastic fibres lets the necessary gases through.

So far, they have tested on a high-concentration sugar solution that mimics the concentration of wastewater, but have not yet tried it on real wastewater. That is one of the next steps, explained Prof Loh.

Another would be genetically engineering strains of algae that grow faster and thus consume more carbon dioxide, a project Prof Tong is working on. After that, scaling up to a pilot or demonstration plant should be straightforward, as the membranes used are commercially available. They reckon the process could even be a net producer of energy, if the algae are digested at the end of their life to harvest methane gas which is then burned to generate power.

http://www.eco-business.com

EUROPE

IRELAND

New process for water filtration

A new process for water filtration using carbon dioxide consumes one thousand times less energy than conventional methods, scientific research published recently has shown. The research was led by Dr Orest Shardt of University of Limerick, Ireland together with Dr Sangwoo Shin (now at University of Hawaii, Manoa), while they were post-doctoral researchers at Princeton University (United States) last year. Dr Shardt expects this new method which uses CO_2 could be applied in a variety of industries such as mining, food and beverage production, pharmaceutical manufacturing and water treatment.

The research, published in open-access scientific journal *Nature Communications*, indicates that the new process could be easily scaled up, "suggesting the technique could be particularly beneficial in both the developing and developed worlds". The new method could also be used to remove bacteria and viruses without chlorination or ultraviolet treatment. "We are at the early stages of developing this concept. Eventually, this new method could be used to clean water for human consumption or to treat effluent from industrial facilities," Dr Shardt stated.

The research by Drs Shardt and Shin demonstrates an alternative membraneless method for separating suspended particles that works by exposing the colloidal suspension to CO_2. "The demonstration device is made from a standard silicone polymer, a material that is commonly used in microfluidics research and similar to what is used in household sealants. While we have not yet analysed the capital and operating costs of a scaled-up process based on our device, the low pumping energy it requires, just 0.1% that of conventional filtration methods, suggests that the process deserves further research," said Dr Shardt.

"What we need to do now is to study the effects of various compounds, such as salts and dissolved organic matter that are present in natural and industrial water to understand what impact they will have on the process. This could affect how we optimise the operating conditions, design the flow channel, and scale-up the process," he continued.

https://www.eurekalert.org

GERMANY

Cleaning wastewater effectively

Researchers from the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Hermsdorf, were able to significantly reduce the separation limits of ceramic membranes and to reliably filter off dissolved organic molecules with a molar mass of only 200 Dalton. Even industrial sewage water can thus be cleaned efficiently.

Dr. Ingolf Voigt, Dr.-Ing. Hannes Richter and Dipl.-Chem. Petra Puhlfuerss from the Fraunhofer IKTS have achieved the impossible. "With our ceramic membranes, we achieve, for the first time, a molecular separation limit of 200 Daltons – and, thereby, a whole new quality," says Voigt, Deputy Institute Director of the IKTS and Site Manager in Hermsdorf. The challenge was to produce pores which were as small as possible, with all of them having more or less the same size. "We achieved these results by refining sol-gel technology says Richter, Head of Department at the IKTS.

The second hurdle was to make such membrane layers defect-free over larger surfaces. The Fraunhofer researchers have succeeded in doing this, as well. "Whereas only a few square centimeters of surface are usually coated, we equipped a pilot system with a membrane area of 234 square meters, which means that our membrane is several magnitudes larger," explains Puhlfuerss, scientist at the IKTS.

Commissioned by Shell, the pilot system was built by the company Andreas Junghans – Anlagenbau und Edelstahlbearbeitung GmbH & Co. KG in Frankenberg, Germany and is located in Alberta, Canada. The system has been successfully purifying waste water since 2016, which is used for the extraction of oil from oil sand. The researchers are currently planning an initial production facility with a membrane area of more than 5,000 square meters. The innovative ceramic membranes also offer advantages in industrial production processes: they can be used to purify partial currents directly in the process as well as to guide the cleaned water in the cycle, which saves water and energy.

http://www.innovations-report.com

UK

Algae water treatment

Replacing chemical treatments with algae farming could make wastewater treatment cheaper and more sustainable, according to researchers at Bath University who are testing the method in partnership with Wessex water. The method is particularly suited to removing phosphorus from sewage, an increasing problem for water treatment.

The Bath team, led by chemical engineer Tom Arnot and Prof Rod Scott of the Department of Biology and Biochemistry, is trying an approach that turns the problems posed by phosphorus into an advantage. Phosphorus-containing wastewater

streams are fed into shallow ponds that have been seeded with algae, and phosphorus acts as a fertiliser encouraging the aquatic plant to grow. This reduces the level of phosphorus in the water. Some of the water and algae mixture is then removed into a settling pond, and the "polished" water, whose quality is suitable for it to be released into rivers and ponds, is separated, leaving the algae behind. The treatment pond is refilled with more wastewater.

The method is currently under test with a small pond at Beckington sewage treatment works. Known as a high rate algal pond (HRAP), it is seeded with algae that can be used as a feedstock for bioplastics, biofuels and agricultural fertiliser. The pond, with a surface area of 60m^2, treats around 3000l of wastewater per day, and is removing 80 to 96 per cent of phosphorus content. The team is hoping to confirm that HRAPs such as this are practical in the inconsistent light and temperature conditions of the UK weather, and believe this method may be particularly suited to smaller sewage treatment works that serve communities of around 1000 people, of which Beckington is a good example.

"In theory, HRAPs could offer an environmentally friendly and sustainable way of removing phosphorus from wastewaters and consequently improving the health of our rivers and lakes without a massive increase in consumer's water bills," said Dimitris Kaloudis, a research associate and operator of the trial. "In this trial, one of the first of its kind, we are looking to establish how the technology performs in realistic scales and conditions as well as to understand and address any challenges that may arise during the course of the trial."

The trial is one of a number being carried out by water and sewerage companies in England and Wales to investigate new phosphorus removal techniques.

https://www.theengineer.co.uk

Seawater desalination breakthrough

Scientists at the University of Manchester have developed graphene oxide membranes with holes small enough to filter out salt. The sieves represent a technological breakthrough in the effort to make desalination more efficient and affordable.

Graphene oxide membranes have been used in desalinatio experiments for years, but never before has the sieve been small enough to filter out smaller particles. One of the major challenges with this process is the natural tendency of graphene oxide membranes to swell in water. This causes their pores to expand, and salt particles to pass through. The scientists, led by Rahul Nair, were able to control the swelling by building epoxy resin walls around the membranes, as noted in the study published in *Nature Nanotechnology*.

"Realization of scalable membranes with uniform pore size down to atomic scale is a significant step forward and will open new possibilities for improving the efficiency of desalination technology," Nair said. "This is the first clear-cut experiment in this regime. We also demonstrate that there are realistic possibilities to scale up the described approach and mass produce graphene-based membranes with required sieve sizes."

https://www.ecowatch.com

NORTH AMERICA

USA

New method for solar desalination

A team of researchers from Rice University in Houston, Texas, has developed a new method for using solar power to desalinate sea water. Part of a federally funded research effort into water treatment, the team has developed a system utilizing a combination of membrane distillation and nanophotonics to turn salt water into fresh drinking water. The team at the Center for Nanotechnology Enabled Water Treatment (NEWT) built on an emerging technology known as membrane distillation, whereby hot salt water is flowed across one side of a porous membrane and cold freshwater across the other, and water vapor is drawn through to the cold side, to create its new 'Nanophotonics-enabled solar membrane distillation' (NESMD) technology.

"Unlike traditional membrane distillation, NESMD benefits from increasing efficiency with scale," said Naomi Halas, leader of NEWT's photonics research. "It requires minimal pumping energy for optimal distillate conversion, and there are a number of ways we can further optimize the technology to make it more productive and efficient."

The technology developed by NEWT integrates engineered nanoparticles, which the team says can harvest as much as 80% of sunlight to generate steam, into the porous membrane, essentially turning it into one sided heating element that heats the water to drive distillation through the membrane. In a study described in the *Proceedings of the National Academy of Sciences journal*, researchers demonstrated proof of concept for the technology based on tests using an NESMD chamber about the size of three postage stamps. The membrane contained a top layer of carbon black nanoparticles, which heat the entire surface when exposed to sunlight.

Qilin Li, Rice University Scientist and water treatment expert, said that the team had already made a larger system of around 70 x 25 centimeters, and that NEWT is hoping to scale the technology up to a modular design where customers could calculate how many panels they need based on their daily water demand. "Direct solar desalination could be a game changer for some of the estimated 1 billion people who lack access to clean drinking water," says Li. "This technology is capable of providing sufficient clean water for family use in a compact footprint, and it can be scaled up to provide water for larger communities."

https://www.pv-magazine.com

Sunlight powered water-purifier

Researchers from the University at Buffalo may have found a solution to purify saltwater and contaminated water at a fraction of the cost. The scientists improved on the common solar still. They improved the efficiency and the freshwater generation rate via a cheap portable device that can convert clean water 2.4 times faster than leading commercial products. Their results are published in *Global Challenges*. "Using extremely low-cost materials, we have been able to create a system that makes near maximum use of the solar energy during evaporation," lead

researcher Qiaoqiang Gan, an associate professor of electrical engineering in the University at Buffalo School of Engineering and Applied Sciences, said in a statement. "At the same time, we are minimizing the amount of heat loss during this process."

The device is a solar vapor generator, which uses the heat from the Sun to evaporate the water and thus separate it from bacteria, salt, and soot. The water vapor is then condensed into drinkable water. "People lacking adequate drinking water have employed solar stills for years, however, these devices are inefficient," says Haomin Song, also at the University of Buffalo and one of the study's leading co-authors. "For example, many devices lose valuable heat energy due to heating the bulk liquid during the evaporation process. Meanwhile, systems that require optical concentrators, such as mirrors and lenses, to concentrate the sunlight are costly."

The breakthrough for the team was to use paper coated in carbon black that absorbs the water and maximizes the amount of sunlight absorption. The device, which is as big as a mini-fridge, floats and uses only surface water, so it can be used on any body of water. The generator, according to the team, can produce between 3 and 10 liters of freshwater a day. Based on the current cost of the material, the device is roughly $1.60 per square meter. It could be brought down even further if they were produced in bulk.

http://www.iflscience.com

Method to clear pollutants from water

A new method developed at MIT could provide a selective alternative for removing even extremely low levels of unwanted compounds. The new approach is described in the journal *Energy and Environmental Science*, in a paper by MIT postdoc Xiao Su, Ralph Landau Professor of Chemical Engineering T. Alan Hatton, and five others at MIT and at the Technical University of Darmstadt in Germany.

The system uses a novel method, relying on an electrochemical process to selectively remove organic contaminants such as pesticides, chemical waste products, and pharmaceuticals, even when these are present in small yet dangerous concentrations. The approach also addresses key limitations of conventional electrochemical separation methods, such as acidity fluctuations and losses in performance that can happen as a result of competing surface reactions.

In the new system, the water flows between chemically treated, or "functionalized," surfaces that serve as positive and negative electrodes. These electrode surfaces are coated with what are known as Faradaic materials, which can undergo reactions to become positively or negatively charged. These active groups can be tuned to bind strongly with a specific type of pollutant molecule, as the team demonstrated using ibuprofen and various pesticides. The researchers found that this process can effectively remove such molecules even at parts-per-million concentrations.

Previous studies have usually focused on conductive electrodes, or functionalized plates on just one electrode, but these often reach high voltages that produce contaminating compounds.

By using appropriately functionalized electrodes on both the positive and negative sides, in an asymmetric configuration, the researchers almost completely eliminated these side reactions. Also, these asymmetric systems allow for simultaneous selective removal of both positive and negative toxic ions at the same time, as the team demonstrated with the herbicides paraquat and quinchlorac. The same selective process should also be applied to the recovery of high-value compounds in a chemical or pharmaceutical production plant, where they might otherwise be wasted, Su says. "The system could be used for environmental remediation, for toxic organic chemical removal, or in a chemical plant to recover value-added products, as they would all rely on the same principle to pull out the minority ion from a complex multi-ion system."

The system is inherently highly selective, but in practice it would likely be designed with multiple stages to deal with a variety of compounds in sequence, depending on the exact application, Su says. "Such systems might ultimately be useful," he suggests, "for water purification systems for remote areas in the developing world, where pollution from pesticides, dyes, and other chemicals are often an issue in the water supply. The highly efficient, electrically operated system could run on power from solar panels in rural areas for example."

Unlike membrane-based systems that require high pressures, and other electrochemical systems that operate at high voltages, the new system works at relatively benign low voltages and pressures, Hatton says. And, he points out, in contrast to conventional ion exchange systems where release of the captured compounds and regeneration of the adsorbents would require the addition of chemicals, "in our case you can just flip a switch" to achieve the same result by switching the polarity of the electrodes.

http://news.mit.edu

Clean Energy Education and Empowerment

The Clean Energy Education and Empowerment Technology Collaboration Programme (C3E TCP) of the International Energy Agency (IEA) aims to raise awareness, share best practices, establish a network for information exchange and commit to action across borders so that more women are encouraged and empowered to become leaders in clean energy. The C3E TCP provides an international platform that will focus on four distinct areas: data collection, career development, recognition and awards programmes and dialogue.

For more information, access:

C3E TCP
E-mail: C3E-TCP@iea.org
Web: https://www.iea.org/tcp/cross-cutting/c3e/

Technological gaps and innovation endeavours relating safe and sustainable water in developing countries

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Abstract

The growing water scarcity is reckoned to be a major threat towards sustainable socio-economic development where the marginalized communities are more at risk in terms of access and quality of water. The challenges being faced in water sector are somehow interlinked with many other sectors especially food, health, ecosystem, and climate change. The Post 2015 Agenda of Sustainable Development Goals recognizes the *water* as a separate agenda though interlinked with several other goals and targets set under SDG-2030. The challenges however relating to safe and sustainable water especially in developing countries in relation to technological gaps and innovation endeavors are required to be understood which mainly include; growing water scarcity, deteriorating water quality, obsolete water infrastructure, lack of water education, and climate change impacts. Less investment in science and technology in developing countries and little support from the developed nations towards technology transfer and knowledge sharing, have been some of the missing actions during the past world's agenda of MDGs. The application of science and technology through partnerships sand innovative technological solutions can play pivotal role as such actions can not only meet the requirements of developed nations but also could be indigenized to support the marginalized populations especially women and children in developing and under developed countries. The application of ICT for building baseline database and introduction of innovative low-cost water management and conservation solutions are way forward especially for the developing and marginalized nations.

State of water

The freshwater availability is only 3% while looking at the total available water on the global scale. Above all, its distribution is not uniform amongst the regions and the countries, resulting serious management and distribution issues. The freshwater sources are under growing pressures due to population growth, droughts, flooding, pollution, and competition from many sectors (USEPA, 2014). Looking at the world population expanding by 80 million annually, the demand for freshwater is increasing by about 64 BCM (billion m^3) per year (WWAP, 2010). In fact, water withdrawals have increased three times over the last 50 years associated with population growth. As the water sources are finite, it has been desirous to best manage the needs of growing populations for drinking, food and civic services thus setting requirements for scientific and technological knowledge and innovations.

After the conclusion of Millennium Development Goals, the Post 2015 Agenda of Sustainable Development Goals recognizes the importance of knowledge as a force of sustainable development where the technology can play a vital role in achieving the set goals and targets towards 2030 (UN-Water et al., 2015). Less investment in science and technology in developing countries and little support from the developed nations towards technology transfer and knowledge sharing have been some of the missing actions during the past world's agenda of MDGs. The water was not given much appreciation as given in SDGs as a separate Goal-6 "*Ensure availability and sustainable management of water & sanitation for all*". The innovative technological solutions in this regard can play pivotal role as these can not only meet the requirements of developed nations but also could be indigenized to support the marginalized populations especially women and the children in developing and under developed countries (ECOSOC, 2017). The global 2030 agenda emphasizes more on working closer regardless of developed or under-developed nations to find solutions through maximization of science and technology applications (Giovannini et al., 2015). This is also important to avoid future major disasters in the form of more food insecure people, malnutrition, droughts, floods and more importantly the overall human security. The actions and policies to strengthen STI (science, technology and innovation) and human capacity building in every country are required to advance knowledge and innovation so that utilizing scientific evidence to help informed policies and science-based solutions (Sachs et al., 2016). Water is central to 17 Goals set under global 2030 agenda, having more or less direct bearing on the socio-economic development of the countries, if properly managed and utilized for the best purposes. The challenges being faced in water sector are somehow interlinked with many other sectors especially food, health, ecosystem, and climate change. The subject

article analyzes the challenges relating safe and sustainable water especially in developing countries in relation to technological gaps and innovation endeavors.

Challenges relating safe and sustainable water

Water scarcity

Water security is not primarily the result of having enough water. Internationally, water scarcity does not itself determine the success or failure of a country's economic and social development. It is more important that countries should recognize the limits of their water endowments and try best to manage within their means. Singapore despite being a water scarce country, has a booming economy having developed water management competencies being recognized internationally (Muller et al., 2009). The global rapid population growth therefore caused the potential water availability to decline from 12,900 m^3 capita per year in 1970 to 9,000 m^3 in 1990, and to about 7,000 m^3 in 2000 (UNEP, 2010). The world's population is further projected to expand from current 6.3 billion to 9.0 billion people by 2050, out of which nearly 3 billion would be living in developing countries, many of which are already experiencing water scarcity (UNESCO, 2012). The future situation is therefore more alarming as the world by 2050 will need to grow 60% more food which will increase up to 100% for developing countries (UNESCO, 2015).

Worldwide, agriculture accounts for 70% of all water consumption, compared to 20% for industry and 10% for domestic use (UNESCO, 2012). In industrialized nations, however, industries consume more water than available for human use. In developing countries like Pakistan, the agriculture on one side is the major contributor in GDP and employment, whereas on other side is consuming 93% of country's available water in contrast to domestic (4%) and industry (3%). The agriculture production has been continuously increasing due to increasing population—34 million in 1950 to current nearly 200 million—as seen from increase in design cropping intensity of 75% to currently about 150% in Pakistan (Qureshi and Sarwar, 2009). This has been at the cost of crop intensification and resource exploitation, resulting numerous complex management and sustainability issues such as waterlogging and salinity, declining groundwater aquifers, deteriorating quality of surface and underground water bodies, mismatching supplies coupled with climate change impacts and above all poorly regulated water sector. The estimates show that the water shortage in Pakistan would be of the order of 31% up to 2025 (Table 1) due to population increase and consequent demand for more food and fiber (GoP, 2001). The situation is not different in most developing countries such as in North Africa where water resources are already almost entirely withdrawn (95% of available water). In 2025, large water inflows are needed from other regions to meet the demand which will grow up to 130% (Peterson and Klepper, 2007).

The agriculture is the major user of water and at the same time most of water losses are being observed in this sector mainly due to technological gaps and innovation. For example, in Pakistan the overall irrigation system efficiency is 40% due to number of inherent reasons (Hussain et al., 2011; GoP, 2013), the important ones are: the obsolete irrigation method of flood irrigation still practicing over an estimated irrigated area of 70% out of 14 million hectares (Mha), typical mindset of applying more water to get more yield without knowledge of actual crop requirements and irrigation scheduling (Hossain et al., 2017), unregulated groundwater sector allowing irrational groundwater pumping causing groundwater depletion and salinization (Qureshi, 2011). Since overwatering reduces crop yield and increases the cost of maintaining the supply of groundwater pumping, many farmers do not find farming profitable enough to sustain their livelihood (Hossain et al., 2017).

Water quality

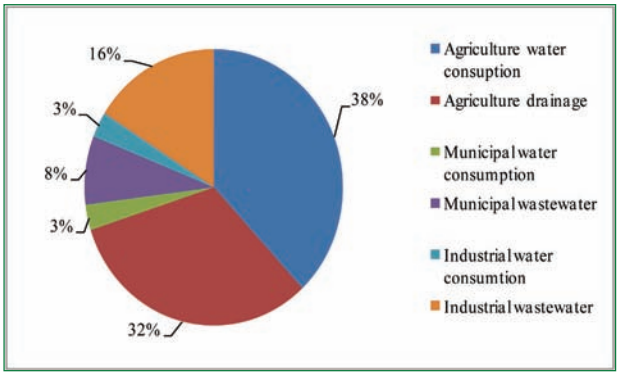
The safe drinking water supply is not only a basic need and prerequisite for a healthy life but it is also a fundamental human right. This can be judged from global trends, as well as from Pakistan's national and local struggles for better access to safe quality and adequate quantity of drinking water, especially under Global SDG-2030 agenda. The freshwater sources however are coming under strict scrutiny due to continuous reduction in per capita availability globally in general and developing countries in particular. The fresh water bodies are getting readily contaminated due to rapidly growing population, industry and anthropogenic factors. Resultantly, consumption of contaminated and unsafe drinking water is resulting into water borne diseases (Nabeela, et al., 2014). FAO's AQUASTAT database estimates global freshwater withdrawals as 3185 MAF (Figure 1), out of which 56% (1739 MAF) is released into the environment in the form of municipal and industrial effluent, and agriculture drainage (UNESCO, 2017). On average, high-income countries treat about 70% of their wastewater, while it drops to 28% in lower middle-income countries. In low-income countries, only 8% of industrial and municipal wastewater undergoes treatment of any kind (Sato et. al, 2013). The situation is more serious for the poor living in slums, who are often directly exposed to untreated wastewater due to lack of water and sanitation services.

About 30,000 hectares of land is irrigated with wastewater and 25% vegetables consumed in Pakistan are produced through wastewater irrigation (IWMI, 2011). The destinations of contaminants from all these ori-

Table 1: Water availability and demand in Pakistan

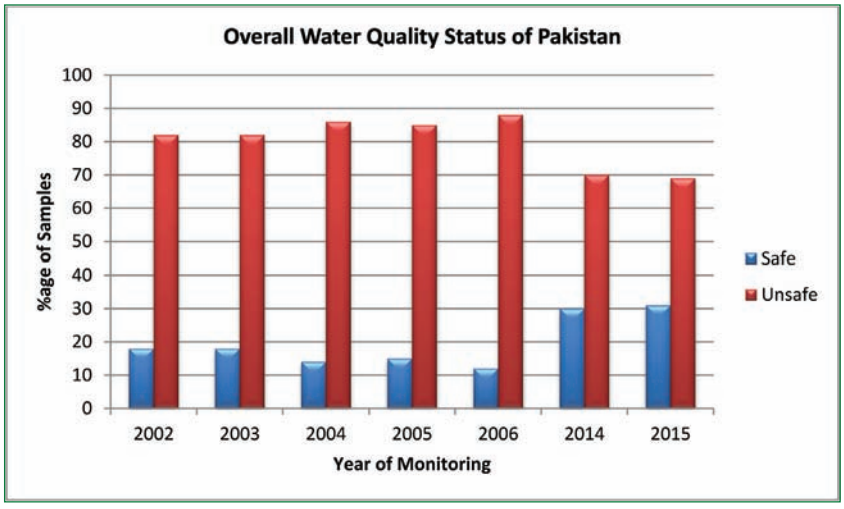
Year	2004 (MAF)	2025 (MAF)
Availability	104	104
Requirement (including drinking water)	115 (3.5%)	135 (4.0%)
Overall Shortfall	11	31

Source: GoP, 2001



Source: UNESCO, 2017

Figure 1: Global freshwater withdrawals: consumption and wastewater



Source: www.pcrwr,gov.pk

Figure 2: Long term overall water quality status in pakistan

gins are water bodies, which ultimately enter into blood stream of humans through food and drinking water thereby causing multiple diseases (Kahlown et al., 2006). The lack of water quality monitoring and database has been the main limitations in the safe supply of drinking water, highlighting the application of scientific and technological tools (Chouler and Lorenzo, 2015).

A leading example is the implementation of national water quality monitoring program by Pakistan of Research in Water Resources (PCRWR) from 2002 to 2015, covering major cities of Pakistan. According to monitoring reports, more than 80% samples were found unsafe for human consumption (Kahlown et al., 2008). The major contaminants found were bacteria (69%), Arsenic (24%), Nitrate (14%) and Fluoride (5%). Based on such database and knowledge, the respective local governments took up corrective measures and also adopted clustered approach for immediate solution by installing filtration plants for safe supply of drinking water. During the year (2014-2015), same sampling sites were selected for monitoring purpose. In 2015, some improvement in water quality of public and private sources has been observed (69% on overall basis) with bacteriological (57%), turbidity (9%), nitrates (7%), TDS (11%), arsenic (7%) and fluoride (3%).

Similar monitoring was also conducted in the rural areas of Pakistan from 2004 to 2010 (Table 2). The situation was almost similar in the rural areas as out of 14,000 samples collected, only 2,550 (18%) were found safe and 82% water samples were found unsafe according to the drinking water quality standards (Tahir et al., 2010).

The major reason for the above water quality situation is direct disposal of wastewater to water bodies without any care for the environmental pollution as the overall treatment is not more than 10% in Pakistan (Bhatti et al., 2009). By 2030, the global demand for energy and water is however expected to grow by 40% and 50%, respectively (UN-Habitat, 2016). Such increase will be more felt in cities where wastewater management will require some innovative approaches where availability of land is a major issue. Such innovative solutions of wastewater management may also provide answers to some other challenges, especially energy generation from solid waste and effluents.

Poor infrastructure

Safe water supplies immediately improve people's health and save their time, which they can use to study, or improve their livelihoods, so that they can earn more, eat healthy foods, and enjoy more healthy lives (ADB et al., 2006, Chouler and Lorenzo, 2015). The investments in water infrastructure and services play a catalyst role for local development in contrast to traditional approach particularly in the developing countries where there is less investment on water infrastructure as compared to other sectors of development (e.g. highways, residential and energy). In developing regions, such as South-East Asia and Africa, fluoride and arsenic are compounds of major concern (WaterAid, 2011). In India alone, it is estimated that 66 million are at risk due to high fluoride content in groundwater and over 10 million due to excess arsenic (Khurana and Sen, 2008).

Over 10,000 existing public and community operated water supply schemes were monitored in Pakistan from 2006 to 2012, out of which about 72% schemes were functional. Out of the 72% functional schemes, only 23% in urban and 14% in rural areas were providing safe drinking water (Table 3). The main reasons were: obsolete infrastructure, maintenance issues due to insufficient technical and human capacity, and lack of water education and awareness (Tahir et al., 2011, 2012 and 2013).

Table 2: Drinking water quality monitoring in rural areas of Pakistan

Province	Districts	Union councils	Villages	Samples collected	No. of water samples			
					Safe		Unsafe	
					No.	%age	No.	%age
Punjab	12	1,227	2,090	10,440	2,183	21	8,257	79
Sindh	3	54	149	745	212	28	533	72
Khyber Pakhtunkhawa	4	211	240	1,200	89	7	1,111	93
Balochistan	4	54	298	1,465	05	03	1,460	99
Federal Capital Area	1	21	30	150	61	41	89	59
Total	**24**	**1567**	**2807**	**14,000**	**2,550**	**18**	**11,450**	**82**

Source: Tahir et al., 2010

Table 3: Water quality assessment of water supply schemes

Province	Districts surveyed	Water supply schemes	Surveyed water supply schemes			Functional	Samples safe for drinking (%)	
			Total	Urban	Rural		Urban	Rural
Punjab	33	4100	3883	746	3137	2725	17	23
Sindh	22	1300	1247	123	1124	529	5	5
KP	16	3000	2203	474	1729	1710	63	26
Balochistan	14	1600	1034	480	554	968	20	13
GB/AJK/FATA	10	2000	1794	18	1776	1379	8	2
Total	**95**	**12000**	**10161**	**1841**	**8320**	**7311**	**23**	**14**

Source: Tahir et al. 2011, 2012 and 2013

In another study, water quality monitoring carried out during unprecedented flood of 2010 in Sindh and Baluchistan provinces of Pakistan revealed that out of 1839 water samples collected from 621 water supply schemes provided that only 22% schemes were delivering water fit for drinking (Tahir et al., 2011). At world level, significant investment is required to renew and upgrade infrastructure, estimated at USD 6.7 trillion by 2050 for water supply and sanitation, while including a wider range of water-related infrastructure could triple that bill by 2030 (OECD, 2015). Freshwater management (surface and groundwater) in general involves a plethora of public, private and other stakeholders in the decision making, policy, project implementation and operation.

Lack of water education

There is much consensus that most of the water issues are related to lack of water education and poor water governance. Water management generally receives little social and political attention in comparison to water supply challenges, especially in the context of water scarcity. Still the two are inherently inter-linked – neglecting wastewater can have highly detrimental impacts on the sustainability of water supplies, human health, the economy and the environment.

Although the most important drivers of water use are population and economic development, but also changing societal views on the value of water (IPCC, 2008). Most of the water losses in the system are due to lack of awareness and follow conventional methods of water use in most of the sectors mainly agriculture, domestic and industry. The importance and value of water is still missing in the literature especially under the scenario of climate change. In our daily life, we waste plenty of water starting from getting ready for office or school, women in the kitchen keeping taps open while cooking or washing, and leakage from public taps due to poor maintenance. About 150-200 liters of water is wasted due to leakage from taps (Ashraf, 2015).

There is need to raise water consciousness among users at grass root levels (gender inclusive) in order to bring water conservation into their lifestyles and to develop positive changes in their behavior relating water conservation. For this, it is also needed to develop effective educational approaches and materials on water management and protection. Youth can play a vital role in this connection. Through schools and colleges we can engage them in educational opportunities about water, science, and technology to create future generation of water stewards and innovators. Similarly, poor water governance is also one of the major reasons of water scarcity. Most of the developing countries still lack comprehensive regulatory framework and policies to control irrational use of water, over-pumping and disposal of wastewater into the freshwater sources.

Climate change impacts

According to 5th assessment of Intergovernmental Panel on Climate Change (IPCC), the global average temperature has increased by 0.85 °C (0.65–1.06 °C) during 1800–2012 (IPCC, 2013), and during the last hundred years (1906–2005), it is observed as 0.74±18 °C (IPCC, 2007). This projected global warming is likely to intensify and disturb the hydrologic cycle of the world. As a result, the hydrologic system is likely to face changes in water availability and extreme events (Khattak et al., 2011). Climate change due to global warming has greatly affected the agricultural activities as well not only in Pakistan but also in the globe. An increase in temperature observed in Pakistan, especially during the last few decades is very sharp. Future trend is also showing the rapid increase in temperature (Figure 3). This increase in temperature will directly influence the evapotranspiration rate and water requirement of crops, in the country (Naheed and Rasul, 2010).

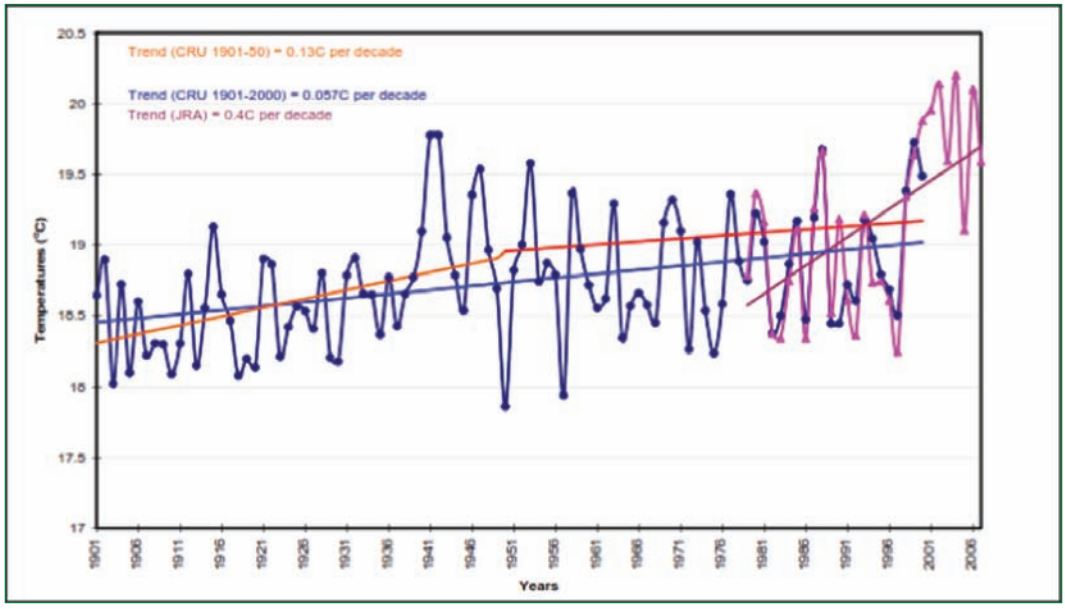
The Tibetan Plateau and surroundings contain the largest number of glaciers outside the polar regions which act as the headwaters of many prominent Asian rivers which are largely experiencing shrinkage and affecting the inflows of large rivers such as the Indus. It has been suggested that both the temperature as well as the precipitation levels in the Tibetan Plateau will increase in the next 90 years (Yao et al., 2012). Climate change and its variability are therefore likely to affect water availability and magnitude for irrigated agriculture and hydropower production in the surrounding countries. There is evidence that the overall average annual river inflows at different rim stations in Pakistan have decreased to about 27% (200 to 147 km^3) in a period of just half a century from 1961 to 2010 (IUCN, 2011).

Due to increasing water demand and consequent water scarcity, the people are more diverting to the use of groundwater thus comparatively an increasing trend in groundwater consumption. However, knowledge of current recharge and levels in both developed and developing countries is poor; and there has been very little research on the future impact of climate change on groundwater, or groundwater–surface water interactions (IPCC, 2008). Groundwater flow in shallow aquifers is part of the hydrological cycle and is affected by climate variability and change through recharge processes especially in the water scarce or drought hit areas (Chen et al., 2002). As the frequency of floods and droughts is increasing due to climate change impacts, this may also modify the water quality which in turn will have impact of sea-level rise on storm water drainage operations and sewage disposal in coastal areas.

The advance knowledge of climate change in connection with impacts on water sustainability remains a question mark as most of scientists still hesitate to appreciate the climate change impacts rather relating it with the increasing population and consequent development needs (IPCC, 2008).

Water security through scientific transformation and innovative solutions

Water is one of the most important factors required for sustaining life, requiring proper attention in terms of uses, management and sustainability. The challenges for scientists and engineers working in the field of water are emerging day by day due to growing demands and technological advancements (Kumar et al., 2014). Thereby the effective use of new techniques and innovations are unavoidable. In order to deal with current and future challenges, it requires robust public policies, targeting measurable objectives in pre-determined time-schedules at the appropriate scale, defining clear tasks and responsibilities across responsible

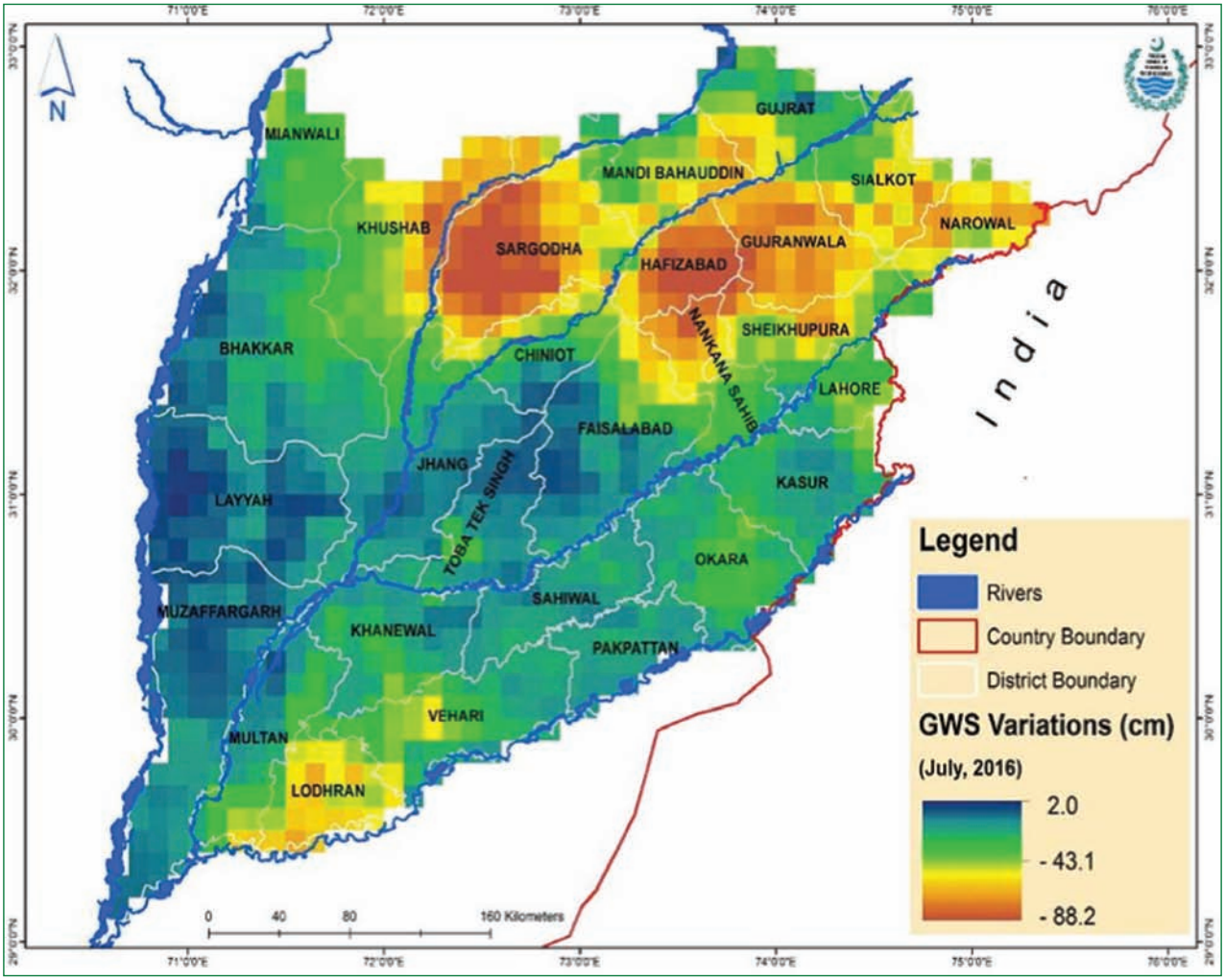


Source: Naheed and Rasul, 2010

Figure 3: Average temperature of Pakistan 1901 – 2008

Source: Hossain et al., 2017

Figure 4: A Pakistani farmer checks his cell phone for weather updates and estimates of how much irrigation water he will need over the next few days



Source: pcrwr.gov.pk

Figure 5: Groundwater fluctuations in Indus Basin

authorities, and subject to regular monitoring and evaluation (OECD, 2015).

South Africa reportedly is using 98% of the available water resources, out of which 60% are allocated to agriculture sector which contributes only 3% of GDP and 7% to employment but agro-processing industry contributes 20% of its GDP. Due to its progressive policies, the country has reached universal access to an improved water source in urban areas whereas in rural areas it increased from 63% to 88% from 1990 to 2012 (WHO and UNICEF, 2014), winning Stockholm Industry Water Award in May 2014 for its transformative and inclusive approach (SIWI, 2014). Approximately 1.3 million hectares of land are irrigated out of which 50,000 ha are small landholdings (UNEP, 2009). The productive use of water for agriculture may be seen from the fact that new Irrigation Development Strategy by the Department of Agriculture proposed expansion of a 600,000 ha additional irrigation land to be fed from water-loss savings and improved irrigation efficiency (Water Affairs Department, 2008).

Similarly, Singapore has limited natural water resources mainly lakes and groundwater. In the past, it was primarily dependent on imported water from Malaysia and rainwater as the major sources of water supply before the 2000s (Public Utilities Regulations, 2004). In a bid to ensure an adequate and sustainable supply of fresh water, the Singapore government adopted various scientific and management strategies in the last two decades to diversify its sources of water supply, manage water demand, and support the development of local water industry (Legislative Council Secretariat, 2016). Currently, the average Singapore resident uses 150 liters of water per day. The government is seeking a reduction to 140 liters by 2030, which is thought not to be enough to prevent future water scarcity. As such, the Singapore government has planned to further expand the capacity to produce NEWater and desalinated water to the extent of meeting up to 55% and 25% of the country's total water demand by 2060, respectively (EWIPO, 2014). Because of its focus on water independence, Singapore is now considered a global leader in water management and technology. Despite a continuous increase in population (now 5.4 million, but expected to increase to 6.9 million by 2030), Singapore is expected to become water-independent by 2060, a year before the expiration of its final water import treaty with Malaysia (Paulson, 2017).

In agriculture sector, even modern farmers lack knowledge of the actual crop water requirement and latest management tools rather relying on the knowledge has been handed down from previous generations. For instance, the water requirements for rice, which consumes more than 60% of irrigation water in Pakistan, are 600 mm in Punjab Province and 1400 mm in Sindh Province (Soomor et al., 2015). In contrast, the farmers apply almost 2200 mm (50 to 60% more if adding application losses on the field and watercourse), resulting in not only a substantial loss of water but also lowering crop yields in addition to extra fuel cost to pump water. In Pakistan, PCRWR in collaboration with University of Washington's SASWE Research Group launched an initiative of Irrigation Advisory through Cell Phone technology in 2016 sending weekly irrigation notifications via text message (Figure 4). These messages are customized according to location and crop type. After completing the pilot project, PCRWR conducted an impact analysis and surveyed the farmers' perceptions of this resource. The encouraging feedback helped to inform PCRWR's plan to scale the program up to 10,000 farmers in 2017. As the Irrigation Advisory is getting popular, the plan is to launch this program nationwide once cell phone operators expand coverage (Hossain et al., 2017).

The groundwater management involves pre-requisite monitoring of groundwater through laborious and expensive task of field observations. However, with the technological advancement, satellite based monitoring (GRACE data application) has made it possible to regularly monitor the groundwater fluctuations (Figure 5) even in large basins like Indus (Iqbal et al., 2016). This advance level monitoring allows frequent information during the year for better management of ground water resources toward sustainability.

In conclusion, it is inferred that application of information technology (ICT) along with scientific and technological solutions, may help achieving the water security with limited resources. The much stressed partnerships under SDG-2030 agenda regardless of developed and developing nations are achievable through mutual collaboration and innovative solutions.

References

- ✓ ADB, UNDP, UNESCAP, and WHO. (2006). Asia Water Watch 2015: Are Countries in Asia on Track to Meet Target 10 of the Millennium Development Goals? 2006 Asian Development Bank.
- ✓ Ashraf, M. (2015). Importance of Water in the Light of Quran and Sunnah and Ways of its Saving, Pakistan Council; of Research in Water Resources (www.pcrwr.gov.pk).
- ✓ Bhatti, Z.A., Mahmood, Q., Raja, I.A., Malik, A.H., Rashid, N., Khan, Z.M. and Maqbool, F. (2009). Low-cost municipal wastewater treatment options for use in Pakistan – A review. A *Scientific Journal of COMSATS – SCIENCE VISION*, Vol. 15 No.1 (January to June 2009).
- ✓ Chen, M., Xie, P. and Janowiak, J.E. (2002). Global land precipitation: a 50-yr monthly analysis based on gauge observations. *Journal of Hydrometeorology*, 3:249–266.
- ✓ Chouler, J. and Lorenzo, M.D. (2015). Water quality monitoring in developing countries: Can microbial fuel cells be the answer?. *Biosensors,* 2015(5):450–470. doi:10.3390/bios5030450.
- ✓ ECOSOC. (2017). Role of Technology in Implementing and Monitoring the SDGs, Economic and Social Council Youth Forum, Trusteeship Council Chamber, United Nations Headquarters, New York, 30 January 2017.
- ✓ EWIPO. (2014). Available from: http://www.pub.gov.sg/EWI/Pages/default.aspx [Accessed February 2016]. Environment & Water Industry Programme Office.
- ✓ Giovannini, E., Niestroy, I., Nilsson, M., Roure, F. and Spanos, M. (2015). The Role of Science, Technology and Innovation Policies to Foster the Implementation of the Sustainable Development Goals Report of the Expert Group "Follow-up to Rio+20, notably the SDGs.

Directorate-General for Research and Innovation, Climate Action, Environment, Resource Efficiency and Raw Materials, European Commission. B-1049 Brussels.

- ✓ GoP. (2001). Ten Year Perspective Development Plan 2001-11, Planning Commission of Pakistan, Government of Pakistan, 2001.
- ✓ GoP. (2013). Pakistan Vision 2025, One Nation – One Vision, Planning Commission, Government of Pakistan, 2013.
- ✓ Hossain, F., Biswas, N., Ashraf, M. and Bhatti, A.Z. (2017). Growing More with Less Using Cell Phones and Satellite Data, Eos, 98, Earth and Space Science News. https://doi.org/10.1029/2017EO075143. Published on 21 June 2017.
- ✓ Hussain, I, Hussain, Z., Maqbool, H., Akram, S.W. and Farhan, M.F. (2011). Water balance, supply and demand and irrigation efficiency of Indus basin. *Pakistan Economic and Social Review,* 49(1) (Summer 2011): pp. 13–38.
- ✓ IPCC. (2007). Climate Change 2007: the physical science basis. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (Eds), Contribution of Working Group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge.
- ✓ IPCC. (2008). Climate change and water, intergovernmental panel on climate change, June 2008.
- ✓ IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovern-mental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535pp.
- ✓ Iqbal, N., Hossain, F., Lee, H. and Akhter, G. (2016). Satellite gravimetric estimation of groundwater storage variations over Indus basin in Pakistan. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 1939-1404 © 2016 IEEE.
- ✓ IUCN. (2011). Water resources of Pakistan: The government's main objectives, in Pakistan Water Gateway. Available from http://waterinfo.net.pk/?q=node/19.
- ✓ IWMI. (2011). 25 Years research achievements, Colombo, Sri Lanka.
- ✓ Kahlown, M.A., Ashraf, M., Hussain, M., Salam, H.A. and Bhatti, A.Z. (2006). Impact assessment of sewerage and industrial effluents on water resources, soil, crops and human health in Faisalabad, PCRWR Research Report 2006.
- ✓ Kahlown, M.A., Tahir, M.A. and Rasheed, H. (2008), 5th Water Quality Monitoring Report 2005–2006. PCRWR Publication No. 133-2007, June 2008, Islamabad.
- ✓ Khattak, M.S., Babel, M.S. and Sharif, M. (2011). Hydro-meteorological trends in the upper Indus River basin in Pakistan. *Climate Research*, 46:103–119. doi: 10.3354/cr00957.
- ✓ Khurana, I. and Sen, R. (2008). Drinking Water Quality in Rural India: Issues and Approaches. WaterAid: Delhi, India, 2008.
- ✓ Kumar, M., Singh, G., Chaminda, T., Quan, P.V. and Kuroda, K. (2014). Emerging water quality problems in developing countries. *Scientific World Journal,* May 12, 2014; Vol. 2014: 215848.
- ✓ Legislative Council Secretariat. (2016). Fact Sheet: Overview of water resources management in Singapore, Research Office Information Services Division, Legislative Council Secretariat, 26 February 2016, South Africa.
- ✓ Muller, M., Schreiner, B., Smith, L., Koppen, B.V., Sally, H., Aliber, M., Cousins, B., Tapela, B., Merwe-Botha, M.V.D., Karar, E. and Pietersen, K. (2009). Water security in South Africa, Development Planning Division Working Paper Series No. 12, Midrand.
- ✓ Nabeela, F., Azizullah, A., Bibi, R., Uzma, S., Murad, W., Shakir, S.K., Ullah, W., Qasim, M. and Donat-Peter Häder, D.P. (2014). Microbial contamination of drinking water in Pakistan—A review. *Environmental Science and Pollution Research*, 14 July 2014, Springer-Verlag Berlin Heidelberg 2014, DOI 10.1007/s11356-014-3348-z.
- ✓ Naheed, G. and Rasul, G. (2010). Recent Water Requirement of Cotton Crop in Pakistan. *Pakistan Journal of Meteorology,* Vol. 6, Issue 12, January 2010.
- ✓ OECD. (2015). OECD Principles on Water Governance, Directorate for Public Governance and Territorial Development, 4 June 2015, https://www.oecd.org/cfe/regional-policy/OECD-Principles-on-Water-Governance-brochure.pdf.
- ✓ Paulson, L.D. (2017). Singapore a model for effective water management, February 17, 2017, https://www.rwlwater.com/water-management-in-singapore/.
- ✓ Peterson, S. and Klepper, G. (2007). Potential impacts of water scarcity on the world economy. In: Lozán, J.L., Grassl, H., Hupfer, P., Menzel, L. and Schönwiese, C.-D. Global change: Enough water for all? *Wissenschaftliche Auswertungen*, Hamburg 384 S. Online: www.klima-warnsignale.uni-hamburg.de.
- ✓ Public Utilities Regulations. (2004). Available from: http://statutes.agc.gov.sg/aol/search/display/view.w3p;page=0;query=CompId%3Ae14596dd-2344-0e90fdbbf50eb07843%20ValidTime%3A20160104000000%20.
- ✓ Qureshi, A.S. (2011). Water management in the Indus Basin in Pakistan: Challenges and Opportunities. *Mountain Research and Development, International Mountain Society*, 31(3):252–260.
- ✓ Qureshi, A.S. and Sarwar, A. (2009). Managing salinity in the Indus Basin of Pakistan. *International Journal of River Basin Management*, Vol. 7, No. 2 (2009), pp 111–117.
- ✓ Sachs, J.D., Modi, V., Figueroa, H., Fantacchiotti, M.M., Sanyal, K., Fahmida Khatun, F. and Shah, A. (2016). ICT and SDGs: How Information and Communications Technology Can Achieve The Sustainable Development Goals. The Earth Institute, University of Columbia, USA and ERICSSON, Sweden (https://www.ericsson.com/res/docs/2015/ict-and-sdg-interim-report.pdf).
- ✓ Sato, T., Qadir, M., Yamamoto, S., Endo, T. and Zahoor, A. (2013). Global, regional, and country level need for data on wastewater generation, treatment, and use. *Agricultural Water Management*, 130(2013), 1–13 August 2013.
- ✓ SIWI. (2014). "Most progressive water utility in Africa" wins 2014 Stockholm Industry Water Award (http://www.siwi.org/prizes/winners/2014-2/).
- ✓ Soomro, Z.A., Arshad, M.D., Ijaz, K., Bhatti A.Z. and Ashraf, M. (2015). Rice cultivation on beds—An efficient and viable irrigation practice. PCRWR Report 2015. Pakistan Council of Research in Water Resources, Islamabad.
- ✓ Tahir M.A., Akram, C.M., Hasan F. and Farooque, M. (2011). Report on Technical Assessment of Water Supply Schemes, Northern and Central Punjab, Vol. I & II, PCRWR Publication No. 149/2011, November 2011, Islamabad, Pakistan.

- ✓Tahir M.A., Akram, C.M., Hasan F. and Farooque, M. (2012). Report on Technical Assessment of Water Supply Schemes, Sindh Province, Vol. I & II, PCRWR Publication No. 150/2012, February 2012, Islamabad, Pakistan.
- ✓Tahir M.A., Akram C.M., Hasan F., and Farooque M. (2013). Report on Technical Assessment of Water Supply Schemes, Gilgit-Baltistan, Vol. I & II, PCRWR Publication No. 152/2013, January 2013, Islamabad, Pakistan.
- ✓Tahir, M.A., Malik, M.A. and Bhatti, A.H. (2011). Post Flood Water Quality Assessment Report. PCRWR, Islamabad.
- ✓Tahir, M.A., Rasheed, H. and Imran, S. (2010). Water Quality Status in Rural Areas of Pakistan. PCRWR Publication No. 143-2010. ISBN 978-969-8469-34-4.
- ✓UN-Water, AQUAE and WCCE. (2015). Water and Sustainable Development. Water for Life 2005–2015. Water Monographies, WM 3, 2015.
- ✓UNEP. (2009). Chief Liquidity Series, Agribusiness. Water-related materiality briefings for financial institutions. Issue 1, October 2009, International Environment House, Genève, Switzerland.
- ✓UNEP. (2010). Vital Water Graphics, An overview of the state of the world's fresh and marine waters: 2nd Edition. United Nations Environment Programme: 2008. Accessed June 15, 2010. http://www.unep.org/dewa/vitalwater/article186.html.
- ✓UNESCO. (2012). WWAP (World Water Assessment Programme). The United Nations World Water Development Report 4: Managing Water under Uncertainty and Risk. Paris, UNESCO.
- ✓UNESCO. (2015). WWAP (United Nations World Water Assessment Programme). The United Nations World Water Development Report 2015: Water for a Sustainable World. Paris, UNESCO.
- ✓UNESCO. (2017). Facts and Figures: Wastewater: The Untapped Resource. The United Nations World Water Development Report 2017, UN-Water and UNESCO.
- ✓UN-Habitat. (2016). Urbanization and development: emerging futures. World Cities report 2016. United Nations Human Settlements Programme, 2016.
- ✓USEPA. (2014). Promoting Technology Innovation for Clean and Safe Water, Water Technology Innovation Blueprint—Version 2, U.S. Environmental Protection Agency Office of Water, April 2014.
- ✓Water Affairs Department. (2008). Water for growth and development in South Africa, Version 6, November 2008, Water Affairs Department, South Africa.
- ✓WaterAid. (2011). *Water Quality Standards and Testing Policy*; WaterAid: London, UK, 2011.
- ✓WHO and UNICEF. (2014). Progress on Drinking Water and Sanitation. 2014 Update, WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland.
- ✓WWAP (2010). "Water in a Changing World," UN Water Development Report 3, (World Water Assessment Programme, 2009), Accessed June 21, 2010. http://www.unesco.org/water/wwap/wwdr/wwdr3/pdf/WWDR3_Facts_and_Figures.pdf
- ✓Yao, T., Thompson, L., Yang, W., Yu, W., Gao, Y., Guo, X., Yang, X., Duan, K., Zhao, H., Xu, B., Pu, J., Lu, A., Xiang, Y., Kattel, D.B. and Joswiak, D. (2011). Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings. *Nature Climate Change*, 663–667 (2012), 15 July 2012, doi:10.1038/nclimate1580

2017 UN World Water Development Report, Wastewater: The Untapped Resource

Most human activities that use water produce wastewater. As the overall demand for water grows, the quantity of wastewater produced and its overall pollution load are continuously increasing worldwide. Over 80% of the world's wastewater – and over 95% in some least developed countries – is released to the environment without treatment. Once discharged into water bodies, wastewater is either diluted, transported downstream or infiltrates into aquifers, where it can affect the quality (and therefore the availability) of freshwater supplies. The ultimate destination of wastewater discharged into rivers and lakes is often the ocean with negative consequences for the marine environment.

The 2017 edition of the United Nations World Water Development Report, entitled "Wastewater: The Untapped Resource", demonstrates how improved wastewater management generates social, environmental and economic benefits essential for sustainable development and is essential to achieving the 2030 Agenda for Sustainable Development. In particular, the Report seeks to inform decision-makers, government, civil society and private sector, about the importance of managing wastewater as an undervalued and sustainable source of water, energy, nutrients and other recoverable by-products, rather than something to be disposed of or a nuisance to be ignored.

The report's title reflects the critical role that wastewater is poised to play in the context of a circular economy, whereby economic development is balanced with the protection of natural resources and environmental sustainability, and where a cleaner and more sustainable economy has a positive effect on the water quality.

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ARSENIC AND THE PROVISION OF SAFE AND SUSTAINABLE DRINKING WATER

ASPECTS OF INNOVATION AND KNOWLEDGE TRANSFER

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Abstract

Safe and sustainable drinking water supplies underpin societies at all stages of economic development. Increasing population, increased standards of living and local and global environmental factors will variably play a role in the Asia-Pacific countries in increasing water stress and reliance on finite vulnerable groundwater resources, many of which are prone to contain hazardous concentrations of arsenic. Arsenic in groundwater-derived drinking water supplies is currently impacting the health and economic productivity of millions of people in these regions. Innovative remediation technologies include graphene oxide based filtration, as well as technologies, such as organic and microbial destruction, that make alternative, hitherto avoided, water sources, as more attractive to consumers, regulators and suppliers. Management of drinking water supplies, including appropriate treatment for arsenic, requires a holistic approach, considering (i) strategic and operational priorities, (ii) criteria for selection of the most appropriate, in a local and/or regional context, treatment and management options in the context of formalised water safety plans, and (iii) effective participation in networks to underpin timely knowledge transfer of relevant robust innovations in the management and treatment of water supplies.

Introduction

Arsenic is toxic and a known human carcinogen (IARC, 2012). Detrimental health outcomes arising from chronic exposure to arsenic from drinking water include cancers (especially skin, lung, bladder, kidney), hypertension and cardiovascular diseases, diabetes mellitus, pulmonary disease, peripheral vascular disease, skin lesions and neurological illnesses and sadly for many people ultimately premature death (Smith et al., 2000). The scale of premature mortality and morbidity attributable to arsenic in drinking water is far greater than that of any other known chemical – the devastation caused in Bangladesh alone has been described as the "largest mass poisoning of a population in history" (Smith et al., 2000). Arsenic-attributable premature mortality in Bangladesh, the country most impacted, is estimated to be on the order of 40,000 (after Argos et al., 2010) and given the extensive exposures outside of Bangladesh, the global figure is likely to be several times this value.

A journalist asked me the other day why so little had been done to remedy the high arsenic content of drinking water supplied to hundreds of millions of people around the world and particularly in the Asia-Pacific region. I replied that this possibly reflected one or more of the following:

(i) Most people are not aware that arsenic in drinking water is responsible for the premature deaths of perhaps as many as 100,000 people every year.

(ii) Most consumers cannot detect arsenic in their drinking water as it is colourless, tasteless and odourless.

(iii) Most people are unaware that heart disease, cancer and suppression of the immune system are all risks associated with regular drinking of water with 10 µg arsenic/L.

(iv) Even many water sector professionals have been unaware that there is increasing evidence of harm arising from consumers regularly drinking water with arsenic concentrations lower than the WHO (World Health Organization) provisional guide value of 10 µg arsenic/L.

(v) Most consumers are not aware that even more people than those that are exposed through drinking water are exposed to arsenic through eating rice, including that irrigated by high arsenic groundwater, and that in West Bengal, India, such rice consumption has been associated with elevated genotoxic effects in consumers (Banerjee et al., 2013).

(vi) Many countries have economic and/or health problems that are, or are perceived as, more pressing.

(vii) Where, nevertheless, substantive efforts have been made to remediate water supplies, difficulties in monitoring, particularly in dispersed small sources, together with additional issues of real-world deployment of laboratory-tested technologies, have led to serious challenges in many impacted countries.

The requirement to effectively reduce toxic arsenic from drinking water sources has become an explicitly recognised component of Goal 6 of the Sustainable Development Goals (SDGs) (UNESCAP/ADB/UNDP, 2017). Furthermore, appropriately integrative innovative solutions have the

potential to further address interlinked SDGs through all of economic, social and environmental dimensions (cf. UNESCAP, 2017). There is increasing evidence for the detrimental economic impacts of high arsenic in drinking water (Gibson et al., 2017) as well as, particularly given the serious age-dependent (Lindberg et al., 2008) and gender-dependent social (Sultana, 2009) and medical (Vahter et al., 2007) consequences of chronic arsenic poisoning, increasing evidence for householders' willingness to pay for appropriate water treatment (Gibson et al., 2016). With increased education, increased public access to the internet and increasing published and otherwise voiced concerns over arsenic in water supplies, public concerns over arsenic in their water supplies can reasonably be predicted to increase. This likely will result in pressures for tighter, more effective regulation and consequently regulatory and financial drivers, including avoidance of fines and reputational damage, for water suppliers, including both companies and public organisations, to consider and implement more effective arsenic remediation.

This article considers some of the recent and current innovations and issues relevant to remedying high arsenic water supplies whilst also considering the wider aspects of knowledge transfer and management helpful to better ensuring safe and sustainable water supplies. Much of what is discussed here may also be applicable to improving water quality with respect to other constituents. A reference list is provided for those interested in more in-depth coverage than is possible here.

Environmental drivers of water quality with respect to arsenic

High concentrations of arsenic in drinking water sources are typically found in groundwaters, although some surface water sources may also have elevated concentrations. High arsenic concentrations in surface waters may derive from natural geothermal inputs (Lord et al., 2012), acid rock drainage, evaporation of saline inland lakes, from upland peats (Rothwell et al., 2009) and more rarely and sporadically from volcanic emissions, as well as from anthropogenic sources, including sulphide-bearing mine and mine treatment sites, industrial waste sites and sites for the manufacture and application of arsenic-bearing pesticides, herbicides and wood preservatives (Polya and Middleton, 2017). High concentrations of arsenic are more widely found in groundwaters, typically derived from (i) microbially mediated reductive dissolution of arsenic-bearing Fe/Mn oxyhydroxide host mineral phases (Islam et al., 2004); (ii) desorption in oxidised groundwaters (Guo et al., 2011); (iii) oxidative dissolution of arsenic bearing sulfides, notably pyrite and arsenopyrite (Smedley and Kinniburgh, 2002); (iv) geothermal inputs (Lord et al., 2012); and less extensively, from (v) anthropogenic inputs. There is also extensive debate (Harvey et al., 2002; van Geen et al., 2003; Polya and Charlet, 2009; Lawson et al., 2016) about whether or not and to what extent massive withdrawals of groundwater for irrigation purposes may be leading to secular increases in groundwater arsenic, particularly in intensively rice-cultivated areas of circum-Himalayan Asia.

High arsenic groundwaters are found in many parts of world. Densely populated deltaic regions of South Asia (e.g. West Bengal, Bangladesh) and South-East Asia (Viet Nam, Myanmar, Cambodia) are areas of particularly pronounced high groundwater arsenic hazard. Global occurrences have been collated by Ravenscroft et al. (2009). Maps of the probability of high arsenic hazard in both reducing and oxidising groundwaters on a global scale have been generated by Amini et al. (2008), whilst similar maps are available for South-East Asia (Winkel et al., 2008), Cambodia (Sovann and Polya, 2014) and China (Rodriguez-Lado et al., 2013) – several of these maps have been collated by Eawag (2017) and geostatistical methodologies discussed by Bretzler et al. (2017).

There are several ways in which environmental factors control drinking water quality with respect to arsenic and consideration of these factors can be useful to inform mitigation options. Notably:

(i) There are clear patterns in the geological environments that are associated with many (but not all) high arsenic groundwaters, for example the geographic distribution of relatively recent orogenic belts (Mukherjee et al., 2014).

(ii) The biogeochemical environment within aquifers plays a key role in controlling the rate and extent to which arsenic may be transferred from aquifer solid phases, in which it represents no substantive risk to human health, to groundwater, in which – depending how the groundwater is used and treated – it may contribute to very substantive human health risks (Smedley and Kinniburgh, 2002).

(iii) Changes in climate, with geographically variable negative or positive impacts on availability of surface waters and on groundwater recharge over the next few decades (Jiménez Cisneros et al., 2014).

(iv) Extremes of rainfall may, on the one hand, in times of low rainfall lead to a deficiency in surface water supplies, whilst on the other, in time of high rainfall lead to flooding and contamination of surface water supplies rendering them less suitable or unsuitable for human consumption – these events may lead to increased demand for groundwater, with the typically higher potential for high arsenic hazard than surface waters.

Regulatory aspects of water quality with respect to arsenic

The regulation of arsenic in drinking water has had a chequered history and, arguably, still is chequered at present. The WHO guideline value for arsenic in drinking water is (and has been since 1993) 10 µg/L (WHO, 2011) and whilst this is widely adopted as a regulatory standard in many countries around the Asia-Pacific region, less protective national regulatory standards of 50 µg/L, equal to the previous (1963) WHO guideline value, are also widespread. In the USA, the 10 µg/L value did not become an enforceable requirement until as recently as 2006. The current WHO guideline value

is described (WHO, 2011) as a "provisional value" reflecting (i) uncertainties in adverse health effects associated with chronic exposure to arsenic in drinking water with concentrations much less than 100 µg/L; and (ii) "practical difficulties in removing arsenic from drinking-water, particularly from small supplies, and the practical quantification limit for arsenic" (WHO, 2011, p.317).

Much of the uncertainty in quantifying adverse health effects arises from (i) the commonness otherwise of many of the health effects (e.g. lung cancer, cardiovascular disease), (ii) the presence of multiple confounding factors (e.g. gender, age, diet, smoking status, other lifestyle factors, genetic susceptibility and exposure to arsenic from other sources such as rice and other foodstuffs) and (iii) arguably that the most robust epidemiological studies on the adverse health effects of chronic exposure to arsenic in drinking water have been conducted on populations exposed to relatively high concentrations of more than 100 µg/L. Extrapolating epidemiological data from such high concentrations to lower concentrations has therefore required the adoption of an assumed model for extrapolation. However this is thwart with difficulties particularly as, NRC (2001) have concluded that "the available mode-of-action data on arsenic do not provide a biological basis for using either a linear or nonlinear extrapolation" or indeed for determining whether or not there is a threshold below which there are no effects.

Meharg and Raab (2010) amongst others, point out that, with many analytical methods capable of quantifying arsenic at concentrations as low 0.02 µg/L, 50 times lower than the WHO provisional guideline value, analytical constraints should not, in the interests of protecting public health, be cited as a valid reason for the provisional adoption of the 10 µg/L guide value.

Notwithstanding the difficulty and expense of sufficiently powerful epidemiological studies to accurately determining dose–response relationships at drinking water concentrations around 10 µg/L and the difficulty of accurately extrapolating higher concentration data to these concentrations, there is increasing evidence that there are substantial adverse health effects associated with consumption of drinking water with arsenic concentration both at and lower than the WHO 10 µg/L provisional guideline value. WHO (2011) cite NRC (2001) modelled likelihood estimates for just lung and bladder cancer alone for USA residents drinking water with arsenic concentrations 10 µg/L to be between 120 and 230 per 100,000 – far higher than the 10 in 100,000 often muted as the upper limit of acceptable cancer risks from drinking water. Smith et al. (1992) estimate the lifetime risk of dying of lung, liver, bladder or kidney cancer from the same 10 µg/L exposure to be 1300 per 100,000 people. Leonardi et al. (2012) estimated adjusted relative risks of acquiring basal cell carcinomas in populations exposed to 7.0–19.43 µg/L arsenic in drinking water relative to a control population to be 1.73 (confidence interval 0.97, 3.11) i.e. 73% more likely to acquire this form of skin cancer. Medrano et al. (2008) report fully adjusted cardiovascular and coronary heart disease mortality rates in Spain were 2.2% (–0.9 %, 5.5%) and 5.2% (0.8%, 9.8%) higher in the population supplied with drinking water with arsenic concentrations of 1–10 µg/L than in that supplied with less than 1 µg/L.

Drivers and barriers for improving water quality with respect to arsenic

There are multiple drivers for water suppliers to improve water quality, in general, and with respect to arsenic, in particular. These include: (i) regulatory compliance and fulfilment of statutory obligations; (ii) avoidance of financial or reputational penalties; (iii) improved customer satisfaction; (iv) improved profits; and (v) the moral imperative underpinning multiple SDGs (UNESCAP/ADB/UNDP, 2017).

However, there are also multiple barriers for water suppliers to improve water quality, including with respect to arsenic. These include: (i) costs in relation to benefits; (ii) lack of desire or awareness of the need to improve water quality; (iii) competing challenges and projects; (iv) lack of awareness of relevant innovations, including in treatment technologies; (v) lack of communication of robustly tested innovative treatment technologies; and (vi) conservative attitudes to change.

An often used description of the water sector in many countries is that it operates in a very conservative risk-averse manner (Alegre et al., 2015). This might be taken to be criticism of a sector generally less likely to adopt disruptive technologies or other innovations than some other sectors, but equally water suppliers typically have substantive responsibilities and obligations to a wide range of stakeholders and the costs of selecting and implementing innovative remediation technologies or procedural/management that do not fully fulfil their predicted operational benefits can be very substantive indeed. Careful consideration of approaches therefore seems prudent.

Criteria for selection of approaches to improve water quality with respect to arsenic

Selection of water remediation approaches can benefit from being done in the context of water safety plans (Davison et al., 2005; see also Richards, 2017). There is a generally not a "one-size-fits-all" best solution, but rather selection criteria need to be used to assess the differing requirements depending upon (i) whether the treatment required is for wastewater or point of entry (POE), centralised points of supply or more dispersed point of end use (POU); (ii) the nature of existing water treatment infrastructure; (iii) the chemical and physical nature of the water being treated and including the nature and extent of other chemical hazards requiring treatment; (iv) stakeholder perceptions; and (iv) budgetary and logistic constraints.

The Committee of Innovation Remediation Technologies, National Research Council (CIRT-NRC, 1997) identified 3 major categories of criteria for selection of remediation approaches, viz. (i) technological performance; (ii) commercial characteristics and (iii) stakeholder acceptability.

Technological performance criteria (CIRT-NRC, 1997) include: (i) improvement in water quality against the relevant regulatory or otherwise selected target value; (ii) robustness – effectiveness of technology over a range of environmental

conditions including water composition and flow rates; (iii) forgiveness – effectiveness of the technology over a range of operating conditions; (iv) ease of implementation; (v) ease of maintenance including required down-time; (vi) ease of scale-up; (vii) compatibility with existing treatment plant and, if appropriate, ease of retro-fitting; (viii) predictability of performance; (ix) minimal production of secondary harmful components, including CO2; and (x) operational lifetime of plant or key components.

Commercial criteria (after CIRT-NRC, 1997) include: (i) capital costs; (ii) operating costs; (iii) replacement costs of whole plant or plant components with respect to anticipated component lifetimes; (iv) availability of technology with respect to licensing or patent restrictions; (v) availability of materials and appropriate trained/expert human resources; (vi) reduction of risk of regulatory non-compliance with respect to anticipated regulatory targets; (vii) overall profitability with respect to the availability of capital and organisational financial performance and targets otherwise.

The relevant major stakeholders include (i) consumers (i.e. public); (ii) regulators; (iii) innovation users (e.g. water supply organizations); (iv) innovation providers (e.g. research organizations) and facilitators (e.g. knowledge transfer networks, industry associations); (v) investors; (vi) insurance companies; and (vii) personnel implementing innovation (e.g. treatment plant workers). Recognising diversity (e.g. related to class and/or gender) of opinions and priorities within stakeholder classes is highly relevant (cf. Crow and Sultana, 2002). Stakeholder acceptability criteria include: (i) compliance with regulatory requirements; (ii) disruption to consumers and local communities; (iii) impacts on environmental and economic amenity; (iv) impacts on taste; and (v) safety of operations.

Amongst other factors, both (i) the maturity of technologies and approaches and (ii) the readiness of communities to aspect remediation options (Kot et al., 2014) may both be critical criteria, which may change over time, particularly if efforts are made to facilitate this. The technology readiness level (TRL) (Mankins, 1995) is a useful metric with 9 stages, ranging from TRL 1 (least mature), where basic principles are observed and reported, up to TRL 9 (most mature) where an actual system has been implemented successfully in the intended operational environment. Such a metric may be useful in risk management and/or decision making in the selection of an appropriate remediation technology as well as identifying technologies that might be useful in the future and which might warrant investment to develop and/or commercialise – such activities represent a potential particularly fruitful area for collaboration between research organisations, manufacturers and suppliers of relevant technologies and water supply companies, and which can be facilitated by all of government, water sector companies and relevant professional organisations.

Decision-making

If nothing else, the lists above reflect the complexity of decision-making where there are (i) multiple selection criteria, many of which are inter-dependent; (ii) multiple stakeholders, who, in turn, may be involved in complex dependencies and relationships; and (iii) notwithstanding the particular importance of arsenic, a multiplicity of other water quality components, inorganic, organic and microbiological, satisfactory control of which is required. Given these circumstances, decision-support systems (DSSs) become increasingly important and represent a major area for innovation and opportunity.

DSSs in the water sector have, to date, largely focussed on the management of water supply, i.e. volume of supply and, to that end, integration with river basin management (IRBM) or groundwater basin scale management. Such approaches include drought modelling (Mishra and Singh, 2011), watershed management (Reddy et al., 2017) and variably utilise approaches including regression analysis, time series analysis, artificial neutral networks, fuzzy expert systems and data mining. Perhaps, in part, because of the complexity and the integration of scales sometimes sensibly required, many of these models have focussed on physical-geographical variables, for example spatio-temporal distribution of rainfall, evapotranspiration, land-use, vegetation types and integration of processes and models over various scales.

There is increasing recognition, however, as to the importance of human activities in modifying water supply, including at the basin-scale, and this has led to innovative and more complex modelling permitting the integration of physical-geographic parameters and processes with socio-economic parameters as well as processes involving various types of stakeholders or agents. Kelly et al. (2017) review five such modelling approaches including the use of System Dynamics, Bayesian Networks, Coupled Component Models, Knowledge Based Models and Agent-Based Modelling. These models are of variable relative utility depending upon the nature and availability of input data, the degree of understanding of relevant processes, the importance of feedback loops and whether or not aggregated affects or interactions between individual stakeholders is preferred (Kelly et al., 2017). How effective these approaches are depends upon the motivation and abilities of stakeholders (cf. Phi et al., 2015). Additionally, the effectiveness of these approaches may also depend upon how they are utilised – for example, agent-based modelling (cf. Harou et al., 2009) might best be utilised by narrowing down the number of broadly equivalent options to be considered and which may then be selected by expert experiential judgement of relevant professionals – thus providing a synergistic balance between highly technical modelling expertise and commercial expertise in circumstances where it is impractical to robustly quantify the relevant weighting of disparate selection criteria (after J. Harou, pers. comm.).

Whilst the purpose of various modelling approaches may primarily be for decision-making, the involvement of stakeholders and the nature of the modelling process may also contribute to one or more of: (i) greater capability to deal with uncertainty

in key parameters, both in the present and in the future; (ii) increased understanding of the relevant environmental/operational/socio-economic systems; and (iii) increased social learning, that is "the capacity of a social network to communicate, learn from past behaviour, and perform collective action" (Kelly et al., 2017 after Fraternali et al., 2012 and Haapasaari et al., 2012). The latter is particularly relevant to decision-making in the management of complex water supplies and infrastructure involving inputs from and impacts on multiple stakeholders with diverse interests and views. Additionally, such social learning may impact positively on the effectiveness of participatory approaches to decision-making and to acceptance by consumers (cf. Leventon et al., 2017a; 2017b).

Arsenic remediation approaches

Human exposure to arsenic in drinking water may be reduced in one or more of two ways, notably:

(i) Removal of arsenic from water supplies (cf. Ravenscroft et al., 2009; Hering et al., 2017).
(ii) Switching to alternative lower arsenic concentration water supplies (cf. van Geen et al., 2003).

Methods for the removal of arsenic from water supplies have been reviewed by many authors including by Ravenscroft et al. (2009) and more recently by Hering et al. (2017), who also list NGOs who have further usefully reviewed information on drinking water treatments. Conventional treatments typically make use of one of more of (cf. Ahmad et al., 2017) (i) precipitation/coagulation/filtration; (ii) adsorption/ion exchange; (iii) membrane filtration; (iv) oxidation; and/or (v) bioremediation, including microbial treatments (Hayat et al., 2017). Advances are currently being made or have the potential to be made in the areas, amongst others, of (a) the use of nano-particles, such as nano zero valent iron (NZVI) to sorb arsenic (Habuda-Stanić and Nujić 2015); (b) graphene oxide for arsenic removal by sorption (Kumar et al., 2014) or potentially through ion-specific tunable nano-filtration (Abraham et al., 2017); and (c) novel metal-organic frameworks (Sarker et al., 2017). Hristovski and Markvoski (2017) highlight the potential benefits of better understanding the thermodynamics and kinetics of contaminant-sorbent interactions to enable the engineering of most appropriate sorbents, including nanocomposites, for particular target chemicals and matrices.

Notwithstanding all these technological solutions, increasing the supply of low arsenic water could be as much about putting in place practices to encourage switching water supplies as it could remove arsenic from an existing (typically groundwater) supply – such practices could include: (i) reducing per capita water demand through education programmes, household practices or agricultural practices (e.g. reducing over-irrigation of rice and other crops); (ii) effective monitoring (cf. Polya and Watts, 2017), evaluation of populations at risk (cf. Crabbe et al., 2017), biomonitoring (Middleton et al., 2016) and communication of arsenic-attributable risks to stakeholders (cf. Polya et al., 2017) (iii) removing microbiological pathogens and organics, such as pesticides and emerging pharmaceutical and other contaminants, from low arsenic waters (cf. organics destruction technology reported by Brown et al., 2004; Nabeerasool et al., 2015), making them more attractive and suitable as alternative water supplies; (iii) development of further alternative water sources, e.g. through rainwater harvesting or managed aquifer recharge. At a time when there are increasing concerns voiced over the "emerging water gap" between demand and supply (2030 Water Resources Group, 2009), reducing the pressure to use arsenic-bearing groundwater for drinking water by reducing the overall demand for water is an attractive win-win option for both addressing water supply and, indirectly, arsenic water quality issues.

Final word – Promoting innovation and knowledge transfer

The water sector across the Asia-Pacific region face increased population, lifestyle and climate-related challenges of both water supply and water quality (WWAP, 2015). Rapid development of communication technologies and social media platforms and the massive increase in open access scientific publications, together with the increased recognition of detrimental health impacts of drinking water arsenic even at what were once considered "low" concentrations is likely to drive tighter regulation of arsenic in water supplies. Such regulation may, to a large extent, be driven by consumer and other stakeholder perceptions and attitudes.

Science, technological and social science innovation will play a key role in the water sector meeting the demands of a changing world. Increased effective communication and partnership working between water sector stakeholders, including innovators (in research organisations or departments in both the public and private sector) and knowledge transfer professionals and organisations (such as knowledge transfer offices, technology innovation centres, Catapults) will create opportunities to meet these challenges. Despite the obvious commercial constraints, there are strong proponents of building upon knowledge transfer initiatives to "Open Innovation 1.0" (i.e. facilitating innovation along value chains through enhanced interactions between innovators and stakeholders) to "Open Innovation 2.0" (i.e. integration of activities beyond bilateral transactions to multi-lateral collaborations involving co-creation by consortia) (EC, 2014). Entrepreneur-driven SMEs may play a pivotal role, both as innovators and as innovation intermediaries. Given the commercial risks, initiatives such as risk sharing instruments and public-private finance are argued by some (EC, 2014) to be key support to facilitate the supply of appropriate venture capital to promote both effective knowledge transfer and open innovation. Lastly, in a sector in which investment is substantially driven by regulatory regimes (IAM, 2013), national governments have a critical role in setting standards and drawing up policy, including in relation to the basis and nature of water pricing.

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References

- ✓ 2030 Water Resources Group. (2009). Charting our water future: Economic frameworks to inform decision-making. Available from http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/charting-our-water-future. Accessed 18 July 2017.
- ✓ Abraham, J., Vasu, K.S., Williams, C.D., Gopinadhan, K., Su, Y., Cherian, C.T., Dix, J., Prestat, E., Haigh, S.J., Grigorieva, I.V., Carbone, P., Geim, A.K. and Nair, R.R. (2017). Tunable sieving of ions using graphene oxide membrane. *Nature Nanotechnology,* 12:546.
- ✓ Ahmad, A., Richards, L.A. and Bhattacharya, P. (2017). Arsenic Remediation of Drinking Water: An Overview. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water*. IWA Publishing, Chapter 7, ISBN13: 9781843393856.
- ✓ Alegre, H., Coelho, S.T., Feliciano, J.F. and Matos, R. (2015). Boosting innovation in the water sector – the role and lessons learned from collaborative projects. *Water Science and Technology*, 72:1516–1523.
- ✓ Amini, M., Abbaspour, K.C., Berg, M., Winkel, L., Hug, S.J., Hoehn, E., Yang, H. and Johnson, A.C. (2008). Statistical Modelling of Global Geogenic Arsenic Contamination in Groundwater. *Environmental Science and Technology*, 42:3699–3675.
- ✓ Argos, M., Kalra, T., Rathouz, P. J., Chen, Y., Pierce, B., Parvez, F., Islam, T., Ahmed, A., Rakibuz-Zaman, M., Hasan, R., Sarwar, G., Slavkovich, V., van Geen, A., Graziano, J. and Ahsan, H. (2010). Arsenic exposure from drinking water, and all-cause and chronic-disease mortalities in Bangladesh (HEALS): a prospective cohort study. *Lancet*, 376:252–258.
- ✓ Banerjee, M., Banerjee, N., Bhattacharjee, P., Mondal, D., Lythgoe, P.R., Martinez, M., Pan, J., Polya, D.A. and Giri, A.K. (2013). High arsenic rice is associated with elevated genotoxic effects in humans. *Scientific Reports*, 3(Art 2195):1–8. DOI:10.1038/srep02195.
- ✓ Bretzler, A., Berg, M., Winkel, L., Amini, M., Rodriguez-Lado, L., Sovann, C., Polya, D.A. and Johnson, A. (2017). Geostatistical modelling of arsenic hazard in groundwaters. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water*. IWA Publishing, Chapter A3, ISBN13: 9781843393856.
- ✓ Brown, N.W., Roberts, E.P.L., Garforth, A.A. and Dryfe, R.A.W. (2004). Electrochemical regeneration of a carbon-based adsorbent loaded with crystal violet dye. *Electrochimica Acta,* 49:3269–3281.
- ✓ Crabbe, H., Close, R., Rimmell, A., Leonardi, G., Watts, M.J., Ander, E.L., Hamilton, E.M., Middleton, D.R.S., Smedley, P.L., Gregory, M., Robjohns, S., Sepai, O., Studden, M., Polya, D.A. and Fletcher, T. (2017). Estimating the population exposed to arsenic from groundwater-sourced private drinking water supplies in Cornwall, UK. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water*. IWA Publishing, Chapter A4, ISBN13: 9781843393856.
- ✓ CIRT-NRC (Committee on Innovative Remediation Technologies, National Research Council). (1997). Innovations in Ground Water and Soil Cleanup: From Concept to Commercialization. ISBN: 0-309-52148-3.
- ✓ Crow, B. and Sultana, F. (2002). Gender, class and access to water: Three cases in a poor and crowded delta. *Society & Natural Resources*, 15:709–724.
- ✓ Davison, A., Howard, G., Stevens, M., Callan, P., Fewtrell, L., Deere, D. and Bartram, J. (2005). Water safety plans: Managing drinking-water quality from catchment to consumer. World Health Organisation, Geneva. WHO/SDE/WSH/05.06.
- ✓ Eawag (Swiss Federal Institute for Aquatic Science and Technology). (2017). Risk Maps. http://www.eawag.ch/en/research/humanwelfare/drinkingwater/wrq/risk-maps/. Last modified 2017; Accessed 14 July 2017.
- ✓ European Commission (EC). (2014). Boosting Open Innovation and Knowledge Transfer in the European Union. Independent Expert Group Report on Open Innovation and Knowledge Transfer. Director-General for Research and Innovation, Directorate B – Innovation Union and European Research Area. Unit B.1 – Innovation Union Policy. European Commission, B-1049, Brussels, 80 pp.
- ✓ Fraternali, P., Castelletti, A., Soncini-Sessa, R., Vaca Ruiz, C. and Rizzoli, A.E. (2012). Putting humans in the loop: social computing for water resources management. *Environmental Modelling and Software,* 37:68–77.

- ✓ Gibson, J., Polya, D.A., Russell, N. and Sauer, J. (2017). Valuing the damage of arsenic consumption: economic non-market valuation methods. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water, IWA Publishing*, Chapter 10, ISBN13: 9781843393856.
- ✓ Gibson, J., Rigby, D., Polya, D.A. and Russell, N. (2016). Discrete choice experiments in developing countries: Willingness to Pay vs Willingness to Work. *Environmental and Resource Economics*, 65:697–721. DOI: 10.1007/s10640-015-9919-8.
- ✓ Guo, H.M., Zhang, B., Li, Y., Berner, Z., Tang, X., Norra, S. and Stüben, D. (2011). Hydrogeological and biogeochemical constraints of arsenic mobilization in shallow aquifers from the Hetao basin, Inner Mongolia. *Environmental Pollution*, 159:876–883.
- ✓ Haapasaari, P., Mäntyniemi, S., Kuikka, S. (2012). Baltic Herring Fisheries management: stakeholder views to frame the problem. *Ecology and Society,* 17(3): 36.
- ✓ Habuda-Stanić, M. and Nujić, M. (2015). Arsenic removal by nanoparticles: a review. *Environmental Science and Pollution Research,* 22(11):8094–8123.
- ✓ Harou, J.J., Pulido-Velazquez, M., Rosenberg, D.E., Medellin-Azuara, J., Lund, J.R. and Howitt, R.E. (2009). Hydro-economic models: Concepts, design, applications, and future prospects. *Journal of Hydrology,* 375(3–4):627–664.
- ✓ Harvey, C.F., Swartz, C.H., Badruzzaman, A.B.M., Keon-Blute, N., Yu, W., Ali, M.A., Jay, J., Beckie, R., Niedan, V., Brabander, D., Oates, P.M., Ashfaque, K.N., Islam, S., Hemond, H.F. and Ahmed, M.F. (2002). Arsenic mobility and groundwater extraction in Bangladesh. *Science*, 298:1602–1606.
- ✓ Hayat, K., Menhas, S., Bundshuh, J. and Chaudhary, H.J. (2017). Microbial biotechnology as an emerging industrial wastewater treatment process for arsenic mitigation: A critical review. *Journal of Cleaner Production*, 151:427–438.
- ✓ Hering, J.G., Katsoyiannis, I.A., Theoduloz, G.A., Berg, M. and Hug, S. (2017). Arsenic Removal from Drinking Water: Experiences with Technologies and Constraints in Practice. *ASCE Journal of Environmental Engineering*, 143(5).
- ✓ Hristovski, H.D. and Markovski, J. (2017). Engineering metal (hydr)oxide sorbents for removal of arsenate and similar weak-acid oxyanion contaminants: A critical review with emphasis on factors governing sorption processes. *Science of the Total Environmen*t, 598:258–271.
- ✓ IARC. (2012). A Review of Human Carcinogens: Arsenic, Metals, Fibres and Dusts. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, 100C, 501pp.
- ✓ Impax Asset Management. (2013). Investing in Water – January 2013.
- ✓ Islam, F.S., Gault, A.G., Boothman, C., Polya, D.A., Charnock, J.M., Chatterjee, D. and Lloyd, J.R. (2004). Role of metal-reducing bacteria in arsenic release from Bengal delta sediments. *Nature*, 430:68–71.
- ✓ Jiménez Cisneros, B.E., Oki, T., Arnell, N.W., Benito, G., Cogley, J.G., Döll, P., Jiang, T. and Mwakalila, S.S. (2014). Freshwater resources. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R. and White, L.L. (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 229–269.
- ✓ Kelly, R.A., Jakeman, A.J., Barreteau, O., Borsuk, M.E., El Sawah, S., Hamilton, S.H., Henriksen, H.J., Kuikka, S., Maier, H.R., Rizzoli, A.E., van Delden, H. and Voinov, A.A. (2017). Selecting among five common modelling approaches for integrated environmental assessment and management. *Environmental Modelling & Software*, 47:159–181.
- ✓ Kot, M., Castleden, H. and Gagnon, G.A. (2014). The human dimension of water safety plans: a critical review of literature and information gaps. *Environmental Reviews*, 23(1):24–29.
- ✓ Kumar, S., Nair, R.R., Pillai, P.B., Gupta, S.N., Iyengar, M.AS.R. and Sood, A.K. (2014). Graphene Oxide-MnFe2O4 Magnetic Nanohybrids for Efficient Removal of Lead and Arsenic from Water. ACS *Applied Materials & Interfaces,* 6:17426–17436.
- ✓ Lawson, M., Polya, D.A., Boyce, A.J., Bryant, C. and Ballentine, C.J. (2016). Tracing organic matter composition and distribution and its role on arsenic release in shallow Cambodian groundwaters. *Geochimica et Cosmochimica Acta*, 178:160–177.
- ✓ Leonardi, G., Vahter, M., Clemens, F., Goessler, W., Gurzau, E., Hemminki, K., Hough, R., Koppova, K., Kumar, R., Rudnai, P., Surdu, S. and Fletcher, T. (2012). Inorganic arsenic and basal cell carcinoma in areas of Hungary, Romania and Slovakia: A case-control study. *Environmental Health Perspectives*, 120:721–726.
- ✓ Leventon, J. (2017a). Community awareness and engagement for arsenic management. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water*. IWA Publishing, Chapter 9, ISBN13: 9781843393856.
- ✓ Leventon, J. (2017b). Case study: The social context of arsenic regulation and exposure in South East Hungary. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water. IWA Publishing*, Chapter A13, ISBN13: 9781843393856.
- ✓ Lindberg, A.L., Ekstrom, A.C., Nermell, B., Rahman, M., Onnerdal, B., Persson, L.A. and Vahter, M. (2008). Gender and age differences in the metabolism of inorganic arsenic in a highly exposed population in Bangladesh. *Environmental Research*, 106:110–120.
- ✓ Lord, G., Kim, N. and Ward, N.I. (2012). Arsenic speciation of geothermal waters in New Zealand. *Journal of Environmental Monitoring*, 14:3192–3201.
- ✓ Mankins, J. C. (1995). Technology readiness levels. White Paper.
- ✓ Medrano, M.J., Boix, R., Pastor-Barriuso, R., Palau, M., Damián, J., Ramis, R., del Bario, J.L. and Navas-Acien, A. (2010). Arsenic in public water supplies and cardiovascular mortality in Spain. *Environmental Research*, 110:448–454.

- ✓ Meharg, A.A. and Raab, A. (2010). Getting to the bottom of arsenic standards and guidelines. *Environmental Science and Technology*, 44:4395–4399.
- ✓ Middleton, D.R.S., Watts, M.J., Hamilton, E.M., Ander, E.L., Close, R.M., Exley, K.S., Crabbe, H., Leonardi, G.S., Fletcher, T. and Polya, D.A. (2016) Urinary arsenic profiles reveal exposures to inorganic arsenic from private drinking water supplies in Cornwall, UK. Scientific Reports, 6, Article 25656; DOI: 10.1038/srep25656.
- ✓ Mishra, A.K. and Singh, V.P. (2011). Drought modelling – A Review. *Journal of Hydrology*, 403:157–175.
- ✓ Mukherjee, A., Verma, S., Gupta, S., Henke, K.R. and Bhattacharya, P. (2014). Influence of tectonics, sedimentation and aqueous flow cycles on the origin of global groundwater arsenic: paradigms from three continents. *Journal of Hydrology* Part C(518):284–299.
- ✓ Nabeerasool, M.A., Campden, A.K., Polya, D.A., Brown, N.W. and van Dongen, B.E. (2015). Removal of metaldehyde from water using a novel coupled adsorption and electrochemical destruction technique. *Water*, 7:3057–3071.
- ✓ NRC (National Research Council). (2001). Arsenic in Drinking Water: 2001 Update. Washington, DC: National Academy Press.
- ✓ Phi, H.L., Hermans, L.M., Douven, W.J.A.M., Van Halsema, G.E. and Khan, F.M. (2015). A framework to assess plan implementation maturity with an application to flood management in Vietnam. *Water International*, 40:984–1003.
- ✓ Polya, D.A. and Charlet, L. (2009). Environmental Science: Rising Arsenic Risk? *Nature Geoscience*, 2:383–384.
- ✓ Polya, D.A. and Middleton, D.R.S. (2017). Arsenic in drinking water: sources & human exposure routes. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water.* IWA Publishing, Chapter 1, ISBN13: 9781843393856.
- ✓ Polya, D.A. and Watts, M. (2017). Sampling and analysis for monitoring arsenic in drinking water. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water*. IWA Publishing, Chapter 5, ISBN13: 9781843393856.
- ✓ Polya, D.A., Richards, L.A., Al Bualy, A.A.N., Sovann, C., Magnone, D. and Lythgoe, P.R. (2017). Groundwater sampling, arsenic analysis and risk communication: Cambodia Case Study. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water*. IWA Publishing, Chapter A14, ISBN13: 9781843393856.
- ✓ Ravenscroft, P., Brammer, H. and Richards, K. (2009). Arsenic pollution – A global synthesis. Chichester, Wiley-Blackwell.
- ✓ Reddy, V.R., Saharawat, Y.S. and George, B. (2017). Watershed management in South Asia: A synoptic review. *Journal of Hydrology*, 551:4–13.
- ✓ Richards, L.A. (2017). Selection of arsenic remediation strategies in the context of water safety plans. In Bhattacharya, P., Polya, D.A. and Jovanovic, D. (Eds.), *Best Practice Guide for the Control of Arsenic in Drinking Water*. IWA Publishing, Chapter 6, ISBN13: 9781843393856.
- ✓ Rodriguez-Lado, L., Sun, G., Berg, M., Zhang, Q., Xue, H., Zheng, Q. and Johnson, C.A. (2013). Groundwater arsenic contamination throughout China. *Science*, 341:866–868.
- ✓ Rothwell, J.J., Taylor, K.G., Ander, E.L., Evans, M.G., Daniels, S.M. and Allott, T.E.H. (2009). Arsenic retention and release in ombrotrophic peatlands. *Science of the Total Environment*, 407: 1405–1417.
- ✓ Sarker, M., Song, J.Y., and Jhung, S.H. (2017). Adsorption of organic arsenic acids from water over functionalization metal-organic frameworks. *Journal of Hazardous Materials*, 335: 162–169.
- ✓ Smedley, P. and Kinniburgh, D. (2002). A review of the source, behaviour and distribution of arsenic in natural waters. *Applied Geochemistry*, 17:517–568.
- ✓ Smith, A.H., Hopenhayn-Rich, C., Bates, M.N., Goeden, H.M., Hertz-Picciotto, I., Duggan, H.M., Wood, R., Kosnett, M.J. and Smith, M.T. (1992). Cancer risks from arsenic in drinking water. *Environmental Health Perspectives* 97:259–267.
- ✓ Smith, A.H., Lingas, E.O. and Rahman, M. (2000). Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. *Bulletin of the World Health Organisation* 78(9):1093–1103.
- ✓ Sovann, C. and Polya, D.A. (2014). Improved groundwater geogenic arsenic hazard map for Cambodia. *Environmental Chemistry*, 11:595–607.
- ✓ Sultana, F. (2009). Fluid lives: subjectivities, gender and water in rural Bangladesh. *Gender Place and Culture*, 16:427–444.
- ✓ UNESCAP. (2017). Integrated approaches for sustainable development goals planning: The case of Goal 6 on water and sanitation. UN, May 2017, Bangkok, Thailand, 57 pp.
- ✓ UNESCAP/ADB/UNDP. (2017). Asia-Pacific sustainable development goals. (Bangkok, Thailand, United Nations (ESCAP), Asian Development Bank (ADB) and the United Nations Development Programme (UNDP). DOI: http://dx.doi.org/10.22617/TCS178699-2.
- ✓ Van Geen, A., Ahsan, H., Horneman, A.H., Dhar, R.K., Zheng, Y., Hussain, I., Ahmed, K.M., Gelman, A., Stute, M., Simpson, H.J., Wallace, S., Small, C., Parvez, F., Slavkovich, V., Lolacono, N.J., Becker, M., Cheng, Z., Momotaj, H., Shahnewaz, M., Seddique, A.A. and Graziano, J.H. (2002). Promotion of well-switching to mitigate the current arsenic crisis in Bangladesh. *Bulletin World Health Organization*, 80:732–737.
- ✓ Vahter, M., Akesson, A., Liden, C., Ceccatelli, S. and Berglund, M. (2007). Gender differences in the disposition and toxicity of metals. *Environmental Research*, 104:85–95.
- ✓ Van Geen, A., Zheng, Y., Stute, M. and Ahmed, K.M. (2003). Comment on "Arsenic mobility and groundwater extraction in Bangladesh" (II). *Science*, 300:584C.
- ✓ WHO. (2011). Guidelines for Drinking-Water Quality. 4th Edition, ISBN 978 92 4 154815 1.
- ✓ Winkel, L., Berg, M., Amini, M., Hug, S.J. and Johnson, A.C. (2008). Predicting groundwater arsenic contamination in Southeast Asia from surface parameters. *Nature Geoscience*, 1:536.
- ✓ WWAP (United Nations World Water Assessment Programme). (2015). The United Nations World Water Development Report 2015: Water for a Sustainable World. Paris, UNESCO. ■

Big data analytics technology for water risk assessment and management

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Abstract

Natural disaster driven by climate variability and climate change pose major impacts to developing countries such as Malaysia. Anthropogenic climate change will add greater pressure on resources, jeopardize sustainability, and intensify inter-sectorial conflicts over water. The resulting disasters take more lives and lead to more damage such as drought and floods. For example, the massive floods occurred in Kelantan, Terengganu and Pahang in December 2014 that caused losses of about RM2.9 billion. Thus, appropriate, effective and innovative decision making tools and adaptation strategies are required to reduce the negative impacts of climate change and to achieve sustainable development specifically on water resources management. Evolution and growth of hydro-climate data would be an added advantage to conduct further analysis on water risk assessment and management. Big Data Analytics (BDA) technology is integrated as a solution to manage, utilise, maximise, and expose insight of climate change data for dealing with water related natural disasters. The aim of this paper is to emphasis on NAHRIM's BDA technology concerning to disaster management through water risk assessment and management focusing on data-driven methodology. The NAHRIM's BDA output visualisation consists of hydro-climate-environment data and information is detailed and comprehensive for facilitating stakeholders to prepare a strategic plan for mitigation and adaptation in order to combat water risk issues due to climate change. Hence, it would help to accommodate preparedness and readiness of water related disasters in the future.

Introduction

Information Technology (IT) plays a pivotal role as integrator in the disaster management system, particularly in tasks of managing the disaster data. However, the data acquired during disaster events such as floods, landslides, mud, soil erosion and so forth often presented in a large volume from heterogeneous sources, thus the data management process for natural disasters is a challenge to be tackled. Issues of heterogeneity of reliable data sources such as from sensors, social media, and others during the period of crises and disasters requires advanced and systematic analytical approach to execute disaster management plan. In times of disasters, government and authorities who act as decision makers are responsible to take action that demands immediate and fast relief activities in the devastated area. But the quality of the decision depends on the quality of data and information obtained (Emmanouil and Nikolaos, 2015). Hence, the data received in times of disaster need to be analysed thoroughly as an input to decision makers to make precise decisions in a limited and ad-hoc time manner.

Big Data Analytics (BDA) has been escalating in various sectors as it increases the value of data utilization in organisations for different purposes. The awareness and understanding of BDA among stakeholders need to be increased for ensuring the data can be analysed, improved and enriched as a new key element of economic factor that can alleviate an organisation's performance.

In BDA, analysing data requires knowledge, and insight from Subject Matter Experts (SME), specifically in the chosen domain. To embrace the understanding requirement from SME towards BDA's targeted output and outcome is another challenging process (Abdullah, 2017).

As mentioned by Phillip Russom in The Data Warehousing Institute (TDWI) Best Practices Report "Big Data Analytics" (2011), the hottest new practices in Business Intelligence (BI) today is BDA. BDA can be achieved by putting massive amounts of detailed information and advanced analytics together. BDA is not just the upgrade and expansion to legacy systems and algorithms, it requires a new set of tools to determine relevant data and to convert this data into useful knowledge (Bi and Cochran, 2014). Companies need to reconsider their methods at the system level strategically, operationally and culturally for data management, and then select the right data, and make right decisions based on it (Troester, 2012).

In the context of natural disaster management which includes water risk assessment, there are many activities that involve decision making under the time pressure. However, decision making in government usually takes much longer and is conducted through consultation and mutual consent of a large number of diverse actors, including officials, interest groups, and ordinary citizens (Kim et al., 2014). This may be due to standard operating procedure, top management discussion and so forth. How those decisions are made is important as the result of the decision-making must compromise the citizens and country accepted standards. Timely decision-making to direct and coordinate the activities of other people is important to achieve disaster management goals (Othman and Beydoun, 2013).

Natural disaster is categorised as external risk, and it cannot be typically reduced or avoided through conventional approaches as it lies largely outside human control. It requires a different

analytic approach either because their probability of occurrence is very low or it is difficult to foresee by normal strategy processes (Kaplan and Mikes, 2012). In response to great pressure for the government to provide service delivery within time and budget constraints, Big Data Analytics may be one of the possible solutions to consider as government holds a great amount of earth-related data owned by the public agencies and departments.

In Malaysia, there were 76 disasters recorded in the period of 1965 to 2016. The type of disasters including wildfire, storm, landslide, mudflows, epidemic, tsunami, drought and more than half of the disasters were flood related hazards (Amin, 2016). In this context, government agencies are the response organisations which by law are obligated to prepare for and manage such crises. Disaster management is the management of the risks and consequences of a disaster in order to reduce or to avoid potential losses from hazards (Othman and Beydoun, 2013). Disaster management is crucial in regard to provide rapid assistance and effective recovery for the victims involved.

The severe floods that occurred in December 2014 in the East Coast States were acknowledged as the worst flood events in modern history. It has been linked to excessive rainfall received and catchment encroachment (land use changes) as well as climate change impact. Based on NAHRIM's hydrological analysis conducted, it is time consuming to analyse the climate change impact with manual calculation due to the huge numbers of climate change data (3,888 gridded data, 15 scenarios and 4 realisations). Therefore, NAHRIM has taken an initiative to develop systems that can manage and evaluate the risk associated with climate change.

Big Data analytics technology trend

NAHRIM as a research institute focusing on R&D for water and environment, archives numerous water related and climate change data for Malaysia either primary or secondary data, collected through sampling activities, modelling, simulation and other R&D activities. Those data are being used for water and environment planning, supporting decision making and identifying new potential R&D areas that can be diversified into various domain such as data projection analysis, climate change impact, sea level rise projection, hydroclimate and water resources related issues (Zulkifli et al., 2015).

The evolution of data utilization through BDA has exploited the big data's potential by specifying BDA initiative as one of the national agenda. In 2013, the Prime Minister of Malaysia has officially announced the Malaysia BDA initiatives. Malaysian Administrative Modernisation and Management Planning Unit (MAMPU) has been mandated to implement the BDA pilot project in government agencies in 2015. This initiative is joined by Malaysia Digital Economy Corporation (MDEC) and MIMOS Berhad as a technology provider for this BDA project. Four public agencies with five pilot projects were selected to develop Malaysia BDA Proof-of-Concept (POC) and NAHRIM was one of them. NAHRIM's BDA POC project titled "Visualizing 90 Years of Projected Rainfall corresponding runoff after-effects based on river basin Malaysian Map" was develop to assist NAHRIM in visualising and analysing almost 1,450 simulation-years of projected hydro-climate data for Peninsular Malaysia based on 3,888 grids.

Modules Involved in this BDA POC were drought, drought & temperature, rainfall & runoff, storm centre and streamflow. We successfully proved the concept of implementing big data analytics using NAHRIM hydroclimate datasets which comprises of time-series historical, current and projected data, acquired through the modelling of historical data. We were able to visualise 3,888 grids for Peninsular Malaysia, detected extreme rainfall and runoff projection data for 90 years, identified flood flow for 11 river basins and 12 states in Peninsular Malaysia, and traced drought episodes from weekly to annual rainfall data for 90 years.

NAHRIM BDA POC project was completed in September 2015, and later in August 2016, NAHRIM BDA project has turned to full project that catered three more modules; Climate Change Factor, Water Stress Index, and Water Stress Index Simulation. With the automated and systematic BDA project, later called NAHRIM Hydro-Climate Data Analysis Accelerator (N-HyDAA) system, will reduce the current manual process by humans and improves the quality and visual of data hence saving time and cost. It will also have benefited in discovering the vast potential data, sharing information and producing more effective decision making in timely manner.

NAHRIM's BDA system has been through a systematic and thorough process to ensure result and outcome produced providing a great impact on managing water issues. Viewing from ICT standpoint, BDA implementation is focusing on resolving dedicated business issues by integrating main key players in the proposed business project. The key players in this context referring to SME who are well versed and experts about the business/domain choosen for the project. Opinions from SMEs will be the core of how the project should be understood and developed to cater the issues arising from the business.

The complete process of implementing NAHRIM's BDA (Table 1) comprises of six phases; BDA Matrix Process, Requirement Analysis, System Architecture, Data Flow Diagram, System Development and Deployment. Details on every phase of the process are explained in Table 1. In the next section, we will go in depth on three crucial phases of this process; BDA Matric Process, System Architecture and Data Flow Diagram.

NAHRIM's BDA system started by defining Business Direction and Business Problem Definition which are the main activities that guide the whole development of the project based on MAMPU assessment. In the Business Direction activity, the tasks were to identify project objectives of the proposed project based on identified business case or domain. The Key Measures as indicator that reflect the performance of the

Table 1: Detailed process of NAHRIM's BDA project

No	Process	Explanation
1	BDA Matric Process	a. Identifying Business Direction and Business Problem Definition for proposed domain and project.
2	Requirement Analysis	a. Develop Requirement Analysis Book to highlight scope of work for the proposed project. b. Itemised scope of work based on importance of features (Must Have, Should Have, Could Have and Won't Have).
3	System Architecture	a. Designing System Architecture of the project based on Requirement Analysis Book.
4	Data Flow Diagram	a. Designing Data Flow Diagram of the system to determine the input data, processing and output data.
5	System Development	a. Development of BDA System including system testing.
6	Deployment	a. Deploy the System for user practice.

project also has been identified. In the Business Problem Definition activity, the tasks were to identify Business Function/ Problem Area, Business Challenges, Problem Statements, Impact of The Problem, Business Questions and Data Sets Usage. The proposed Business Function/Problem Area is to identify the specific domain or business area for the project. The Business Challenges is to explain the current challenges faced that must be tackled. Statement that will guide through the implementation of the project is created in Problem Statements to ensure the project is on-track with the business direction. Impact or issues based on business challenges were listed in Impact of the Problem task. In Business Questions, potential question that could be asked from the project was prognosis and finally data sets that are required in the project were identified in Data Sets Usage.

Table 2 shows the essence of NAHRIM's BDA project info over NAHRIM requirement analysis. From Table 2, it shows hydrologists and engineers are the main pillar of this project that lead to the usage and direction of the project to cater issues under Climate Change (CC) domain.

Regional Hydroclimate Model (RegHCM)

Two studies have been conducted in Peninsular Malaysia by NAHRIM entitled "Study of the Impact of Climate Change on Hydrology Regimes and Water Resources (2006)" and "Extension Study of the Impact of Climate Change on Hydrology Regimes and Water Resource (2014)" to determine the expected changes in the hydrologic regime and water resources consequent to global CC and local land use changes. The extension study conducted in 2014 was based on 15 climate projections for the 21st century by 3 different coupled land-atmosphere-ocean Global Climate Models (GCMs) that are ECHAM5 of the Max Planck Institute of Meteorology of Germany, CCSM3 of the National Centre for Atmospheric Research (NCAR) of USA, and MRI-CGCM2.3.2 of the Meteorological Research Institute of Japan under four different greenhouse gas emission scenarios (A1Fi, A2, A1B, B1).

They were dynamically downscaled at hourly intervals by the Regional Hydroclimate Model of Peninsular Malaysia (RegHCM-PM) to assess the impacts of CC on 13 watersheds (Kelang, Selangor, Perak, Muda, Kelantan, Dungun, Pahang, Muar, Batu Pahat, Johor, Linggi, Kuantan and Kemaman) and 12 coastal regions (Figure 1). The RegHCM-PM is a combination of mesoscale atmospheric model and regional land surface hydrology model where it was downscaled to 6km x 6km spatial resolution. It is able to capture the impact of steep topography on local climatic conditions.

In 2010, NAHRIM has conducted a study on Impact of Climate Change on the Hydrologic Regime and Water Resources of Sabah and Sarawak (RegHCM-SS) as shown in Figure 2. Atmospheric model component of the RegHCM-SS which is similar to RegHCM-PM, is used to downscale the available global historical and climate change atmospheric databases, produced by two different coupled land-atmosphere-ocean General Circulation Models (GCMs), which are the ECHAM5 of the Max Planck Institute of Meteorology of Germany and MRI-CGCM2.3.2 of the Meteorological Research Institute of Japan. The two models has the grid resolution of 1.875° X 1.875° (208 km x 208 km) and 2.8° X 2.8° (310 km x 310 km) respectively, and it has been downscaled to Sabah and Sarawak region at fine spatial resolution of 9 km x 9 km, and hourly time interval.

Explicitly, the Integrated Regional–Scale Hydrologic – Atmospheric Model (IRSHAM) which has a land surface module that is based on areal-average hydrologic conservation equations has been used in the developed RegHCM for Sabah and Sarawak region. It has capability with the varying scale in the grid scale of the atmospheric model that interact with the land surface hydrology model. In order to compute the flow at the outlet of a watershed from land surface hydrology model, a stream channel storage routing algorithm is used where it describes the process that the watershed stores river inflow and releases outflow as a function of its storage.

Watershed Environmental Hydrology – Hydroclimate Model (WEHY-HCM)

The WEHY-HCM is a coupled model of atmospheric and hydrologic processes

Table 2: NAHRIM's BDA Matrix Table

Activitiy		Task	Role
Business direction	1. Project objective	• Domain climate change has been identified in this project, by focusing on: a. Water security (water stress & water availability); b. Weather extreme events (floods & droughts); c. Disaster risk reduction; • To prepare early data & information of potential water related disaster to related Agency for: a. Possible issues arise in identified domain; b. Risk management planning; • To ensure an effective & efficient asset and resource management in risk management plan and issues in related domain; • To avoid, reduce and safe guard a high-risk area due to water related disaster and climate change; and • To identify and reduce lost (life, properties and ecosystem) due to disaster happened.	NAHRIM's SME
	2. Key measures	• Number of lives that can be saved from hydrometeorology disasters; • Number of loss that can be saved from hydrometeorology disasters; • Number of risk management plan that has been implemented; • Size of potential area affected from hydrometeorology disaster; and • Amount of area, infrastructure, life, properties and ecosystem that can be save from hydrometeorology disasters.	NAHRIM's SME
Business problem definition	1. Business function/ problem area	• Water related disaster risk management & climate change impacts; and • A systematic management and decision making for potential disaster related to hydrometeorology.	NAHRIM's SME
	2. Business challenges	• To highlight, use and disseminate disaster information related to climate change extensively in Malaysia such as flood, drought, sea level rise etc.	NAHRIM's SME
	3. Problem statements	• Citizens concern on disaster related to hydrometeorological (pre & post), especially flood which has a high frequency and a large magnitude. Similarly, the occurrence of flash floods in major cities across the country in Malaysia where the cost to fix is very high.	NAHRIM's SME
	4. Impact of the problem	• Loss of life; • Loss of properties (Government, Business and People); • Loss of income and jobs; and • Loss of ecosystem.	NAHRIM's SME
	5. Business questions	• How many loss of life in the events? • How much loss from the event (Government, Business, and People)? • What are preparation taken by Government? • What are policies would be taken by Government to face potential disaster?	NAHRIM's SME

Table 2: (*Continued*)

Activitiy		Task	Role
	6. Data sets usage	• Hydrometeorology and weather data; • Climate change projection data; • Landuse data; • Department of Stastical's data; • Catchment data; • Waterbodies & water treatment plan data; • Satellite data; • Water intake data; • Infrastructure & water resource facilities data (groundwater & surface); and • Socio economy data.	NAHRIM's SME

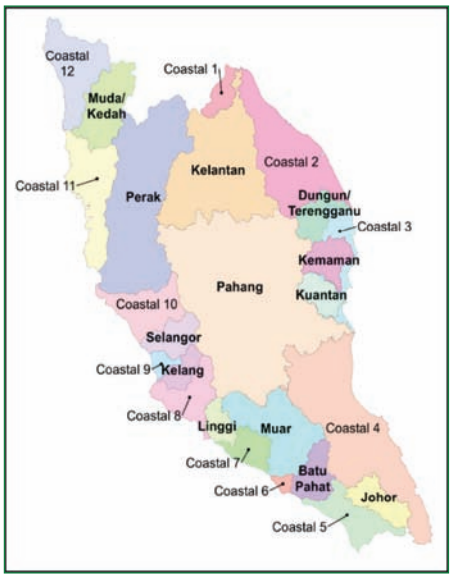


Figure 1: The 13 selected watershed and 12 coastal regions of peninsular Malaysia

at watershed scale, based on the Watershed Environmental Hydrology Model (WEHY) coupled with MM5 atmospheric model through the atmospheric boundary layer. The WEHY-HCM consists of three components which are an atmospheric model component, a land-surface model component that includes the atmospheric boundary layer; and a watershed hydrology module that includes a hill slope process model component with coupled groundwater flow-river channel flow routing model component (Figure 3).

These processes are mutually interacting within the WEHY-HCM-PM. The MM5 atmospheric component of the WEHY-HCM is also the atmospheric component of RegHCM-PM. Similarly, the land-surface component of WEHY-HCM is also the land-surface component of RegHCM-PM.

WEHY-HCM-PM was employed as the watershed hydrologic module. WEHY model utilizes up-scaled hydrologic conservation equations to account for the effect of heterogeneity within natural watersheds coupled with the MM5 within the WEHY-HCM-PM. WEHY model is a physically based spatially distributed watershed hydrology model that is based upon up scaled conservation equations for interception, evapotranspiration, infiltration, unsaturated flow, subsurface stormflow, and overland flow at each hill slope, and interacting channel network flow and regional groundwater flow over the whole modelled watershed.

N-HyDAA project acquired pre-processed data generated from NAHRIM Regional Hydroclimate Model for Peninsular Malaysia (RegHCM-PM). The RegHCM-PM was developed by coupling the Mesoscale Atmospheric Model and the Regional Watershed Environmental – Hydrology Model (WEHY).

NAHRIM Hydroclimate Data Analysis Accelerator – Climate Change Knowledge Portal (N-HyDAA)

NAHRIM Hydroclimate Data Analysis Accelerator known as Malaysia Climate Change Knowledge Portal (N-HyDAA) was developed as Water Risk Assessment and Management with Engineering Tools in providing support for decision making and engineering design to the stakeholders (Figure 4).

Two main references for the development of N-HyDAA modules and data preparation were the extension Study of the Impacts of Climate Change on the Hydrologic Regime and Water Resources of Peninsular Malaysia (NAHRIM, 2014) and EPU Economics of Climate Change study for Malaysia (NAHRIM, 2012).

N-HyDAA used approximately 10 billion projected hydroclimate data under the changing climate scenario of IPCC

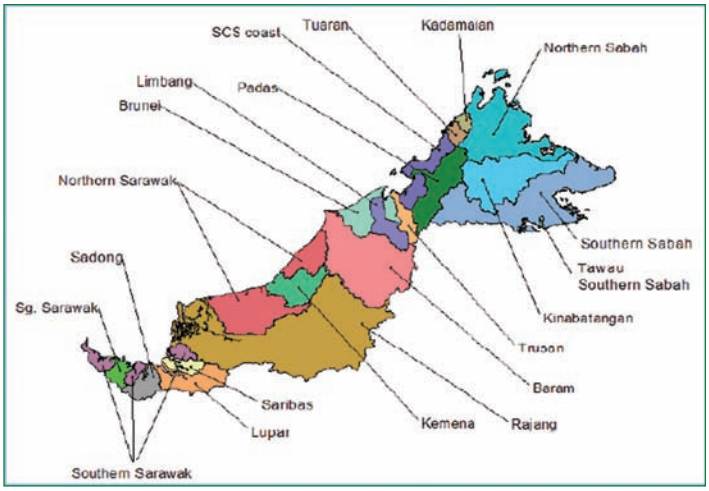
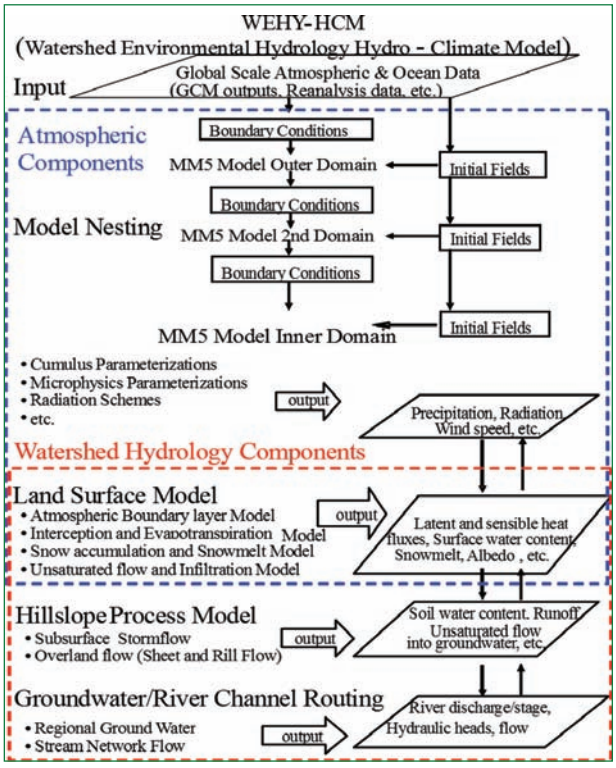


Figure 2: The selected divisions of Sabah and Sarawak



Source: NAHRIM, 2014

Figure 3: Model components of WEHY-HCM watershed hydro-climate model

SRES A1Fi, A1B, A2 and B1. It has eight hydroclimate-environment modules, which amongst others are rainfall, floods, droughts and water stress condition using BDA technology by means of comprehensive analysis and interactive visualization tools. N-HyDAA assists business entities, water operators, engineers, planners and decision-makers in designing, planning and developing water related program and risk management.

Technology of General Purpose Graphical Processing Units (GPGPU) are used to extract, analyze and integrate 10 billion of projected hydroclimate data. In order to strengthen this system, data from various agencies is also used. Based on the VISUALISE, IDENTIFY, DETECT and TRACE concepts, 8 main modules have been developed as the dashboard information.

The visualization of climate-environment data and information is precise and comprehensive to facilitate analysis and decision by stakeholders. This portal through N-HyDAA generates projected multiple maps by indicating specific area affected due to climate change such as floods and droughts to stakeholders not limited to government agencies but also to developers, town planners, risk managers, insurance companies and water operators etc. to have a strategic plan for mitigation and adaptation for combating climate change.

In addition, the analyses data obtained from this portal has speeded up the development of three climate change engineering technical guidelines. The three NAHRIM Technical Guidelines are "Estimation of Future Design Rainstorm under the Climate Change Scenario in Peninsular Malaysia", "Estimation of Future Design Rainstorm under the Climate Change Scenario in Sabah and Sarawak", and "Estimation of Design Low Flow under the Climate Change scenario for Peninsular Malaysia". Typically, the complete process will require about 12 to 18 months.

N-HyDAA is a web-based information system that uses internet web technologies to deliver information and services. In N-HyDAA project, the design of system architecture and data flow diagram had been prepared based on the requirement book gathered during requirement analysis phase. Figure 5 shows NAHRIM System Architecture that represents the IT and non-IT components identified and involved in the project. IT component deals with data management, data authorization & authentication, data storage, operating system, web server and ICT infrastructure to run the system. The non-IT component in NAHRIM's BDA project involves module that required Data Accelerator for accelerating data processing and the modules are (i) Drought/ Storm Center/ Streamflow/ Rainfall/ Runoff; (ii)

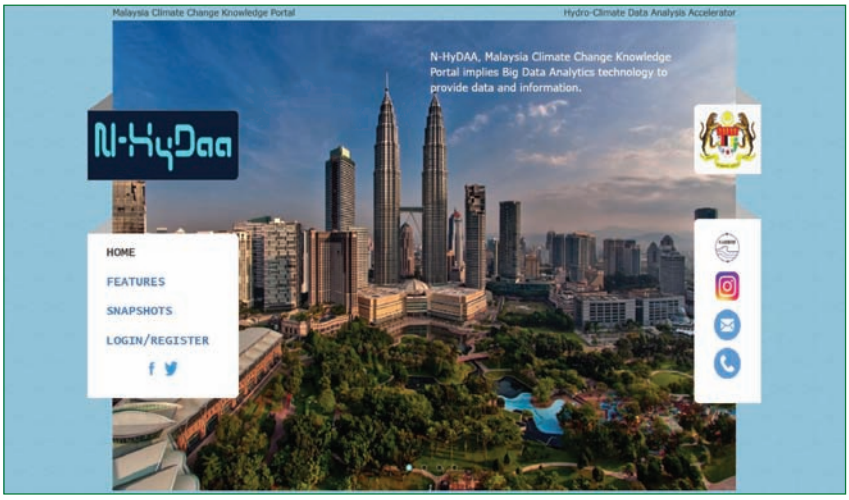


Figure 4: N-HyDAA website landing page

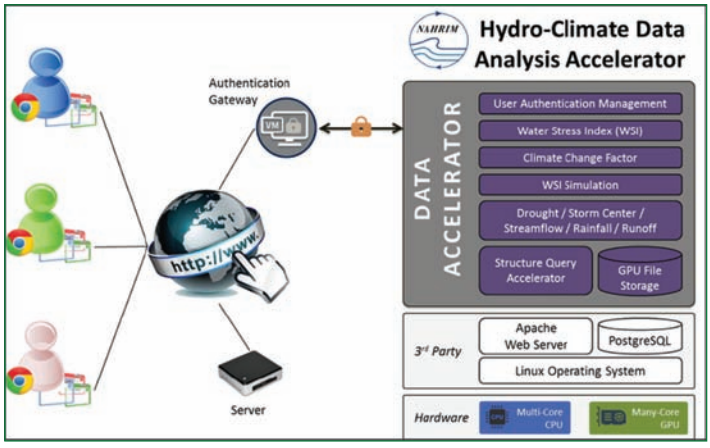


Figure 5: N-HyDAA system architecture

Climate Change Factor; (iii) Water Stress Index (WSI); and (iv) WSI Simulation.

The Data Flow Diagram showed in Figure 6 explains the overall flow of data that are required in the project. We divided the flow into 5 layers: (i) Data Acquisition (ii) Data Cleaning & Integration (iii) Data Repository (iv) Analytic and (v) Presentation. Each data layer performs a particular function. Data Acquisition consists of components to gather raw, pre-process or unclean input data from all sources, such as rainfall, runoff, streamflow, and so forth. Data Cleansing & Integration consists of integration and process components in amending or removing data flow from the sources to the data repository layer in the architecture. Data Repository stores data in a columnar storage format for accelerating data parallel processing and improving query performance and extensibility. In Analytics layer, the queried data will be extracted from the repository to make it easier for users to perform big query processing and what-if analysis. Presentation layer gives access to different set of users where it consumes the data through web pages that are defined in the reporting tool (NAHRIM, 2016).

Impacts assessment of climate change through BDA technology

The impacts of global CC in the 21st century on the hydroclimate of Peninsular Malaysia are assessed with respect to air surface temperature, rainfall, evapotranspiration, soil water storage and streamflow. The global historical atmospheric databases and global future climate simulation databases as reported in Special Report on Emission Scenarios by the Inter-Governmental Panel on Climate Change, Assessment Report No. 4 (SRES IPCC AR4) are used for the impacts assessment where an ensemble averaged of 15 scenarios climate change projections for the future 2010–2100 period and 1970–2000 historical period were assessed. In addition, the analyses of water yields and water stress indices (WSI) were also conducted to project future water surplus and scarcity in the districts of Peninsular Malaysia.

Air temperature and rainfall

The mean annual air temperature and rainfall were downscaled based on historical period (1970–2000) and 15 hydroclimate projections (2010–2100) at the 13 watersheds and 12 coastal regions. An ensemble averaged of downscaled databases were analysed based on 30-year mean annual air temperature (MAAT) and mean annual rainfall (MAR) for three period namely, 2010–2040, 2040–2070 and 2070–2100. The magnitude of changes for 30-year MAAT and MAR from 2010 until the end of 21st century is given in Table 3. The ensemble averaged of the basin-average MAAT has a linear warming trend towards the end of 21st century with a range of increment between 2.5°C - 2.95°C (2010 – 2100) compared to the 1970–2000 historical period. The two largest changes in MAAT are 2.95°C and 2.85°C as projected for Coastal Regions 9 and 11 respectively. The increment rate of MAAT is projected to reach a maximum of 11% by the end of the 21st century.

The MAR is projected to gradually increase from 0.4% to 33% by the end of the 21st century over the 13 watersheds and 12 coastal regions. The magnitude of increase in the 30-year MAR is the smallest between the historical period and early 21st century, while it is the largest between the middle and the end of the 21st century period. The magnitude of increase in MAR for the 13

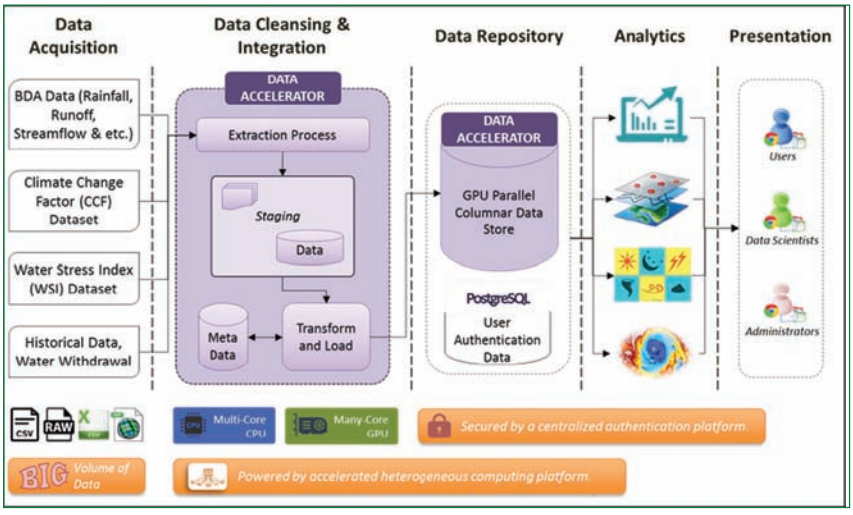


Figure 6: N-HyDAA data flow diagram

Table 3: The magnitude of change for 30-year basin-average MAAT and 30-year basin-average MAR for Peninsular Malaysia

Period	30-yr Annual Surface Temperature		30-yr Annual Rainfall	
	°C	%	mm	%
2010–2040 (early century)	0.87 – 1.05	3 - 4	12 - 121	0.4 - 6
2040–2070 (middle of century)	1.91 – 2.25	7 - 8	96 - 278	5 - 13
2070–2100 (end of century)	2.52 – 2.95	10 - 11	348 - 714	17 - 33

watersheds and the 12 coastal regions are different, and there are no significant patterns with respect to their locations.

In the context of future Average Recurrence Interval (ARI) or return period for rainfall, the rainfall towards the end of the 21st century is generally the highest among the three periods for all durations over most of the 13 watersheds and 12 coastal regions. Dungun watershed, is projected to have the highest 100-year rainfall ARI for the middle and the end of 21st century periods. The 100-year rainfall ARI for the end of the 21st century period is similar to that of the mid-21st century period over Coastal Regions 1 - 3. The 100-year rainfall ARI during the early 21st century period is similar to that of the mid-21st century period over Coastal Regions 4, 5, 8 and 9.

Additional analyses have been carried out to determine the expected declining degree of safety level based on 1-day maximum rainfall of the 100-year ARI associated with an increase in rainfall ranging from 10% to 50%. The results for selected rainfall stations are given in Table 4.

The average reduction of safety level will be decreasing from 59-year ARI with 10% increase of rainfall to 11-year ARI with 50% increase of rainfall for a 100-year ARI designed hydraulic structure in current practice. The reduction in the degree of safety level and the increment in the magnitude of future ARI rainfall gives an indication that the CC impacts will affect water resources related structures and infrastructures including dams, barrages, bridges, jetties and roads as well as drainage systems.

Potential evapotranspiration

In relation to potential evapotranspiration (PET), the ensemble averaged basin-average annual PET is projected to increase gradually throughout the 21st century over all watersheds, but, it is almost the same for all coastal regions. The coastal regions on the west have higher basin-average annual PET than those on the east. The coastal regions in the north have lower annual PET during every period. The change in the basin-average annual PET is slightly larger on the west coast than in the east coast.

River flows

The projected 2010–2100 climate data from 15 downscaled GCM projections was used as an input in Watershed Environmental Hydrology (WEHY) model to route the water through the selected watersheds at hourly intervals throughout the 21st century in order to assess the impact of CC on water balances and hydrologic extremes of the 13 watersheds. WEHY is a coupled model of atmospheric and hydrologic processes at watershed scale that projected the hydrologic conditions over each of the selected watershed at hourly intervals throughout the 21st century.

Ensemble averages of the annual mean flows (AMF) of the 15 dynamically downscaled projections show increasing trends for the 13 watersheds, especially in the second half of the 21st century. In the context of historical and future mean monthly flows, the impacts of expected CC is considered statistically significant for all the selected watersheds particularly after the middle of 21st century. The results of analyses show that while the estimated average mean monthly flow increases during the 21st century over all watersheds, the increase in the projected maximum mean monthly flows and the decrease in the projected minimum mean monthly flows are also quite substantial. The changes of magnitudes for the projected high flows and low flows for the selected watersheds are given in Tables 5 and 6 respectively.

The projected high flow rates for the nine selected watersheds increase towards the end of the 21st century with

Table 4: Declining degree of safety level for selected rainfall stations

Station name	Rainfall depth (mm)	Rainfall intensity (mm/hr)	Return period (year)				
			x1.1	x1.2	x1.3	x1.4	x1.5
Pejabat Daerah Kampar	249	10.4	53	29	17	10	6
Setor JPS Kajang	225	9.4	55	32	20	12	8
Gunung Brinchang	167	7.0	56	33	20	13	8
Hulu Jabor	734	30.6	66	45	32	23	17
JPS Kemaman	536	22.3	62	40	27	19	13
Setor JPS K. Terengganu	629	26.2	64	42	29	20	15
JPS Kuala Krai	461	19.2	66	45	32	23	17
Setor JPS Kota Bharu	552	23.0	64	43	29	21	15
Bukit Sebukor	241	10.0	57	34	21	14	9
Komplek Prai	329	13.7	63	41	27	19	14
Setor JPS Alor Setar	262	10.9	58	34	21	14	9
Stor JPS Johor Bahru	244	10.2	56	33	20	13	8
Puchong Drop	203	8.5	53	30	18	11	7
Ibu Pejabat JPS1	214	8.9	51	29	17	10	7
Setor JPS Sikamat	207	8.6	57	34	21	13	9
SM Bukit Besar	296	12.4	61	39	26	17	12
Rmh. Tapis Segamat	317	13.2	65	44	31	22	16
Average			**59**	**37**	**24**	**16**	**11**

Table 5: Projected High Flow Rates Based on Mean Maximum Monthly Flow Discharges

Watershed	Future 2010–2100 (m3/s)	Historical 1970–2000 (m3/s)	Percentage of change
Muda	2,702	510	+430%
Perak	9,937	2,658	+274%
Selangor	1,194	584	+108%
Klang	319	148	+115%
Kelantan	10,115	4,088	+147%
Dungun	671	415	+62%
Pahang	4,561	2,748	+66%
Muar	2,630	401	+556%
Batu Pahat	283	101	+180%
Average	3,601	1,295	+215%

(Source: NAHRIM, 2014)

an average percentage of change of 215% (Table 3). On the other hand, low flows analyses highlighted the critical dry periods which may cause water supply disruptions. As shown in Table 4, the Muda, Selangor, Kelantan, Pahang, Johor and Linggi watersheds are projected to experience water supply problems due to the decrease in minimum mean monthly flows towards the end of the 21st century.

BDA technology visualisation

BDA technology visualization has been incorporated in N-HyDAA where users are flexible in determining the type and format of the information to be analysed and stored, for example based on time interval, shape of region, analysis model, total average interval etc. This unique feature is a distinctive facility to increase the ability of data analysation based on suitability and requirement of the user. The combination and integration of spatial and non-spatial data for analysis and output display is value added to increase understanding and facilitate the delivery of information to the non-technical groups. The display of detailed and dynamic data is a combination of data from various agencies, which for each 6km x 6km area of 3,888 grid consists of 1186 MCU data from NAHRIM DEM, 13 river basin, land use data, water demand data, meteorological data and geospatial data. The response time to analyse 10 billion records data is about 14 seconds for one scenario model or 3.5 minutes for 15 scenarios models enable early warning system and precaution planning been set up and developed.

N-HyDAA acts as an intelligent platform of climate-environment impact assessment and action. For example, this system managed to identify, determine and visualize future water yield and water stress pattern, magnitude, and index, which is helpful to face the extreme drought episodes in future due to El Nino as occurred in 2016 that caused water shortage and rationing throughout the country due to the drawdown of water supply dam storage (Bukit Merah Dam, Timah Tasoh Dam, Upper Layang Dam and etc.).

Future water yields based on simulated future runoff as produced from the WEHY model have been investigated. They were evaluated for four different gas emissions scenarios (B1, A1B, A2 and A1FI) by means of an average of 14 projections (A1B, A2 and B1), average A1B, average A2 and average B1 for period 2010 – 2100. Historical simulations were based on the average runoff from three control run GCMs (CCSM3, ECHM5 and MRI). The visualisation result of water yields for historical and future periods of 2030 and 2050 for 80 districts are given in Figures 7 and 8 respectively.

Water yields in 2030 under the average of 14 scenarios, A1B and A2 are projected to increase compared to historical period (by 2 BCM to 8 BCM) except for B1 where the water yield is projected to decrease by 3 BCM (Figure 7). In 2050, water yields for all scenarios are projected to increase with a range of 8 BCM to 17 BCM and the largest change of 195 BCM was obtained from the average A2 scenario. Generally, the projected water yields for all districts show increasing trends (more water), with the exception of a few districts in Kedah and Johor.

In the context of Water Stress Index (WSI), the approach developed by Stephen Pfister was used to construct the district-based water stress indices by means of projected water yield and water demand that is possibly impacted by CC conditions. WSI is defined as an index calculated based on Stephen Pfister's model to represent the level of water stress in a specific area by means of a ratio of total water demand or consumption against water yield or availability (Brown et.al, 2011). The constructed district-based WSI for the respective districts and time horizons are given in Figures 9 and 10 for 2030 and 2050 respectively. WSI is divided into five stress categories namely, low (< 0.1); medium low (0.1 - 0.2); moderate (0.2 - 0.5); high (0.5 – 0.8) and extremely high (> 0.8). Nearly high and extremely high WSI are located in the West Coast particularly in urban and high populated areas, and also irrigation schemes. Overall, the highest and smallest average WSI are projected in Pulau Pinang-Perlis-Kedah-Klang Valley-Johor Bahru and Pahang-Terengganu respectively.

Figure 11 shows the constructed WSI for the average 14 scenarios in 2030 and 2050 whereby the marked areas are the projected districts with increased WSI. For example, the high WSI in Sabak Bernam, Selangor would affect the irrigation water availability for Barat Laut Selangor Integrated Agricultural Development Authority (IADA-BLS) irrigation scheme. On the other hand, the extremely high WSI in Johor Bahru will pose challenges to Syarikat Air Johor (SAJ) to provide sufficient treated water supply to the consumers.

Table 6: Projected low flow rates based on mean minimum monthly flow discharges

Watershed	Future 2010–2100 (m3/s)	Historical 1970–2000 (m3/s)	Percentage of change
Muda	8	15	-48%
Selangor	118	122	-4%
Kelantan	52	93	-44%
Pahang	27	54	-49%
Johor	26	33	-23%
Linggi	1	3	-62%

Source: NAHRIM, 2014

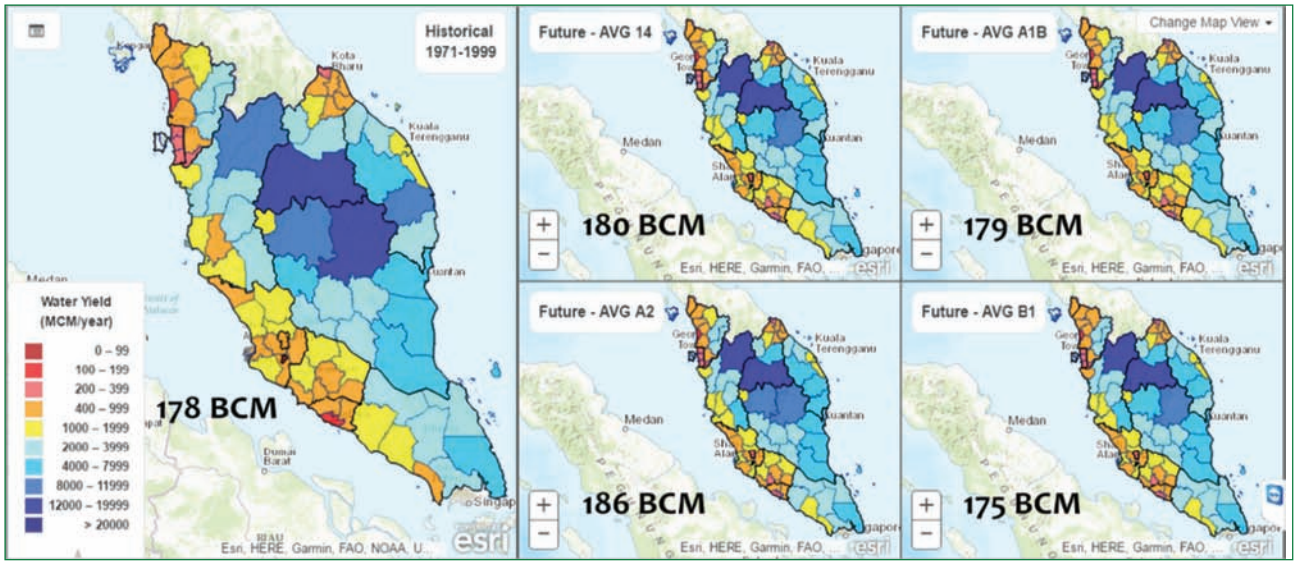


Figure 7: Comparison between simulated historical and future water yields in 2030 (billion cubic meters, BCM)

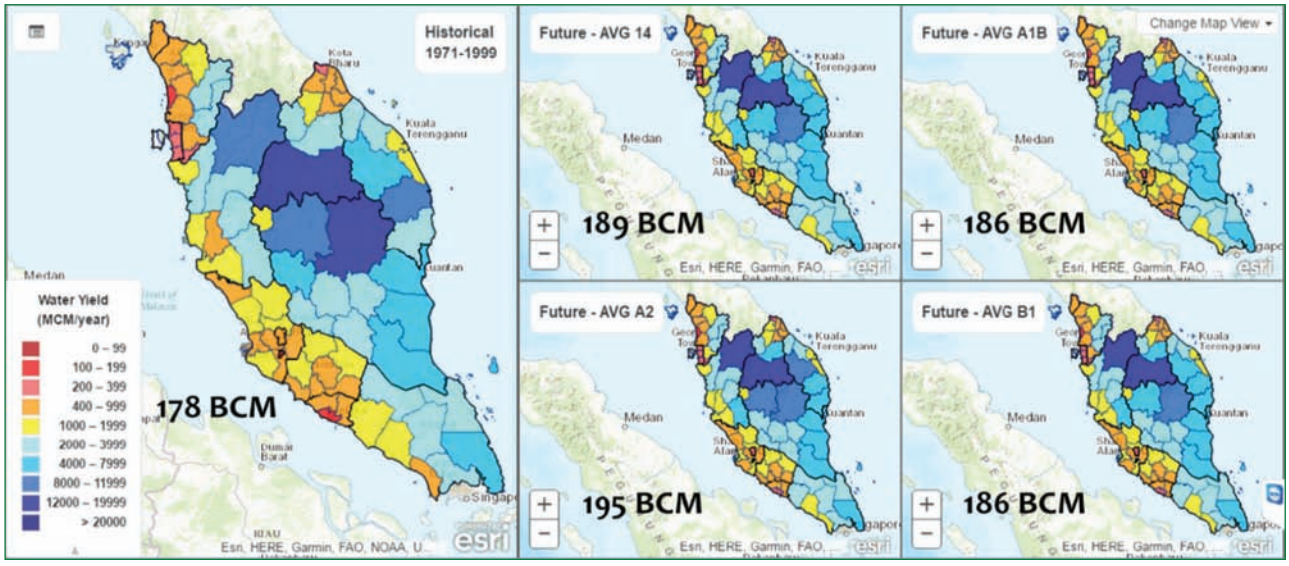


Figure 8: Comparison between simulated historical and future water yields in 2050 (BCM)

Conclusions

With the changing climate, the prognosis is that weather extremes such as floods, drought and El Nino are likely to increase in frequency and intensity causing huge economic losses and affecting human lives. NAHRIM's BDA technology implies data driven approach through RegHCM, WEHY and N-HyDAA to trace, detect, identify and visualise future water issues associated with the adverse impacts of climate change in Malaysia.

The visualization of climate-environment data and information is precise and comprehensive to facilitate analysis and decision by stakeholders. This portal through N-HyDAA generates projected multiple maps by indicating specific area affected due to climate change such as floods and droughts to stakeholders not limited to government agencies but also to developers, town planners, risk managers, insurance companies and water operators etc. to have a strategic plan for mitigation and adaptation for combating climate change.

NAHRIM's BDA technology acts as an intelligent platform of climate-environment impact assessment and action. It can help decision-makers develop long-term and comprehensive climate proofing and risk management strategies particularly in water related sectors and cross-sectorial issues such as agriculture, energy and health sectors. This prompt action would help to reduce the related risk management cost on potential water related crisis whether to have too little or too much water, and minimizes the risk of loss of lives, infrastructures, properties and environmental degradation. It is also to ensure for water-energy-food security in the context of sustainable development for the country. Therefore, adaptation action against potential flood and droughts can be determined in advance through the "climate change factor and water stress index" modules developed towards improving governance and security of flood disaster and water supply security in line with the latest government policy.

In general, NAHRIM's BDA technology has been supporting Malaysia to achieve the United Nation Sustainable Development Goals (SDG) specifically for (i) Goal 11 - Make cities and human settlements inclusive, safe, resilient and sustainable; (ii) Goal 12 -Ensure sustainable consumption and production patterns; and (iii) Goal 13 - Take urgent action to combat climate change and its impact. Through NAHRIM's BDA technology developed, it helps stakeholders to determine areas prone to climate change impacts and thus promote risk reduction, and able to improve communication, planning, management and analysis towards achieving a sustainable development and to minimise the disaster impact of climate change.

Challenges and way forward

Undeniably climate change has impacted on water resources planning and management. Malaysia and the rest of the world are facing the challenge to reduce and cushion the impacts of climate change on water resources. Amongst the major challenges faced by water resources managers are ensuring water security in terms of both quantity and quality for public water supplies and irrigation as well as power generation. Other major challenges include floods both riverine and coastal flooding. The latter is contributed by the projected sea level rise consequent to global warming. The efforts for providing climate change resilient framework and programmes need to be strengthened, integrated and coordinated by considering both non-climatic and climatic forcing factors.

The developed NAHRIM's BDA technology has potential to further enhance for

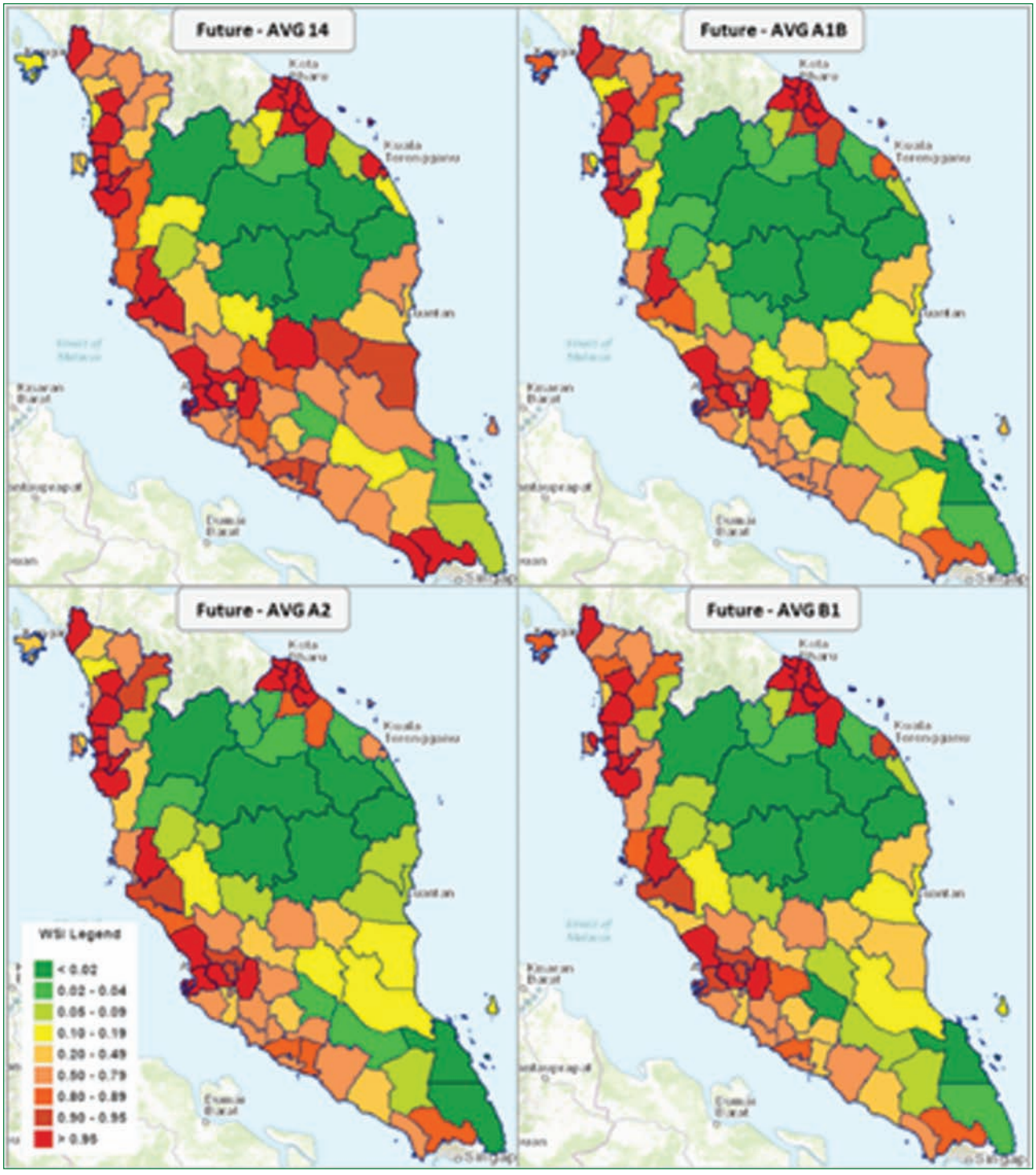


Figure 9: WSI for each scenario based on the districts in 2030

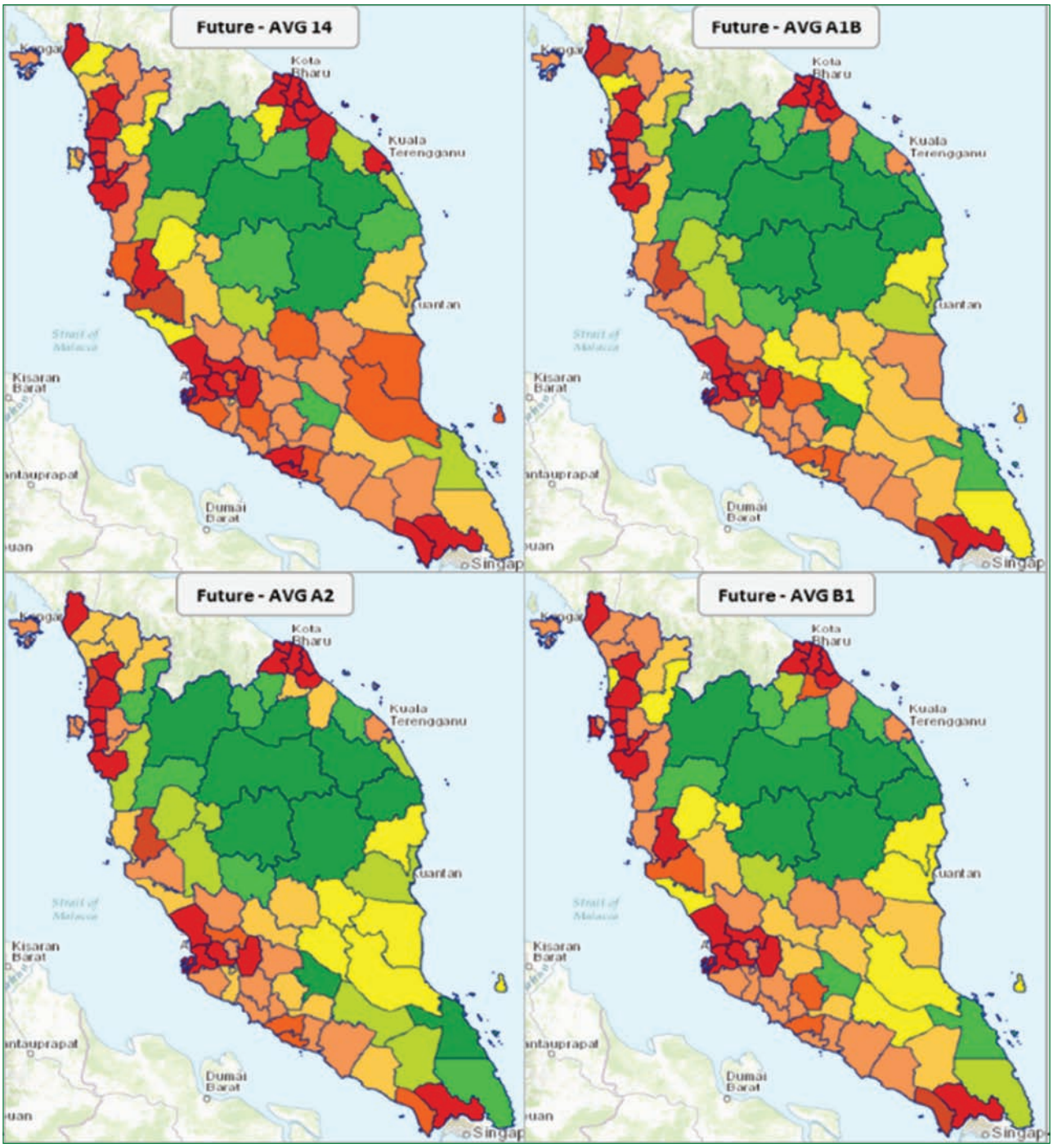


Figure 10: WSI for each scenario based on the districts in 2050

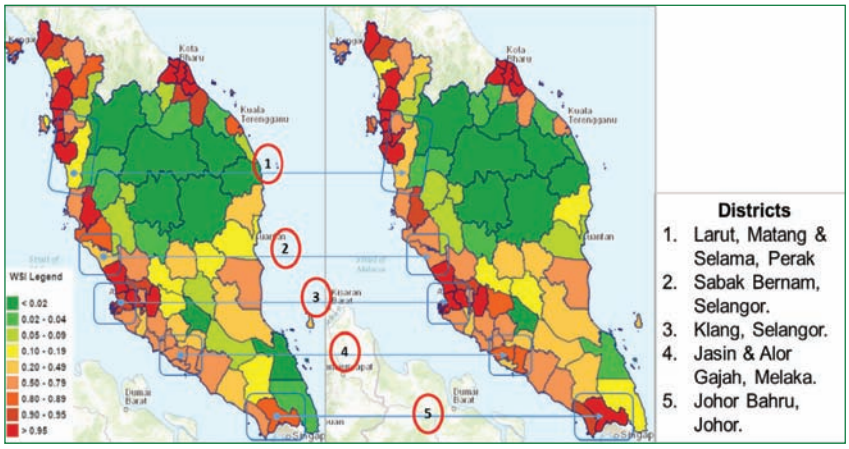


Figure 11: WSI comparison for A1B scenario in 2030 and 2050

natural disaster management in Malaysia related to climate change impacts. There is a need to link disaster risk reduction and climate change adaptation through BDA technology which will assist decision makers to receive sufficient data and information. Exploiting hydro climate data to their full potential by leveraging the benefits offered by BDA technology will accommodate in prevention, mitigation, preparation, adaptation, response and recovery of disasters.

Data and information analysed through NAHRIM's BDA technology particularly from N-HyDAA is being used for Sustainable Water Consumption through Water Footprint and Water Risk Management project in 2017. The project's main objective is to develop a Decision Support System (DSS) based on sub-watershed scale model of water stress indices that are generated from water projection in the context of climate change impacts on future water resource, availability and demand (use) for water risk management.

Moving forward, the present Integrated Land Use and Water Resources Management plan need to be integrated with BDA technology framework for sustainable socio-economic development to ensure best use of resources and near zero negative impacts from climatic and non-climatic impacts. Based on NAHRIM's BDA technology developed, the information can be expanded to various key economic sectors that are related to climate change such as water, coastal, agriculture, infrastructure, energy and health sectors.

References

- ✓ Abdullah, M.F., Ibrahim, M. and Zulkifli, H. (April, 2017). Resolving The Misconception on Big Data Analytics Implementation Through Government Research Institute in Malaysia. In 2nd International Conference on Internet of Things, Big Data and Security (pp. 261–266).
- ✓ Abdullah, M.F., Ibrahim, M. and Zulkifli, H. (April, 2017). Big Data Analytics Framework for Natural Disaster Management in Malaysia. In 2nd International Conference on Internet of Things, Big Data and Security (pp. 406–411).
- ✓ Amin, M.Z.M. (2016). Applying Big Data Analytics (BDA) to Diagnose Hydrometeorological Related Risk Due To Climate Change. GeoSmart Asia. [online] Available at: http://geosmartasia.org/presentation/applying-big-data-analytics-BDA-to-diagnose-hydro-meteorological-related-risk-due-to-climate-change.pdf [Accessed 1 November 2016].
- ✓ Bi, Z. and Cochran, D. (2014). Big data analytics with applications. *Journal of Management Analytics*, 1(4):249–265.
- ✓ Brown, A., and M. D. Matlock, (2011). A Review of Water Scarcity Indices and Methodologies. Sustainability Consortium, Food, Beverage and Agriculture, White Paper No. 106, April 2011.
- ✓ Emmanouil, D. and Nikolaos, D. (2015). Big data analytics in prevention, preparedness, response and recovery in crisis and disaster management. In The 18th International Conference on Circuits, Systems, Communications and Computers (CSCC 2015), Recent Advances in Computer Engineering Series (Vol. 32, pp. 476–482).
- ✓ Kaplan, R.S. and Mikes, A. (2012). Managing Risks: A New Framework. *Harvard Business Review,* 90, no. 6.
- ✓ Kim, G.H., Trimi, S. and Chung, J.H. (2014). Big-data applications in the government sector. *Communications of the ACM*, 57(3):78–85.
- ✓ NAHRIM. (2006). Study of the Impact of Climate Change on the Hydrologic Regime and Water Resources of Peninsular Malaysia.
- ✓ NAHRIM, (2012). Economics of Climate Change for Malaysia. National Hydraulic Research Institute of Malaysia. Selangor, Malaysia.
- ✓ NAHRIM. (2014). Extension Study of the Impact of Climate Change on Hydrology Regimes and Water Resource for Peninsular Malaysia.
- ✓ NAHRIM, (2016). NAHRIM Hydro-Climate Data Analysis Accelerator (N-HyDAA) Final Report. National Hydraulic Research Institute of Malaysia. Selangor, Malaysia.
- ✓ Othman, S.H. and Beydoun, G. (2013). Model-driven disaster management. *Information & Management*, 50(5):218–228.
- ✓ Russom, P. (2011). Big data analytics. The Data Warehousing Institute (TDWI). Best Practices Report, Fourth Quarter, pp.1–35.
- ✓ Troester, M. (2012). Big Data Meets Big Data Analytics: Three Key Technologies for Extracting Real-Time Business Value from the Big Data That Threatens to Overwhelm Traditional Computing Architectures. SAS Institute. SAS Institute Inc. White Paper.
- ✓ Zulkifli, H., Kadir, R.A. and Nayan, N.M. (2015 November). Initial user requirement analysis for waterbodies data visualization. In International Visual Informatics Conference (pp. 89–98). Springer International Publishing. ■

Microbial biopolymers as innovative, exploitable 'green tools' for sustainable treatment of water

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Abstract

Affording water quality and safety is an important national criterion and sustainable option advocated for water treatment and may be envisaged as a scientific function of innovations, parallel technology development and policy decision. Over the past decade our focus have been to develop *green polymers* as alternatives of currently used chemical water treatment agents and apply them as biosensors for rapid and effective detection of waterborne bacterial pathogens and parasites to facilitate timely intervention. To this end, we have demonstrated the potential prospects of several microbial biopolymers as flocculating biopolymers, and surface engineered selected biopolymers for effective binding and killing of prominent waterborne bacterial pathogens. High throughput detection using selected protozoal binding biopolymers have been designed for rapid detection of oocysts in water, a persistent threat to human life. The specific ability of some biopolymers to sequester phosphate have led us to develop these class of biopolymers as novel phosphate removal agents apt in aquatic bodies with high phosphate concentration; their abilities were exploited to design biosensors for rapid detection of phosphate in water. Given the enormous functional attributes, non toxicity and robustness of microbial biopolymers, the cumulative profile of their applicability is highlighted through our studies. A significant technological application of these green polymers in water safety and quality for application for benefitting national health is proposed.

Introduction

India offers a huge potential for optimal utilization of its water resources. With extensive river and canal system of about 195.210 km, comprising of 14 major rivers, 44 medium rivers and numerous small rivers and streams, the pond and tank resources are estimated at 2.36 million. In spite of this abundance, source sustainability is a serious challenge for India which is heavily dependent of groundwater. About 80% of the schemes are groundwater-based where recharge of the source has lacked persistently. Since groundwater-based water service delivery is increasingly challenging, there is a shift to surface water. However, the sustainability of surface water sources fluctuates significantly by climate variability, snow melting, insufficient flow in rivers and scanty rainfall. Therefore, water conservation, recharge and source security are critical for the Government of India to reach its ambitious target to cover 55% of households by piped water connections by 2017 and also to reach everyone by 2025 (Water aid, 2017)

Contamination of water sources, both bacteriological and chemical, has emerged as a critical problem over the years. Water treatment technologies need to be sustainable and institutions nearer to the users to develop quick and sustainable solutions. In fact, environmental un-sustainability, specifically arising from improper solid and liquid waste disposal, calls for linking sanitation into the whole water delivery chain. Whereas, new National Rural Drinking Water Programme (NRDWP 2010) guidelines and the Government of India XII Five Year Plan (2012–17) are anticipated to provide a paradigm shift in approach to the right direction, innovation led research for providing safety and affordability of water quality is clearly the need of the hour.

'Green polymers' have occupied the global center-stage as an enabling and transformative technology with a strong biotechnological and interdisciplinary involvement leading to platforms, which can be drivers of new value-chains, industries and employment opportunities. Moreover, the creative use of biopolymers can offer solutions for sustenance in agriculture, medical, health, water and environmental management. The growing relevance of the indispensable role of biopolymers in sustainable development, has spurred significant interest amongst scientists for translation of concerted ideas and inventions to technology for economic development and global competitiveness.

Our research efforts have concentrated on developing sustainable approaches using biotechnological means to achieve solutions to conventional chemicals used for treating water. Over the past decade, our laboratory have consistently investigated polymers of biogenic origin particularly those elaborated by microorganisms. Several biopolymers have been characterized with unique structural and functional attributes apt for human applications; being completely biodegradable and non toxic, they pose no threat or problems for applications. A major objective of our research has being translation of functional properties of these biopolymers for water safety and quality. We used two specific approaches in efforts to contribute to the existing water problems: (a) Development

of sustainable microbial polymers which can act as flocculants and inactivation agents for water treatment and phosphate binding biopolymers; and (b) Microbial biopolymers which can be used for specific binding to bacterial pathogens and protozoal parasites in water and can be used as novel biosensors for accurate detection of microbial risk.

Case studies

(a) Microbial biopolymers as green flocculants for source water treatment

Microorganisms represent the nature's greatest library of sustainable resource. Extensive prospecting for potential microorganisms capable of producing biopolymers enabled creation of a library comprised of biopolymer producers. Exhaustive screening and characterization of the biopolymers as flocculating agents (Khaira et al., 2014) led us to select *Klebsiella terrigens* biopolymer which was subsequently shown to bind and remove water borne pathogens *Salmonella typhimurium, Shigella flexneri* 2a, *Escherichia coli* O157:H7 in addition to other water contaminants. Performance of this microbial flocculant was extensively trialled in poultry effluent and surface waters with comparable and better results with their chemical counterparts. These studies initiated through research grants from the University Grants Commission (UGC) and Water Technology Initiative of the Department of Science and Technology (DST–WTI) inspired us to surface engineer the flocculant targeted to inactivate the water borne pathogens simultaneously. In subsequent studies, we introduced chemical moieties onto surfaces of the biopolymer. These new class of surface engineered biopolymers demonstrated effective binding and killing of waterborne pathogens possessed excellent shelf, pH stability and specifically inactivated *Salmonella, Shigella* flexneri 2a *Aeromonas hydrophila* and *Escherichia coli* O157:H7(Khaira et al., 2014; Khaira and Ghosh, 2016).

Established to be completely nontoxic and biodegradable, we envisage potential applicability of the biopolymer for imparting high degree source safety to water as well as prime candidates for ensuring water bio-security.

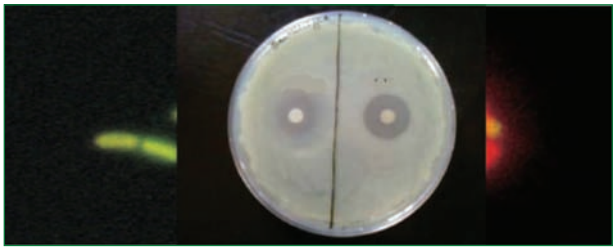

Figure 1: The inactivation of water borne pathogens by surface engineered microbial biopolymers. Live pathogens are stained yellow and dead orange.

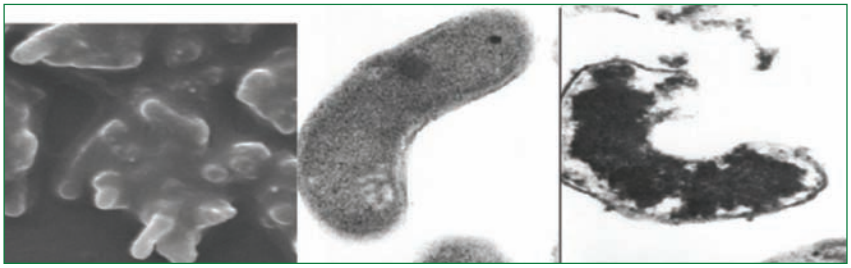

Figure 2: Electron micrographs of water borne pathogens: *Salmonella* typhimurium and *Shigella flexneri* 2a treated with surface engineered microbial biopolymer. The complete damage leading to cell death is evident from the morphology of treated cells.

(b) Harnessing microbial biopolymers as biosensors

As a protozoan parasite, *Cryptosporidium* presents a unique threat to human health and continues to be a concern with significant morbidity and mortality across the globe. Its resistance to both environmental stress and standard water treatment chlorination disinfection procedures enable it to survive for up to 16 months in water. Additionally, these organisms are ubiquitous in the environment and have an extremely low infectious dose. For some *C. parvum* isolates, one of the human pathogenic species, less than ten oocysts can be required to cause infection. This number should be compared against the billions of oocysts that an infected host could shed during an episode of infection. (During a clinical infection a calf may shed around ten thousand millions oocysts, which would provide enough parasites to infect the whole human population of Europe.) The greatest challenge, lie in its early and accurate and detection so as to initiate immediate intervention. Using earlier leads from our research (Ghosh et al., 2009) and financial grant from DST-UKIERI bilateral project, we (University of Edinburgh, Heriot Watts University, UK) carried out extensive experiments on evaluating *Cryptosporidium* oocyst binding to multitude of bacterial biopolymers. Our ultimate aim was to design a rapid, biological detection system for the oocysts in water using the biopolymer array. The selected biopolymers, proven to be non toxic and with exceptionally high degree of oocyst binding were incorporated into detection chips. The system was able to bind and thereby detect oocysts in various water samples. We are in a process of commercializing this novel approach (Sharma et al., 2015, Bridle et al., 2014). In future we expect rapid, accurate detection platforms through lab-on-chip systems, which will incorporate these biopolymers for both detection of *Cryptosporidium* oocysts and water borne bacterial pathogens.

Phosphates in water pose an important problem for water reuse and aquatic life. An environmentally isolated bacterial strain of *Acinetobacter* showed remarkable

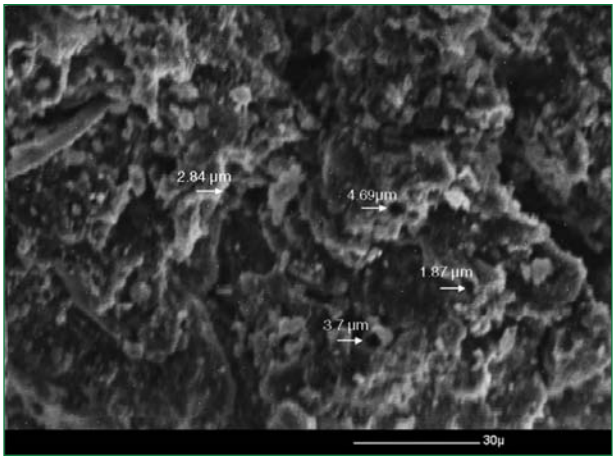

Figure 3: Scanning electron micrograph of *Cryptosporidium* binding biopolymer produced by bacteria

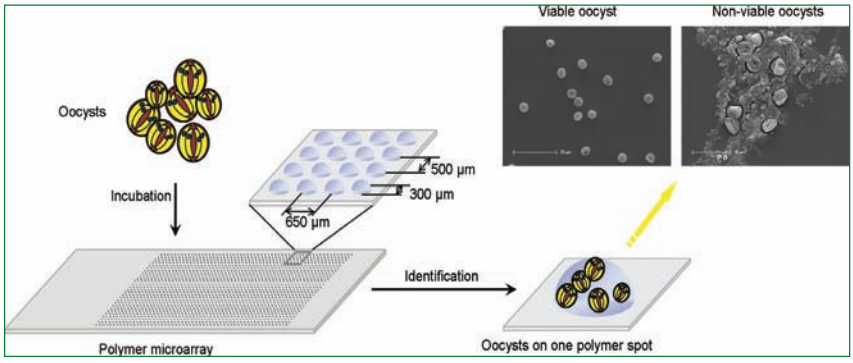

Figure 4: A biopolymer microarray developed for high throughput detection of *Cryptosporidium* oocysts. Inset: Left - shows viable oocysts and right: oocysts bound to biopolymer as detected in array.

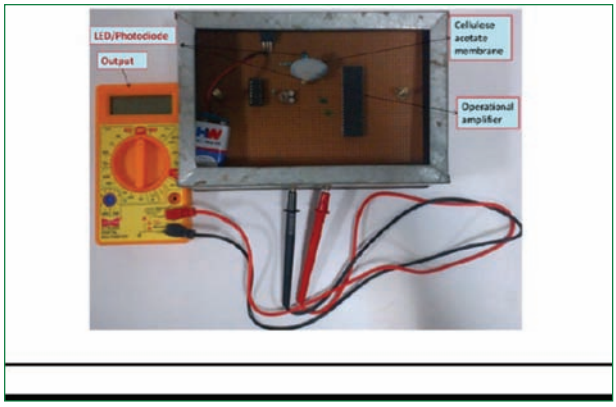

Figure 5: Biosensor developed with microbial phosphate binding biopolymer. The biosensor is capable of detecting phosphate concentrations of 1 µgL^{-1} in aquatic systems.

ability to sequester phosphate reversibly. This raised hope for double use of this biopolymer in phosphate removal and replenishing them through biopolymer itself in phosphate depleted soil (Kaur et al., 2014).

To monitor phosphate levels, a biopolymer based sensor utilizing simple colorimetric detection was devised. The biosensor could detect phosphate concentrations over a wide range and could be beneficial for analyzing phosphate in aquatic bodies as routine measures; it is worth mentioning that existing detection devices usually do not possess sensitivity to either high or low levels of phosphate or are complicated and costly.

Conclusion and future direction

With the use of globally available knowledge and technological advancements, India would be able to address some of its major problems related to water—lacking awareness of total ground water resources, wasted water due to leakages and flooding during monsoon or tropical storms. Judicious actions made regarding the mentioned challenges, will enable smarter infrastructural decisions and thereby provide water to a larger segment of the population, who currently receive intermittent or no supply. The challenges of water safety at source and water reuse require more critical approaches. Sustainable options have become most important in addressing this issue. Exploiting the abundant and diverse microorganisms for biopolymers with unique capabilities especially for water safety, require technological partnering between institutions, groups or individuals for scale up applications. Needless to say, a multifaceted approach in resolving the complex issues of water quality and safety is most desirable with close partnership of government agencies. Besides, value driven research in this area, national and international technology transfers and formulation of pockets of excellence catering to business models and national policies in water will be extremely important in this regard.

Acknowledgement

The financial support of University Grants Commission, Department of Science & Technology (Water Technology Initiative), UKIERI for carrying out the work is deeply acknowledged. I am thankful to my past and present students for their contributions in water innovations over these years in my laboratory.

Conflict of Interest

The author declares that there are no conflict of interest.

Disclaimer

The views, process, products described herein, do not necessarily endorse them for any specific application.

References

- ✓ Bridle, H. and Ghosh, M. (2014). Polymers for use in the monitoring and treatment of waterborne protozoa. Biomaterial Applications: Macro to nanoscales. Oakville, ON: Apple Academic Press, Inc.; Boca Raton, FL: CRC Press.
- ✓ Ghosh, M., Pathak, S. and Ganguli, A. (2009). Effective Removal of Cryptosporidium by a Novel Bioflocculant. *Water Environment Research*, 81:123–128.
- ✓ Khaira, G.K., Ganguli, A. and Ghosh, M. (2014). Antimicrobial efficacy and in vivo toxicity studies of a quaternized biopolymeric flocculant. *Journal of Water and Health*, 12(4):656–662.
- ✓ Khaira, G.K., Kumarya, R., Chibber, M. and Ghosh M. (2013). Development of a quaternized chitosan with enhanced antibacterial efficacy. *Journal of Water and Health*, 11(3):410–418.
- ✓ Khaira, G.K., Ganguli, A. and Ghosh, M. (2014). Rapid inactivation of Salmonella by a quaternized biopolymeric flocculant. *Water Science & Technology*, 14(1):31–37.
- ✓ Khaira, G.K and Ghosh, M. (2016). Surface engineered green polymer for enhanced water decontamination-International Conference on Environmental Science & Technology (ICEST-2016), American Association for Advancement of Science, Houston, Texas, July 8–10.
- ✓ Kaur, T., Sharma, J., Ganguli, A. and Ghosh, M. (2014). Application of biopolymer produced from metabolic engineered Acinetobacter sp. for the development of phosphate optoelectronic sensor. *Composite Interfaces*, 21(2):143–151.
- ✓ Sharma, V., Bridle, H and Ghosh, M. (2015). Studies on Biopolymeric Material-*Cryptosporidium* Interactions for Developing Detection/Treatment Systems in Water. (International Society for Biomedical Polymers & Polymeric Biomaterials, Orlando, Florida, U.S., 8–10 July.
- ✓ WaterAid (2017). Drinking water quality in rural India: issues and approaches. www.wateraid.org/~/media/Publications/drinking-water-quality-rural-india. Downloaded on 5 July 2017. ■

South Asia Water Initiative (SAWI)

The South Asia Water Initiative (SWAI) is a World Bank programme that aims to increase regional cooperation in the management of the major Himalayan river systems in South Asia to deliver sustainable, fair and inclusive development and climate resilience. The program is funded by Governments of United Kingdom, Australia and Norway.

The major Himalayan river systems — the Indus, Ganges and Brahmaputra — span multiple countries (Afghanistan, Bangladesh, Bhutan, China, India, Nepal and Pakistan), landscapes (mountains, valleys, lowlands and deltas) and cultures. The program therefore works across basins and countries to support knowledge generation and sharing, capacity development, dialogue, participatory decision processes, and investment designs. In the context of water resources planning and management, the program promotes poverty alleviation, economic development, gender inclusion and climate change adaptation.

The program is structured into five Focus Areas (FAs): the three major Himalayan river basins of South Asia (Indus, Ganges and Brahmaputra), the Sundarbans Landscape and Regional Cross-Cutting activities. The program aims to achieve the following results:

- Increases in trust and confidence in regional or basin water management as a result of dialogue processes.
- Strengthening of stakeholder inputs to government decisions as a result of participatory processes that facilitate transboundary knowledge generation and sharing.
- Strengthening of the capacity of water resources organizations in areas relevant to transboundary cooperation
- Increases in accessible regional basin or sub-basin-level knowledge
- Design of regional, basin or sub-basin-level interventions that improve livelihoods and ecosystem sustainability

SAWI supports activities across multiple sectors such as Water, Environment and Energy in order to achieve the above-mentioned results.

For more information, access:

http://www.worldbank.org/en/programs/sawi#1

Tech Events

2017

Nov 30 - Dec 2
Wellington, New Zealand
The Eighth Annual Asia Pacific Innovation Conference
Contact: Conference Secretariat
E-mail: apic@swin.edu.au
Web: http://ap-ic.org

Nov 30- Dec 2
Bengaluru, India
CeBIT INDIA 2017
Contact: Tejinder Singh, Project Head, CeBIT INDIA
Tel: +91-9970159012
E-mail: tejinder.singh@hmf-india.com
Web: http://www.cebit-india.com

Dec 4-7
Hong Kong, China
3rd International Conference on Surfaces, Coatings and Nanostructured Materials – Asia (NANOSMAT-Asia)
Contact: Conference Secretariat
One Central Park, Northampton Road, Manchester
M40 5BP, United Kingdom
Tel: +44 (0) 161 918 6673
Fax: +44 (0) 161 918 6781
E-mail: info@nanosmat-asia.com
Web: http://www.nanosmat-asia.com

Dec 5 -6
Kuala Lumpur, Malaysia
Global Entrepreneurship Community Summit 2017
Contact: Conference Secretariat
E-mail: partnership@mymagic.my
Web: http://www.gecommunity.co

Dec 7-8
Hong Kong, China
Business of IP Asia Forum
Contact: Hong Kong Trade Development Council
38th Floor, Office Tower, Convention Plaza 1 Harbour Road, Wanchai, Hong Kong, China
Tel: (852) 1830 668
Fax: (852) 2824 0249
E-mail: bipasia@hktdc.org
Web: http://bipasiaforum.com

Dec 14 - 15
Bangkok, Thailand
Intellectual Property Summit Asia 2017
Contact: i-Sprint Innovations (i-Sprint)
Blk 750D Lobby 1 Chai Chee Road
#08-01 Viva Business Park
Singapore 469004
Tel: +65 6244 3900
Fax: +65 6244 8900
Web: http://www.i-sprint.com/intellectual-property-summit-asia-2017/

2018

Jan 13–14
Kolkata, India
International Conference on Sustainability and Business
Contact: Conference Secretariat, Indian Institute of Management Calcutta (IIMC)
E-mails: susbus2018@iimcal.ac.in, ramendra@iimcal.ac.in
Web: https://www.iimcal.ac.in/international-conference-sustainability-and-business-susbus-2018

Feb 15–17
New Delhi, India
World Sustainable Development Summit 2018 (WSDS)
Contact: TERI (The Energy and Resources Institute), Darbari Seth
Block, IHC Complex, Lodhi Road,
New Delhi - 110 003, India
Tel. (+91 11) 2468 2100 and 41504900,
Fax (+91 11) 2468 2144 and 2468 2145,
E-mail: wsds@teri.res.in
Web: http://wsds.teriin.org

Jan 16–18
Energy Malaysia
Kuala Lumpur, The 4th International Conference on Renewable Technologies (ICRET 2018)
Contact: Lily L. Chen
Conference Secretary
Tel: +86-28-8777-7577
E-mail: icret@young.ac.cn
Web: http://www.icret.org

Mar 13–15
Danang, Viet Nam
Seventh International Conference and Exhibition on Water Resources and Renewable Energy Development in Asia
Contact: Mrs. Margaret Bourke
Tel: +44 8773 7250,
or -7251 or -7252
E-mail: Asia2018@hydropower-dams.com

Mar 19–20
Tokyo, Japan
BIO Asia International Conference
Contact: Conference Secretariat
E-mail: register@bio.org
Web: https://www.bio.org

Mar 21–22
Singapore
IoT Asia 2018
Contact: SingEx Exhibitions Pte Ltd
#01-01, 11 Tampines Concourse
Singapore 528729
Tel: +65 6403 2100
E-mail: registration.iotasia@singex.com
Web: http://www.internetofthingsasia.com

Mar 22–24
Kitakyushu, Japan
2018 3rd International Conference on Renewable Energy and Smart Grid (ICRESG 2018)
Contact: Ms. Max Chen
Tel: +852-30697937
E-mail: icresg@smehk.org
Web: http://www.icresg.org

Apr 4–6
Daegu, Republic of Korea
International Green Energy Expo Korea 2018
Contact: EXCO Korea Energy News
90, Yutongdanji-ro
Buk-gu
Daegu
Republic of Korea
Tel: +82 (053) 601-5375
Fax: +82 (053) 601-5372
E-mail: energy@excodaegu.co.kr

Apr 27–29
Shanghai, China
2018 8th International Conference on Environment and Industrial Innovation (ICEII 2018)
Contact: Ms. Zero Jiang
Conference secretary
Tel: +852-3500-0137;
+86-28-86528465
E-mail: iceii@cbees.org
Web: http://www.iceii.org

May 29–Jun 1
Kuala Lumpur, Malaysia
2018 International Conference on Smart Grid and Clean Energy Technologies
Contact: Conference Secretariat
E-mail: secretariat@icsgce.com
Web: http://www.icsgce.com

Jun 6–9
Bangkok, Thailand
ASEAN Sustainable Energy Week 2018
Contact: UBM ASIA (Thailand) Co Ltd.
503/23 K.S.L. Tower
14th Floor Sri Ayuthaya Road
Kwaeng Thanon Phayathai
Khet Rajathewee,
Bangkok 10400
Thailand
Tel: +66 0 2642 6911
Fax: +66 0 2642 6919-20
E-mail: info@cmpthailand.com

Jul 17–19
Kuala Lumpur, Malaysia
Green Energy Expo & Forum 2018
Contact: United Business Media (M) Sdn Bhd A-8-1,
Level 8, Hampshire Place Office 157
Hampshite, 1 Jalan Mayang Sari 50450
Kuala Lumpur, Malaysia.
Tel: +(603) 2176 8788,
Fax: +(603) 2164 8786
E-mail: ridzuan.husin@ubm.com

Tech Ventures & Opportunities

Business Coach

Tech Opportunities

Setting up a business in Thailand

Reporting requirements

Thailand Board of Investment
http://www.boi.go.th

Books of accounts and statutory records

Companies must keep books and follow accounting procedures as specified in the Civil and Commercial Code, the Revenue Code, and the Accounts Act. Documents may be prepared in any language, provided that a Thai translation is attached. All accounting entries should be written in ink, typewritten, or printed.

Accounting period

An accounting period must be 12 months. Unless the Articles of Association state otherwise, a newly established company should close accounts within 12 months of its registration. Thereafter, the accounts should be closed every 12 months. If a company wishes to change its accounting period, it must obtain written approval from the Director-General of the Revenue Department.

Reporting requirements

All juristic companies, partnerships, branches of foreign companies, and joint ventures are required to prepare financial statements for each accounting period. The financial statement must be audited by and subjected to the opinion of a certified auditor, with the exception of the financial statement of a registered partnership established under Thai law, whose total capital, assets, and income are not more than that prescribed in Ministerial Regulations. The performance record is to be certified by the company's auditor, approved by shareholders, and filed with the Commercial Registration Department of the MOC and with the Revenue Department of the Ministry of Finance (MOF).

For a private limited company, the director is responsible for arranging the annual meeting of shareholders to approve the company's audited financial statement within 4 months of the end of the fiscal year, and filing the audited statement and supporting documents, including a list of shareholders on the date of the meeting, to the Registrar no later than 1 month after the date of the shareholder meeting.

For a foreign company, i.e. branch office, representative office or regional office, and excluding joint ventures, the Manager of the branch office must submit a copy of the financial statement to the Registrar no later than 150 days after the end of the fiscal year. Approval of the shareholder meeting is not required.

For a public limited company, the director is responsible for arranging the annual meeting of shareholders to approve the audited financial statements of a company within 4 months of the end of the fiscal year. A copy of the audited financial statement and annual report, together with a copy of the minutes of the shareholder meeting approving the financial statement, should be certified by the director and submitted to the Registrar, along with a list of shareholders on the date of the meeting, no later than 1 month after approval at the shareholder's meeting. In addition, the company is required to publish the balance sheet for public information in a newspaper for a period of at least 1 day within 1 month of the date it was approved at the shareholder's meeting.

Accounting principles

Any accounting method adopted by a company must be used consistently and may be changed only with approval of the Revenue Department. Certain accounting practices of note include:

Depreciation: The Revenue Code permits the use of varying depreciation rates according to the nature of the asset, which has the effect of depreciating the asset over a period that may be shorter than its estimated useful life. These maximum depreciation rates are not mandatory. A company may use a lower rate that approximates the estimated useful life of the asset. If a lower rate is used in the books of the accounts, the same rate must be used in the income tax return.

Accounting for Pension Plans: Contributions to a pension or provident fund are not deductible for tax purposes unless they are actually paid out to the employees, or if the fund is approved by the Revenue Department and managed by a licensed fund manager.

Consolidation: Local companies with either foreign or local subsidiaries are not required to consolidate their financial statements for tax and other government reporting purposes, except for listed companies, which must submit consolidated financial statements to the Securities and Exchange Commission of Thailand.

Statutory Reserve: A statutory reserve of at least 5% of annual net profit arising from the business must be appropriated by the company at each distribution of dividends until the reserve reaches at least 10% of the company's authorized capital.

Stock Dividends: Stock dividends are taxable as ordinary dividends and may be declared only if there is an approved increase in authorized capital. The law requires the authorized capital to be subscribed in full by the shareholders.

Auditing requirements and standards

Audited financial statements of juristic entities (*i.e.* a limited company, registered partnership, branch, representative office, regional office of a foreign corporation, or joint venture) must be certified by an authorized auditor and be submitted to the Revenue Department and to the Commercial Registrar for each accounting year.

Startup India

National Portal of India

https://india.gov.in

Startup India is a flagship initiative of the Government of India, intended to build a strong eco-system to encourage new ideas and Startups in the country that will lead to economic growth and generate large scale employment opportunities.

Startup means an entity, which is registered in India not over five years and the annual turnover not exceeding Rs.25 crore in any financial year. It is an entity which works towards innovation, development, deployment or commercialization of new products and services driven by technology or intellectual property.

The action plan announced by the Government in this regard, hopes to address all aspects of the Startup ecosystem and accelerate the spreading of this movement.

Components of Startup India

Simplification and handholding

- **Compliance regime based on self-certification:** The idea is to reduce the regulatory burden on startups, so that they can focus on their core business and keep the cost of compliance low. The regulatory regimes will thus be made simpler and flexible; inspections more meaningful and simple.
- **Startup India hub:** Creation of a single point of contact for the entire startup ecosystem to enable the exchange of knowledge and access of funding. The Government will be the main stakeholder and will collaborate with Central and State Governments, Indian and foreign VC's, angel networks, banks, incubators, legal partners, consultants, universities and R&D institutions.
- **Rolling out of mobile app and portal:** It will act as an interacting platform for startups with the Government and regulatory institutions.
- **Legal support and fast:** Tracking Patent Examination at Lower Costs- To promote and create awareness in startups about IPRs and ensure continuous growth and development of new startups, this scheme will make the task of filing patents easier.
- **Relaxed norms of public procurement for startups:** The aim is to provide equal opportunity to Startups as compared to experienced companies. The Government will exempt startups from the criteria of 'Prior experience/Turnover' in case of tenders floated by Government or by PSU's, without relaxation in the quality parameters.
- **Faster exit for startups:** The Action Plan will make it easier for Startups to wind up operations in case they fail to succeed. An insolvency professional will be provided to the Startups, who will be in-charge of the company for liquidating the assets and paying the creditors in six month's time. This process will accept the concept of limited liability.

Funding support and incentives

- **Provide funding support to startups:** The Government will set up an initial fund of Rs.2,500 crore per year and a total of Rs.10,000 crore over a period of 4 years.
- **Credit guarantee for startups:** To encourage Banks and other Lenders to provide Venture Debts to startups, Credit guarantee mechanism through National Credit Guarantee Trust Company (NCGTC)/ SIDBI is being considered with a budget of Rs.500 crore per year for the next four years.
- **Tax exemptions on capital gains:** To promote investments into Startups, the Government will give tax exemption to those who have capital gains during the year and have invested such capital gains in the Fund of Funds recognized by the Government.
- **Tax exemption to startups for three years:** To address the working capital requirement, stimulate the development of Startups in India and provide them a competitive platform, the profits of Startups will be exempted from Tax for a period of 3 years.
- **Tax exemption on investments over fair market value:** Investment by incubators in Startups will be exempted from Tax.

Industry - Academia partnership and incubation

- **Organizing startup fests for showcasing innovation and providing a collaboration platform:** To strengthen the Startup ecosystem in India, the Government has proposed to introduce Startup fests at both national and international levels. This will be a platform for the Startups in India, to showcase their work and ideas and work with a larger audience comprising of potential investors, mentors and fellow Startups.
- **Launch of Atal Innovation Mission (AIM) with Self Employment and Talent Utilization (SETU) Program:** This will serve as a platform for promoting world- class innovation hubs, grand Challenges, Startup businesses and other self-employment activities particularly in technology driven areas.
- **Harnessing private sector expertise for incubator setup:** Government will create a policy and framework for setting up incubators across the country in public private partnership.

- **Building innovation centers at national institutes:** To increase the incubation and R&D efforts in the country, Government will set up 31 centers of innovation and entrepreneurship at national institutes. For 13 centers an annual funding of Rs.50 Lakhs will be provided for 3 years to encourage student driven Startups.
- **Setting up of 7 new research parks modeled on the research park set up at IIT Madras:** In order to give a push to successful innovation through incubation and joint R&D efforts between academia and industry, the Government will set up 7 new Research Parks in institutes with an initial investment of Rs.100 crore each. The Research Parks shall be modeled based on the Research Park setup at IIT Madras.
- **Promoting startups in the biotechnology sector:** The Biotechnology sector in India is on a strong, growth trajectory. Department of Biotechnology endeavors to scale up the number of Startups in the sector by nurturing approximately 300-500 new Startups each year to have around 2000 Startups by 2020.
- **Launching of innovation focused programs for students:** The Government will promote research and innovation among young students and has thus launched a few programs like- Innovation Core, NIDHI (a grand challenge program) and Uchhatar Avishkar Yojna. These schemes will initially apply to IIT's only and each project may amount Rs.5 crore.
- **Annual incubator grand challenge:** Incubators play an important role in identifying early stage Startups and supporting them across various phases of their lifecycle to build an effective Startup ecosystem. The Government is proposing to make forward looking investments towards building world class incubators in its first phase; the aim is to establish 10 such incubators. The Government will hence identify 10 incubators having the potential to become world class. These will be given Rs.10 crore each as financial assistance and such incubators will become reference models for other incubators. These will then be showcased on Startup India Portal. An Incubator Grand Challenge exercise will be carried out for the identification of such incubators and this will be an annual exercise.

Translation Tool for Patent Documents

The World Intellectual Property Organization has developed a ground-breaking new "artificial intelligence"-based translation tool for patent documents, handing innovators around the world the highest-quality service yet available for accessing information on new technologies.

WIPO Translate now incorporates cutting-edge neural machine translation technology to render highly technical patent documents into a second language in a style and syntax that more closely mirrors common usage, outperforming other translation tools built on previous technologies. WIPO has initially "trained" the new technology to translate Chinese, Japanese and Korean patent documents into English. Users can already try out the Chinese-English translation facility on the public beta test platform.

The high level of accuracy of the Chinese-English translation is the result of the training of the neural machine translation tool, which compared 60 million sentences from Chinese patent documents provided to WIPO's PATENTSCOPE database by the State Intellectual Property Office of the People's Republic of China with their translations as filed at the United States Patent and Trademark Office. WIPO plans to extend the neural machine translation service to French-language patent applications, with other languages to follow. The PATENTSCOPE database integrates with other translation engines freely available on the internet and continues to use existing statistical-based translation technology for languages where it performs well. WIPO has shared its translation software with other international organizations, including the United Nations conference management service, Food and Agriculture Organization, International Telecommunication Union, International Maritime Organization, World Trade Organization, and The Global Fund to Fight AIDS, Tuberculosis and Malaria.

For more information, access:

Media Relations Section
World Intellectual Property Organization (WIPO)
34, chemin des Colombettes
CH-1211 Geneva 20, Switzerland
Tel: (+41 22) - 338 81 61 / 338 72 24
Fax: (+41 22) - 338 81 40
Web: http://www.wipo.int

Compulsory license for exploitation of a patent in China

State Intellectual Property Office, China

http://english.sipo.gov.cn

Article 48: Under any of the following circumstances, the patent administration department under the State Council may, upon application made by any unit or individual that possesses the conditions for exploitation, grant a compulsory license for exploitation of an invention patent or utility model patent:

(1) When it has been three years since the date the patent right is granted and four years since the date the patent application is submitted, the patentee, without legitimate reasons, fails to have the patent exploited or fully exploited; or

(2) The patentee's exercise of the patent right is in accordance with law, confirmed as monopoly and its negative impact on competition needs to be eliminated or reduced.

Article 49: Where a national emergency or any extraordinary state of affairs occurs, or public interests so require, the patent administration department under the State Council may grant a compulsory license for exploitation of an invention patent or utility model patent.

Article 50: For the benefit of public health, the patent administration department under the State Council may grant a compulsory license for manufacture of the drug, for which a patent right has been obtained, and for its export to the countries or regions that conform to the provisions of the relevant international treaties to which the People's Republic of China has acceded.

Article 51: If an invention or utility model, for which the patent right has been obtained, represents a major technological advancement of remarkable economic significance, compared with an earlier invention or utility model for which the patent right has already been obtained, and exploitation of the former relies on exploitation of the latter, the patent administration department under the State Council may, upon application made by the latter, grant it a compulsory license to exploit the earlier invention or utility model.

Under the circumstance where a compulsory license for exploitation is granted in accordance with the provisions of the preceding paragraph, the patent administration department under the State Council may, upon application made by the earlier patentee, grant it a compulsory license to exploit the later invention or utility model.

Article 52: If an invention involved in a compulsory license is a semi-conductor technology, the exploitation thereof shall be limited to the purpose of public interests and to the circumstances as provided for in Subparagraph (2) of Article 48 of this Law.

Article 53: Except for the compulsory license granted in accordance with the provisions of Subparagraph (2) of Article 48 or Article 50 of this Law, compulsory license shall mainly be exercised for the supply to the domestic market.

Article 54: A unit or individual that applies for a compulsory license in accordance with the provisions of Subparagraph (1) of Article 48 or Article 51 of this Law shall provide evidence to show that it or he has, under reasonable terms, requests the patentee's permission for exploitation of the patent, but fails to obtain such permission within a reasonable period of time.

Article 55: The decision made by the patent administration department under the State Council on granting of a compulsory license for exploitation shall be notified to the patentee in a timely manner and shall be registered and announced.

In a decision on granting of the compulsory license for exploitation shall, according to the reasons justifying the compulsory license, be specified the scope and duration for exploitation. When such reasons cease to exist, and are unlikely to recur, the patent administration department under the State Council shall, upon request by the patentee, make a decision to terminate the compulsory license after examination.

Article 56: Any unit or individual that is granted a compulsory license for exploitation shall not have an exclusive right to exploitation and shall not have the right to allow exploitation by others.

Article 57: The unit or individual that is granted a compulsory license for exploitation shall pay reasonable royalties to the patentee, or handle the issue of royalties in accordance with the provisions of the relevant international treaties to which the People's Republic of China has acceded. The amount of royalties to be paid shall be subject to consultation between the two parties. In the event of failure to reach an agreement between the two parties, the patent administration department under the State Council shall make a ruling.

Article 58: If a patentee is dissatisfied with the decision made by the patent administration department under the State Council -on granting of the compulsory license for exploitation, or if the patentee, or the unit or individual that has obtained the compulsory license for exploitation is dissatisfied with the ruling made by the patent administration department under the State Council regarding the royalties for the compulsorily licensed exploitation, it or he may take legal action before the people's court within three months from the date of receipt of the notification of the ruling.

Technology transfer arrangement in the Philippines

Intellectual Property Office of the Philippines (IPOPHL), Philippines

http://www.ipophil.gov.ph

The signing of Republic Act 8293, otherwise known as the Intellectual Property (IP) Code, on June 6, 1997 liberalizes regulations on technology transfer registration particularly the rate of fees or royalties and strengthens intellectual property rights protection in the Philippines. Voluntary Licensing has been provided by the Code. Recordal with the IP Philippines of agreements that involve transmission of rights is necessary. However, registration is no longer required where the agreement is in conformity of the requirements of the law under Sections 87 and 88.

Section 87 of the IP Code covers the prohibited clauses which are adverse to competition and trade.

Prohibited Clauses (Section 87, IP Code)

1. Those which impose upon the licensee the obligation to acquire from a specific source capital goods, intermediate products, raw materials, and other technologies, or of permanently employing personnel indicated by the licensor;
2. Those pursuant to which the licensee reserves the right to fix the sale or resale prices of the products manufactured on the basis of the license;
3. Those that contain restrictions regarding the volume and structure of production;
4. Those that prohibit the use of competitive technologies in a non-exclusive technology transfer arrangement;
5. Those that establish full or partial purchase option in favor of the licensor;
6. Those that obligate the licensee to transfer for free to the licensor the inventions or improvements that may be obtained through the use of the licensed technology;
7. Those that require payment of royalties to the owners of patents for patents which are not used;
8. Those that prohibit the licensee to export the licensed product unless justified for the protection of the legitimate interest of the licensor such as exports to countries where exclusive licenses to manufacture and/or distribute the licensed product(s) have already been granted;
9. Those which restrict the use of the technology supplied after the expiration of the technology transfer arrangement, except in cases of early termination of the technology transfer arrangement due to reason(s) attributable to the licensee;
10. Those which require payments for patents and other industrial property rights after their expiration or termination of the technology transfer arrangement;
11. Those which require that the technology recipient shall not contest the validity of any of the patents of the technology supplier;
12. Those which restrict the research and development activities of the licensee designed to absorb and adapt the transferred technology to local conditions or to initiate research and development programs in connection with new products, processes or equipment;
13. Those which prevent the licensee from adapting the imported technology to local conditions, or introducing innovation to it, as long as it does not impair the standards prescribed by the licensor; and
14. Those which exempt the licensor from liability for non-fulfillment of his responsibilities under the technology transfer arrangement and/or liability arising from third party suits brought about by the use of the licensed product or the licensed technology.

On the other hand, Section 88 of the IP Code contains provisions which need to be included in voluntary license agreement as follows:

1. That the laws of the Philippines shall govern the interpretation of the agreement and in the event of litigation, the venue shall be the proper court in the place where the licensee has its principal office;
2. Continued access to improvements in techniques and processes related to the technology shall be made available during the period of the technology transfer arrangement;
3. In the event the technology transfer arrangement shall provide for arbitration, the Procedure of Arbitration of the Arbitration Law of the Philippines or the Arbitration Law of the United Nations Commission on International Trade Law (UNCITRAL) or the Rules of Conciliation and Arbitration of the International Chamber of Commerce shall apply and the venue of arbitration shall be the Philippines or any neutral country; and
4. The Philippine taxes on all payments relating to the technology transfer arrangement shall be borne by the licensor.

Venture capital for MSMEs in India

Small Industries Development Bank of India (SIDBI)

https://smallb.sidbi.in

Venture Capital is emerging as an important source of finance for small and medium-sized firms, especially for starting the business and business expansion. An entrepreneur usually starts the business with his own funds, and those borrowed from banks. It is during expansion that they find it difficult to raise funds. SMEs have traditionally been dependent on Bank finance for expansion and working capital requirements. However, in the recent past, bankers have curtailed lending to SMEs due to the greater risk of non-performing assets (NPAs) in a downturn. Thus, even though many SMEs have profitable projects and expansion plans, they find it difficult to get finance for their projects, as bankers may not be willing to fund high risk projects.

In order to provide financial support to such entrepreneurial talent and business skills, the concept of venture capital emerged. Venture capital is a means of equity financing for rapidly-growing private companies. Finance may be required for the start-up, expansion or purchase of a company. Venture capitalists comprise of professionals in various fields. They provide funds (known as Venture Capital Fund) to these firms after carefully scrutinizing the projects. Their main aim is to earn higher returns on their investments, but their methods are different from the traditional moneylenders. They take active part in the management of the company as well as provide the expertise and qualities of a good bankers, technologists, planners and managers.

Venture capital for MSMEs in India

Traditionally, Venture Capitalists in India have shied from the MSME sector. The non-corporate structure and small size of majority of MSMEs in India makes the Venture Capitalists and Private Equity Players reluctant to investing in them due to higher transaction costs and difficulties in exits out of such investments. However, the VC scenario in India is rapidly changing. Alternative funding like VC is picking up in the India, including in the MSME sector. Moreover, the VCs are expanding their reach into areas besides the traditional VC sectors like Information Technology (IT); nowadays interest in sectors like clean energy, healthcare, pharmaceuticals, retail, media, etc. is also growing.

The Small Industries Development Bank of India (SIDBI) is the main public financial institution involved in VC funding operations. SIDBI operates through wholly owned subsidiary, SIDBI Venture Capital Limited (SVCL). It co-finances state-level funds, and sometimes co-invests with private sector VCs on a case-by-case basis.

Benefits of VC over other funding methods

Venture capital has a number of advantages over other forms of finance:

- It injects long term equity finance which provides a solid capital base for future growth.
- The venture capitalist is a business partner, sharing both the risks and rewards. Venture capitalists are rewarded by business success and the capital gain.
- The venture capitalist is able to provide practical advice and assistance to the company based on past experience with other companies which were in similar situations.
- The venture capitalist also has a network of contacts in many areas that can add value to the company, such as in recruiting key personnel, providing contacts in international markets, introductions to strategic partners, and if needed co-investments with other venture capital firms when additional rounds of financing are required.

Venture capital funds in India

In India, venture capital funds (VCFs) can be categorized into the following groups:

- Promoted by the Central Government controlled development finance institutions, for example:
  - SIDBI Venture Capital Limited (SVCL)
  - IFCI Venture Capital Funds Limited (IVCF)
- Promoted by State Government controlled development finance institutions, for example:
  - Gujarat Venture Finance Limited (GVFL)
  - Kerala Venture Capital Fund Pvt Ltd.
  - Punjab Infotech Venture Fund
  - Hyderabad Information Technology Venture Enterprises Limited (HITVEL)
- Promoted by public banks, for example:
  - Canbank Venture Capital Fund
  - SBI Capital Markets Limited
- Promoted by private sector companies, for example:
  - IL&FS Trust Company Limited
  - Infinity Venture India Fund
- Overseas venture capital fund, for example:
  - Walden International Investment Group
  - SEAF India Investment & Growth Fund
  - BTS India Private Equity Fund Limited

Private sector funding for SMEs in Malaysia

SME Corporation Malaysia
http://www.smeinfo.com.my

Banking institutions

SMEs can approach Commercial Banks and Islamic Banks for funding, depending on their needs.

Conventional as well as Islamic financing products are available for a wide range of needs. These would cover items like term loans, leasing and industrial hire-purchase for asset acquisitions or business expansions; overdrafts, revolving credit facilities and factoring for working capital; letters of credit (LC), trust receipts, banker's acceptance (BA) and Export Credit Refinancing (ECR) for trade financing; and bank guarantee as well as shipping guarantee facilities.

Development financial institutions

Aside from commercial banks and Islamic banks, there are also Government-backed Development Financial Institutions (DFIs) which can provide SME financing.

Development Financial Institutions (DFIs):
(governed by the Development Financial Institutions Act 2002)

- Bank Perusahaan Kecil & Sederhana Malaysia Berhad (SME Bank)
- Bank Pembangunan Malaysia Berhad
- Export-Import Bank of Malaysia Berhad
- Bank Kerjasama Rakyat Malaysia Berhad
- Bank Pertanian Malaysia
- Bank Simpanan Nasional

Other DFIs:

- Malaysian Industrial Development Finance Berhad
- Credit Guarantee Corporation Malaysia Berhad (CGC)

Leasing and factoring companies

Leasing

SMEs in need of expensive machinery need not only rely on hire-purchase arrangements as a means to financing their business.

They can also choose to lease equipment, which would give them use of equipment owned by a leasing company, in return for regular lease payments over a specific period of time.

This allows SMEs use of vital equipment without ever having to buy it.

Any moveable asset can be leased. This includes office equipment, vehicles, industrial and manufacturing equipment, as well as construction and heavy equipment.

Features

- A facility which allows SMEs to lease equipment from financial institutions without having to purchase the equipment.
- There are 2 types of leasing facilities available:
  1. *Operating Lease.*
     Ownership is held by the financial institutions.
  2. *Finance Lease.*
     Ownership is held by the financial institutions. However, the lessee has the option to purchase the asset at the end of the tenure.

Benefits

- Facilitate management of funds, as leasing instalments amount is predetermined.
- For an operating lease, maintenance cost is borne by the lessor (financial institution).
- Instalments paid for leasing are eligible for full tax relief.

Factoring

SMEs can also choose to pledge their future income in order to obtain working capital. Factoring companies specialise in buying debt owed to a business, or account receivables, at a discounted price. If this happens, the factoring company will take over collection of the debt, while the company selling the debt receives money for a debt earlier, and up front.

- Malaysian Industrial Development Finance Berhad
- ORIX Leasing Malaysia Berhad

Venture capital companies

SMEs in need of capital injections might also look to venture capital companies. Venture capitalists willing to take a stake in a business will provide capital, usually in exchange for a minority stake in the company concerned.

Businesses with expansion and the potential for and eventual listing on the stock exchange are favoured targets of venture capitalists. The money is often provided for long-term expansion projects undertaken by the company concerned.

Social innovation in Thailand

National Innovation Agency, Thailand
http://www.nia.or.th

Social innovation business

It is a new strategy that is globally important to bring innovation to solve social problems. It is a process, a tool and an operation to make the society better by meeting the needs of society. An important foundation in the development of the country, Sustainable Social Business has main drivers such as Community Enterprises (CE), Cooperatives, Farmers, and Social Enterprises (SE). The social innovation strategy includes value added with innovation and using innovation to offer new solutions, new thinking approaches, and new ways of solving problems.

The National Innovation Agency (NIA) is the main organization in the development of the National Innovation System (NIS) in Thailand, using both academic and financial mechanisms. It has initiated the action plan, **"Social Innovation Business"** as the foundation for the development of a community-based business innovation that is sustainable.

Sci-Tech Coupon Programme

The Ministry of Science and Technology of Thailand supports the development of One Tambon, One Product (OTOP) entrepreneurship by community enterprises by using science, technology and innovation to research and develop innovative products through:

- Development and design of packaging, development and design of production processes.
- Development of standard systems.
- Development and design of machinery, improving the quality of raw materials, water, contributes to the agricultural sector.
- Industry trade and service sectors in the fields that respond to the direction of economic and social development of the country.

The target group has 3 categories:

1. **OTOP Start-up manufacturers or entrepreneurs who have just started (OTOP Start-up):** Community enterprises, cooperative groups, unlicensed cooperatives that require science, technology and innovation to use, build and develop products, services and create new businesses.
2. **Existing:** OTOP operators and existing groups of entrepreneurs who have registered as OTOP entrepreneurs who need to be scientific.
3. **Overtop entrepreneurs** who are companies or partnerships and want to increase the growth potential of the entrepreneurial group of companies. Limited partnership that produces and distributes community products / local products / OTOP products has been listed as an OTOP entrepreneur that needs science, technology and innovation.

There are 6 service areas:

1. Develop product innovation.
2. Development and design of packaging.
3. Develop and design production process.
4. Develop standard system.
5. Development and design of machinery.
6. Upstream quality development.

National Innovation Agency (NIA), Thailand plays a key role in driving the social enterprise sector into a systematic thinking process for innovation. It is in tune with innovation insights.

Example of NIA's contribution to the creation of a community product of a social enterprise:

- The batik color separator from rubber with Songkhla Batik community enterprise.
- Translucent and lightweight pottery with nano soil, together with community enterprises, handicrafts.
- Pottery House Kung Mine.
- Natural textiles with soft shadows and softness, together with the community enterprise, ancient weaving village of Ban Phueang.

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 political 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. This was made possible by close cooperation with our eCommerce ecosystem players, thereby transforming Malaysia's e-commerce landscape.

In addition to programmes like #MYCYBERSALE, #MYGlobalExport, and eTRADE, the National e-Commerce Strategic Roadmap was developed to double the eCommerce growth rate from 10.8% to 20.8% by the year 2020. This is done through specific government interventions along these Six Strategic Thrusts:

- Accelerate seller adoption of e-commerce
- Increase adoption of e-Procurement by businesses
- Lift non-tariff barriers
- Realign existing economic incentives
- Make strategic investments in selected e-commerce player(s)
- Promote national brands to boost cross-border e-commerce

Internet of Things (IOT)

In the world of rapid digital interaction, IoT gives insights on how consumers integrate technology in their daily lives, a valuable information that can be used in various ways. The growing need for internet-related products and services is driving this transition, not only globally but also here in Malaysia.

In 2015, the Ministry of Science, Innovation & Technology Malaysia launched the National IoT Strategic Roadmap, which forecasted opportunities to reach RM9.5 billion in 2020 and RM42.5 billion in 2025. This is all done to create a national ecosystem to make IoT a new source of economic growth with its industrialisation and proliferation of use.

The National IoT Strategic Roadmap outlines 3 national goals:

- Malaysia as the Regional Development Hub for IoT
- Create a conducive IoT industry ecosystem
- Strengthen technopreneur capabilities in Apps & Services layer

The 3 long-term strategies for IoT are:

- Open Innovation Framework
- Open Community Data Framework
- IoT Malaysia

MDEC has been tasked to lead the IoT industry developmental charter called IoT Malaysia. With this mandate, we have focused our efforts on key verticals that will not only increase the digital adoption and growth of IoT in Malaysia, but also digitalize the way they operate, which include Smart Manufacturing, Smart Agriculture and Smart Transportation.

- Industry Development – to raise critical mass and competitiveness of IoT companies to drive demand
- Digital Transformation – to facilitate IoT adoption and proliferation through public-private partnership for business, government and citizen
- Ecosystem Development – to facilitate the development of IoT ecosystem and enabling environment

Creative Productivity Index: Analysing Creativity and Innovation in Asia

This report presents the results and analysis of the Creative Productivity Index (CPI) for a select number of Asian economies. The CPI was built by The Economist Intelligence Unit. The Asian Development Bank (ADB) commissioned the work on developing the CPI as part of an overall study on Asia's knowledge economies. The report provides a benchmarking of a number of economies in Asia on creative productivity, an important attribute for strengthening knowledge-based economic development. This index gives policy makers a unique tool to assess how to foster creativity and innovation in Asia. Innovation-led growth is crucial for developing Asia to maintain and accelerate the pace of growth of its economies.

Following are the key findings of the CPI:

- Japan leads the CPI, followed by Finland and the Republic of Korea;
- Cambodia and Pakistan, with much room for improvement, are ranked lowest in the CPI;
- Singapore leads the CPI for innovation inputs;
- Finland and Hong Kong, China are best in the CPI for innovation outputs;
- Low- and middle-income economies will benefit most from policies to increase creative inputs; and
- There are many different dimensions of creativity that are captured in this report.

Many Asian developing economies face a challenge to avoid being stuck in the middle-income trap. They need to transition from an imitation-driven economy to an innovation-based growth model more commonly found in developed countries. Richer economies are clearly able to invest more in physical infrastructure such as transport networks, communications, and power generation, which are key underlying factors in economic creativity and innovation. However, some differences are a result of the enabling environment that facilitates the generation of creative outputs from creative inputs. A poorer country may not be able to muster the same level of creative inputs as a richer country, but can still benefit by using what resources it does have efficiently. While the precise policy recommendations will differ for each economy, the results of this report highlight a number of important policy areas where an increased emphasis would be beneficial for many Asian economies.

For more information, access:

Asian Development Bank
6 ADB Avenue, Mandaluyong City 1550
Metro Manila, Philippines
Tel: + 63 2 632 4444; Fax: +63 2 632 4442
Web: http://www.adb.org

Tax incentives for green industry in Malaysia

Malaysian Investment Development Authority, Malaysia

http://www.mida.gov.my

To strengthen the development of green technology, the Government will continue to provide incentives in the form of investment tax allowance for the purchase of green technology assets and income tax exemption for the use of green technology services and system.

The incentives which were announced in Budget 2014 will cover broader scope of green technology activities in the areas of energy, transportation, building, waste management, and supporting services activities. It also facilitates the transition of the expired (by 31 December 2015) tax incentives relating to renewable energy (RE) and energy efficiency (EE) projects under the Promotion of Investment Act (PIA), 1986.

Tax incentive for green technology project

Investment Tax Allowance (ITA) of 100% of qualifying capital expenditure incurred on a green technology project from the year of assessment 2013 (date on which the first qualifying capital expenditure incurred is not earlier than 25 October 2013) until the year of assessment 2020. The allowance can be offset against 70% of statutory income in the year of assessment. Unutilised allowances can be carried forward until they are fully absorbed.

Green technology project related to renewable energy, energy efficiency, green building, green data centre, and waste management can qualify for this tax incentive.

Tax incentive for green technology services

Income tax exemption of 100% of statutory income from the year of assessment 2013 until the year of assessment 2020.

Green technology services related to renewable energy, energy efficiency, electric vehicle (EV), green building, green data centre, green certification and verification, and green township can qualify for this tax incentive.

Applications received by 31 December 2020 are eligible for this incentive. Applications should be submitted to MIDA.

Tax incentive for purchase of green technology assets

Investment Tax Allowance (ITA) of 100% of qualifying capital expenditure incurred on green technology asset from the year of assessment 2013 (date on which the first qualifying capital expenditure incurred is not earlier than 25 October 2013) until the year of assessment 2020. The allowance can be offset against 70% of statutory income in the year of assessment. Unutilized allowances can be carried forward until they are fully absorbed.

Incentives for establishment of Waste Eco Parks (WEPs)

Waste Eco Park (WEP) aims to promote waste recycling, recovery and treatment activities by the industries and provides a sustainable solution to waste management problem. This will encourage investments in facilities and infrastructure towards holistic waste management activities. In order to promote the activities, there are incentives available for WEP Developer, WEP Manager and WEP Operator (companies operating in the WEP).

WEP Developers

Applications received by MIDA from 1 January 2016 until 31 December 2020, are eligible to be considered for this incentive.

WEP Managers

Applications received by MIDA from 1 January 2016 until 31 December 2020, are eligible to be considered for this incentive.

WEP Operators (companies operating in WEP)

Applications received by MIDA from 1 January 2016 until 31 December 2020, are eligible to be considered for this incentive.

WIPO GREEN Database

WIPO GREEN, an interactive marketplace that connects technology and service providers with those seeking innovative solutions, was established by the World Intellectual Property Organization (WIPO) in 2013. WIPO GREEN consists of an online database and network that brings together a wide range of players in the green technology innovation value chain, and connects owners of new technologies with individuals or companies looking to commercialize, license or otherwise access or distribute a green technology. These technologies are available for license, collaboration, joint ventures and sale. The database helps not only to accelerate innovation and diffusion of green technologies, but also contributes to the efforts of developing countries in addressing climate change.

For more information, access:

https://webaccess.wipo.int/green/

Net-metering solutions for using renewable energy in Sri Lanka

Sri Lanka Sustainable Energy Authority (SLSEA), Sri Lanka

http://www.energy.gov.lk

Net-metering is a policy that allows an electricity customer to use renewable energy sources within his premises to generate electricity and utilise it within his premises, and to export it to the national grid if excess power is being generated, to be recovered when needed. Therefore, the grid acts like an energy bank for the customer. This policy originated in the USA, but has now spread too many countries. Both electricity distributors, that is, the Ceylon Electricity Board (CEB) and the Lanka Electricity Company Pvt. Ltd. (LECO), offer net-metering to their customers.

Both regulations are nearly the same, with the only difference in fees for net-metering. Net-metering involves a ten-year contract, a generation facility with a limit of 10 MW or the contract demand of the premises and any renewable resource for power generation. The surplus will be credited to the customer but no payment will be made for the surplus nor can the customer sell it to another customer.

Technically, any renewable resource like hydro, wind, solar and biomass can be used for net-metering. But at household level, solar PV systems are the preferred option, owing to resource availability, smaller space requirements and ease of operation and maintenance. Solar PV systems are available in the market in wide variety, quality and of course, price. The most advanced solar technologies require no special expertise to install. The basic requirements are a solar PV panel, a grid-tied inverter and careful integration of the system together. The inverter output requires to be connected to the household supply, accompanied with necessary protection and isolating equipment, while a two way meter is installed in the house by the electricity service provider. The net-metering scheme can become operational upon signing an agreement.

Tips on installing a net-metered system

- It's appropriate to study the past electricity bills, of about three years, to ascertain variations in the electricity waste pattern. The average electricity bill should be considered for the selection of an appropriate system.
- Scan the surrounding environment of the house and select an exposed, sunny, south sloping roof area to locate the panel and an enclosed are to install the inverter.
- In Colombo, solar panels need to be oriented at an angle of 7 degrees to the horizontal sloping in the southern direction, for maximum yield. However a more angle of 15° is recommended to facilitate.
- The solar panels should be purchased accompanied with a suitable inverter and other appropriate items, known in the PV industry as Balance of System (BoS), and installed conforming to wiring regulations governing such installations.
- Solar tracking systems are capable of tracking the motion of the sun throughout the day to get maximum power generated from the solar panels. Such tracking systems can be installed for better results, but are significantly expensive.
- The customer is required to enter into an Agreement, with the utility (CEB or LECO), namely, the "Agreement and Grid Interconnection Standards for Net-metering of an On-grid Renewable Energy based Generating Facility."
- The electricity distributor would take necessary steps to install the net-metering setup, after which the facility could start generating. The surplus could be banked to the grid legally as per the contract.

Configurators

The SEA developed user-friendly configurators (tools) to help users identify the 'right size' for a solar net-metering solution which would enable making the best choice for a net-metered solar system based on the level of investment. The tariff effective since September 16, 2014 is applicable for this configurator.

1st Configurator

This configurator helps you make choices based on:

- Your level of investment.
- Need of replacing or adding electrical equipment.

You can make choices based on the two options given above. The configurator will select a suitable system for you, assuming the following:

- 17% plant factor
- Utility cost of LKR 65,000
- System cost of LKR 350,000 per kW
- Your energy bill will be reduced to the lowest possible value (close to zero). The tool has been optimised, therefore it is practically impossible to get zero units, but the tool would give you the best deal between the highest saving and the lowest investment.

2nd Configurator

This configurator is based on data of list prices of panels and inverters provided by solar companies. You can make choices based on:

- Prices of systems.
- Payback periods.

You can make choices based on the two options given above. The configurator will select a suitable system for you, assuming the following.

Results would be displayed at your convenience. For example, if you wish to seek a system that fits your budget, you could select systems sorted according to their prices or simple payback periods. Alternatively, if you wish to seek reputed brands, you could select companies sorted in the alphabetical order. We also give contact details of companies, so that you could get more information about the products from them.

3rd Configurator

This configurator is built for micro inverters. Micro inverters are compact units that convert direct current (DC) to alternating current (AC) immediately at the solar module. As compared to solar PV installations that use string or central inverters, micro inverters deliver 5% to 10% greater energy harvest over the system lifetime by applying Maximum Power Point Tracking (MPPT) to each solar module to optimise energy harvest. Micro inverter technology delivers more kilowatt-hours daily, monthly and yearly, even though the partial shade of clouds, trees, or structural obstructions are present. As a result, there is no dramatic reduction in system output when a solar module, or part of a module, has its output reduced by shading or build-up of surface debris. Micro inverters are designed for high reliability operations and they generally have a longer lifespan than that of string or central inverters.

This configurator is based on data of list prices of panels and micro inverters provided by solar companies. You can make choices based on:

- Prices of systems.
- Payback periods

Results would be displayed at your convenience, and are listed according to their payback periods.

4th Configurator

Sometimes, you may need to replace a few household items, for example, an old refrigerator, incandescent lamps, or even you might need to purchase new items, such as an air conditioner, a double door refrigerator etc. You will lower your electricity bill when you remove items in use, and you would increase your bill when you add new items. This configurator will calculate your new electricity bill, based on the items you choose to add or remove.

This tool uses the average wattages of common household electrical equipment. The tool will help you make choices based on:

- Items you wish to replace, add or remove.
- The tentative duration which these equipment will be operated.

Publications on SMEs competitiveness

Innovation and SME Financing in Selected Asian Economies

This publication highlights the different policy measures taken by the governments of seven Asian economies to stimulate innovation among SMEs. It contributes to the current discourse on the importance of financing innovations to create a conducive environment for long-term SME growth.

Contact: Asian Productivity Organization, Leaf Square Hongo Building, 2F, 1-24-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan. Tel: 81-3-3830-0411, Fax: 81-3-5840-5322, E-mail: apo@apo-tokyo.org, Web: http://www.apo-tokyo.org

Exchanging Value - Negotiating Technology Licensing Agreements: A Training Manual

The manual provides an introduction to some of the basic issues that arise in technology licensing negotiations and offers useful insights into how they may best be handled. In a highly competitive and dynamic marketplace, technology licensing is a useful option for companies seeking to maintain their competitive advantage and a healthy balance sheet. It covers a wide range of basic issues that arise during technology licensing negotiations and offers useful insights into how they may best be handled in practice.

Contact: Media Relations and Public Affairs Section, WIPO. Tel: + 41 22 338 8161 or 338 95 47, E-mail: publicinf@wipo.int, Web: http://www.wipo.int

Globalization and Performance of Small and Large Firms

The report examines whether and how globalization has differential effects on small and (or versus) large firms and aims at identifying policy issues to be addressed to achieve stronger and more resilient economic growth in East Asian countries. Globalization in this research is broadly defined to include trade and foreign direct investment (FDI) liberalization, trade (exports and imports), international capital flows, outsourcing and traded intermediate goods. The research conducted 10 country studies for 8 countries in the Asia-Pacific region, namely, China, Indonesia, Japan, Korea, Malaysia, Philippines, Thailand, and Viet Nam.

Contact: Economic Research Institute for ASEAN and East Asia, Sentral Senayan II , 6th floor Jalan Asia Afrika No.8, Gelora Bung Karno, Senayan, Jakarta Pusat 10270, Indonesia. Tel: (62-21) 57974460, Fax: (62-21) 57974463, E-mail: contactus@eria.org, Web: http://www.eria.org

Technology Offers

CHINA

Fogger sprayer and high-range sprayer

Description

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. 6HY series fogger sprayers 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. 6HW series high-range sprayers have been 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

- 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 have 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 226631

HUNGARY

Transdermal medical gas delivery technology

Background information

The technology can deliver all kinds of noble and medical gases through non-invasive means. The company's first application of this technology is with CO_2 gas. The physiological change with dry CO_2 balneotherapy naturally occurs in the human body when CO_2 is delivered into the microcirculation in the skin. In the blood stream CO_2 enables hemoglobin in red blood cells to release more oxygen and automatically deliver the O_2 to tissues where the body needs it.

Areas of Application

- Spas, skin care and wellness centers, bath houses, and alternative treatment centers, with limited therapeutic claims
- Medical clinics, home healthcare service providers, nursing homes, elder care centers, retirement homes, etc., with targeted medical claims.
- Mass end user market, targeted medical claims.
- Sport centers, teams, sport medical centers and sports related service providers, with targeted medical claims.
- Veterinary products, professional veterinary and home veterinary markets with targeted medical claims.

Advantages

The technology is completely mechanical and no electricity is needed for operation, has no moving parts and therefore requires almost no maintenance. The device provides treatment at the point of care (effected body parts) or full body treatment. It is small (size of a shoe box) and portable, completely safe and user friendly. It is fast, requiring only about 3 minutes for preparation for a first-time user and 20 minutes for the treatment. Absolutely no training or special knowledge is needed to operate it. The technology has "instant" measurable health effects after the first treatment. It costs quarter of the price of rival technologies.

Transfer Terms

- Technology licensing
- Research partnerships

contact:

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

INDIA

Chitin and chitosan

Description

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 the important 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.

Areas 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 exchange chromatography, removal of metal ions from industrial effluents, manufacture

of pharmaceuticals and cosmetics and as an additive in food industry.

Environmental Aspects

Waste utilization

Development Status

- Pilot plant
- Fully commercialized

Transfer Terms

- Consultancy
- Technology licensing

Virgin coconut oil

Description

Virgin Coconut Oil (VCO) is the oil obtained from fresh, mature endosperm (kernel-meat) of the coconut by mechanical or natural means, with or without use of heat, no chemical refining, bleaching or de odorizing and maintain the natural aroma and nutrients.

Area of Application

Many potential applications in food, health and cosmetics sectors.

Development Status

- Pilot plant
- Commercial prototype

Transfer Terms

- Consultancy
- Technology licensing

Retort pouch technology

Description

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.

Areas 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 to make it safe for consumers

Development Status

- Pilot plant
- Fully commercialized

Transfer Terms

- Consultancy
- Technical services
- Technology licensing

For the above three offers, contact:

Central Institute of Fisheries Technology (CIFT), Matsyapuri,
Willingdon Island
Cochin 682029, India

Food processing equipment

Description

We are the manufacturers of food processing machinery - Grinding Mill, in which grinding media is Flour Mill Emery Stone which is exclusively manufactured by Natural materials with oxychloride process. The stones are hard and have good wearing qualities, which means less wear and thus a long life. Our Flour mill machine is good for health and easier in grinding. With this particular grinding media our food machinery is better than the one made of iron grinders. Sharad Enterprises flour plant is more than just some machines. To us flour is not only a question of production, but also a question of nutrition.

Areas of Application

For grinding of sesame, coffee, spices, pulses, chemicals, salt, seeds, wet grinding, paste and all kinds of grains.

Environmental Aspects

Systems integration

Development status

Fully commercialized

Legal Protection

Trade Mark

Transfer Terms

Equipment supply

Contact:

Spice Board
144 Prem Nagar Pal Road
Jodhpur 342008, India

Herbal pesticide

Description

The technology provides a sprayable biopesticidal composition comprising *Photorhabdus luminescens* for controlling and eradicating various agricultural pests. It is for the first time that the insecticidal activity of *P. luminescens* is used without its symbiotic carrier nematode. In this technology, the actively growing cells of *P. luminescens* are encapsulated in sodium alginate beads and examined for their ability to infect insect hosts. Several laboratory and field testing programme were carried out to evaluate and assess the product. Elaborative and extensive field trials were conducted to study the efficacy of the product on the serious pest of sugarcane. The results obtained from these experiments have given a clear indication that the product is very effective and is novel based on the bacterium Photorhabdus luminescence and the plant, bacterial and insect chitinase purified to greatest extent and stabilized for longer shelf life.

Technology Offers

INDIA

Areas of Application
Agriculture

Advantages

- Better alternatives to the conventional chemical compositions.
- Extremely effective in controlling the spread of *Ceratovacuna langiera.*
- Effective for both soil and aerial applications.
- Useful for crops such as cabbage, cotton, pulses, peas, sugarcane, bamboo, grapes, citrus, mango and guava.
- Capable of being applied with commonly used agricultural equipment like sprayers and dusters.
- Results are comparable to chemical insecticides.
- Environment friendly.

Development Status
Laboratory model

Legal Protection
Patent applied for

Transfer Terms
Technology licensing

Contact:
SkyQuest Technology Consulting Pvt. Ltd.
501, Krishna Complex,
Opp. Devashish School,
Bodakdev
Ahmedabad 380054
India

Formulation for controlling storage pests

Description
We have developed a herbal formulation, which is very effective in controlling the storage pest in the food grains.

Area of Application
Agriculture, Food processing industry

HUNGARY

Advantages

- No harmful effect on the users.
- Easy availability of the raw materials.
- Longer shelf life of the product and can be prepared in the liquid and solid forms.

Environmental Aspects

- Waste utilization

Development Status

- Laboratory model
- Pilot plant

Technical specifications

- Herbal formulation completely stops the storage pest in the grains.
- No harmful effect on the users.
- Easy availability of the raw materials.
- Longer shelf life of the product

Transfer Terms

- Consultancy
- Joint venture
- Technical services
- Technology licensing
- Research partnerships

Contact:
Hiran Biotech, Research and Development Division, 66 Turner Road Cantt., Kanpur 208004, U.P., India

Control circuit for diode-based RF circuits

Description
We are willing to offer the technology to design a Driver circuit for stepwise temperature invariant performance of diode-based RF circuits such as p-i-n and Schottky diode-based attenuator, phase shifter, linearizer etc.

Areas of Application

- Electronically controlled RF attenuators for various RF/Microwave instruments.
- Electronically controlled RF phase shifters for RF/Microwave instrument and digital beam forming networks.
- Gain control of RF/Microwave amplifiers for on-board and ground based instrument.
- RF Linearisers for TWTAs, SSPAs

Advantages

- The driver circuit will provide bias to the RF diodes to provide temperature compensated RF performance 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 RF diodes themselves, thus any temperature gradient will not affect the temperature compensation.
- Temperature changes induced by RF energy dissipated within the diodes are also compensated.
- No trial and error method is involved to optimize the circuit performance

Legal Protection
Patent

Transfer Terms
Technology licensing

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

Technology Requests

FRANCE

Bioethanol

Description
A French firm is interested to acquire Bioethanol production technology. They are planning to use the bioethanol manufactured in their plant for various projects on a global scale.

Area of Application
Biotech industry, Chemical industry, Energy industry

Project Type
Start-up

Contact:
Mr. François Lecomte
BOCCARD Bureau Commercial
189 rue du Faubourg Saint Honoré - 75008 – Paris, France
Tél: +33 (0)1 45 63 50 77
Fax: +33 (0)1 45 63 84 48
E-mail: flecomte@boccard.fr

INDIA

Magnetized fertilizer from fly ash

Description
An Indian firm is interested in the technology for production of magnetized fertilizer from fly ash. The company wants the technical know-how for this technology and wish to receive technical and price quotes for the same.

Area of Application
Agriculture

Project Type
Start-up

Contact:
Biocare India Pvt Ltd.
Biocare House, M. A. 23, Laxminagar Nagpur – 22, India
Tel: +91-712 - 2224344,
Telefax: +91-712 - 5611766
E-mail: info@biocareindia.biz

Rice husk ash to concrete blocks

Description
We are looking for a partner to provide us the technology to convert Rice husk ash or any other ash into construction of concrete blocks consist of ash cement sand as these blocks will then be used for poor people. The conventional bricks are getting costlier day by day so these blocks will prove to be very beneficial.

Area of Application
Construction sector

Project Type
New idea

Contact:
Nav Bharat International Limited
C-3/19, Ashok Vihar, Phase-2
Delhi - 110052
India

Ethanol production plant

Description
We are looking for a potential partner who can provide small scale Ethanol production plant.

Area of Application
Ethanol from Sweet sorghum/Sugarcane

Studies
Techno Feasibility Report

Project Type
New idea

Target Countries
India

Assistance from Partner
Complete plant on turnkey basis and equity partner

Contact:
Yugal Green Urja Solution Private Limited
F-103, IRWO Classics, Rail Vihar, Sector 57
Gurgaon 122004, India

Manufacture of bio-fertilizers

Description
An Indian Non-Governmental Organization would like to start up a venture in bio-fertilizer industry. They need more information on the know-how of manufacturing aspects of biofertilizer and also about the cost factor.

Area of Application
Agriculture and agroindustry, Biotechnology

Project Type
Start-up

Contact:
Mr. Preetam Singh Lingwal
Village: Thamana
Pauri Garhwal
Uttarakhand, India
E-mail: preetam.lingwal@gmail.com

Cotton seed oil extraction and refining plant

Description
An Iranian company is planning to establish a cotton seed oil extraction and refining plant. It is looking for help of established Indian company in this field. It will decide about the contribution of each side for manufacturing part of the project after negotiations.

Area of Application
Agriculture, Agro-industry

Transfer Terms
Technology transfer

Target Countries
India

Contact:
Iranian Research Organization for Science and Technology (IROST)
No. 71 Forsat St. Enghelab Ave. P.O. Box 15815 Tehran, Islamic Republic of Iran - 15819
Tel: +982188280517, Fax: +98218838340

ISLAMIC REPUBLIC OF IRAN

PUBLICATIONS from APCTT

PERIODICALS

(Free access at www.techmonitor.net)

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BOOKS	Indian Rupees* (India, Bhutan and Nepal)	US Dollars*
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❑ Proceedings of the Consultative Meeting on Technology Management Education and Training for Developing Countries, 1997	800.00	40.00

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  - Waste Technology
  - Non-Conventional Energy
  - Food Processing
  - Ozone Layer Protection
- Read articles on
  - Technology Trends
  - Technology Markets
  - Technology Transfer
- Gain knowledge on
  - Start-up venture creation
  - Venture financing
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