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UK – VIETNAM

Research and Innovation Partnership

Foreword

Welcome to the UK - Vietnam research and innovation partnership, delivered through the Newton Fund Vietnam and the Global Challenge Research Fund. The Newton Fund Vietnam is a bilateral partnership programme between the UK Government and the Vietnamese Government, established in 2014. The Global Challenges Research Fund is the UK Government›s science partnership programme with developing countries, including Vietnam, which began in 2016.

Over the past 9 years, the Newton Fund Vietnam and the Global Challenge Research Fund have provided more than 300 grants, connecting our research communities, provided mobility and professional skills training for early career scientists, and built capacity for Vietnam›s science and technology system, especially joint research projects.

This booklet presents 14 outstanding research projects.

We will walk you through some important issues in the development process in Vietnam today. These include a wide range of topics, such as cancer, antibiotic resistance, disease outbreak forecasting, sustainable agricultural production, environmental pollution, disaster risk response, digital transformation and innovation capacity building.

In each story, we can see how the research communities of our two countries have come up with important questions, and employed new research methodologies, to make practical recommendations for Vietnam. Beyond that, some research groups have found new grant funding to continue their research cooperation in Vietnam after the Newton projects ended.

2023 marks the 50th anniversary of diplomatic relations between the UK and Vietnam. We hope you can spread the information in this booklet so that research findings can go further and inspire even more scientific cooperation

and innovation programmes, deepening the bilateral relationship between the UK and Vietnam

We would like to express our sincere thanks to the Vietnamese Ministry of Science and Technology as the co-executing body of the Newton Fund Vietnam.

We also would like to acknowledge the significant contribution of partner organisations involved in the Newton Fund Vietnam and the Global Challenge Research Fund, including Department of International Cooperation, Department of Organization and Personnel, Institute of Science, Technology and Innovation, National Agency for Technology Enterprise and Commecialisation Development, National Foundation for Science and Technology Development (Ministry of Science and Technology); Department of International Cooperation, Department of Secondary Education (Ministry of Education and Training); Vietnam Meteorology and Hydrology Administration (Ministry of Natural Resources and Environment); Vietnam Academy of Science and Technology; British Council; UK Academies; UK Research and Innovation; UK Met Office; UK Space Agency.

Our deepest appreciation goes to the scientists who make our programmes successful. And finally, we would like to thank the Science and Development Newspaper for joining us to develop this booklet.

Hanoi, February 2023

British Embassy to Vietnam

Contents

Image for illustration.
Source: Adobe Stock.

Whole-genome sequencing to investigate multidrug-resistant healthcare-associated infections

Healthcare-associated infections are infections that patients acquire at least 48 hours after admission to healthcare facilities. On average, one in ten patients in Vietnam suffered from an infection while receiving treatment (World Health Organization, 2018). This rate was even higher in intensive care units (ICU) in central hospitals. ICU patients are particularly vulnerable to healthcare-associated infections as they are critically ill, have multiple invasive medical devices, and are frequently treated with broad-spectrum antibiotics. For infections caused by multi-drug resistant organisms (MDRO i.e. bacteria resistant to at least three classes of antibiotics), the treatment options can be very limited.

According to Dr Tran Thi Hai Ninh from the National Hospital for Tropical Diseases (NHTD), most hospitals in Vietnam have only been able to determine the level of antimicrobial resistance (AMR) of bacteria through standard laboratory methods e.g. antibiotic susceptibility testing. These methods are not as discriminatory as molecular methods such as whole genome sequencing (WGS).

Between 2016-2020, medical doctors and researchers at NHTD, the University of Cambridge, the Oxford University Clinical Research Unit, the Sanger Institute and European Bioinformatics Institute conducted a research project under the Newton Fund Vietnam to look at the prevalence and transmission of MDROs in two intensive care units at NHTD and Bach Mai Hospital in Hanoi, using WGS.

The Vietnam team conducted a large, prospective surveillance study of MDROs. Clinical samples were collected weekly from all adults admitted to the two ICUs and environmental samples were collected monthly during the six-month study period. The samples were processed in the microbiology laboratory at NHTD prior to shipment to the University of Cambridge for further testing. WGS was performed at the Wellcome Sanger Institute and bioinformatic analyses were performed by European Bioinformatics Institute and Wellcome Sanger Institute. The analysis focused on three World Health Organization designated "critical priority" bacteria, namely *Klebsiella pneumoniae, Acinetobacter baumannii* and *Escherichia coli*, as these were the most frequently isolated species.

The results showed that 76% of ICU patients were infected with at least two of the three bacterial species of concern. Resistance to more than five antibiotic drug classes was observed in 97% of *K. pneumoniae* isolates, 90% of *E. coli* isolates, and 41% of *A. baumannii* isolates. However, the analysis did not identify clear differences between the lineages or AMR genes found in the two ICUs. This was surprising as patients were not usually transferred between the two ICUs and the medical teams were different. These findings suggest that transmission had occurred in other healthcare settings or in the community before admission to ICU. Dr Estee Torok, University of Cambridge, commented that these findings emphasise the need to conduct detailed prospective surveillance studies for AMR in community and lower-level healthcare settings to determine the levels of AMR and reduce the risk of MDRO infections in hospitals and ICUs. This study was published in the Lancet Microbe.

Dr Hai Ninh shared that the project was meaningful since prior to the project, there was no available data about prevalence of MDROs in critical care settings in Vietnam. In addition, this project enabled clinicians and scientists in NHTD to gain experience in the use of WGS to investigate antimicrobial resistance and transmission of bacteria in healthcare settings. As a result, they will be able to investigate future outbreaks and inform local infection control procedures.

Project: Whole-genome sequencing to investigate the prevalence and transmission of multidrug-resistant organisms in intensive care units in Hanoi, Vietnam.

Research Partners: University of Cambridge; Oxford University Clinical Research Unit; Wellcome Sanger Institute; European Bioinformatics Institute (UK); National Hospital for Tropical Diseases; Bach Mai Hospital (Vietnam).

HPV vaccination recommended for both women and men

The HPV Real-time PCR kit.
Source: National Institute of Hygiene and Epidemiology.

Cervical cancer is the seventh most common cause of female cancer deaths in Vietnam (Catalan Institute of Oncology & International Agency for Research on Cancer – IARC, 2021). More than 5,000 cases of cervical cancer are recorded every year in the country, and 51% of people die within two years of diagnosis. The main cause of this disease is infection with Human Papillomavirus (HPV), one of the most common and sexually transmitted viruses.

Given more than 80% efficacy for reduction of pre-cancer lesions in the cervix, HPV vaccination, when given at appropriate ages, can effectively prevent cervical cancer. While HPV vaccination is a very common practice in developed countries, HPV vaccine coverage in Vietnam remains low and the HPV vaccine has not been included in the expanded programme on immunisation. This is partially due to the lack of epidemiological evidence on HPV infection and HPV-related disease burden in the population.

According to Associate Professor Nguyen Van Trang, National Institute of Hygiene and Epidemiology, the majority of studies on HPV in Vietnam focused on assessing knowledge and attitudes toward HPV-related diseases and cervical cancer prevention. There have not been many studies on the burden of HPV infections and related diseases which require HPV testing, due to high cost of testing and large sample size required (thousands of

people). Furthermore, studies on HPV prevalence among the group aged 18-60 were often limited to married women, excluding high risk groups. In addition, some studies were based on sexual health clinics, and so it was much harder to get actual population-based data.

Fuelled by the desire to bridge such a data gap, from 2016 to 2021, scientists from the London School of Hygiene and Tropical Medicine and the National Institute of Hygiene and Epidemiology conducted a joint research project under the Newton Fund Vietnam to collect evidence required to promote the wider use of HPV vaccine in Vietnam.

The National Institute of Hygiene and Epidemiology collaborated with Pasteur Institute in Ho Chi Minh City and three public universities (University of Science - Vietnam National University Hanoi, Hue University of Sciences and University of Science - Vietnam National University Ho Chi Minh City) to collect samples and conduct HPV testing in three groups: students, female sex workers and men who have sex with men. Results showed that the prevalence of any HPV infection was 4%, 26.3% and 31.5% for the three groups respectively. These figures will serve as evidence for the decision to push forward HPV vaccination for both women and men to prevent virus transmission and ano-genital cancers.

The research team has also assessed HPV-related disease burden. By extracting data related to cervical cancer patients at the Ho Chi Minh City Oncology Hospital and the National Cancer Hospital in Hanoi (including the HPV related diseases and cancer rates, ages of patients when diagnosed, and outcomes and cost of treatment) the research team was able to quantify the potential benefits of the HPV vaccination in Vietnam. The study showed considerable HPV related disease burden with more than 50,000 ano-genital cases reported during 1995-2015. Quality of life for patients with HPV related diseases and cancer reduced significantly. In particular, the average quality of life score was 0.74/1.0, ranging from 0.67 to 0.78 among patients with cervical cancer of different stages. Scores from the Vietnamese patients were much lower than those from some Asian countries such as Indonesia and Taiwan. Professor Kim Mulholland, London School of Hygiene and Tropical Medicine highlighted that the cervical cancer rates in Ho Chi Minh City are substantially higher than Hanoi. Overcrowded treatment facilities and crippling financial costs borne by families point to the urgent need to control this disease by vaccination, screening and effective and affordable treatment. While high risk groups do bear a greater burden, this is a public health problem affecting the whole community.

Another specific deliverable of the project is the successful development of a Real-time PCR kit to detect 14 high-risk HPV types. The kit has a specificity of 100%, a sensitivity of at least 90%, a detection limit of 5 copies/reaction for HPV16 and HPV18 (the two strains behind 70% of cervical cancer cases worldwide), 10-50 copies/reaction for the others, and a high similarity index of 0.8-0.94 with other commercial kits. The diagnostic kit will assist future HPV epidemiologic studies on various subjects as well as effectiveness assessment of vaccines, thereby make further recommendations in the selection of vaccine types and risk-based vaccination approaches.

Associate Professor Nguyen Van Trang revealed that the project has paved the way for various new research directions that the group is working on. The group is evaluating the use of HPV vaccine in young female sex workers, a group at very high risk of cancer which has not been studied for vaccine impact before. In addition, the team is evaluating different vaccination strategies and developing a local vaccine so Vietnam can be proactive on the vaccine supply. This is a vital step to make HPV vaccines more affordable for Vietnamese people. It is even more relevant and meaningful as the Vietnamese government has recently approved the inclusion of cervical cancer vaccines in the Expanded Programme on Immunisation from 2026.

Project: Epidemiological features, national burden of HPV-related diseases in Vietnam.

Research Partners: London School of Hygiene and Tropical Medicine (UK); National Institute of Hygiene and Epidemiology; Pasteur Institute Ho Chi Minh City (Vietnam); Murdoch Children's Research Institute (Australia).

An aedes mosquito – a vector for dengue fever.
Source: Adobe Stock.

Satellite-based dengue forecasting

Vietnam is a dengue fever hotspot in the world with an increasing rate of incidence. While there were over 100,000 new dengue cases reported in Vietnam in 2009, the figure almost doubled in less than ten years (by 2017). In 2022, there were more than 345,000 new dengue cases and 131 deaths.

Dengue fever prevention and treatment remain a challenge. At present, there is no specific medication for dengue fever and only one approved dengue vaccine globally, whose efficacy is not well backed by data and which is only administered to those with a documented history of dengue fever.

Thus, the most feasible measures remain conventional preventive ones including eliminating mosquito breeding sites, raising awareness so that everyone can protect themselves from mosquito bites and conducting regular screening and surveillance. In order to optimise these measures, a quality forecasting model is needed.

D-MOSS is a dengue forecasting model co-developed by UK and Vietnamese scientists under the project "Dengue forecasting MOdel Satellite-based System". The project was led by HR Wallingford as part of the International Partnership Programme (IPP) of the UK Space Agency, which was funded by the Global Challenges Research Fund. According to Professor Vu Sinh Nam, a dengue expert at the National Institute of Hygiene and Epidemiology, Vietnam and a member of the project team, this is one of the most practical and effective dengue forecasting models in Vietnam at the moment.

There were previously other dengue forecasting models in Vietnam, which often input direct contributing factors such as temperature, vector density and herd immunity (i.e., percentage of the population that has developed resistance to different strains of the dengue virus). However, the last two inputs require extensive and costly investigation, and their accuracy is not necessarily high.

D-MOSS has taken a different approach. While previous models zoom in on dengue fever, D-MOSS zooms further out. Since dengue fever is transmitted to humans through the bite of infected mosquitoes, its spread depends primarily on weather and environmental conditions. For instance, higher temperatures, higher humidity and more open water reservoirs make it easier for mosquitoes to grow and transmit the disease. Based upon this principle, D-MOSS harnesses available data of dengue cases over the course of over 20 years (2000-2022) and incorporates contributing factors to the growth of mosquitoes such as precipitation, temperature, humidity (with monitoring data obtained from satellites operated by the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA)), modelled water availability parameters and weather forecasts (provided by the UK Met Office). It is the first early warning system of dengue fever outbreaks that has integrated Earth observation and weather forecast data. With their high scanning frequency and spatial resolution, Earth observation data are some of the most important and accurate inputs for D-MOSS. In the future, this model is intended to incorporate population and socio-economic factors like migration flows based on satellite images.

At present, D-MOSS is capable of forecasting an outbreak up to six months in advance for each province. When tested against records of past dengue outbreaks, D-MOSS produced a good degree of accuracy, especially with forecasts three to four months ahead. This web-based model was piloted in Hanoi, Dak Lak, Khanh Hoa, and Dong Nai from mid-2020 to early 2022. The National Institute of Hygiene and Epidemiology, Central Highlands Institute of Hygiene and Epidemiology, Pasteur Institute Nha Trang and Pasteur Institute in Ho Chi Minh City monitored outbreak forecasts on the website to coordinate training and give instructions for local preventive health practitioners to activate campaigns to kill larvae, release fish, collect waste and procure chemicals.

D-MOSS matters even more as the National Target Programme on Prevention and Control of Dengue Fever is being reduced. “D-MOSS has been effectively used to produce forecasts six months in advance for 63 provinces. Thanks to this model, we can save our resources to focus on the top high-risk areas.” said Professor Vu Sinh Nam.

D-MOSS has won many technology awards, including three at the IT Industry Awards 2021 and the Big Data/IoT Project of the Year (non-profit category) at the Digital Technology Leaders Awards.

Dengue fever is estimated to exceed 400 million cases every year, including 100 million severe cases and 21,000 deaths. Asia is the epicentre of dengue and constitutes over 70% of the cases worldwide. D-MOSS can be deployed in many other countries in the world. After its successful launch in Vietnam, D-MOSS has also been implemented in Malaysia and Sri Lanka.

Project: Dengue forecasting Model Satellite-based System (D-MOSS).

Research Partners: HR Wallingford; London School of Hygiene and Tropical Medicine; Met Office; Oxford Policy Management (UK); National Institute of Hygiene and Epidemiology; Central Highlands Institute of Hygiene and Epidemiology; Pasteur Institute Nha Trang; Pasteur Institute Ho Chi Minh City; Institute of Hydrology, Meteorology and Climate Change (Vietnam); UNDP, WHO.

Chickens in a market, Vietnam.
Source: Adobe Stock.

"One Health" in poultry production

Vietnam's poultry population is over 550 million, with a projected annual growth rate of 4% to 2030. Given such a rapid expansion and a complex poultry production and distribution network with multiple intermediate traders, increased investment in surveillance and prevention measures is required to save a significant loss caused by zoonoses and antibiotic resistance down the line.

The One Health Poultry Hub is one of 12 high profile Research Hubs funded by the UK Global Challenge Research Fund. It is implemented in four study countries, namely Vietnam, India, Bangladesh, and Sri Lanka during the period of 2019-2024. This is also the largest joint research project in the agricultural sector between Vietnam and the UK, contributing to the implementation of the One Health Partnership Framework for Zoonoses over the 2021-2025 period in Vietnam.

"One Health" is an interdisciplinary approach that emphasises the relationship, balance and optimal health status of three factors: humans, animals and environment. Accordingly, the Hub explores why and how the expansion of poultry production facilitates the emergence, transmission and spill over to humans of zoonotic diseases and antibiotic-resistant microbes. Its outcomes include up-to-date research findings that will contribute to evidence-based policy recommendations on sustainable poultry production, reduced risks to human health and ensured animal welfare.

Globally, the Hub is led by the Royal Veterinary College (UK) and, in Vietnam, it is implemented by the National Institute of Veterinary Research, National Institute of Animal Science, Vietnam National University of Agriculture, Department of Animal Health (under Ministry of Agriculture and Rural Development), and National Institute of Hygiene and Epidemiology (under Ministry of Health) in collaboration with the French Agricultural Research Centre for International Development (CIRAD). As an impact-driven project, the Hub takes a value chain approach and engages scientists in the fields of veterinary medicine, biology, mathematics and social sciences, as well as men and women farmers, traders, veterinarians, private sector and policymakers.

The Hub consists of four interconnected workstreams. Programme 1 investigates chicken production and distribution networks and their determinants in the North of Vietnam. Programme 2 quantifies the spread and evolutionary dynamics of zoonotic health hazards along these networks. Programme 3 provides flexible funding for researcher mobility and pump-priming grants. Programme 4 connects and builds capacity for stakeholders and provides evidence for refining and developing appropriate policies.

In Programme 1, the National Institute of Animal Science and the Vietnam National University of Agriculture completed a value chain map of poultry production and trading networks in the four Northern provinces namely Ha Noi, Hai Duong, Bac Giang, Quang Ninh that feature the most vibrant poultry production activities in Vietnam. Subsequently, Vietnam National University of Agriculture undertook a social and anthropological study to identify behaviours and practices of actors in the poultry value chains and environmental factors that increase zoonotic disease risks. They are also exploring how gender norms and relations have implications for decision making and the different tasks performed by men and women as well as investigating why there is apparent reluctance to move away from traditional small-scale slaughter to more modernised facilities.

Based upon these understandings and as part of Programme 2, the National Institute of Veterinary Research took samples from broilers and the environment in key nodes along the network to test for avian influenza virus, foodborne pathogens, antibiotic residues and antimicrobial resistance. The results show that the prevalence of avian influenza virus H9N2 (which is transmissible to humans) identified from the samples increased from 4% in poultry farms to 7% in wholesale markets, 16% in retail markets and up to 30% in informal slaughterhouses. In a second round of testing, the National Institute of Hygiene and Epidemiology and the National Institute of Veterinary Research are taking samples from poultry and in-contact persons in their environment to determine the genetic similarity of pathogens isolated from those two subjects.

Findings from Programmes 1 and 2 will allow the Department of Animal Health to test and evaluate novel interventions in animal husbandry and veterinary management to minimise health risks for humans and poultry.

To create sustainable and long-term positive impact on policies and practices, Programmes 3 and 4 focus on connecting and building capacity for all stakeholders in the value chain. The Hub has delivered a series of scientific and training seminars on poultry disease control and management, antibiotic usage and antibiotic resistance where scientists, veterinarians, farmers and businesses could share know-how and experiences. The results of these activities will serve as empirical data for advocacy and policy refinement and development discussions in 2023 and beyond.

"A good degree of trust and respect has developed between researchers and stakeholders from diverse disciplines and sectors and it will be important to sustain an inclusive One Health approach into the future. As agricultural intensification continues, understanding precisely how food systems generate zoonotic threats, and why particular practices and behaviours exist, will become ever more necessary if we are to find effective and practical ways to monitor, manage and minimize risk to people, animals and the environment." said Professor Fiona Tomley, Royal Veterinary College, Project Director.

Project: UKRI GCRF One Health Poultry Hub

Research Partners in Vietnam: Royal Veterinary College (UK); National Institute of Animal Science; National Institute of Veterinary Research; Vietnam National University of Agriculture; National Institute of Hygiene and Epidemiology; Department of Animal Health (Vietnam); French Agricultural Research Centre for International Development.

Website: www.onehealthpoultry.org

Hanoi (left) and Ho Chi Minh City (right).
Source: Istock/Getty Images.

Air pollution in the two largest cities of Vietnam

60,000 deaths in Vietnam in 2016 were linked to air pollution (World Health Organization - WHO). The average concentration of PM2.5 (fine particles of extremely small sizes that can go deep into the lungs) in Vietnam is usually 4-5 times higher than WHO standards. Annual economic losses associated with air pollution were estimated to be 5.2% of the country's Gross Domestic Product (World Bank, 2016).

Globally and in Vietnam, the inventory and assessment of ambient air quality are often conducted in large cities due to the pollution level and scale of its impact, derived from the density of traffic, industry, and population. Yet, studies on air pollution in Vietnam often focus on matters listed in the National Technical Regulation on Ambient Air Quality (QCVN 05:2013/BTNMT). Moreover, work to clearly determine sources of emissions is still limited.

In that context, scientists at University of Science - Vietnam National University Ho Chi Minh City, University of Science - Vietnam National University Hanoi (Vietnam), University of East Anglia, University of York, and University of Manchester (United Kingdom) selected Hanoi and Ho Chi Minh City as subjects for the project "A two city study of air quality in Vietnam" under the Newton Fund during the period of 2017-2021.

According to Associate Professor To Thi Hien, University of Science - Vietnam National University Ho Chi Minh City (VNUHCM-US), co-PI of the

project, the project aimed to (i) Measure and compare air pollution levels between the two cities; (ii) Predict sources of the pollutants; and (iii) Explain the role of natural and social conditions in the formation of pollution. Unlike many studies that focus on PM2.5 concentration, this project focused on analysis and comparison of components of fine particles in the two cities, namely dissolved trace metals (metals in very low concentrations) and volatile organic compounds (VOCs). When dissolved trace metals and VOCs enter the human body through inhalation, they can be accumulated and cause long-term and negative effects on the nervous system and a number of other organs, as well as being potentially carcinogenic. VOCs are also important precursors in the formation of ozone, a pollutant known to cause respiratory problems and cause damage to crops.

The study focused on 15 dissolved trace metals in fine particles. The analysis of samples collected seasonally at two sites in Hanoi and three sites in Ho Chi Minh City showed that zinc was the most common component in fine particles in both cities, and mainly from emissions of road vehicles.

Concentrations of most trace metals, including potentially carcinogenic elements such as arsenic, cadmium, and chromium, were much higher in Hanoi than in Ho Chi Minh City. Only two trace metals, nickel and vanadium, were found in higher concentrations in Ho Chi Minh City than in Hanoi.

Trace metal concentrations in Hanoi during the dry season and the rainy season did not differ significantly. In Ho Chi Minh City, trace metal concentrations in the dry season were significantly lower than in the rainy season.

The difference in the trace metal concentrations between the two cities can be explained by differences in natural and social conditions.

The first reason why Ho Chi Minh City was found to be less polluting than Hanoi is due to its geographical location, topography, and weather. In the dry season, the wind from the sea blows through Can Gio biosphere reserve into the inner city of Ho Chi Minh City and contributes to the dilution of pollutants. Meanwhile, as Hanoi has a low-lying terrain, it is difficult for the pollution to diffuse.

The second reason could be the difference in pollution sources between the two cities. Trace metals in Hanoi may originate from 15 coal-fired power plants, about 200 km from Hanoi, and non-ferrous metals facilities. In Ho Chi Minh City, high concentrations of nickel and vanadium could be explained by the burning of heavy fuel oil of ships on the river and at the port.

In addition, the project also measured the effects of trace metals in the air on the health of people in the two cities. The results showed that the cancer

risk from inhaling trace metals in fine particles in both cities was much higher than acceptable levels by the US Environmental Protection Agency (EPA). Furthermore, that risk was nearly twice as high in Hanoi as in Ho Chi Minh City.

For the VOCs emissions, the study showed that the concentrations of VOCs in the air in Hanoi and Ho Chi Minh City in the two seasons were similar. However, when measured at the same time, the concentration of VOCs in Hanoi was higher than in Ho Chi Minh City. The researchers also found that VOCs in the two cities were similar in composition to gasoline and were primarily derived from road traffic.

This project is one of pioneering studies in Vietnam on dissolved trace metals and VOCs in fine particles. The results of the project have contributed important data to the picture of air pollution in Vietnam's urban areas. At the same time, the study has provided recommendations so that authorities can focus their resources in the right place and at the right time to reduce air pollution.

According to Professor David Oram, University of East Anglia, project co-PI, another interesting element of the project was real-time measurements of the major greenhouse gases. The project identified some strong urban sources of both methane and nitrous oxide which will be important to consider in the development of national emission inventories. Based upon the Newton project, the University of East Anglia has won research grants to continue the collaboration with VNUHCM-US and will conduct two new projects on greenhouse gas sources in urban and coastal areas in Vietnam from 2023.

Project: A two city study of air quality in Vietnam.

Research Partners: University of East Anglia; University of York; University of Manchester (UK); University of Science - Vietnam National University Ho Chi Minh City; University of Science – Vietnam National University Hanoi (Vietnam).

Image for illustration.
Source: Adobe Stock.

Tracing sources, impacts and solutions to marine plastic pollution

Along Vietnam's 3,260-kilometre coastline, there are over 100 estuaries and more than 50 bays and lagoons. The coastal environment supports people's livelihoods such as tourism, fisheries and aquaculture. However, coastal fisheries and aquaculture are one of the main sources of plastic that enters the ocean. Plastic can arise from materials discarded after each aquacultural cultivation cycle and abandoned, lost, or discarded fishing gear (ALDFG). A study in 2016 estimated that fishing alone accounted for about 20% of the plastic debris in Vietnam's river and marine systems. Moreover, according to a World Bank report published in 2022, about 3.1 million tons of land-based plastic waste is discharged in Vietnam every year, and at least 10% of this goes into the ocean. With two large river systems flowing through many countries before pouring into Vietnam, understanding the source of plastic pollution is very complex.

During the period of 2021-2025, Heriot-Watt University, Phenikaa University and five other Vietnamese partner organisations jointly implement the project "Sources, Sinks, and Solutions for the Impact of Plastics on Coastal Communities in Vietnam" (3SIP2C). This is one of five projects under a research programme about plastic waste funded by the UK Research and

Innovation - Global Challenges Research Fund.

The project aims to assess the current status of plastic pollution in coastal areas of Vietnam and its potential impacts on coastal communities and business activities, as well as on human and environmental health. In addition, the project will carry out analysis of plastic waste management policies in Vietnam to find out the strengths and gaps, thereby providing a roadmap for effective and informed interventions through a comprehensive and participatory programme at the local, regional and national levels.

It consists of five work packages that correspond to five objectives: (1) Quantifying, identifying sources and modelling the flow and deposition of plastics in the environment. (2) Assessing how macroplastics impact lives of coastal communities. (3) Exploring how microplastics impact ecosystems and human health. (4) Undertaking policy analyses and highlighting effective interventions to mitigate the effects of plastic pollution. (5) Increasing awareness of communities and co-designing effective solutions with partners.

The project takes places in three main areas namely Cat Ba island, Red river delta and Mekong river delta.

In work package 1, the team will simultaneously assess microplastic pollution through actual sample analysis and develop a model of the flow of plastic waste from large rivers into coastal areas and along the coast. The modelling is based on physical properties of various types of plastic waste found in the water column (from surface water to bottom sediment), as well as effects of freshwater currents, ocean currents and waves and their seasonal changes on the flow of waste.

Work package 2 focuses on macroplastic waste (more than 50 mm in diameter). The research team uses community-based surveys to understand the main reasons why people discard plastic waste into the marine environment and the level of marine plastic pollution. Using physical modelling and laboratory research, the team will be able to predict hot spots of plastic waste, their distribution over time, and their disintegration in the marine environment. Finally, economic losses to businesses caused by plastic waste in fisheries, aquaculture and tourism will be quantified.

Work package 3 focuses on microplastics (less than 1 mm in diameter). The researchers will assess impact of microplastics and toxins (such as heavy metals and persistent organic pollutants) attached to their surfaces on aquatic organisms through genetic and enzyme biomarkers. They will also use mathematical models to assess their impact on the health of coastal communities that consume aquatic food contaminated with microplastics and associated toxins. According to Dr Ngo Thi Thuy Huong, Phenikaa University, co-PI of the project, this package 3 is a special contribution of the project given the lack of scientific research on this matter in Vietnam.

As the project takes a solution-oriented approach and has its advantages in terms of scale, it puts much emphasis on public awareness raising and policy advocacy in work packages 4 and 5 to deliver findings from the first three work packages to policymakers and communities. Initial awareness raising activities took place, such as beach cleaning activities with students in Nam Dinh, training for students in Hanoi, and knowledge sharing on social media channels and science shows on Vietnam Television, etc.

“Engaging with communities and government at the local, regional and national scale is essential for this project to have a meaningful benefit to Vietnam. Our initial conversations with coastal businesses indicates considerable variation in people’s understanding of how plastic impact on their day to day lives and business activities” said Professor Michel Kaiser, Heriot-Watt University, Project Director.

Project: Sources, Sinks, and Solutions for the Impact of Plastics on Coastal Communities in Vietnam.

Research Partners: Heriot-Watt University (UK); Phenikaa University; University of Science and Technology of Hanoi - Vietnam Academy of Science and Technology; Fisheries and Technical Economic College; Institute of Vietnamese Studies and Development Sciences - Vietnam National University Hanoi; Institute of Strategy and Policy on Natural Resources and Environment; Institute of Fisheries Economics and Planning (Vietnam)

Website: www.lessplasticvietnam.com
www.3sip2c.com

Sand mining in Vinh Long.
Source: Hien Phung/Adobe Stock.

Suggested solutions for a changing Mekong Delta

The Mekong Delta in Vietnam is one of the most vulnerable deltas in the world, with significant sensitivity to anthropogenic impacts, including climate change and relative sea-level rise (Intergovernmental Panel on Climate Change - IPCC, 2007). The development of sustainable adaptations to these impacts and building resilience to future changes is a urgent priority for Vietnamese and international research teams.

In 2017, scientists from Can Tho University and University of Hull collaborated to identify sustainable solutions for the Mekong Delta through a research project entitled "Resilience and sustainability of the Mekong Delta to changes in water and sediment fluxes" under the Newton Fund Vietnam.

Professor Daniel Parsons, University of Hull, project co-PI, highlighted that from the beginning, the research team aimed to assess the changes in water and sediment fluxes from upstream, and determine the impacts of climate change on these processes. Development activities upstream, including changes in land use and damming, and direct impacts within the delta itself including sand mining, along with sea level rise may combine to pose a suite of negative impacts to the Mekong Delta. Prof Parsons identified that understanding these interactions was key to predicting the future of the delta. One of the important and visible changes was in the riverbed morphology, where reduced sand supply from upstream along with sand mining was beginning to alter the flows of water through the delta, including changes to tidal flows and increased salinity.

Using modern riverbed surveying equipment from the University of Hull and measurement data collected from 2000 to present by Southern Institute of Water Resources Research and additional data from Can Tho University, the researchers found changes in the geomorphological characteristics and sediment fluxes of the main river system in the delta. The research team built a complex mathematical model of the morphological and hydro-sediment fluxes to simulate the natural development of the river system in the past and to predict some potential future changes under a range of climate and land use scenarios.

The simulations showed a link between human activities and significant changes in the delta system, particularly human activities upstream and the increasing impacts of sand mining across the delta. The predictions show that climate change and sea level rise combine to cause substantial changes. For example, the riverbed was lowered and widened, leading to bank erosion. In addition, saltwater is projected to intrude much further inland and affect agricultural production and daily lives of delta residents.

The simulations and project findings have already been confirmed by real-life events in the Mekong Delta such as increased bank erosion, formation of deep holes along the main river system and increasing saltwater intrusion.

These substantial changes in the river system are projected to have negative impacts on residents, especially communities who live in bank erosion-prone areas or whose livelihoods depend on the river. Poor people who live temporarily by the river will be greatly impacted. If these conditions persist and the projections realised, they will be forced to migrate, potentially leading to social issues. The project found that 70% of the 220 households surveyed in Dong Thap and An Giang provinces had been impacted by bank erosion and their capacity to cope in the short-term had been limited.

Associate Professor Van Pham Dang Tri, Can Tho University, project co-PI, said that in order to respond to the deteriorating conditions of the Mekong Delta, some interventions must be promptly implemented, including: (1) Developing public awareness and dedicated programmes of engagement that have a focus on practicality and effectiveness for communities; (2) Timely issuing of appropriate policies at the local and central levels to protect and support affected communities, especially disadvantaged groups; and (3) Developing river monitoring programmes and establishing a river database and plans. This database must be technical, updated, managed, and shared at an appropriate level for scientific research and community service. In addition, the river restoration efforts are not only about the restoration of sediment fluxes but also consideration of the river network with full functions of the local surrounding ecosystem. This is a critical issue for the implementation of the Vietnamese government's master plan for the Mekong Delta.

Project: Resilience and sustainability of the Mekong Delta to changes in water and sediment fluxes.

Research Partners: University of Hull (UK); Can Tho University; Southern Institute of Water Resources Research (Vietnam).

Mekong Delta viewed from above.
Source: Adobe Stock.

Sustainable development of deltas

Deltas occupy only 1% of the global land area but are home to more than half a billion people. Over time, many deltas have become dynamic social-ecological systems (SESs), often playing a pivotal role in national economies. The mega-deltas located in South Asia and Southeast Asia, including the Red River Delta and the Mekong Delta in Vietnam, are among the most vulnerable in the world.

Human impacts exacerbated by climate change are pushing these deltas ever closer to a number of 'tipping points'. Initially, these deltas were in equilibrium with the physical processes that created and maintained them from the outset of the Holocene epoch over 11000 years ago. The tension between human resource use and the desire for development increasingly threatens delta livelihoods. It poses a highly complex development challenge: how to maintain South and Southeast Asian deltas as functioning SESs in the face of continued human exploitation and environmental degradation.

To seek sustainable solutions, address the United Nations' Sustainable Development Goals (UN SDGs) agenda more specifically in deltas, and to raise resilience and adaptive capacity in delta populations vulnerable to global change and delta degradation over time, the Global Challenges Research Fund (GCRF) has funded the five-year UKRI GCRF Living Deltas Research Hub (2019-2024). The Hub works across three heavily populated mega-deltas: the Red River Delta, the Mekong River Delta (Vietnam) and the Ganges-Brahmaputra-Meghna River Delta (Bangladesh and India).

The Hub aims to understand changes to these deltas caused by a range of threats and drivers. These include sea level rise and saline intrusion; loss of biodiversity; mangrove forest degradation and loss of coastal buffer zones; climate change, especially monsoons and incidences of damaging cyclones; population growth; changes in land use, community health and well-being; unsustainable technical interventions. These often act in synergy. By seeking transdisciplinary solutions to these and other issues, the Hub intends to significantly contribute to ongoing efforts for more sustainable development of the delta SESs.

An equal balance between the natural and physical sciences, the social science and the arts and humanities enables the Hub to work in a highly interdisciplinary way. Reflecting this, the Hub works via six academic work packages and a seventh management work package, given the complexity of managing such a large project with over 130 active participants. Early career researchers make up 50% of these colleagues, promoting Hub legacy beyond its five-year funding period, and, importantly, the Living Deltas Hub seeks gender equity in all it does. Together these work packages enable the Hub to study delta heritage, livelihoods, and culture to provide a vivid picture of the past, present, and potential future of each delta. The Hub co-produces, with delta dwellers, new understandings of behaviour and response to change and rising risks and threats to the delta SESs.

The Hub is creating new monitoring of deltas when none existed before to produce new baselines of delta water quality and new understanding of delta evolution over time. An intended outcome is a Living Deltas Index, an innovative and accessible assessment tool for the status of delta ecosystems. Reflecting the co-design of the GCRF Hub programme by UNDP, the Hub is developing frameworks for localising the UN SDGs in delta-specific contexts, and new ways of monitoring the SDGs based on their natural and cultural heritage values as well as their other contexts.

This interdisciplinary approach involves 22 research institutions, with Newcastle University acting as the lead research organisation. In Vietnam, together with international Hub partner organisations, six Vietnamese institutions, with their unique academic strengths and insights into Vietnam-specific issues, actively address four key questions: (a) how are Asian mega-deltas changing, and what are possible causes and consequences? (b) how do we use local knowledge and local cultural heritage to underpin a better future for these deltas? (c) how can delta communities' capacity and adaptability be enhanced to ensure the SDG message that 'no one is left behind'? (d) how can infrastructure, inequality, and resilience issues be addressed to encourage more sustainable delta futures?

Over halfway through its funding period, the Hub is now at the completion of its main phase of data collection. "The sheer scale and ambition of the Living Deltas Hub is what makes it so exciting, and so too is how we work through equitable partnership and engaging a diverse range of stakeholders in co-creating more resilient deltas. Partnering with FCDO to ensure impact, our research is vital for government and delta managers to understand where we are today and what we can achieve together for the future." said Professor Andy Large, Living Deltas Hub Director, based at Newcastle University.

Project: UKRI GCRF Living Deltas Hub.

Research Partners in Vietnam: Newcastle University (UK); Central Institute for Natural Resources and Environment Studies - Vietnam National University Hanoi; Institute of Environmental Technology - Vietnam Academy of Science and Technology; Climate Change Institute - An Giang University; Can Tho University; Vietnam Atomic Energy Institute; Natural Resources Conservation and Sustainable Development Joint Stock Company (Vietnam).

Website: www.livingdeltas.org

Typhoon Vamco hitting Vietnam in 2020.
Source: NASA.

Climate and weather: from scientific research to professional forecasting

Events such as typhoons, floods, thunderstorms, or landslides are part of the natural world. Whether these hazards become disasters for humans depends on our own ability to forecast and respond. The more humans understand the rules of nature, and the more tools we have to produce early and accurate warnings about weather and climate events and their impact in a specific socio-economic context, the more we are able to manage and reduce their associated risks.

The project "Weather and Climate Science for Service Partnership" (WCSSP), co-implemented by the Met Office in the UK and four Southeast Asian countries, namely Indonesia, Malaysia, the Philippines and Vietnam, follows this approach. It is intended to develop and improve global and regional forecasting systems, and to advance understanding of the nature and pattern of common high-impact weather events in South East Asia such as heavy rainfall events and tropical cyclones, thus producing forecasts more effectively. The project comprises three components: (1) Understanding large-scale weather phenomena, such as tropical waves, the Madden-Julian Oscillation and the development processes in tropical cyclones; (2) Improving regional scale forecast modelling; and (3) Improving the representation and utilisation of forecast modelling results, thus developing impact-based forecasts and warnings. The first and second components provide scientific evidence to improve the utilisation and quality of forecasts generated in the third component.

What sets this project apart from others funded by the Newton Fund is that the four delivery partners are national weather service agencies. Therefore, the coordination with researchers and forecasters on the ground has made the research results more relevant and the transfer of research results more direct and faster. Capacity building for the staff of partner organisations has made a long-term impact as the project results can be applied in their day-to-day work.

To elaborate, the partner organisations have co-created ideas and co-conducted research on the characteristics and causes of high-risk weather hazards such as heavy rainfall events, typhoons, and tropical depressions in South East Asia in general and partner countries in the region in particular, including Vietnam. Apart from enhancing the forecasting quality of models and tools and the capacity of forecasters, many articles have been published in prestigious international journals like the Journal of Geophysical Research: Atmospheres.

One of the unique selling points of this project compared to other international partnerships in which the National Centre for Hydro-Meteorological Forecasting under Vietnam Meteorological and Hydrological Administration has engaged is the third component. It focuses on developing tools to represent and utilise forecast modelling results, including those of composite forecasts which incorporate specific socio-economic data when natural disasters occur to eventually generate impact-based forecasts for Vietnam (Currently, the country primarily produces intensity- and disaster-level-based forecasts). This new approach requires assessing the extent of impact that a specific typhoon level, wind velocity or precipitation will potentially have on reservoirs, aquaculture, shipping or housing, in order to make forecasting, warning and response decisions. According to Dr Hoang Phuc Lam, Deputy Director of the National Centre for Hydro-Meteorological Forecasting, this trend is what the World Meteorological Organisation is pursuing and has only just started in Vietnam. The ultimate goal of this approach is to put in place a forecasting system, which engages all disaster management actors to build a common understanding and course of action between the national weather service and subnational governments by using an impact matrix and a response matrix. The staff of the Vietnam Meteorological and Hydrological Administration has now been able to incorporate information on disaster impact in their forecasts to some extent.

“The participation in the WCSSP project has been crucial to shaping the development of the hydro-meteorological sector of Vietnam towards modernity and adoption of advanced technologies of developed countries, including the UK. As individual and organisational capacity has been improved, forecasts and warnings will be improved in quality and utilised more effectively to reduce damage caused by natural disasters,” said Dr Hoang Phuc Lam.

Project: Weather and Climate Science for Service Partnership.

Research Partners: Met Office (UK); National Centre for Hydro-Meteorological Forecasting - Vietnam Meteorological and Hydrological Administration (Vietnam).

High tide in Can Tho.
Source: Shutterstock.

Compound flooding in the Mekong Delta, Vietnam

Floods are among the most dangerous and costly natural hazards. More than half of fatalities and economic loss caused by floods have occurred in densely populated low-lying coastal deltas.

In coastal deltas, flooding arises from three main sources: (i) Storm tides downstream; (ii) Rainfall and river discharge upstream; and (iii) Direct surface runoff. Due to the lack of information on their inter-dependence, and because of the perceived difficulty in collecting and processing necessary underpinning statistics, the majority of flood risk assessments in coastal deltas have considered these causes separately. However, flood risks can increase disproportionately when three flood sources occur concurrently or successively, resulting in an extreme event referred to as "compound flooding".

Since 2019, the University of Southampton (UK) and Southern Institute of Water Resources Research (Vietnam) have jointly conducted a research project, with the participation of Vrije Universiteit Amsterdam (the Netherlands) and the Southern Regional Hydro-Meteorological Centre (Vietnam) under the Newton Fund Vietnam to improve accuracy of coastal flood mapping in the Mekong Delta.

Scientists used data from 423 past storms in Vietnam (between 1980-2017) as inputs to create approximately 98,637 computer-simulated storms (within 10,000 years) by the Synthetic Tropical Cyclone Generation Model (STORM). This set of storms became inputs for three models: (1) A hydrodynamic

model for the entire South China Sea which covers a large area including Taiwan, the Philippines, Malaysia, Indonesia and Vietnam to examine impacts of storms on sea level rise; (2) A rainfall-runoff model for the entire Mekong river in Vietnam to measure storms' flood impacts upstream; and (3) A one-dimensional mathematical model for a detailed river and canal system to determine storms' impacts on surface water. These models were run simultaneously and combined to "respond" to each other and demonstrate a complex flood pattern. Subsequently, these results were transferred into flood hazard maps for the area.

Scientists at the Southern Institute of Water Resources Research have developed models to examine flood impacts of individual causes over the last 20 years and constantly updated them. In addition, data and the STORM model, created by scientists at Vrije Universiteit Amsterdam and the University of Southampton have been recognised by international reviewers and introduced in the journal Scientific Data. Overall, this project's mathematical model for compound flooding has good reliability (at 85-90%), which means it can relatively well reflect the flood impacts from multiple sources in coastal provinces of the Mekong Delta for the present and future periods (prediction until 2050).

Associate Professor Nguyen Nghia Hung, Deputy Director of the Southern Institute of Water Resources Research is confident that these outcomes will bring about long-term benefits for communities. The map will help local authorities identify the most flood-prone areas and most vulnerable communities, and plan evacuation routes when floods occur. This integrated mathematical modelling approach will be very useful for planning and constructing important infrastructures such as highways, airports among others, including the Can Tho - Ca Mau expressway or the Master Plan of the Mekong Delta.

This study on compound flooding has enriched a pool of studies about how increased extreme climate events caused by global warming have affected characteristics of storms, rain and natural hazards. Data on heavy and extreme rainfall across Southeast Asia indicates that Vietnam's precipitation and number of days with heavy and extreme rainfall have increased by over 50% over the last four decades. This seems to have correlation with the increased evaporation due to the significant warming in South China Sea. The storm model also shows that in the next 30 years when tropical cyclones become more powerful and likely to pass through the South China Sea, extreme storm surges will frequently occur along the coastal regions of Vietnam and amplify flood and inundation risk in the area.

Associate Professor Nguyen Nghia Hung commented that there is currently a high risk of floods in Mekong Delta provinces. The risk is likely to increase while infrastructures are not resilient enough. Not to mention storms, just rain or high tide water is enough to make many areas in Can Tho, Bac Lieu, Soc Trang, Vinh Long and Ca Mau provinces suffer from severe inundation. Floods and inundation not only disrupt traffic and economic activities but also result in potential environmental incidents, epidemics and stress for people.

To contribute to the sustainable development of the Mekong Delta, the project has planned to transfer their integrated flood risk map to local authorities. Researchers will provide training on the map use for local officers so they can easily consider flood risk while making decisions about infrastructure investment projects.

Project: Compound flooding in coastal Vietnam.

Research Partners: University of Southampton (UK); Southern Institute of Water Resources Research (Vietnam).

A storm in Nha Trang.
Source: Adobe Stock.

Wireless communication in disasters

Vietnam is one of the countries most affected by climate change. From 2005 to 2014, it was hit by 649 natural disasters. Prompt and continuous communication of early warnings and search and rescue efforts is key to minimise loss, particularly in remote areas. Yet, present telecommunication networks are not designed to cope with adverse conditions, for instance, base stations being destroyed, power supply being cut off, or networks being congested. As a result, messages do not come through.

During the period of 2015 - 2021, thanks to sponsorship of the Newton Fund Vietnam and support of network operators, scientists from Queen's University Belfast, Duy Tan University and Nong Lam University Ho Chi Minh City jointly conducted research on the application of wireless networks as a mechanism to maintain communications and disseminate early warnings in disasters.

According to Professor Nguyen Kim Loi, Nong Lam University Ho Chi Minh City, there are some solutions to this problem in the world, including Alcatel-Lucent's Broadcast Message Centre, Cisco's Network Emergency Response Vehicle, and Ericsson's WLAN. However, they are all effective only in small sites with short ranges and limited connectivity and they have high operational costs. Hence, they cannot be deployed in disaster-prone countries with many isolated rural areas like Vietnam.

To achieve both flexibility and affordability, the research team came up with an Integrated Heterogeneous Wireless System (IHWS). This system optimises 4G networks of telecommunications companies by integrating Wireless Sensor Networks (WSN), Wireless Mesh Networks (WMN), Mobile Ad hoc Networks (Manet), Mobile Cellular Networks (MCN), internet-enabled IoT networks, Device-to-Device (D2D) networks, Unmanned Aerial Vehicle (UAV) networks, big data, and cloud computing. When conventional telecommunications networks are interrupted by disasters, the networks in the IHWS will synergise and create various avenues to transmit signals, enabling messages from mobile phones of those in the affected areas to reach their recipient, in order to seek help or notify their loved ones.

In addition, to monitor disasters and generate immediate forecasts in areas without full-fledged monitoring stations, the research team set up small monitoring stations, including fixed and mobile ones, and integrated them into the IHWS. The WSN is made up of sensors, including weather sensors, water level sensors and seismic sensors, to detect adverse natural events such as typhoons, floods, landslides, and earthquakes. The sensors should be power-efficient, robust in all settings, and capable of running on surrounding energy sources such as wind and solar. All sensors are connected to General Package Radio Service (GPRS) modules and send data to the server via the MCN's GPRS. The server then stores, analyses and processes data from the sensors, and it sends alerts about adverse developments to local governments and residents (if necessary) in a timely manner.

Professor Duong Quang Trung, Queen's University Belfast said "What makes IHWS different is its utilisation of unmanned aerial vehicles. They do not only act as mobile transceiver stations, thus maintain connectivity, but also monitor affected sites from above and perform measurements, thus capture the current state and predict the extent of loss caused by floods in place where monitoring stations have been damaged or washed away."

To prolong battery life and optimise performance of the devices, the research team, under the guidance of Professor Duong Quang Trung, Dr Vo Nguyen Son (Duy Tan University), and Professor Nguyen Kim Loi (Nong Lam University Ho Chi Minh City), has developed a mechanism for allocating resources across the system in real-time, and combined it with efficient flight routes. Therefore, they can last three to five times longer than amateur drones and are significantly cheaper. After a disaster passes, mobile monitoring stations (including UAVs) will be placed in storage and the risk of damage will be minimised in comparison to fixed monitoring stations.

The research team has deployed the IHWS in 25 monitoring stations in Quang Nam - one of the most disaster-prone provinces in Vietnam. Furthermore, a web portal was developed to display data from sensors in the form of charts to make it easier to monitor the sites, including Song Tranh hydropower dam, Hoi An City, Ha Lam - Thang Binh, Dien Hoa Commune - Dien Ban District in real time. Over 1,000 students from 20 universities throughout Vietnam have been trained in the system under the project.

The project won the Newton Prize in 2017. It received the Best Paper Award at IEEE GLOBECOM 2019 in Hawaii, which is the most prestigious conference in the field of telecommunications.

Project: Building a foundation for sustainable development: Networked societies for the cities of tomorrow.

Research Partners: Queen's University Belfast (UK); Duy Tan University (Vietnam).

Project: Fly-by Flood Monitoring.

Research Partners: Queen's University Belfast (UK); Nong Lam University Ho Chi Minh City (Vietnam).

Thang Long bridge, Hanoi.
Source: Pham Anh/Istock/Getty Images.

Digital twins for structural health monitoring of bridges

Thang Long bridge is an important gateway for traffic in Hanoi. It is one of the first bridges in Vietnam to be studied using digital twin technology.

In the second half of 2020, the bridge underwent six months of repairs to address the problematic adhesion issue between the asphalt overlay and the orthotropic steel deck, which was caused by frequent and heavy traffic from more than 50,000 vehicles per day. The Directorate for Roads of Vietnam said the digital twin-based solution helped save a substantial amount of time and money in this repair project.

Positive outcomes from Thang Long bridge project have facilitated digital twin development to more key bridges across the country such as Chuong Duong, Nhat Tan (in Hanoi), Can Tho, My Thuan (in Vinh Long), Nam O (in Da Nang) and Kien (in Hai Phong).

This was the outcome of a collaborative research project between Middlesex University (UK) and the University of Transport and Communications (Vietnam) funded by the Newton Fund Vietnam from 2019 to 2021. The project aimed to develop an advanced system for early damage detection and structural health monitoring by using digital twin technology.

A digital twin creates a virtual replica of a real object to facilitate its optimal operation and adapt to any environmental changes. The object could be a building, an airport, a bridge, a car, a human being (i.e., resembling an electronic medical record of a person) or even a process (surgery operation or manufacturing process). To develop a digital twin for structural health monitoring (SHM) in bridges, engineers place sensors (ideally internet-connected) on key positions of a bridge to measure parameters such as strain, deflection, inclination, deformation and so on. Data collected from these sensors help those who monitor and maintain the bridge to see its "health" in real time. Data also inputs to the development of testing models and simulation scenarios to predict changes and the impact of nature or humans to prevent adverse effects from happening during future operation and repairs.

These are not all the benefits of a digital twin. Even if more than 20,000 bridges in Vietnam had their own data collection mechanism for SHM, it would still be costly to maintain a dedicated workforce to monitor and analyse this huge volume of data in an ongoing manner. Meanwhile, the annual state budget in Vietnam is still prioritised for new construction instead of maintenance and monitoring. This is where machine learning comes in. Integrated with digital twins, most of the data from sensors are read and processed by computers. With real time data collected daily, health and performance (related to tension, fracture, subsidence and more) of a bridge in the future could be predicted by its digital twin.

The machine learning based digital twin model was developed by the London Digital Twin Research Centre and the IoT and 5G/6G research team at the Middlesex University. In addition, the dataset and structural "know-how" used to train the model to analyse and correlate current "health" data with incoming damage risks of a bridge came from the University of Transport and Communications.

Associate Professor Bui Tien Thanh, project co-leader, Head of the Department of Bridge Engineering and Underground Infrastructure, Faculty of Civil Engineering, University of Transport and Communications, said that training data for the machine learning were collected not only from more than 20 bridges in the project but also from the inspection of thousands of bridges in Vietnam by the University of Transport and Communications in the past. This was precondition for the research team to expand the data warehouse by applying various methods such as simulation-generated data, data augmentation techniques, semi-supervised machine learning

(to address the issue of lacking useful training data), and transfer learning - transfer a pre-trained model of one bridge to another.

According to Professor Nguyen Xuan Huan, Director of London Digital Twin Research Centre, Middlesex University, globally there has been lack of useful data on structural damages, particularly in old constructions like those in Vietnam. Even in Europe where bridges have been there for hundreds of years, scientists still find it difficult to collect data due to the lack of appropriate places for sensors to be installed. For a machine learning based digital twin model, if there is no data on historical "damages", most of the predictions will be of little value. Therefore, the dataset as well as the results from this project have attracted great attention from scientific communities in the UK, France, Belgium and Vietnam.

Though the project has come to close, it has opened the door for new discoveries. The scientists have decided to share the results from this research to the public.

Professor Nguyen Xuan Huan said "At the beginning of the project, we did not consider it, but in the end, everyone agreed to develop a cloud computing platform to share access to the data and model with other research teams. I believe that the development of digital twins of Thang Long bridge and Can Tho bridge shall be beneficial to market research departments of other organisations."

Project: Digital twin model for structural health monitoring of lifeline infrastructures in Vietnam.

Research Partners: Middlesex University (UK); University of Transport and Communications (Vietnam).

A seaport in Hai Phong.
Source: Adobe Stock.

Optimising seaport logistics operations

Maritime transportation is one of the world's most important methods of transporting goods. In Vietnam, it is an essential driver of economic growth as up to 90% of the country's export and import volume is carried by sea. Yet, ports in Vietnam, North of Vietnam in particular, have not kept up with the country's demand for logistics services, even though they have received investment and been upscaled in recent years.

If port logistics operations are suboptimal, it will be hard for local ports, which can only accommodate small-sized vessels, to compete with other ports in the region. In the long run, this will slow down the development of Vietnam's logistics industry and lower the competitiveness of local logistics service providers.

In 2015-2016, under the Newton Fund Vietnam's Institutional Links Programme, scientists from Liverpool John Moores University, University of Engineering and Technology - Vietnam National University Hanoi and Vietnam Maritime University began jointly exploring solutions to aspects of these challenges through the application of information technologies, designed to coordinate core port services in an optimal and automated manner.

The research team used Greenport, a port situated by the Cam river in Hai Phong city, as a case study. Greenport was open to service in September 2004 and has since faced challenges as a port in Vietnam. The daily volume of incoming and outgoing containers requires the port and its warehouses to work at full tilt. Greenport Management Board hoped to modernise and automate its port operations and management. Modernisation would improve efficiency, reduce costs and avoid risks of disruption and economic loss when facing an unexpected event. For example, if a container truck carrying commodities from a satellite port five to ten kilometres away was delayed reaching Greenport as scheduled due to road incidents.

Researchers wanted to explore ways to optimise efficiency and prevent/respond to potential risks.

The research team reviewed and analysed the port's operational data and introduced algorithms that optimise core logistics operations including container loading and unloading on the vessel on the quay and in the yard; container handling and quay operation planning; and optimal equipment/fleet sizing. The complexity of these algorithms lies in not only identifying ways to cut costs and improve productivity, but also satisfying the countless constraints of port operations (such as the cargo handling time or the cargo loading code of practice, e.g., light goods should be stowed on top of heavy goods), weather conditions, and the availability of port equipment.

The research team developed several modules, which can be integrated into the existing terminal operating system to optimise critical operations. This includes container stacking in the yards, berth planning, vessel stowing and unloading, port simulation, fleet sizing, container stuffing, and gate congestion management.

According to Associate Professor Nguyen Ha Nam (a former lecturer at the University of Engineering and Technology - Vietnam National University Hanoi, who is now working at Vietnam Institute for Advanced Study in Mathematics), once integrated into the terminal operating system, these modules enable an operator to coordinate any of the aforementioned operations simply by keying in his/her request and the system will provide him/her with an optimal solution.

In addition, the technical components and modules help optimise and accelerate loading and unloading processes, raise productivity, cut operational costs and improve competitiveness. When tested on Greenport's real-life data, the research team's solution was shown to reduce about 23% of the container loading and unloading cost; 21% of the container trucks; 98% of the vessel imbalance; and 4.6% of the CO2 emissions and 5.5% of the NO2 emissions.

Although there is no one-size-fits-all solution to optimising port services, this project has successfully created a customisable framework for other ports in Vietnam.

According to Professor Trung Thanh Nguyen from Liverpool John Moores University, it is worth noting that the project has helped establish a logistics industry network between the UK and Vietnam, and enabled 18 different organisations, including industry partners and academic partners, to collaborate, exchange experiences, and discuss solutions to tackling real problems faced by ports in Vietnam through research. This collaboration is expected to be a platform for researchers across various fields to come together and address future challenges.

Project: UK-Vietnam institutional link in digital innovation for sustainable maritime logistics in Vietnam.

Research Partners: Liverpool John Moores University (UK); University of Engineering and Technology - Vietnam National University Hanoi; Vietnam Maritime University; VICONSHIP; Peel Ports (Vietnam).

Image for illustration.
Source: Adobe Stock.

CSIE: Creating social impacts at universities

Launched in 2017, Centre for Social Innovation and Entrepreneurship (CSIE) of National Economics University (Vietnam) has been a pioneer in supporting social impact start-ups at universities in Vietnam. The Project "Building capacity for National Economics University to set up Hanoi Impact Hub" under the Newton Fund Vietnam from 2018 - 2019 has laid a foundation for CSIE to position itself and connect to external resources.

As an autonomous unit, CSIE is not funded by its university. At the beginning, CSIE struggled to find its direction, especially when "social impact start-up" was a new concept in Vietnam. The Institute for Social Innovation and Impact (ISII) at the University of Northampton (UK) - a partner of CSIE in the project - was a model for CSIE to learn from. Similar to ISII, CSIE built its operating model based on three pillars including: research, education, and social impact business incubation.

In the project, ISII and CSIE collaborated based on these pillars. For research activities, experts from University of Northampton and CSIE co-conducted a national study on "Fostering the Growth of the Social Impact Business sector in Vietnam" for the United Nations Development Programme in 2018. This process did help CSIE not only gain experience and credibility but also develop a network of 50 scholars to advise its research activities on the promotion of social impact business.

The University of Northampton's ISII supported CSIE to build Impact Space - the first impact start-up incubator in Vietnam. The two partners conducted market assessment so that CSIE identified opportunities and potential start-ups. Unlike normal incubators where success was measured by financial investment efficiency, Impact Space needed a different tool given its social goals. Scientists at the University of Northampton and CSIE worked together to develop an impact measurement toolkit for Impact Space. This toolkit includes a range of indicators to monitor long-term social impacts (up to 3 years) of beneficiaries when joining an incubation programme.

Through workshops and training courses, experts from ISII and CSIE trained 25 resource trainers on social impact entrepreneurship across the country and many start-up mentors. These trainers and mentors not only support the incubation activities of CSIE but also contribute to the social impact start-up ecosystem in Vietnam generally.

Associate Professor Truong Thi Nam Thang, Director of CSIE, shared that the Newton Fund project and other support from the British Council's Higher Education Programme had enabled CSIE to continue to grow. Since 2018, CSIE has annually carried out at least one national study or written a monograph and held an international conference for academic exchanges between researchers, businessmen and managers on issues related to social impact business. CSIE has developed a 3-6-month incubation curriculum. Each year, the centre organises one incubation programme for students at the National Economics University (100 students/year) and two incubation programmes in collaboration with other partners for social enterprises (20 enterprises/year). Moreover, over the last six years, CSIE has provided training for 500-600 university lecturers on social entrepreneurship and nearly 1,000 young business people on impact entrepreneurship in general. CSIE has planned to develop an accredited Master's Degree Programme about entrepreneurship in the future.

CSIE is becoming a brand of National Economics University. National Economics University has a strategy to become a university with three member schools, namely the School of Economics and Public Management, School of Business, and School of Science and Technology in the next three years. The last one will focus on digital transformation, AI application in economics, business and management. At that time, CSIE will become a critical bridge that links the three schools to take forward the technology and business ideas of students, lecturers as well as interdisciplinary projects, thereby promoting social impact activities.

Project: Building capacity for National Economics University to set up Hanoi Impact Hub.

Research Partners: Institute for Social Innovation and Impact (ISII) - University of Northampton (UK); Centre for Social Innovation and Entrepreneurship (CSIE) - National Economics University (Vietnam).

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