New Issue

TECHNOLOGY

Asian Outlook on Engineering and Technology

March 2021

[Smarter Solutions]

This magazine is a publication of the Asian Institute of Technology

AIT Asian Institute of Technology

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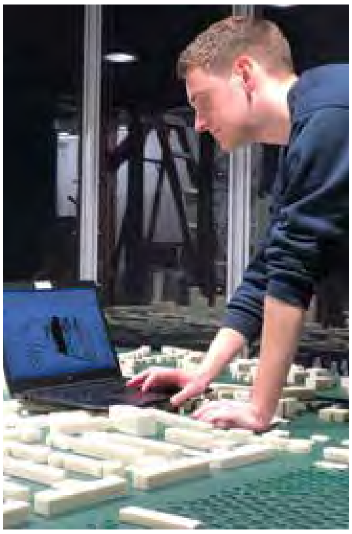
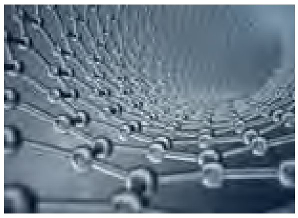
March 2021







ISSN 2286-9158

Technology Asian Outlook on Engineering and Technology, is published by AIT Solutions
Asian Institute of Technology, P.O. Box 4, Klongluang, Pathumthani 12120, Thailand

Editor's Note

The current industrial and societal challenges need the transformative power of smarter solutions derived from innovative technologies. Once applied, these smarter solutions have the ability to enable remarkable advances in societal and economic well-being.

Through this issue we are bringing an industry and societal perspective to the challenges that we face in building infrastructures, balancing environment and economic growth, and deployment of digital technologies, and the way it can be addressed through research based smarter solutions.

Considering the multifaceted nature of the challenges that the world is facing, this issue provides a glimpse into the multifaceted world of research based innovative solutions in various sectors, by bringing together research, solutions, and discussions from experts and authors in the field of wind engineering, water engineering, nanotechnology, urban environment management, and construction management.

As you read through this issue, you will find that there have been significant advancements in researching, and devising innovative and smarter solutions in the earlier mentioned fields. These advancements such as the application of nanotechnology in infrastructure and medicines, satellite based monitoring and conserving of earth's freshwater resources, applying circular economy, rethinking and redesigning of our consumption pattern and waste management, and deployment of digital technologies for construction management, are reflected in the research and discussions put forward by the authors.

I am thankful to all our experts at AIT and our partners who have provided their valuable contribution, as well as our editorial team for making this issue informative and creative.

This magazine is a knowledge product of AIT Solutions and a professional communication platform for experts and a window to its readers to the upcoming technologies, events, and developments.

Do let us know your feedback.

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Towards a Seamless Integration Between Experimental and Computational Wind Engineering for Wind Microclimate Studies

Stefano Cammelli, Joshua Millar, and Aidan McLoughlin

Understanding, characterising and controlling turbulent wind in the context of an urban environment is vital for the commercial success of a new development.

Towards a Seamless Integration Between Experimental and Computational Wind Engineering for Wind Microclimate Studies

Understanding, characterising and controlling turbulent wind in the context of an urban environment is vital for the commercial success of a new development. In countries that are subjected to large extra-tropical depressions, the focus is in ensuring that both comfort and safety of pedestrians are achieved under varying wind conditions [1], whilst in regions where 'day-to-day' winds are generally calmer, the goal is to promote a good and 'healthy' level of air ventilation at street level in order to enhance air quality [2].

In the United Kingdom (UK) in particular, the impact of new large-scale developments on the urban wind microclimate is nowadays facing an increasing level of scrutiny by planning authorities.

The introduction of a new building can modify the local wind flow patterns at street level and potentially produce uncomfortable and/or unsafe wind conditions for pedestrians. This is particularly true for high-rise developments or for buildings which are much taller than their neighbours. Fast-moving high-level winds can downdraft to street level along the windward faces of buildings. As air then moves into the low-pressure wake of the buildings, it can accelerate around corners and/or funnel through restrictions, causing localised regions of relatively high wind speeds.

The assessment of environmental wind flows in the built environment lies outside the scope of codes of practice for the assessment of wind effects on buildings, which primarily focus on wind loading. Also, there are no handbooks or engineering methods from which reliable assessments of the complex environmental wind flows that shape the pedestrian level wind conditions can be derived. The assessment of pedestrian level wind conditions within and in the vicinity of a new development is therefore typically carried out using either Computational Fluid Dynamics (CFD) – typically with Reynolds Averaged Navier-Stokes (RANS) approaches – or experimental wind tunnel testing (WTT) carried out in atmospheric boundary layer facilities. Comfortable and safe wind conditions can be achieved with either adjustments to the massing of the proposed building(s) or through the introduction of more localised wind mitigation measures (e.g. soft and hard landscaping). Historically, the development and validation of wind mitigation measures in the UK is achieved through interactive workshop sessions held in the wind tunnel where the wider design team works with the wind specialist to find the optimum solution for the site. Wind tunnel time is not cheap and interactive workshops on complex sites can protract in time often contributing to project delays.

Whilst CFD and WTT are often used independently and are rarely simultaneously deployed on the same project, there are significant gains to be had when these two design tools are used in a fully complementary manner. Although a fully integrated CFD-WTT approach has been extensively used in other industries for some time (e.g. automotive, Formula One and aerospace), its application within the highly unsteady turbulent regions of the urban canopy is far from trivial. In order for this synergic approach to work, a deep understanding of how limitations and assumptions of each tool fit within the wider wind engineering framework is required. In the authors' experience, an effective and efficient integration can only be achieved when wind engineers are in full control of both computational and experimental tools. The complementarity of these two tools in the context of urban wind microclimate is summarized in Table 1.

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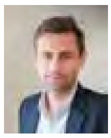

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Table 1. Advantages and disadvantages of wind tunnel testing and CFD (Reynolds-averaged, steady state).

Wind tunnel testing	CFD (RANS)
Longer set-up time	Quicker set-up time
Quicker run-time	Longer run-time
Model scale (Reynolds number not matched)	Full scale
Low resolution (i.e. discrete results)	High resolution (i.e. more granular results)
Turbulence: realized and measured	Turbulence: statistically modelled
Surrounding area: 300m to 600m radius	Surrounding area: 500m to 1000m radius
Trees: modelled according to experience	Trees: modelled following pressure drop data

When using an integrated CFD-WTT approach, it is extremely important to make sure that the following parameters are matched in the two tools:

- Building geometry and extent of the surrounding area that is explicitly modelled.
- Flow boundary conditions.
- Number of wind directions.
- Site-specific wind statistics.

In the post-processing of the CFD and WTT results, it is also important that the same comfort / distress criteria are used.

A CASE STUDY

By minimising the time spent in the wind tunnel and maximising the benefit of digital flow visualisation, the following case study illustrates how a fully integrated CFD-WTT approach can help wind engineers developing effective aerodynamic solutions within very attractive timescales.

The case study here presented consists of a mixed-use high-rise development in the UK for which wind microclimate had to be thoroughly assessed as part of the planning process. The proposed development includes two structurally linked tall buildings (45- and 55-storey) comprising residential units, a hotel, flexible workspaces, restaurants and retail spaces.

A detailed 1:400 scale wind tunnel model was designed, manufactured and instrumented with a total of 94 surface-mounted omni-directional wind speed sensors [3] installed at street level and 11 across podium and terrace levels. The construction of the wind tunnel physical model was based on the same 3D CAD geometry that was used in the CFD simulations. A full-scale radius of 600m around the project site was considered and explicitly modelled.

As the physical wind tunnel model needs to be machined or hand-crafted, simplifications of the geometries are often made. Numerical modelling does not suffer from this. When a fully integrated CFD-WTT approach is used like in this case, it is essential that extra care is taken in order to ensure that the buildings in the physical and in the numerical model exactly match. A photo of the wind tunnel model and an image of its numerical counterpart are shown in Figure 1.

Figure 1: *Physical wind tunnel model (left) and CAD model used in the CFD simulations (right).*

The total cell count in the CFD model was approximately 40 million and data have been collected from approximately 760,000 of them.

The boundary conditions of the experiment and the inlet of the numerical simulations, both based on a target generated using the ESDU model of the atmospheric boundary layer [4], were perfectly aligned (see Figure 2).

All wind tunnel experiments took place in the '10 × 5 Wind Tunnel' of the Imperial College London [5], whilst all CFD simulations were run on WSP's bespoke HPC.

Data from the CFD simulations and from the WTT were subsequently combined with the same set of wind statistics and results compared against the LDDC version of the Lawson criteria [6].
Discrete WTT results, in terms of pedestrian level wind annual safety exceedances around the base of the proposed development without any wind mitigation measure in place, were produced and overlaid on top of the more granular ones obtained from CFD. Figure 3 shows the very good match that was obtained from the two tools.

One of the major benefits of an integrated CFD-WTT approach is the ability to visualise the flow digitally whilst developing and testing wind mitigation measures in the wind tunnel (see Figure 4). In this case, understanding complex 3D flow features from the CFD helped the development of bespoke and effective wind mitigation measures in a very time efficient manner (see Figure 5).

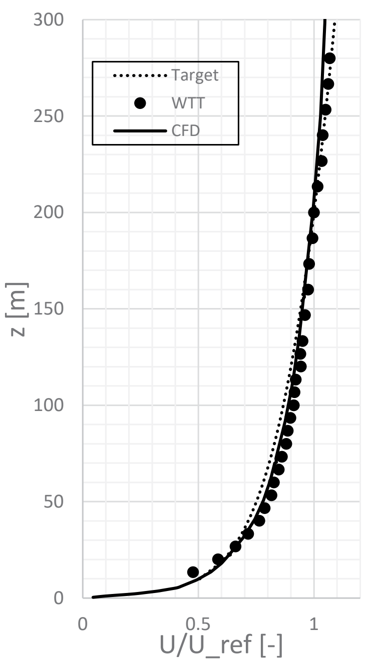

Figure 2: *Flow boundary conditions: site-specific target, WTT (modelled) and CFD (achieved).*

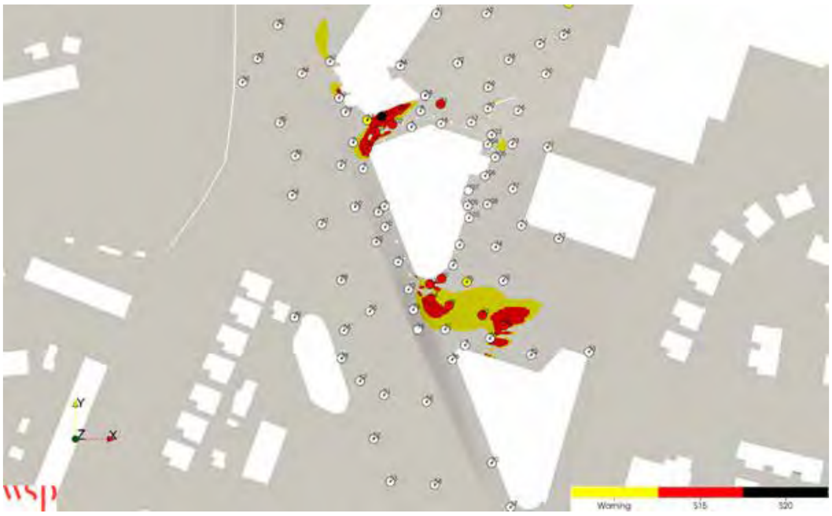

Figure 3: *Pedestrian level wind annual safety exceedances: CFD vs. WTT.*

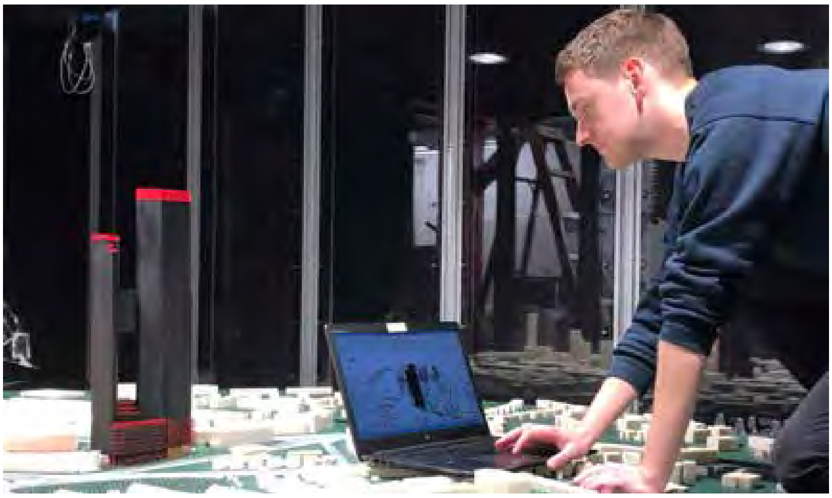

Figure 4: *Interrogation of digital flow visualisation in the wind tunnel.*

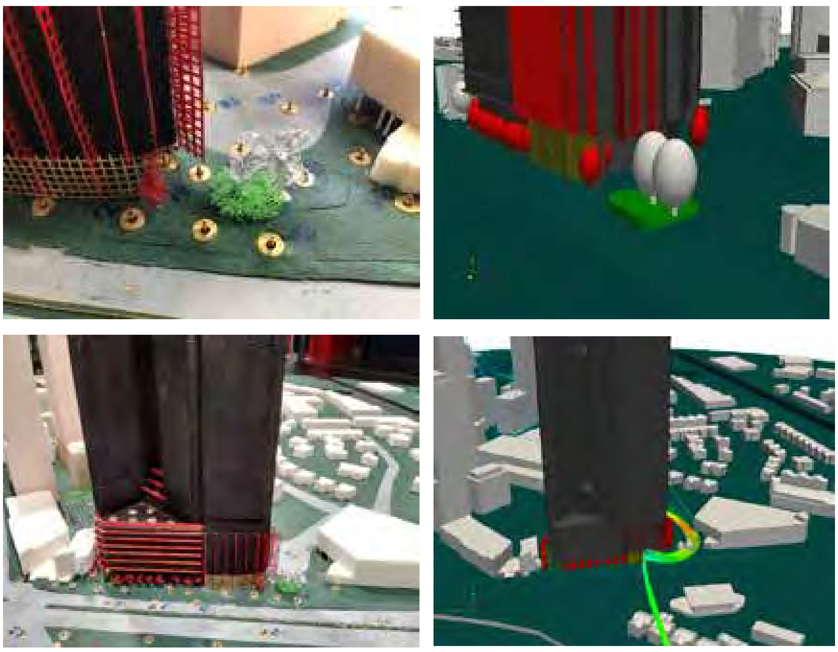

Figure 5: *Wind mitigation measures as designed in the WTT (left) and CFD (right).*

NEXT FRONTIERS

Once a well-calibrated CFD-WTT methodology has been established, it is possible to construct new models using both sets of data. These methods, made possible with modern and accessible machine learning libraries, allow for the benefits of both approaches to be embedded in a single model.

One typical use for such a model is when analysing projects which are particularly susceptible to gusty winds. It is in fact difficult to accurately predict gust speeds using standard steady-state CFD and so there is a risk that results from the CFD, not accounting for gusts, will begin to diverge from the baseline WTT results as the design develops. However, a gust wind speed analogy model can be constructed and trained on gust speed data available from the WTT. Although this model typically needs to be high order and is not general - meaning that each project requires a unique complex model to be trained - it provides a level of certainty that ongoing CFD simulations of a developing design will be reflected in subsequent WTT.

When optimising mitigation concepts, surrogate models can also be constructed in order to query the effect of a change in the mitigation parameters (for example, the effect of canopy height, or baffle porosity). Both wind tunnel and CFD responses, along with higher-fidelity simulation data, can be incorporated into the construction of this surrogate model, to provide a measure of the level of certainty of the surrogate model's ability to reflect reality.

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Groundwater Solutions to Climate Change in Urbanizing Cities

Sangam Shrestha, and Saurav KC

Groundwater faces several challenges such as water level depletion, land subsidence, saltwater intrusion, and water quality degradation due to rapid urbanization and climate change. This is likely to bring social and right-based conflict among multiple actors at different levels. Several structural and non-structural solutions should be planned, developed, and implemented either individually or as a combination to combat the groundwater challenges induced by climate change and urbanization.

Groundwater Solutions to Climate Change in Urbanizing Cities

Globally, groundwater contributes to the sustainable development of many cities. The United Nations projects an increase in the number of all sized cities (small to mega) by 2030 (Figure 1) and the world's population living in cities is likely to be 68% by 2050 with the major contribution from the developing nations of Asia and Africa. Water, being the basic requirement for human well-being is finite and only renewable when properly managed. Out of 2.5% freshwater available on the Earth (Figure 2), much of the portion is locked up in glaciers and ice, leaving groundwater as the major source of freshwater resources.

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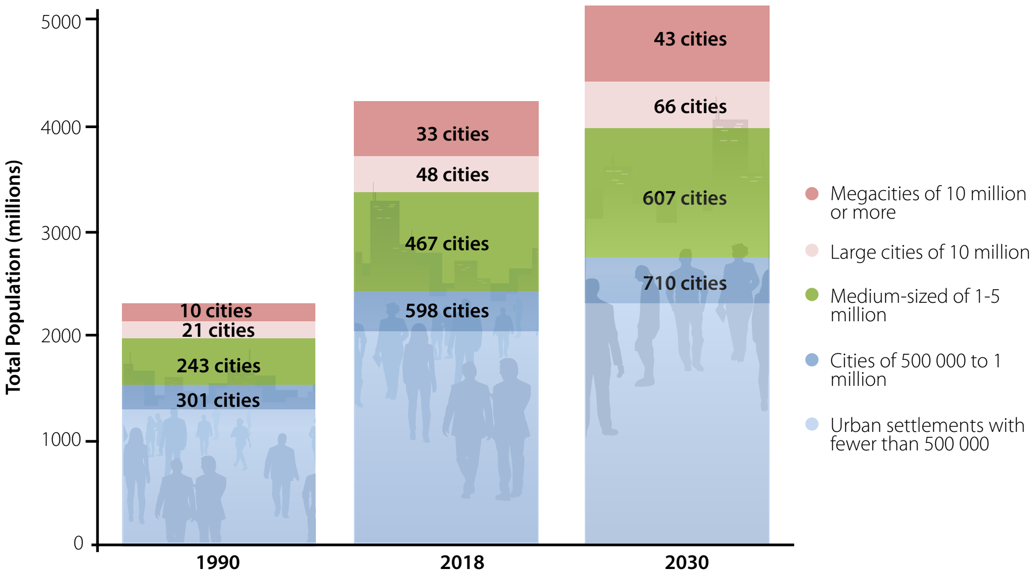


Figure 1: *Number of cities (world) by size of urban settlement (Source: UN, 2018)*

Importance of Groundwater to Socio-economic Developments in Cities

Groundwater is a common-pool resource of global importance and is the source of one-third of all freshwater withdrawals (Figure 2). Globally, 67% of groundwater withdrawn worldwide is used for agriculture while 22% and 11% of withdrawals are used for domestic, and industrial purposes, respectively. At least half of the world's population uses groundwater as a drinking water supply and with the rapid transformation of rural areas to urban, the major population and the administrative bodies in those areas are increasingly dependent on groundwater resources. One of the major backbone of the city's socio-economic development is the expansion of its industries where groundwater is the major input and a vital constituent of the industrial product itself. In addition, this freshwater resource is most readily available in better quality with uniform regional spread, a very lesser tendency to periodic fluctuation, reduced investment and operational cost has comparatively strengthened its importance and exploitation for socio-economic development in urban centers.

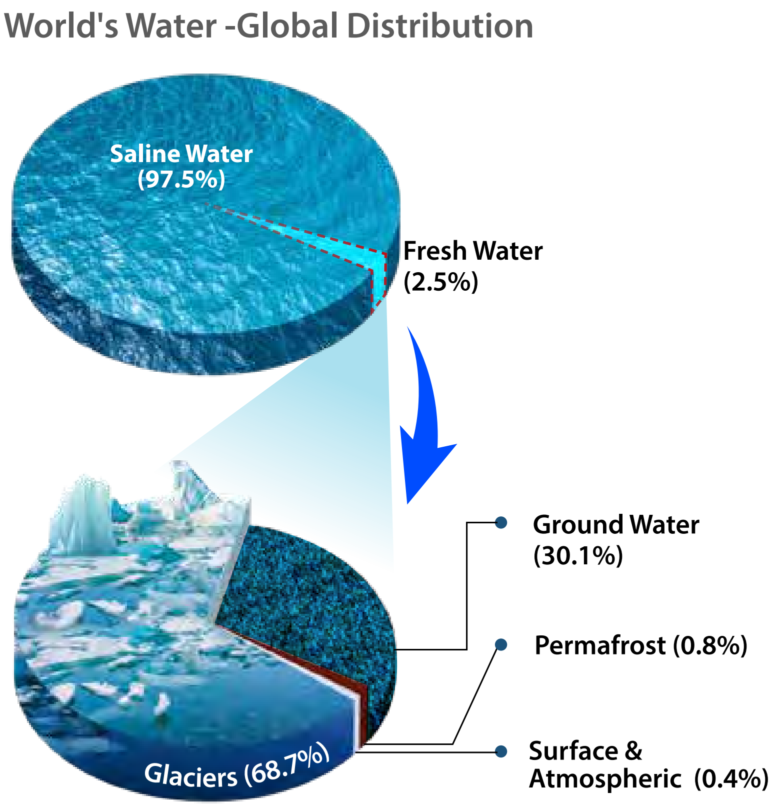


Figure 2: *Global distribution of world's water and share of freshwater resources*

Climate Change and Urbanization: Challenges to Groundwater Management

Freshwater resources are being threatened more and more due to multiple stresses such as urbanization and climate change impacting its flow, storage, and chemical properties. Additionally, alteration in the water cycle, surface energy budget, and yield is the result of a significant impact due to rapid urban development and climate change affecting availability and demand. Several studies worldwide have revealed that the groundwater resources are threatened by urbanization, global and local climate change, agricultural commercialization, and industrial development making it scarcer and more vulnerable to its availability and contamination. The following sections briefly outlines the major challenges to groundwater management:

Groundwater Cycle Alteration:

The replacement of natural land cover with the impervious surface in cities is the major transformation as a process of urbanization which increases the surface runoff and rate of sediment deposits, but decreases the infiltration capacity of the surface retarding the process of groundwater recharge (Figure 3). On the other hand, the rough and reflecting urban surfaces and increased local temperature as a result of climate change creates the urban heat island (UHI) effect which modifies the urban micro-climatic parameters exposing the urban population to increased heat stresses and changing the pattern of urban rainfall. Together, these changes in local climatic conditions increases the rate of evaporation and the rapid pace of urbanization decreases the rate of infiltration, thus significantly impacting the groundwater cycle.

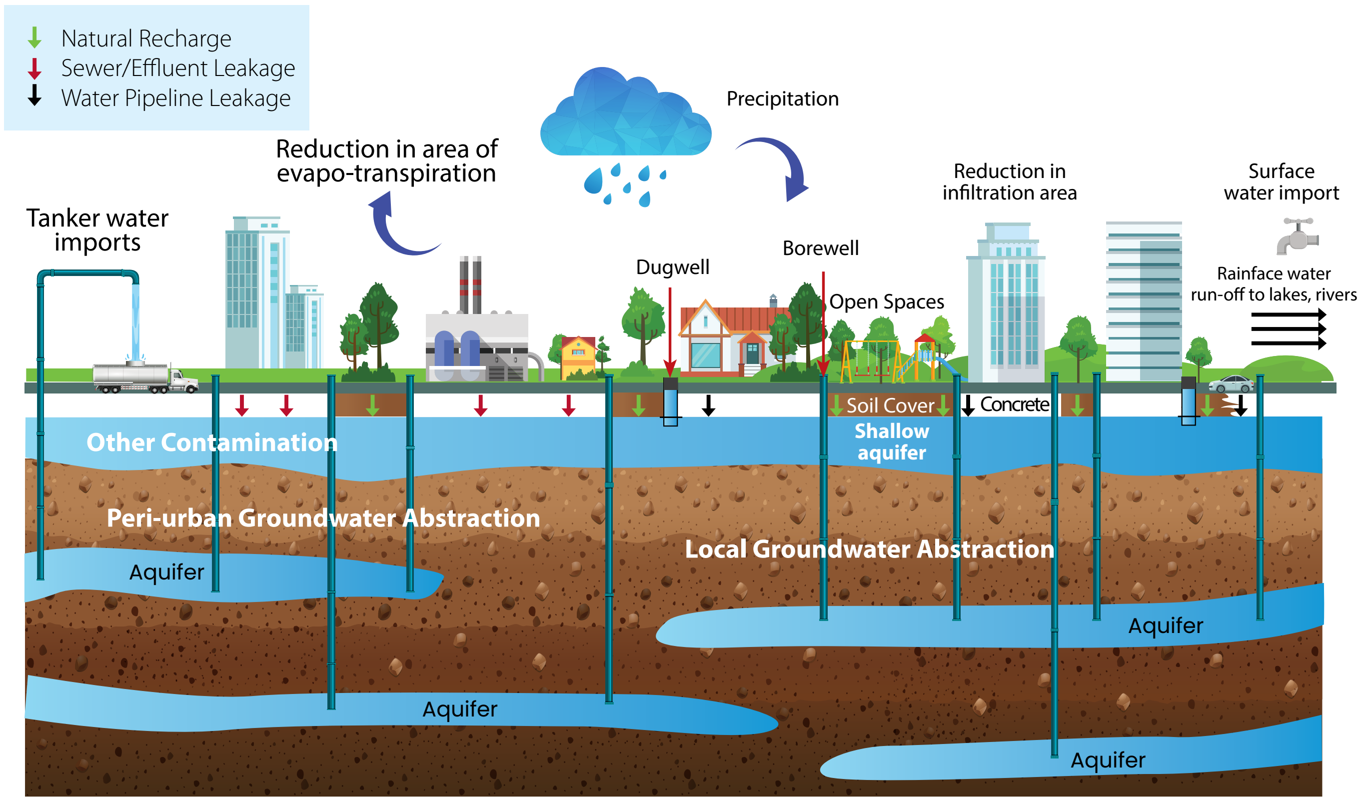


Figure 3: *Schematic for urban groundwater cycle (Image Credit: ACWADAM, India)*

Groundwater Over Drafting and Land Subsidence:

The change in the climatic conditions of cities increases the urban heat stress, alters the rainfall distribution. While the process of urbanization leads to escalated basic water demand, increased imperviousness, change in living standard, access to new drilling technologies and demand for water and food security. This combination of climatic conditions and urbanizations leads to an increase in the overexploitation of groundwater resources to balance the demand and supply. This on one hand, depletes the groundwater table and on the other hand, is likely to create gradual settling or sudden sinking of subsurface leading to land subsidence.

Groundwater Contamination:

Urbanizing cities demands and uses a significantly high volume of water for its socio-economic development, consequently increasing the effluent with various impurities. When these pollutants from numerous sources (such as from onsite sanitation systems, landfills, effluent from industries and treatment plants, leaking sewers, petrol filling stations, excessive application of agricultural fertilizers, etc.) make their way down into the aquifer zone (Figure 4), groundwater contamination occurs. Thus, the fresh resources face contamination challenges because of urbanization, and using polluted groundwater causes public health hazards through poisoning or the spread of disease.

Saltwater Intrusion:

Saltwater intrusion is a phenomenon that occurs at the interface between groundwater and saltwater, when the higher density saltwater displaces the lower density freshwater in the interface zone, thus contaminating the fresh groundwater aquifer. The phenomenon can occur in deep aquifers with the upward advance of saline waters of geologic origin, in shallow aquifers from surface waste discharge, and in coastal aquifers from an invasion of seawater. The process of saltwater intrusion in freshwater resources is amplified by the depletion of the natural groundwater level due to the process of urbanization and increased imperviousness, as well as an increase in the sea level due to an increase in mean temperature, based on the projected (and also prevailing) trend for changes in climatic conditions.

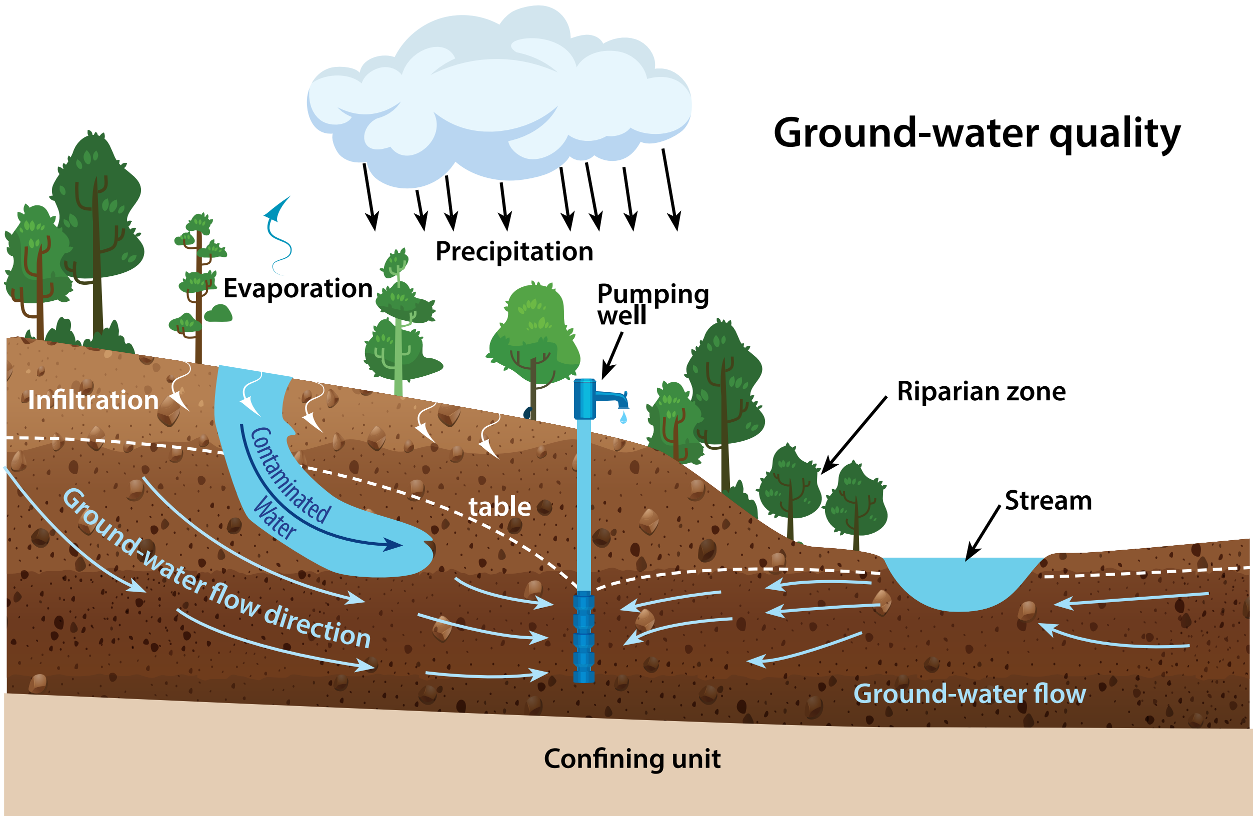


Figure 4: *A schematic for the process of groundwater contamination (Credit: U.S. Geological Survey)*

Social and Right-based Conflicts:

The rapid urbanization and climate change pose a risk in groundwater depletion and degradation and consequently a large population of these urbanizing cities face threats of both water scarcity and water contamination. Also, the many competing demands on groundwater resources among different socioeconomic sectors leads to an unfair allocation of groundwater extraction among different water user groups and/or sectors. This increase in demand and unequal allocation or access to the limited resource, develops a foundation to different social and water-use right based conflicts among multiple actors. Often, conflicts over this common pool resource occur due to over-exploitation from dominated sectors or social groups over the other sectors or group posing great challenges for operational groundwater management.

Groundwater Solutions to Existing and Anticipated Challenges

Both "structural and non-structural" solutions, either individually or combined should be planned and implemented in cities to combat the existing and anticipated challenges on groundwater because of climate change and the rapid pace of urbanization. Structural solutions include more technological and engineered solutions whereas the non-structural solution includes more institutional and social-based solutions. These solutions are contextual and entirely depends on the prevailing and expected challenges. Some of them are discussed below:

Increasing Groundwater Recharge:

Capturing locally available water (rainfall, runoff) through recharge can be accomplished in cities using a variety of techniques naturally or artificially. Some of the examples of artificial recharge in cities are the construction of infiltration basins, or ponds, constructed wetlands, or simply injecting water directly into the subsurface through injection wells. This will reinforce the existing groundwater level and protect against saltwater intrusion in coastal aquifers.

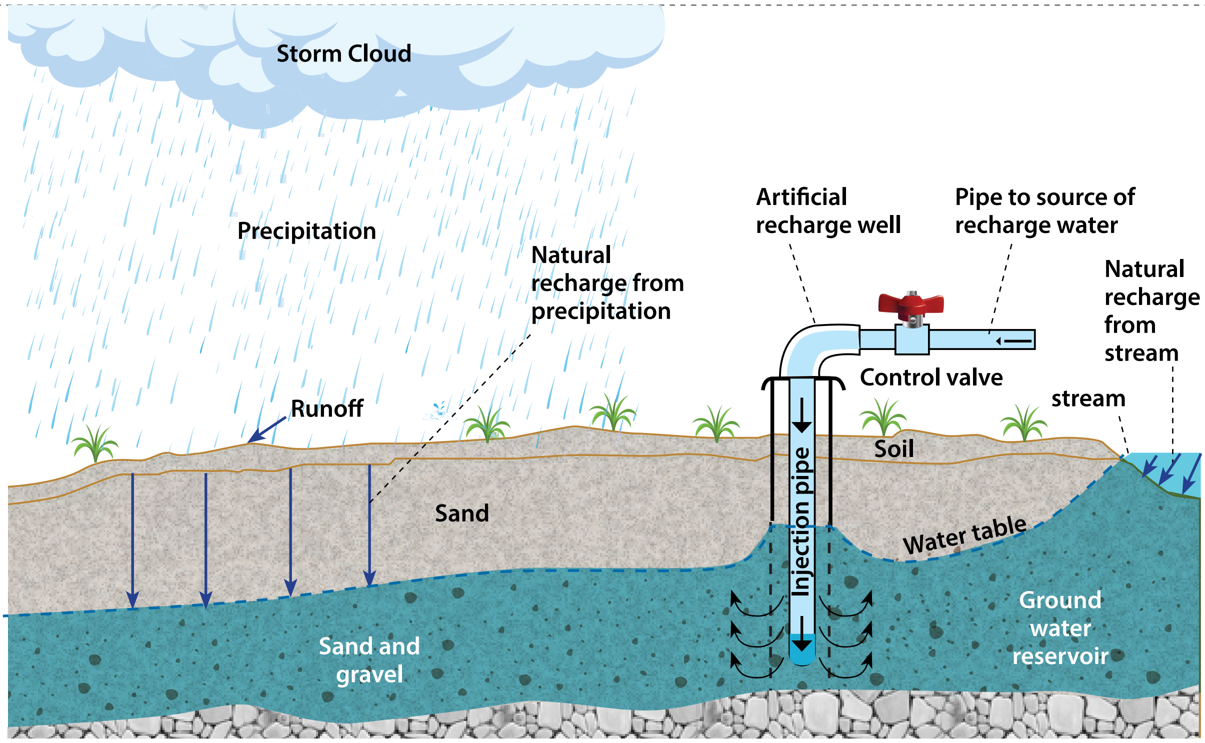


Figure 5: *A schematic for natural and artificial recharge of groundwater (Credit: U.S. Geological Survey)*

Water Transfer:

One of the classic solutions to the groundwater scarcity problems is to increase locally available supply by sourcing from further afield. In terms of groundwater management, the development of water transfer structures and imports from new sources of supplies can substitute additional local groundwater use, lessen the drawdown, or can also be a source of artificial recharge.

Conjunctive Use:

The concept of conjunctive water use from both groundwater and surface water sources in rapidly-expanding cities can be planned and optimized, providing much greater water-supply security with an advantage of natural groundwater storage in aquifers and larger net water-supply yield. Furthermore, from an agriculture irrigation perspective, conjunctive use can be effective because the availability of surface irrigation (as well as rainfall) is variable and the groundwater resources can be used as a buffer to ensure water for crop growth and basin water productivity.

Water-saving technologies:

Water-saving technologies can raise the productivity of the groundwater supplies for all agricultural, domestic, and industrial sectors. Evidence from both the developed and developing world has shown the effectiveness of these technologies in increasing water productivity as measured by the decrease in pumping. Furthermore, change in groundwater using patterns combined with water-saving technology can be the other sustainable groundwater solution for the emerging challenges. For instance, urban agriculture and industries can increase their productivity by shifting groundwater use from low to high-value products or from more to less groundwater intensive products.

Critical Zoning:

The overexploitation of groundwater and their possibility of contamination can be relatively minimized through zoning of critical areas, land use planning, delineation of groundwater protection area (GPA), etc. within the current and/or anticipated vulnerable areas.

Regulatory Measures:

The (i) formulation and implementation of regulations and water-use rights, including rules, permits, entitlements, and licenses, which establish the privileges, restrictions, and obligations of groundwater users and; (ii) the groundwater use pricing (economic instrument) aremajor non-structural solutions for the sustainable development, use, and management of groundwater under multiple stresses such as climate change, urbanization, increase in demand, etc. The success of these measures is based on acquiring sufficient

Structural Solutions (Sample Photos)

Figure 6: *Rapid infiltration basins, Orlando, Florida, United States (Credit: U.S. Geological Survey)*

Figure 7: *Thammasat University Rooftop Farm (TURF), Thailand for storing and utilizing runoff (Credit: https://www.contemporist.com/urban-farm-on-rooftop/)*

information (groundwater level, contamination level, pumping rate); establishing acceptable methods for determining how extraction rights are distributed between users, and developing mechanisms to enforce rules. Furthermore, these approaches can be reinforced by applying structural measures such as the establishment of monitoring stations, early warning systems, etc.

Strengthening Groundwater Governance:

The successful management of groundwater lies within a good governance mechanism. A good groundwater governance comprises multi-stakeholder engagement and participation; favorable legal and institutional framework; precise and widely shared information & knowledge; and policies and incentive structures aligned with the goal. Understanding and strengthening groundwater governance is the soft measure of sustainable groundwater management. However, the governance of groundwater should be visualized, planned, and applied based on its transboundary nature, either locally within a country's administrative boundaries or internationally.

Figure 8: *Antibiotics in Groundwater Tracer Injection for reducing groundwater contamination (Credit: U.S. Geological Survey/Photo by Denis R. LeBlanc)*

Figure 9: *Wetlands at the groundwater and surface water interface to increase groundwater level (Credit: U.S. Geological Survey/Photo by Robert B Swanson)*

Non-Structural Solutions (Sample Photos)

Figure 10: *Providing 'water education' in early childhood can address sustainability issues of water use and water conservation (Credit: Water Engineering and Management/AIT)*

Figure 11: *Regional information and knowledge sharing workshop for groundwater sustainability to multiple stresses (Credit: Water Engineering and Management/AIT)*

GROUNDWATER ACT,

B.E. 2520 (1977)

Section 1

Section 2

Section 3 In this Act,

Figure 12: *Groundwater Act of Thailand (Credit: http://extwprlegs1.fao.org/docs/pdf/tha181034.pdf)*

Summary

Groundwater is a hidden treasure of global importance and is a crucial source of supply for domestic, agricultural, industrial sectors, and ecosystem services. Furthermore, this freshwater resource is vulnerable to unrestricted exploitation by humans without considering the interests of the wider community and thus, is also a challenging component for effective and efficient management in the context of increased stress and demand. One of the key stresses for this escalating dependence is rapid urbanization leading to demographic growth, increased freshwater demand, and change in climatic conditions (naturally and/or human-induced) impacting both demand and supply. Groundwater faces several challenges such as water level depletion, land subsidence, saltwater intrusion, and water quality degradation due to the rapid urbanization and climate change. This is likely to bring social and right-based conflict among multiple actors at different levels. Several structural (infiltration basins, or ponds, constructed wetlands, conjunctive use, water-saving technologies) and non-structural (delineation of groundwater protection area, regulatory frameworks, policies, public awareness, strengthening groundwater governance) solutions should be planned, developed, and implemented either individually or a combination to combat against the groundwater challenges induced by the climate change and urbanization.

Nano Everywhere–from Bio-based Roads to Detection of Anti-Cancer Drugs

Tanujjal Bora

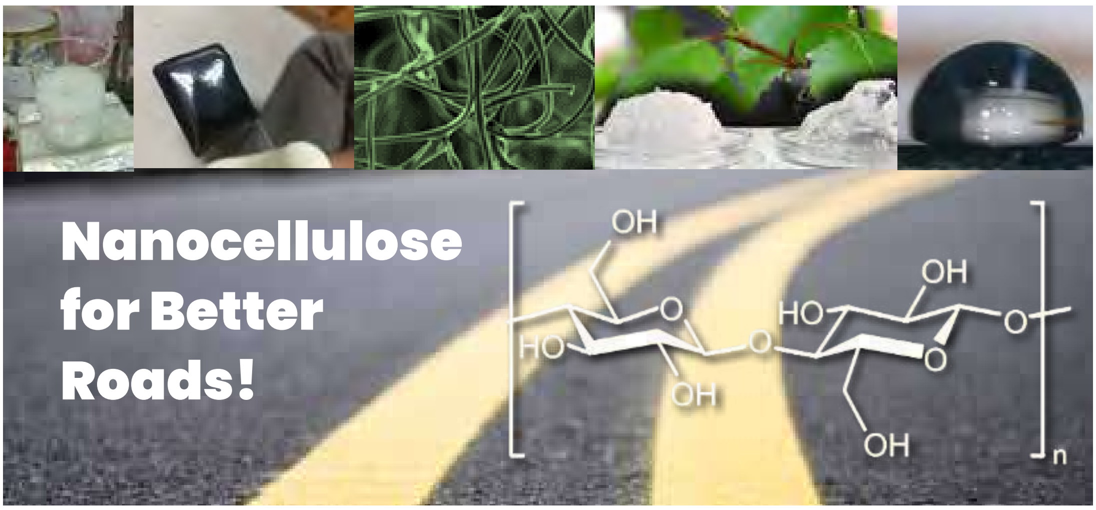
The researchers at CoEN have demonstrated Nanocellulose-asphalt mixture that improves the binder elastic behavior as well as improves the resistance to permanent deformation of asphalt. The researchers are also working towards detection of anti-cancer drugs using a highly sensitive technique known as Surface-enhanced Raman Spectroscopy (SERS).

Nano Everywhere-from Bio-based Roads to Detection of Anti-Cancer Drugs

Roads around us are mostly constructed by using asphalt mixtures, the black sticky material that becomes a part of our daily life. The asphalt binder serves two fundamental functions in the road pavement, first it binds the aggregates firmly and second it acts as a water sealant. Like any other man-made structures, asphalt pavements deteriorate with the passage of time. Moisture damage is considered as one of the major causes of distress in an asphalt pavement. Though all the damage is not caused directly by the moisture, its presence increases the extent and severity of already existing distresses like cracking, potholes and patches, and rutting. The presence of moisture results in the degradation of the mechanical properties of the asphalt mixture i.e. loss of stiffness and mechanical strength which could ultimately lead to the failure of the roads structure. This has a significant impact on the road infrastructure economy as it would cause premature failure of road surface and hence results in increased rehabilitation and maintenance costs.

At the Center of Excellence in Nanotechnology (CoEN), we started looking into this issue of moisture damage of asphalt from nano-perspective, while at the same time considering the environmental and socio-economic aspects of the issue. With a group composed of Civil Engineers and Material Scientists, we have come up with a unique and innovative asphalt mixture to address our problem that uses the power of nanocellulose, a biopolymer from the nature. Nanocellulose (NC), cellulose at nano-scale (a nanometer is one billionth of a meter, 0.000000001 or 10–9 meters), is one of the most prominent green materials of modern times, with attractive and excellent characteristics such as abundance, high aspect ratio, better mechanical properties, renewability, and biocompatibility.

Our NC-asphalt mixture demonstrated improved moisture and permanent deformation resistance with good dispersion of the NC in the asphalt matrix. NC is a water-loving material, which is difficult to mix with asphalt. With our innovative formula, we have uniformly distributed NC within the asphalt matrix and a strong bonding between NC and asphalt was established by interfacial hydrogen bonding for the effective transfer of applied stress in between them to prevent damage. A patent has been now filed for the innovation. Our NC modified asphalt matrix has the following features:



- Even dispersion of NC in the asphalt matrix with good chemical compatibility
- Improved binder elastic behavior compared to the regular asphalt binders
- Higher rutting resistance
- Improved resistance to permanent deformation of asphalt
- Less susceptible to moisture damage
- Better adhesion of the NC-asphalt binder to aggregates
- Biodegradable additive

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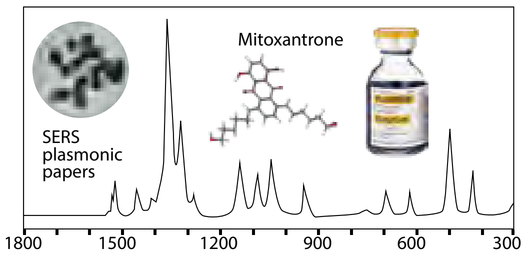
At the same time, CoEN researchers are also working towards detection of anti-cancer drugs using a highly sensitive technique known as Surface-enhanced Raman Spectroscopy (SERS). Given the rapid growth of the cancer research field in the recent times, the development of new analytical methods for the detection of anti-cancer drugs is of great interest. Monitoring the concentration of these drugs is important for the optimization of therapy and management of side effects, as at too low doses the effects can be reduced or even lost, while at too high doses side effects and toxicity can occur. Therefore, the detection and monitoring of anti-cancer drugs in biological samples and pharmaceuticals is of paramount importance.

In a collaborative research led by the NANOTEC, Thailand, CoEN researchers have recently developed a simple plasmonic paper-based SERS detection of Mitoxantrone (MTX), an anti-cancer ("antineoplastic" or "cytotoxic") chemotherapy drug used for advanced prostate cancer, acute myelogenous leukemia, breast cancer and non-Hodgkin's lymphoma. The developed plasmonic paper is based on a combination of graphene oxide (GO) and gold nanorods (AuNRs) on cellulose substrates using a simple layer-by-layer immersion method, which exhibits the synergism between the electromagnetic (EM) effect originating from AuNRs and the chemical enhancement (CE) effect deriving from the GO. The advantages of the paper-based SERS detection are:

- Low cost
- High rates of sample collection
- High physical flexibility
- Relative ease of fabrication



Our developed plasmonic paper can detect MTX anticancer drug with a detection limit of 5 μM concentration which is practical for detection of MTX after injection via IV within 24 hours at the level of standard dosage. A patent has been filed for the innovation and the research outcomes are recently published in the New Journal of Chemistry *(https://doi.org/10.1039/D0NJ02448A)*.

About CoEN

The Center of Excellence in Nanotechnology (CoEN) at the Asian Institute of Technology (AIT) is a leading applied and interdisciplinary research center in the emerging field of nanotechnology. The unifying concept in the center is to make use of inexpensive techniques to synthesize nanomaterials and innovate technologies and futuristic device components. As a research center, COEN is renowned for its excellence in nanotechnology-based applications, set up to promote technological change and address relevant developmental issues in the region. The group uses innovative techniques inspired from nature (biomimicry) to pioneer "poor man's nanotechnology" to infer nanotechnology conducted with minimal resources. CoEN's research is dedicated to developing applications and awareness that address relevant societal needs, such as clean drinking water, affordable energy, food safety, among others. Due to its wide-range research on nanotechnology applications, CoEN has attracted extensive collaborations with the government, local and international universities, industries, and non-governmental organizations.

CoEN is also an international platform for curriculum, faculty, and instruction to the Nanotechnology Academic Program to provide education towards the attainment of Master of Science, Master of Engineering, or Doctoral degrees. It is committed to the students' knowledge and training for research and development, technology transfer, and promotion of public and industrial awareness of nanotechnology. Its faculty and students are not only interdisciplinary but are multicultural, expanding its sphere from Thailand, India, Russia, Egypt, Germany, France, the United States, Bangladesh, Myanmar, Philippines, Vietnam, Nepal, and Pakistan. With the collaborative environment, students' research is aligned to the thrust of CoEN and AIT, carrying out nanotechnology that adds capability and brings quality applications to address relevant developmental issues. The students' current research activities focus on the development and utilization of inexpensive wet-chemical methods to innovative materials and fabricate device components for inorganic solar cells, piezo-electronics devices, sensors, opto-electronic devices, IOT, thin films, optical coatings, photocatalysis applications, among others.

CoEN also offers a safe environment for support to the students' health and mental well-being through its various group activities and retreats outside AIT and Bangkok. Students are also encouraged to participate in conferences, workshops, and schools to enhance their capacity and create networks for research and future careers. To know more about CoEN, visit our website *www.nano.ait.ac.th*

From AIT Alumni

Circular Water Transition

Water water everywhere and not a drop to drink...

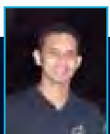
On December 9th 2020, water, just like oil and gold, became a traded commodity on Wall Street; an event which has the potential to affect every living species on the planet. Currently there are more than 785 million people without access to clean water & another 2 billion who live in perpetual shortage of water resources.

This combined with the growing population and dwindling fresh water supply, makes the water issue on par with the most severe challenges ever experienced in the civilized world.

While there has been a significant delay in taking a holistic approach to solving the water crisis, individual technologies which are smart, sustainable and promote circular water economy have made their way into the commercial market. New and innovative advanced oxidation methods such as photocatalysis, photo-fenton processes, ozonation and smart platform technologies like capacitive deionization (CDI) can be integrated with existing methods to bring about a radical change in the water treatment industry. The key aspect to understand here is that there is no single magical solution which enables a complete circular water economy. Rather, the answer lies in the selection of several smart solutions, carefully integrated to meet the needs of a specific application, resulting in sustainable water use. Irrespective of whether the application lies in the industrial, agricultural or urban sector (which together consume more than 90% of all fresh water used), the right combination of technologies will enable the implementation of zero liquid discharge (ZLD), where all the water is cleaned, and only solid waste is produced. ZLD is slowly taking precedence, especially in highly polluting sectors, where government regulations has forced the industry to find new ways to reduce their water and carbon footprint. As an example, the drive to clean the river Ganges in India, led to new regulations which ended up closing close to 80% of the tanneries which were discharging contaminated water into the river. Hence the combined action of international regulatory bodies, government institutions and industrial partners is of primordial importance to effect the concept of circular and smart water economy.

This is also one of the pillars for the development of future smart cities which we are all so excited about. Cities which are self-reliant, where the energy and water resources are recycled, re-used and conserved, where the energy to clean water is from renewable sources and where the waste produced is environmentally benign or a product for another industry. This is where the smart water treatment solutions like Capacitive Deionization, which are platform independent and highly programmable to remove a wide array of contaminants in water, can implement advanced AI software and sensor array to optimize their working efficiency and work entirely on renewable energy can be a way forward.

The tools necessary to start transitioning our man-made water cycle towards sustainability are at our disposal and the key to start the transition is in our hands. It is not the first thought on everyone's mind but try to imagine a life without water and things will fall into perspective. We need to take care of this limited and necessary resource, so that we don't end up living in a world, where water is the most expensive liquid on earth. As the famous British poet W.H Auden rightly said and I quote, *"Thousands have lived without love, not one without water".*



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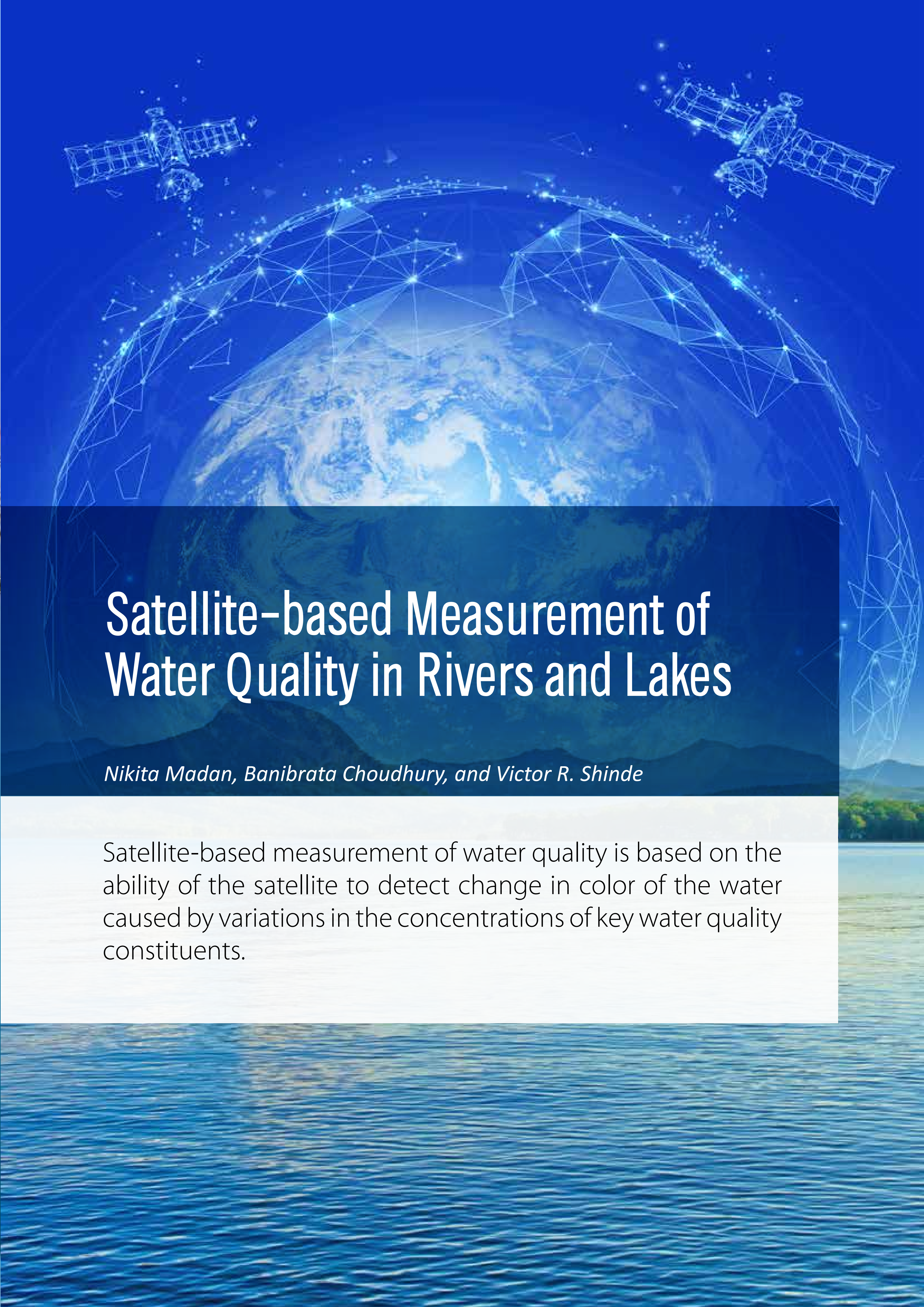
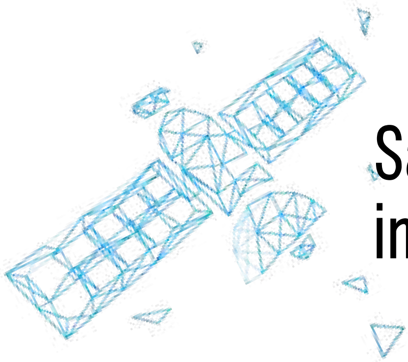


Satellite-based Measurement of Water Quality in Rivers and Lakes

Nikita Madan, Banibrata Choudhury, and Victor R. Shinde

Satellite-based measurement of water quality is based on the ability of the satellite to detect change in color of the water caused by variations in the concentrations of key water quality constituents.



Satellite-based Measurement of Water Quality in Rivers and Lakes

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Rivers and lakes across the world are facing increasing threats on multiple fronts. On the one hand, especially in developing countries, there are ubiquitous concerns with pollution. On the other, development pressures have had a serious impact on the river flows, in some cases causing complete drying up. In addition to these, other issues such as changes in river morphology due to dam construction, channelized river banks, increased sedimentation, loss of river-related biodiversity, weak citizen-river connect, and inadequate river governance are being observed with alarming frequency.

There is an ever-growing understanding that economic development does not have to come at the cost of rivers. In fact, sustained economic growth in the truest sense will not be possible to achieve without due consideration for natural environmental assets such as rivers. Governments around the world are beginning the realization of potential of rivers in the path of economic development, and are taking measures to leverage on this potential through sustainable river management philosophies and management practices. An example is a strategic framework for managing urban river stretches developed by the authors for the Ganga River Basin[1] , India, which emphasizes on economic and social measures of management in addition to the traditional environment.

A vital component in the management of rivers and lakes is monitoring the water quality. Conventionally, water quality monitoring has been based on in-situ measurements of a set number of parameters at specific locations, and subsequent laboratory analyses of the parameters. The conventional method works well for stretches that do not display significant spatial disparity in water quality parameters. If there is disparity, then there will be a need for monitoring at several locations, which is both time consuming and expensive. Similarly, these methods become even more cumbersome if the water quality changes frequently. Satellite-based measurement of water quality becomes very useful in such cases.

Satellite-based measurement of water quality is based on the ability of the satellite to detect change in color of the water caused by variations in the concentrations of key water quality constituents. Other parameters may be estimated by making use of additional information through appropriate bio-geophysical assumptions, ancillary data, and mechanistic models. Figure 1 presents a schematic that explains the working of satellite-based measurement. When sunlight falls on a water body, a part of it is directly reflected from the surface, and the remaining passes through the water. The light that enters the water interacts with water molecules as well as the organic and inorganic materials dissolved and suspended in the water. These materials that interact with light (through the processes of absorption and scattering) are called optically active constituents (OACs), which have measurable, often unique, absorption and scattering signatures, called Inherent Optical Properties. By absorbing or scattering light at different wavelengths, OACs determine the intensity and color of light scattered upwards back through the surface (the water-leaving radiance). This water-leaving radiance signal is detected by sensors mounted on a satellite and interpreted in terms of key water quality parameters[2].

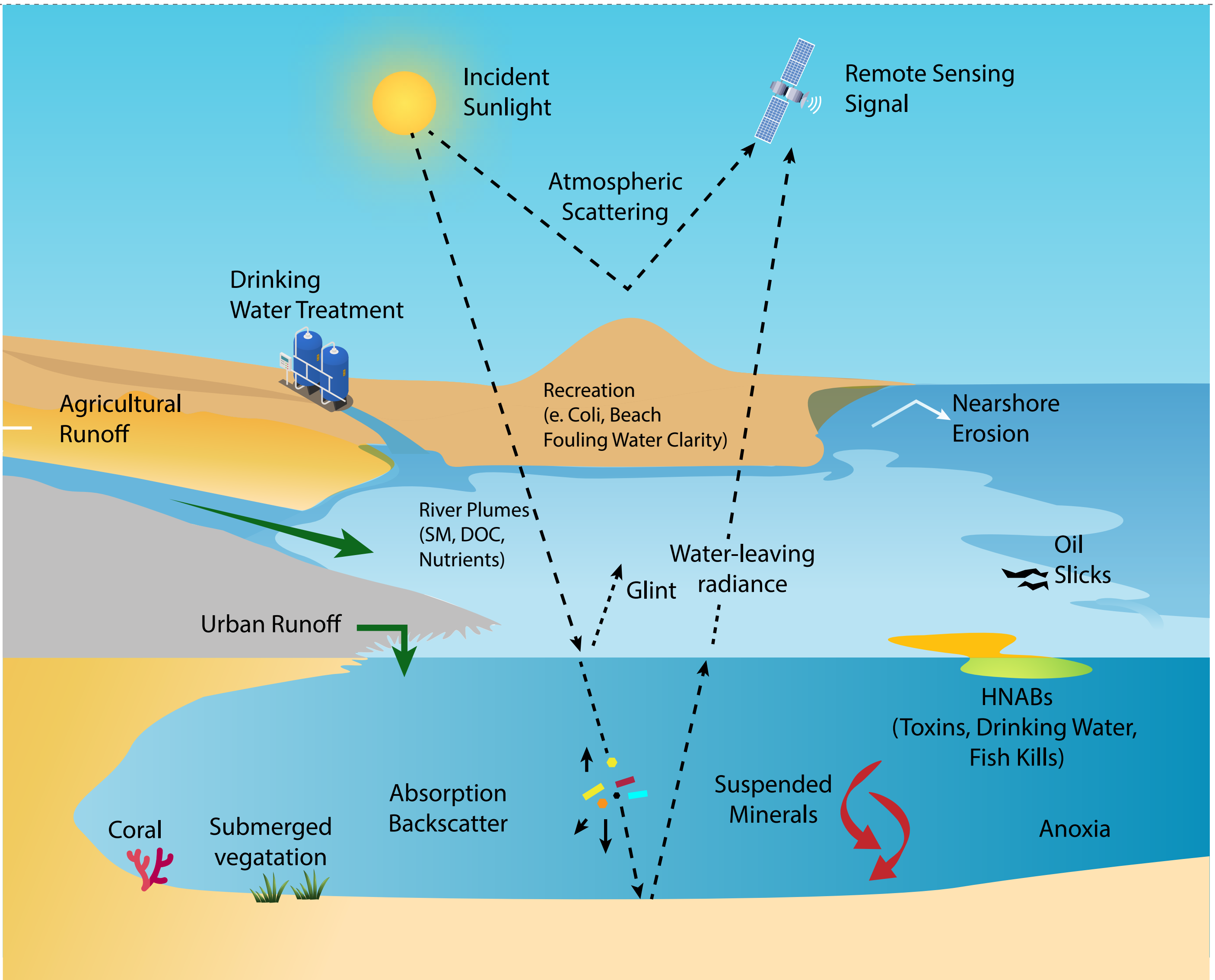

Figure 1: *Schematic of the working of satellite-based water quality monitoring (Source IOCCG, 2018)*

The water quality parameters that can be measured through satellites include turbidity, chlorophyll concentration, sediment, colored dissolved organic matter, algal bloom, and temperature, among others. The satellite sensor pixel spatial resolution depends upon the type of satellite and could be as fine as 30 m. Likewise, temporal resolution, or the amount of time that passes between measuring the same location repeatedly, could be on a daily basis.

There are several examples of well-established mechanisms for satellite-based monitoring of water quality. For instance, the SERVIR initiative, a joint venture between USAID and NASA has created a water quality visualization tool for Lakes Malawi and Victoria in Africa. The Tool uses Google Earth Engine and the Tethys platform to process and display Landsat, Sentinel, and MODIS Earth observation data for mapping water quality parameters that include Chlorophyll-a, lake surface temperature, and total suspended matter. All measurements are provided on a daily, weekly, monthly, and seasonal basis. The Tool also analyzes Earth observation data to generate static maps of the coverage of water hyacinth and land use and land cover for specific epochs. Figure 2 presents a snapshot of the water quality in Lake Victoria estimated by the Tool. Lake Victoria is the largest lake in Africa and the chief reservoir of the River Nile.

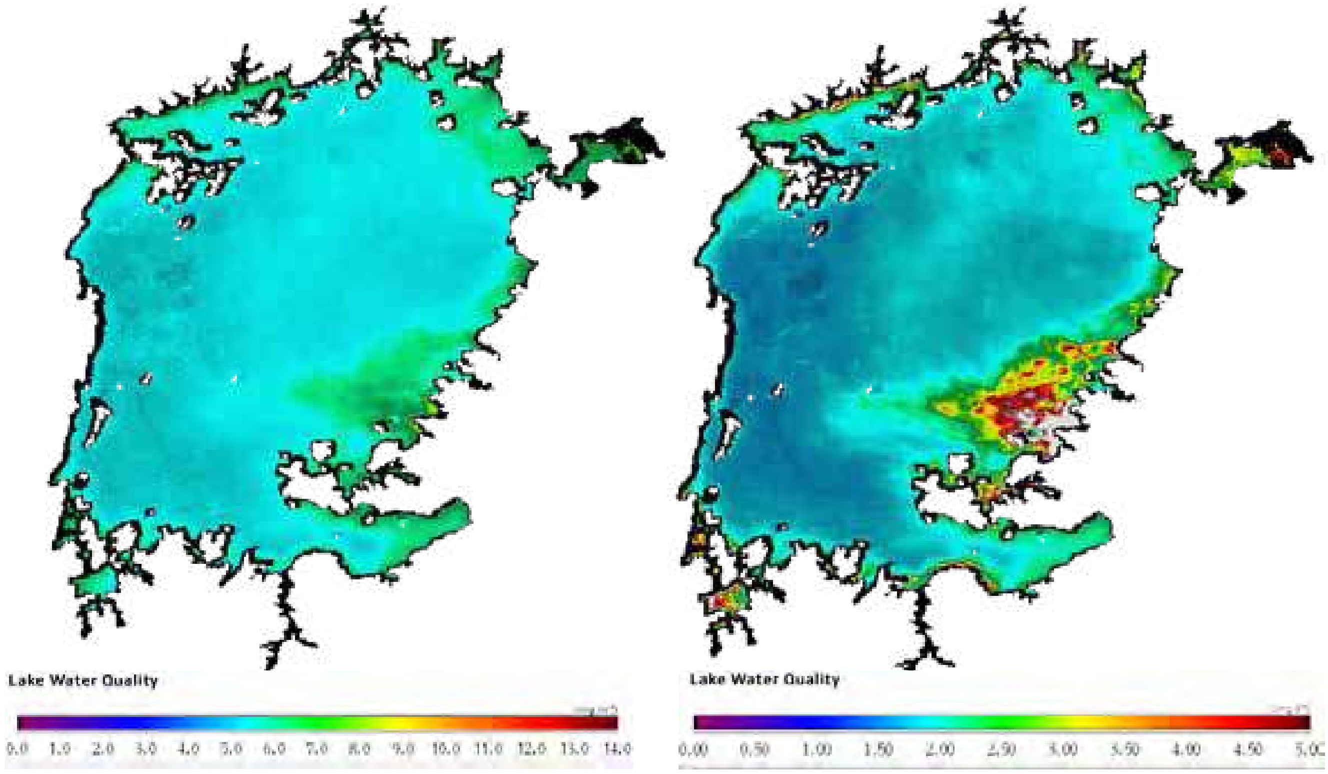

Figure 2: *Satellite-based monitoring of Chlorophyll (left) and suspended solids (right) in Lake Victoria, Africa (Source: SERVIR Africa)*

Similarly, in 2018, UNESCO launched a water portal called International Initiative on Water Quality (IIWQ) Portal[4], which provides information on freshwater quality at the global scale using remote sensing data. The portal provides data on five key indicators of the state of water quality: turbidity and sedimentation distribution, chlorophyll-a, Harmful Algal Blooms (HAB), organic absorption and surface temperature. Figure 3 presents an analysis of the turbidity content in the River Nile and the Aswan Reservoir.

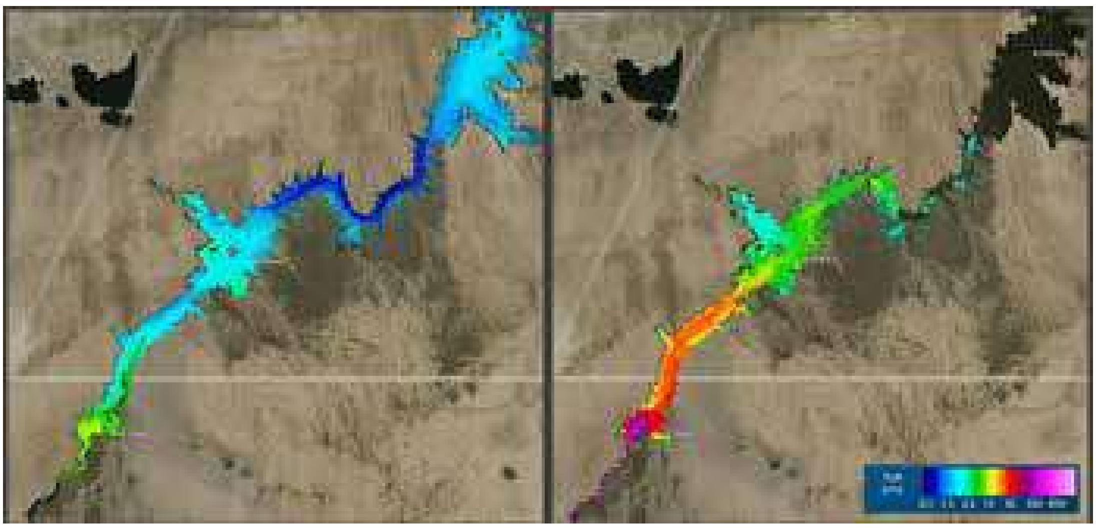

Figure 3: *Turbidity distribution in the River Nile and Aswan Reservoir on 17 January and 20 August 2016 (Source: IIWQ, 2016)*

From a government's perspective, since 2010, the city of Barcelona has been using an information service based on satellite imagery called "Barnamar[5]" for monitoring coastal water quality, given that its beaches are a major avenue for tourism activities. Barnamar provides information about four water quality parameters, i.e., the suspended solids, transparency of the water, temperature, and algae bloom. The service is operational during bathing season, which runs from June to September. The maps are updated every two to three days, with a 24-hour delay for processing the images. Many developing countries have also been quick to embrace the the use of satellite-based water quality monitoring. For example, researchers in India are working with the University of Chicago on the Water to Cloud project[6], a cyber-physical sensor network system for water quality mapping and monitoring. The project uses a mix of methods, including satellite-monitoring, traversing stretches of the river to collect water samples and using special sensors to measure bacterial and chemical pollution.

With advances being made in geospatial science, satellite-based measurements of surface water quality are becoming a popular choice across the world. However, such systems have their limitations. For example, cloud cover can significantly impact temporal coverage, because satellite sensors cannot measure through clouds. Furthermore, given the costs of a satellite-based monitoring mechanism, it works best for monitoring large areas or stretches where the economics will balance out. For smaller areas, in situ measurements are still the most optimal option. In today's time, it is best if satellite data is viewed as a means to complement field measurements, and not as a standalone system of measurement.

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3. *Lake Water Quality Visualization Tool (http://apps.rcmrd.org/waterquality/index.php)*
4. *4International Initiative on Water Quality Portal (http://sdg6-hydrology-tep.eu)*
5. *5The City of Barcelona uses a satellite-based service to monitor coastal water quality (http://www.eurisy.eu/stories/the-city-of-barcelona-uses-a-satellitebased-service-to-monitor-coastal-water-quality_141/?__GP_URL__=the-city-of-barcelona-uses-a-satellitebased-service-to-monitor-coastal-water-quality_141)*
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Towards a Circular Solution with Innovative Measures for Sustainable Packaging and Urban Systems

Vilas Nitivattananon, and Yung-Hsin Lin

Circular Economy concept encourages rethinking and redesigning of our packaging system to ensure the smallest possible leakage of used packaging materials.

Towards a Circular Solution with Innovative Measures for Sustainable Packaging and Urban Systems

Introduction

Packaging has developed into an indispensable industry in our times since the industrial revolution, which brought the development of new manufacturing processes and new materials, such as metal can, glass bottle, paperboard, and plastics (Risch, 2009). With the growth in packaging applications, ever-increasing waste has become a threat to our environment. It is estimated that packaging waste accounts for about one-third of solid waste generated globally, and the recycling rates of packaging materials are found significantly lower in developing cities: Manila and Bangkok have a recycling rate (glass, paper, plastic, and metal) of around 14%, while Singapore (45%) and Hong Kong (36%) obviously outperform them (Tangwanichagapong, 2017). Meanwhile, increasing consumption of single-use packaging in ASEAN due to economic growth, rapid urbanization, and changing consumption and production patterns, such as a growing "takeaway food culture" and "e-commerce activities", further deteriorated the situation (GIZ, 2018).

In addition to the common 3Rs principle - reduce, reuse, and recycle –in solid waste management, this article argues that what's more fundamental is a circular thinking in replace of the old linear one to transform packaging value chains into a sustainable packaging system. The concept of Circular Economy (CE), based on the 3Rs principle while further including "rethinking" and "redesigning", aims to minimize, track, and eradicate waste through careful design of circular cycles, or closed loops (Tangwanichagapong, 2017). Beyond waste management, the CE concept has been widely perceived as an important driver to the Sustainable Development Goal (SDG) 12 – responsible consumption and production. In addition, the Sustainable Packaging Coalition (2011) also recognized the CE concept as part of the criteria for sustainable packaging.

Innovative CE Applications in Selected Packaging Materials

To apply the CE concept to the packaging industry, O'Dea (2015) illustrates feasible circular flows in the packaging value chain (see Figure 1). In addition to the common reuse and recycling, packaging materials can also be repurposed or revalued to create higher added values. More fundamentally, the CE concept also encourages rethinking and redesigning of our packaging system to ensure the smallest possible system leakage of used packaging materials.

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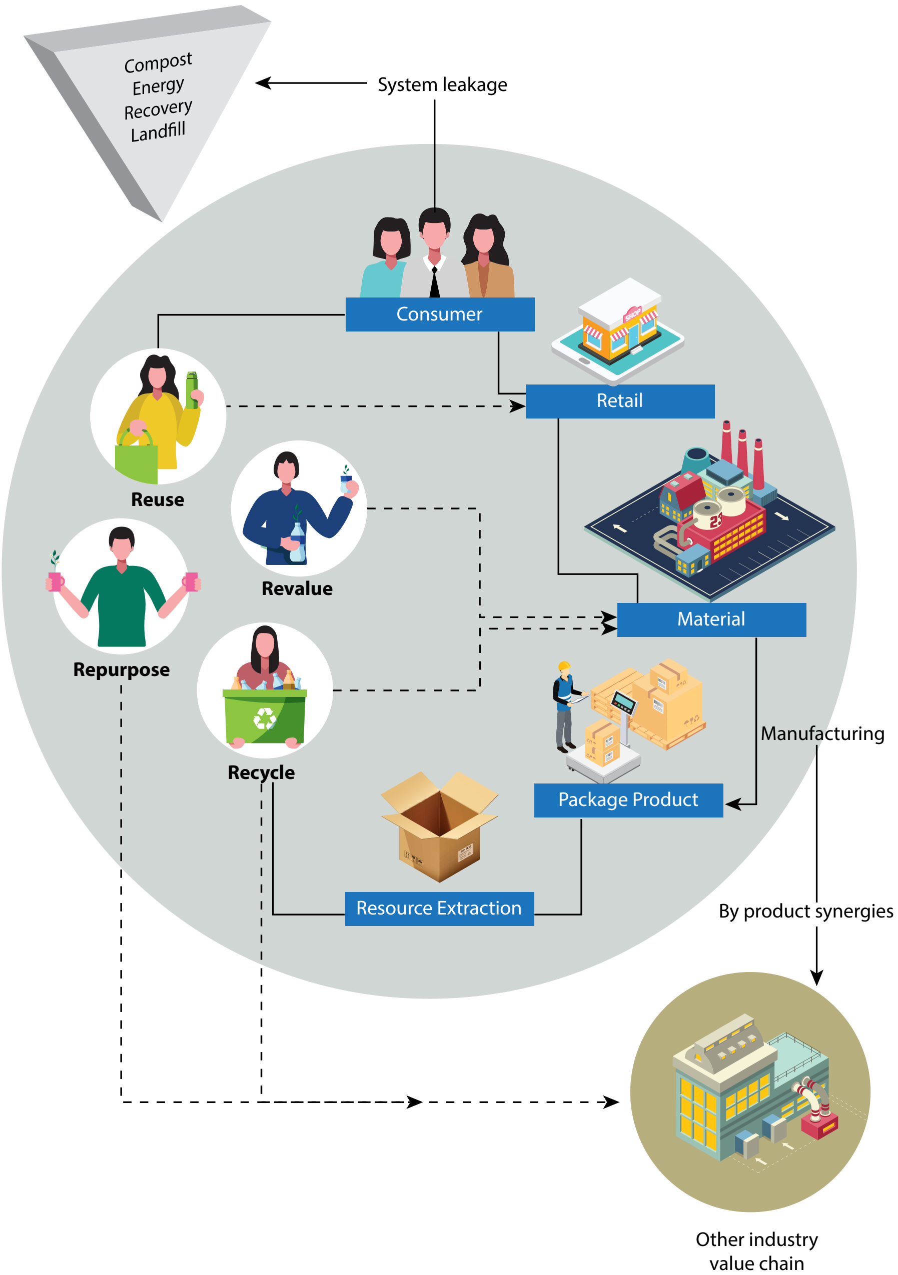


Source: *O'Dea, 2015; as cited in Tangwanichagapong, 2017*

Figure 1: *Circular chain of packaging*

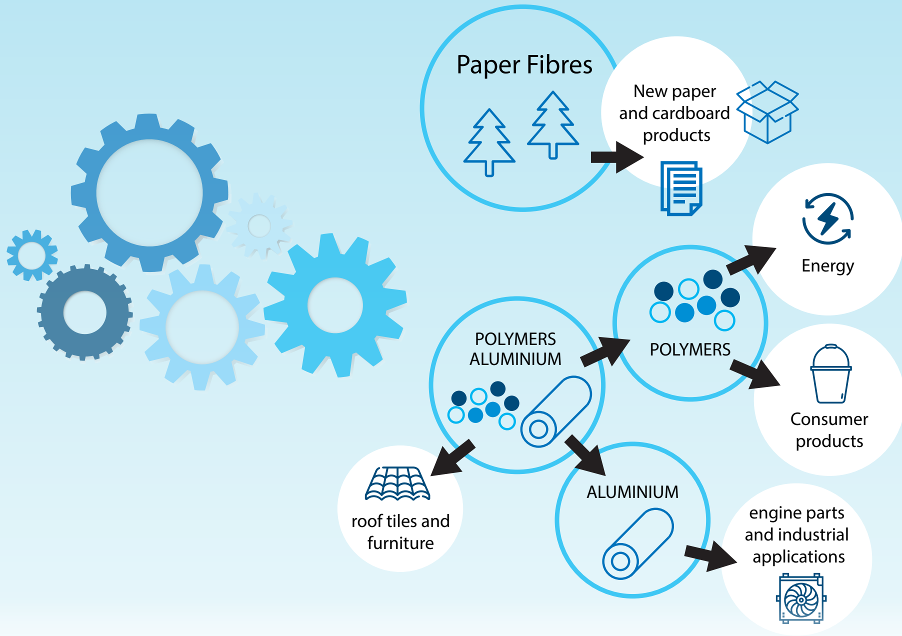
Based on previous researches, two fully recyclable but relatively less discussed packaging materials, beverage cartons and glass bottles, are introduced below as examples to demonstrate how the circular solution can contribute to sustainable packaging.

Used Beverage Cartons (UBCs)

Used beverage cartons are fully recyclable (see Figure 2), and recycling rates are steadily growing year on year. The unique advantage of recycled UBCs is that the paper fibers that make up around 75% of each beverage carton remain high-quality even after they are recovered from used cartons. Therefore, they can be repurposed to create a wide range of new paper and board products, including cardboard boxes, paper bags, office paper, and even tissue.

Recycled cartons are spurring eco-innovation. In Thailand, SIGnals showcased recycling by building a school canteen made almost entirely from recycled cartons. More than 1.4 million cartons were used to create the walls, the roof tiles and the furniture for the eco-canteen. Ecoplasteam uses PolyAl from cartons in its innovative EcoAllene® material that can be used for all sorts of applications from clothes pegs to construction, garden tools to toys, furniture to fashion accessories. A new hygiene solution from Lucart Professional utilizes all the materials recovered from cartons to make tissue paper and an accompanying dispenser made from PolyAl. And collection bins made out of recycled cartons are being used to promote further packaging recycling at a fun park in Mexico through SIG's partnership with SCTP and Ventura Entertainment (Nitivattananon, 2020). In addition, Fiber Pattana Co., Ltd. (FP), a major important recycle center of Thailand, has played important role in collecting and recycling UBCs. The UBCs and its straw are recycled and produced eco-products such as eco-pulp paper, eco-name card as well as green roofs. FP has acquired UBCs for recycling through their waste brokerage network and recycling projects, jointly implemented with Tetra Pak Co., Ltd. and other partners. In 2019, they recycled around 6,700 tons of used beverage cartons and aim to increase recycling tonnage through diverse environmental activities.

FOSTER RECYCLING

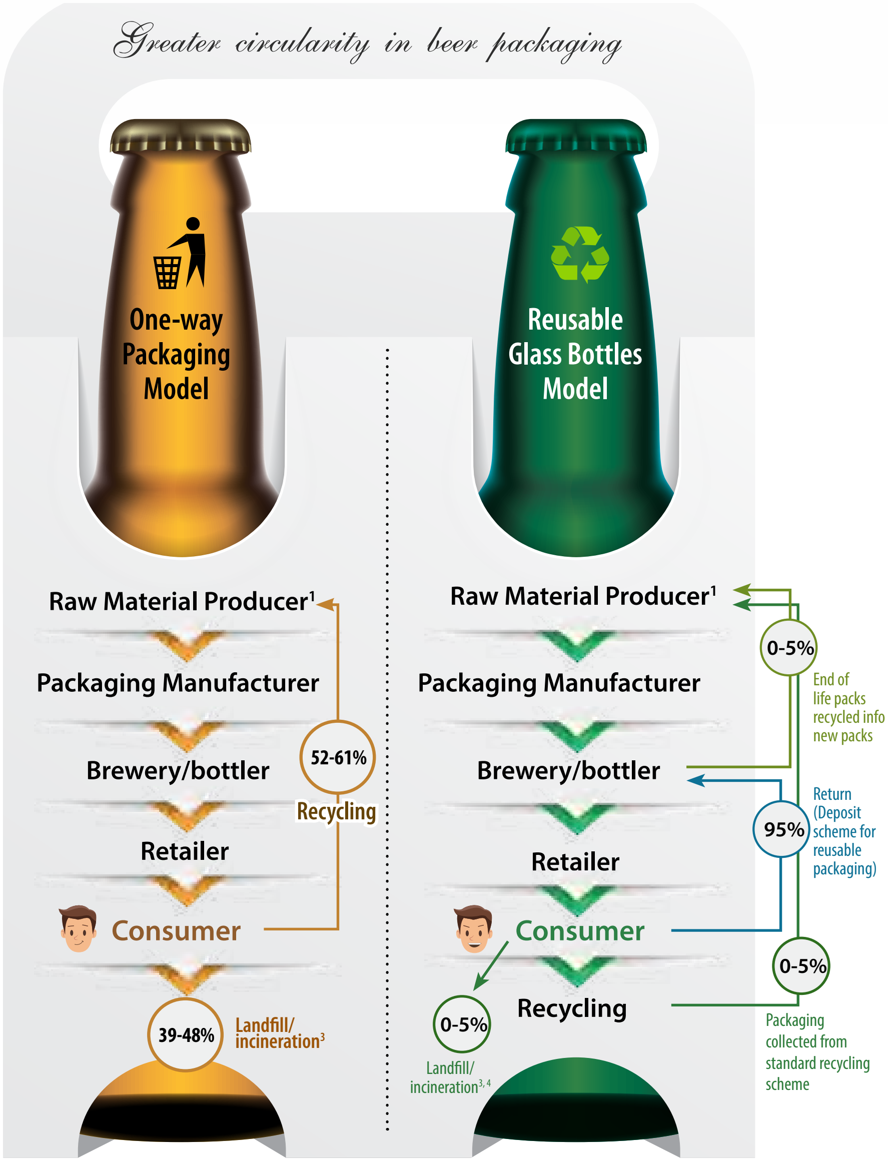


Source: *SIGnals, 2019*
Figure 2: *A new life for used cartons*

Used Glass Bottles

Glass bottles are infinitely recyclable and reusable. The major issue is that glass bottles can easily be broken, contaminating other recycled items. Therefore, many recycling companies are not willing to take used glass bottles (Fitzgerald, 2019). The most efficient and effective way to increase glass bottle recycling and reuse is to make the bottlers recover their own bottles (see Figure 3). To ensure that used glass bottles can be returned back to the production system at the post-consumption stage, in some places like Denmark and Scotland, glass bottles are recycled through a deposit-return scheme where consumers are required to pay a deposit when buying any glass-bottled drinks, and they will only get their deposit back upon returning the used bottles to the designated machines or handlers.

In terms of recycling innovation, the Thai Beverage Recycle Co., Ltd. (ThaiBev) in Thailand transformed its bottle sorting process using cutting-edge AI technology, which allows it to deliver used glass bottles with zero risk of human error and minimize the cost of transporting defective bottles. ThaiBev also works with its Myanmar partner to retrieve glass scraps by using reverse logistics to ensure that they are handled in a responsible manner and recycled by glass bottle manufacturers (ThaiBev, 2019). In light of the Coca-Cola Company's goal of 100% packaging recovery by 2030, the Coca-Cola System in Thailand has already a sizable returnable glass bottles business, which allows for a near complete reuse of these bottles. (The Nation Thailand, 2019). In Taiwan, the largest glass recycler Spring Pool Glass specialises in the so-called "upcycling" activities by repurposing used glass into new products of higher value, such as green building materials, customized glass products and artwork.



Source: *Ellen MacArthur Foundation, 2013*
Figure 3: *Greater circularity in beer packaging*

1. Example: PET resin, glass cullet, aluminium blocks
2. Recycling - Plastic bottles 52%, aluminium cans 60%, glass bottle 61%
3. Incineration ('waste to energy') or PET bottles. If done cleanly, is preferable to landfilling
4. Additional glass in municipal waste streams may be sorted in mixed-waste material recovery facility (MRF), but unlikely to be back into food-grade glass bottles dur to regulations

Innovative Environmental Management Measures (EMMs) for Urban System Improvement

Environmental management measures (EMMs) consider the following: regulatory, economic and finance, voluntary and information measures with supporting instruments suitable to the objectives, issues and local conditions for potential improvement in sustainable urban systems.

Several challenges exist for closing the loop of our packaging system. For example, Nguyen and Nitivattananon (2019) found the conflicts between formal and informal sectors within waste separation and collection activities which compromised potential synergies to increase recycling rates, income and job opportunities, and save waste management costs. Moreover, the mixed waste discarded from households makes waste separation time-consuming and wet waste (such as leftovers) would contaminate recyclable items which then lose value for resale in the market.

To improve system efficiency, inclusive design of material management systems can help to engage informal waste pickers in formal activities. To reduce contamination of recyclables and operating cost of waste treatment and disposal, source separation should be encouraged, of which the common approach is to color garbage bins for different types of waste, but it would be ineffective if people do not responsibly follow the instructions for expected practices. Therefore, an innovative approach is experimented in Taiwan, where smart waste-disposal stations were installed on the street, offering credit rewards based on the volume of recyclable items to financially encourage source separation and recycling (Drillsma, 2018; ESM, 2017).

Some regulatory EMMs for packaging waste include restrictions on excessive packaging, imposed in countries like the UK and Korea; and the Extended Producer Responsibility (EPR), which has been mainstreamed in Indonesia's Waste Law (GIZ, 2018). In the Greater Taipei Metropolitan Area of Taiwan, the Pay-As-You-Throw (PAYT) system along with other EMMs have reduced waste generation while increasing recycling rates up to around 55% (RTA, 2019). For voluntary EMMs, Singapore Packaging Agreement as a voluntary initiative requires signatories to record and adopt cost-effective solutions to their packaging waste (GIZ, 2018). "Ah! Ah! Don't litter. Magic Eyes are watching you," is a light-hearted jingle familiar to many Thais, organized by the Thai Environment and Community Development Association (aka Magic Eyes), the performance raises awareness about waste reduction and recycling. Magic Eyes ran projects and presented an annual stage performance regarding environmental conservation in earlier years.

Box: Extended Producer Responsibility & Pay-as-You-Throw

Extended Producer Responsibility (EPR) is an approach that requires producers to bear a certain degree of responsibility for the environmental impacts of their products throughout the life cycle (OECD, 1996). In terms of packaging waste, producers can take their EPR by reducing packaging, using recyclable materials, and recovering their used packages for reuse or repurposing.

On the other hand, Pay-As-You-Throw (PAYT) is a financial disincentive based on the polluter-pays principle to discourage residents, mostly consumers, from generating waste and encourage them to separate recyclables from waste. In practice, a PAYT may charge people a fee for each garbage bag or for each unit of waste disposed.

Taken together, these two EMMs can address the issue of packaging waste in a synergetic way by making producers and consumers share their responsibilities for sustainable urban systems. For example, In Taiwan, EMMs have been put in place on a nation-wide basis since decades ago to constrain waste generation and to increase recycling rates. Taiwan has called for the recycling of Municipal Solid Waste (MSW) to be around 28 percent of that total (7.5 million tons). The development of a waste management policy is based on the 1988 principle of EPR of manufacturers and retailers. Among all, PAYT charging system is perhaps the main difference in EMMs for solid waste management across all municipalities.

Conclusions

From linear to circular, the CE concept challenges our traditional approach by rethinking used items as resources rather than waste, and eventually redesigning our systems to be closed loops. To this end, a single approach is not sufficient as our production-consumption patterns are extremely complex, involving a variety of interested parties. The CE concept therefore promotes a systems thinking subject to urbanization that brings together different approaches through multi-stakeholder partnerships. A wide range of innovative measures, both mandatory and voluntary, carrots and sticks, are available to facilitate our efforts towards circular solution, but it is our ability to rethink, redesign, and rebuild our urban systems in a circular way that will ultimately make significant difference in sustainable packaging.

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Digital Technologies for Construction Management in Tall Building Projects

Narong Leungbootnak, and MIN Vuthea

Digital technologies such as BIM, IoT in construction, VR, AR are rapidly re-shaping the construction industry, and specifically for tall building projects.

Digital Technologies for Construction Management in Tall Building Projects

Introduction

The growth in world population has led to land availability constraints and subsequent space optimization by construction of tall buildings in crowded urban cities, which is also true for Bangkok, Thailand. With the increase in the number of tall buildings being constructed in urban centers, it has become challenging for the Construction Project Management practitioners to successfully manage the project scope, time, cost, quality, as well as meet the requirements of the project owner and key stakeholders involved. Considering the challenges faced by construction project management practitioners, it is also vital to note the role of digital technology in bringing efficiency and effectiveness in the construction management of tall building projects. Currently, the digital technologies that are being used and which may well be commonly used in the future for construction projects include: BIM application, Internet of Things (IoT) in construction, data storage, Virtual Reality (VR) and Augmented Reality (AR). The technologies mentioned above is just an example of how the digitalization is rapidly re-shaping the construction industry, and specifically for the tall building projects.

Figure 1: *Dr. Narong Leungbootnak and Mr. Thaung Htut Aung, Director, AIT Solutions at the knowledge transfer session on 'Construction Technology for Tall Building projects' on 27th October 2020 at the Asian Institute of Technology, Thailand.*

Digital technology transformation is needed for all the stakeholders involved in a construction project. This transformation can be accelerated through knowledge transfer activities which can be done through online medium to reach a wider audience of construction project management practitioners as well as relevant stakeholders. One of the knowledge transfer activities conducted by Dr. Narong Leungbootnak focused on "Construction Technology for Tall Building projects".

BIM Application, 8D for Tall Building Projects

Building Information Modeling is used to digitally construct one or more accurate virtual models of a building. This development of the virtual model aids in the different phases of the design process, that allows for an effective analysis and control when compared with the process done manually. Once the computer generates virtual models, these models provide precise information that includes the geometry and the relevant data that supports the construction, fabrication, as well as the procurement processes in the overall realization of a building project.[1]

The creation of the information became automated with the arrival of CAD, and BIM supports in the automation of the use of the created information. BIM supports a collaborative workflow wherein through the 3D model software it focuses on accuracy and capability to handle lots of information, as well as compatibility with other solutions. Companies (e.g. Skanska and Barton Malow) that have applied BIM in their projects, have reported benefits for project management, scheduling, estimation and risk analysis, as well as better collaborative processes and facility management.

BIM enables to try out the solutions in advance through model-based workflow, before actual

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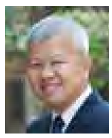

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construction on-site. With this prototyped virtual model, various project stakeholders can easily understand and review the design, its accuracy, and its completeness. This also enables the stakeholders to easily visualize and evaluate the cost, time, and other project parameters. As some of the companies who have applied BIM in their projects have experienced, these features of BIM results in improvement in communication between the project stakeholders with due quality control.

While we are focusing on BIM, it must be noted that all the construction computer models and drawings representing a building are not BIM. For e.g. BIM is/ are not the models that contain only visual 3D data but no object attributes, or those that allow changes to dimensions in one view but do not automatically reflect those changes in other views. The mentioned examples do not include the data for supporting the construction, fabrication, and procurement. In future, construction stakeholders may need to focus on 8D BIM, as highlighted in the following figure.

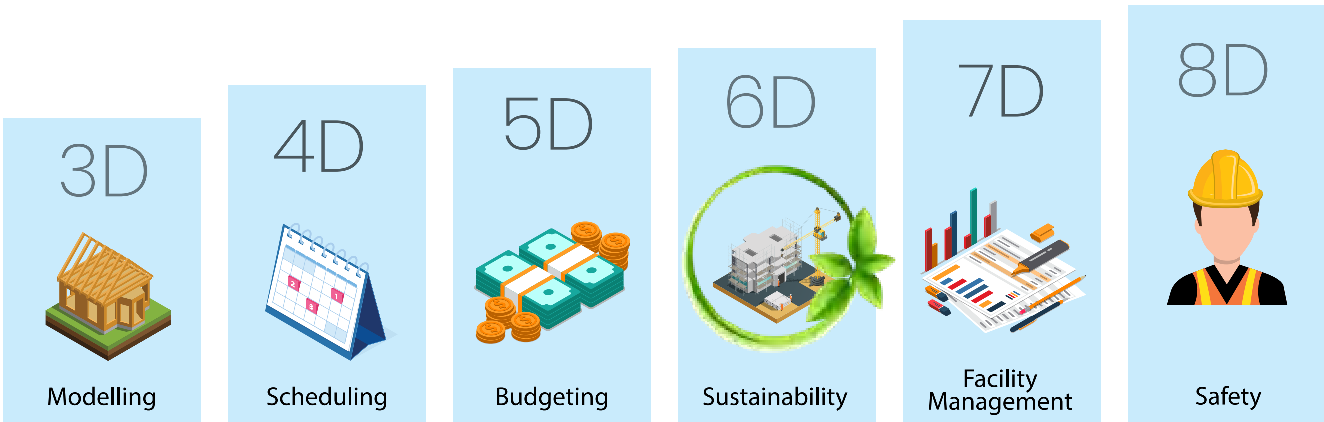

Figure 2: *8D BIM for construction projects.* [3]

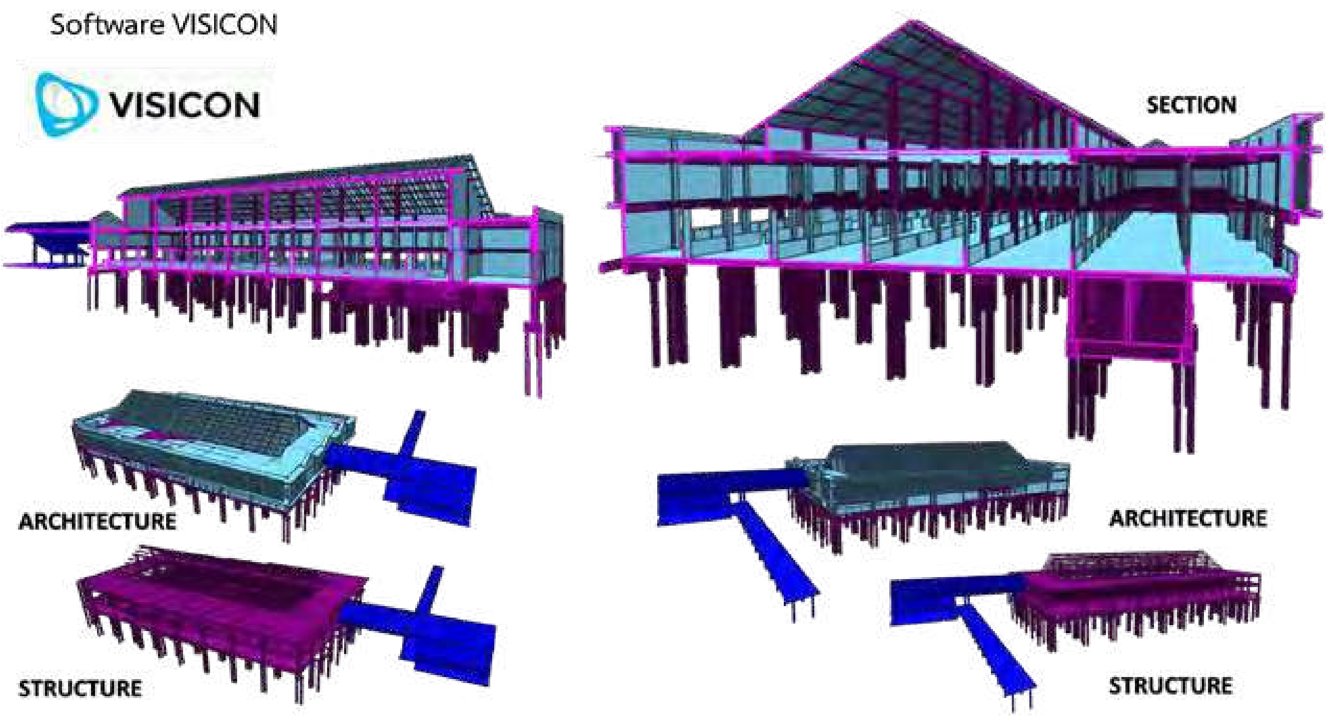

Figure 3: *Example for BIM for Architecture and structure.* [4]

Augmented Reality and Virtual Reality in Construction Management

One of the key items in executing a construction project is the quality of design provided to carry out the construction works. If the design quality does not meet the standards and/ or information is not conveyed correctly through the design, it may lead to missing the project objectives as well as cost overruns and delays. [5]

In order to address this aspect of a construction project, the construction industry as a whole is exploring on adopting technologies that support in design review. These technologies include: Augmented Reality (AR) and Virtual Reality (VR). VR can be applied in demonstrating the design to the developer in virtual reality as a model from the design. Instead of the developer waiting for the real construction to happen and realizing the design, the developer with the aid of VR can view in advance and identify any modifications/ customization needed at the design phase. This results in highly developer centric and customization of the designs.

While VR helps in visualizing the design before an actual construction, AR can support in checking whether the completed construction has addressed all the modifications/ customizations identified at the design phase. The AR combines the virtual design objects with the real on-site works. AR can also be applied in seamless review and revision of interior designs. [6]

AR provides a realistic experience in an actual building wherein the user may review/ revise the wall colors, furniture items, design elements with a touch of a screen until the final meets the user requirements.

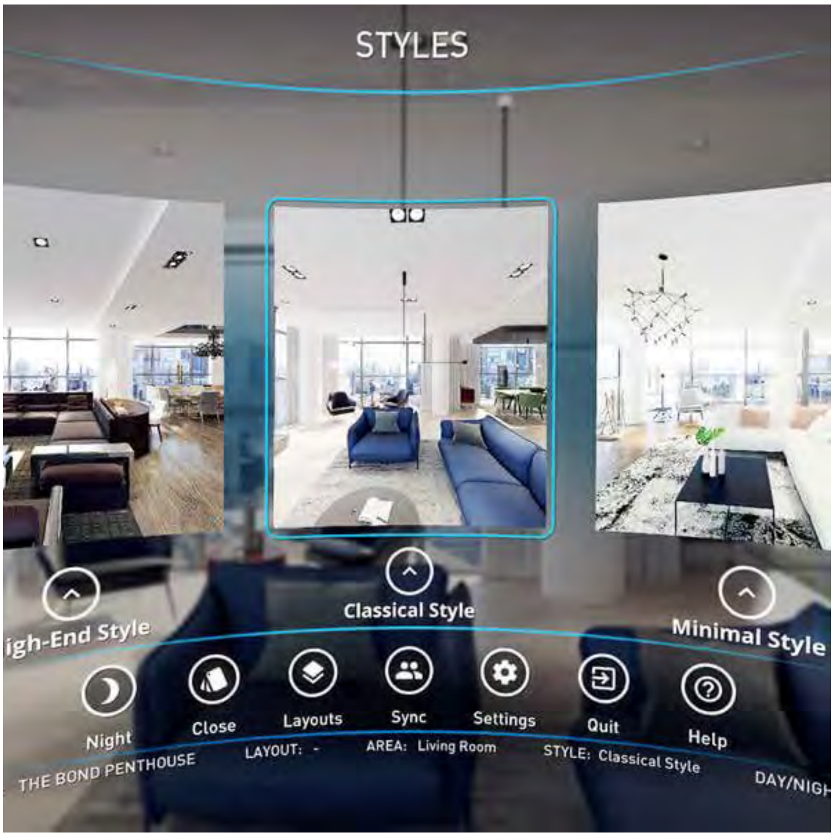

Figure 4: *An example of virtual reality tours and AR demonstrating the interior design in seamless review.* [7]

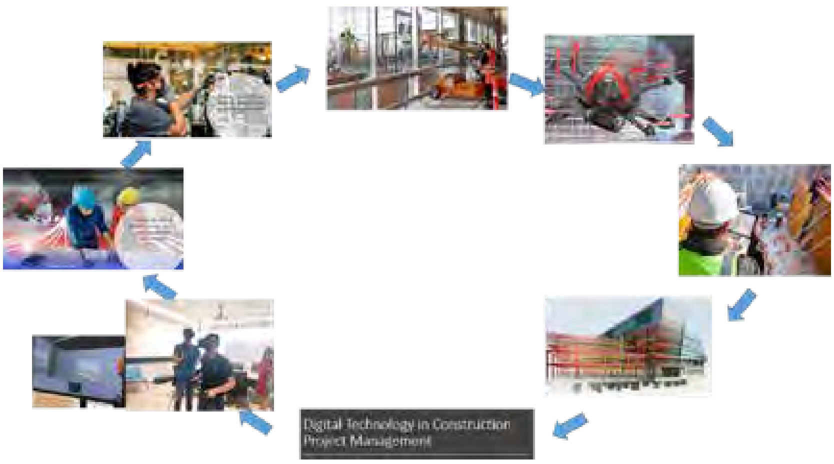

Figure 5: *Digital technology use case in construction project management.*

Quantitative Risk Analysis using the Simulation from Tall Building Construction Project Data

Quantitative risk management in project management helps in determining the probability of cost overruns and time delays. In the case of tall building projects, the cost items and schedule of activities are standardized and planned for data collection, which forms the basis of big data input for each data distribution. For each project activities there are various identified risks, which leads us to the importance of generating distribution profile. [8]

There are some software tools (Primavera, Microsoft Project) available that can support in conducting analysis related to project scheduling and cost items, by utilizing the big data inputs. In relation to projects involving tall buildings, cost and schedule scenarios simulation through big data inputs and application of QRA approach, may result in more accuracy. Of the several benefits of this analysis, one of it is on deciding on the investment in the project and prediction of the investments. An example of QRA approach for tall building projects is illustrated in the following Figure.

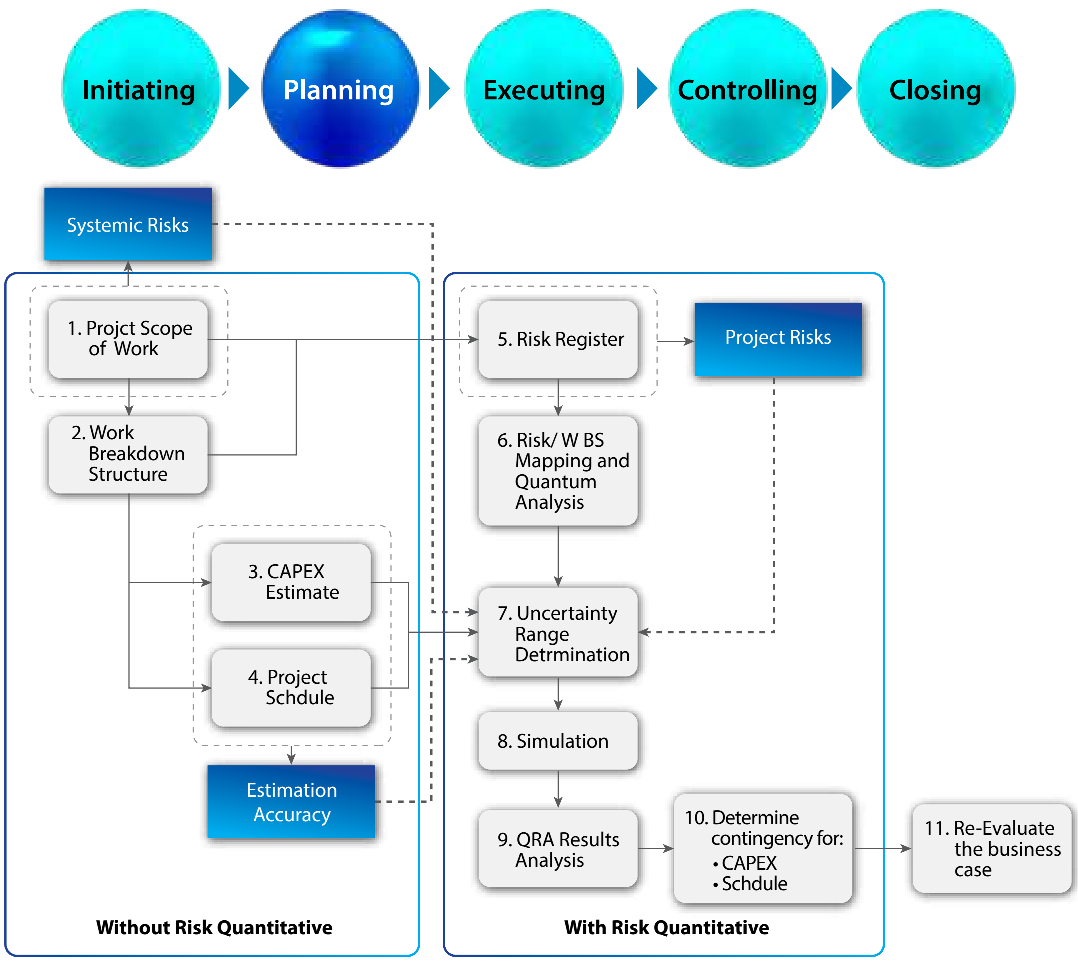

Figure 6: *: Illustration of planning process for QRA in determining contingency for cost and schedule for tall building project.* [9]

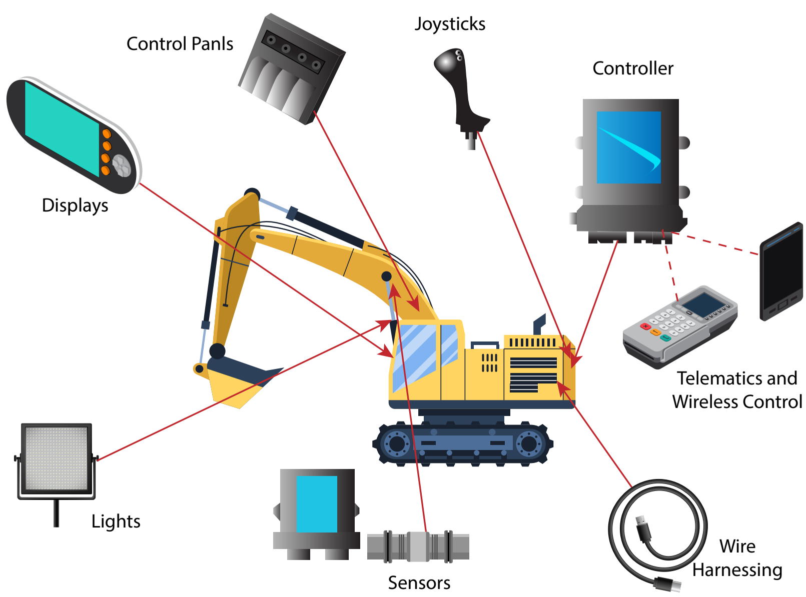

Figure 7: *Construction equipment control using IoT.* [11]

Internet of Things in Construction Management

In the current world context, people are better connected with the things around them. In future, people will be connected with the things around them much faster and easier, and most likely replace human intervention in some of the tasks through the use of Machine Learning and Artificial Intelligence (AI). With the aid of Internet of Things (IoT), many construction equipment could be automated thereby decreasing the human factor in the construction works.

Looking at the current growth of technology and technology enabled equipment and devices, it is more likely that in the near future heavy civil construction may be the largest user of IoT enabled equipment and devices. Though as the technology matures, it can further integrated into wider range of projects. Application of IoT besides controlling the machines/ equipment/ devices, also helps in the real time monitoring of the overall success, development and status of the project. This seamless connectivity can be utilized to design and correlate other building activities, thereby increasing efficiency and minimizing delays. Figure 7 provides an example of the application of IoT in the construction industry. [10]

Application of IoT goes beyond just controlling the construction equipment, which includes how the structure is planned, evaluated, and submitted for construction approvals and implementation, followed by monitoring and design controls.

Conclusion

The application of digital technologies can be an important tool for assisting the project manager and the construction management team to integrate, plan, execute, monitor, control, and close the project successfully, especially for complex project such as tall buildings. Digital technologies that are currently being used and which may most likely be needed in the future include: BIM applications, IoT in construction, data storage, VR and AR.

Digitalization is fast re-shaping the construction industry and specifically for tall buildings. Considering the pace of digitalization, the skills of the workforce need to be enhanced in order to adapt to the changing trends in the construction industry. For the skill enhancement, institutions of higher learning may need to devise new curriculum that meets the need of the learning of future applicants, and thus ensure their successful future in the construction industry.

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Knowledge Management as a Catalyst for Development and Transformation

Q&A with Dr. Naveed Anwar
Vice President for Knowledge Transfer
Asian Institute of Technology

One of the aspects that set the best organizations apart in the current knowledge economy is how they consistently create new knowledge, disseminate it widely throughout the organization, and leverage it in their business processes and products. The way we manage the knowledge in the organization has an impact not just internally but can be a catalyst for development and transformation.

How can we define knowledge management (KM) in the context of development and transformation?

Dr. Naveed: As we know that knowledge is the third tier in the knowledge pyramid starting with data, information, and then knowledge. These days, data, which is the basis for knowledge is expanding both in volume and depth at an exponential rate. It is often said that there's more data generated every hour now than it was generated in the entire history in the previous centuries, leading to the term, the Knowledge Century.

When we have so much data, it will lead to a lot of information that can be generated and the need to use that information to create knowledge, and to use it to gain wisdom or create value, and when we create knowledge, we need to manage it properly. This management includes both extracting and creating knowledge. Storing it, processing it, transferring, and disseminating properly and efficiently. With the increased level of data generation coming from so many sources, knowledge management has become one of the most important challenges for many organizations. I think, any organization not focusing on knowledge management, exchange, and transfer will not be able to do well in the current environment. For example, AIT, which is an academic and research institute is a source of applied knowledge creation, and as such we have to have a proper knowledge management system to convert this knowledge, manage it, share it effectively to be impactful.

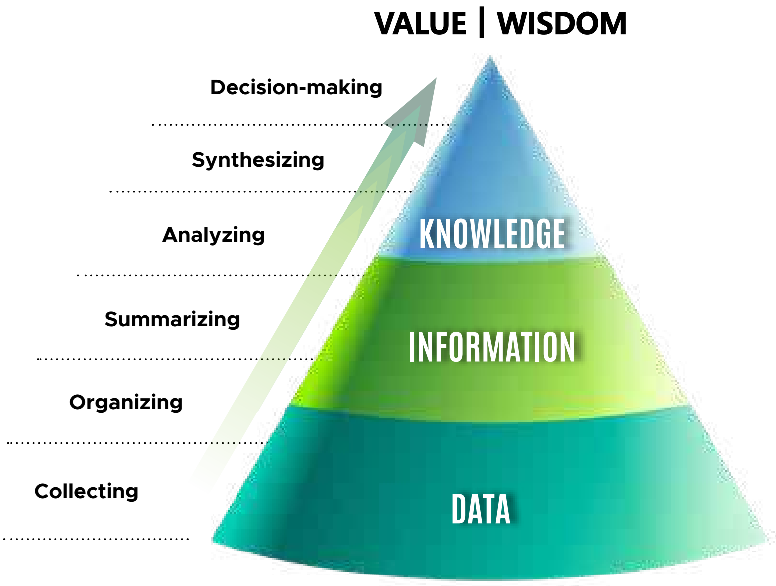

***Figure 1:** Knowledge management is the process of collecting, organizing, summarizing, analyzing, synthesizing and effectively using knowledge for smart decision making.*

What is the 'smarter' solution in knowledge management?

Dr. Naveed: I think the key elements of being smart in most people's eye is somehow related to computers/ automation or AI (Artificial Intelligence). To me smartness means doing something faster, more efficiently, accurately, and reliably while using less resources and with a broader perspective.

To help achieve this, AIT have developed a KM platform, we call Knowledge Portal, to be able to pull the data within the organization and make it useful not just for us in AIT but for the outside world as well. AIT Knowledge Portal provides access to various forms of data which is processed to create valuable information and presented in the relevant context for a knowledgeable decision-making and understanding.

For example, when you search for a thesis or research carried out by faculty or researcher on a certain topic, the portal will provide not just the list of thesis topics related to your search but also other relevant information such as researcher profile, related application, geographic location, timeframe, and so on. Any person accessing this platform gets the complete picture rather than just a listing of the topics searched, which helps to create better understanding and leads to better and smarter decision making.

We believe that this Knowledge Portal will help in not only providing informed and in-depth answers to some key questions about AIT's, but also help to consolidate and preserve knowledge.

Figure 2: *: AIT Knowledge Portal provides access to various forms of data which is processed to create valuable information and presented in the relevant context for a knowledgeable and smarter decision-making and understanding.*

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