News

Higher Education Improvement Project (HEIP) activities have been funded by an IDA Credit, equivalent to 90.0 million USD, as well as a 2.5 million USD contribution from the Government of Cambodia. The project will be implemented over a 6-year period—starting in July 2018 and ending in June 2024. The Project Development Objective (PDO) of the HEIP is to improve the quality and relevance of higher education and research in the STEM and Agriculture fields at target higher education institutions (HEIs), as well as to improve governance of the sector. As part of Component 2 of the HEIP project, "Improving Research in STEM and Agriculture", the Royal University of Phnom Penh has been granted 4.3 million USD to assist researchers and faculty members to conduct and publish scientific research in international peer-reviewed journals.

These research projects aim to realise the vision of RUPP becoming Cambodia's leading university in applied and academic research, as stated in the Policy on Research Development and Innovation. Research proposals must fall into one of three Windows: (1) Research for industry; (2) Research for policy making; and (3) Frontier research. In early 2020, the HEIP approved eight research projects across different faculties at the Royal University of Phnom Penh (RUPP) with a total budget of 828,926 USD.

Research Project 1

Research Topic: Innovative solutions for improving the quality of drinking water and community water supplies in rural Cambodia

Duration of the Sub-project: 3 years

Total Cost of the Sub-project: 59,000 USD

Research Team: Dr. Chan Oeurn Chey (Principal investigator), Dr. Phan Kongkea (Member) and Dr. Sao Vibol (Member)

This project will focus on water quality monitoring and the development of innovative solutions for improving drinking water quality used to source community water supplies in rural Cambodia. It will be conducted in climate prone areas within the coastal zone (Kep, Kampot, Sihanoukville and Koh Kong) and areas surrounding the Tonle Sap (Kampong Chhnang, Pursat, Battambang, Siem Reap and Kampong Thom). Drinking water sources (n =50) and community water supplies (n=10) from each province will be sampled at random. Groundwater samples will be collected from a tube wells 5-10 minutes after flushing to remove any standing water. A grab sampler will be used to collect water from hand-dug wells. Water samples will be collected in two polyethylene bottles for different analytical purposes. Raw samples will be analyzed for F^-, NO_3^- and NO_2^-. Acidified water samples will be analyzed for As, Ba, Cu, Fe, Mn and Zn. Simultaneously, on-site measurement of water temperature, pH, ORP, conductivity, total dissolved solids (TDS), salinity, dissolved oxygen (DO) and turbidity will be conducted. Water samples will be also collected from water treatment facilities and at the point-of-use in households within each province by the same approach.

It is expected that approximately 500 water sources including well, ponds and canals 100 water supply plants in the study area will be tested for water quality and contaminants of concern. The will result in more effective monitoring and management of water quality in rural Cambodia. Concurrently, treatment technologies will be developed to remove heavy metals and other contaminants of concern using locally available and low-cost

materials. It is expected that these technologies will provide sustainable solutions to the provision of drinking water in this context.

Research Project 2

Research Topic: Study on urban climate resilience and mitigation in Phnom Penh, Siem Reap, and Preah Sihanouk provinces

Duration of the Sub-project: 4 years

Total Cost of the Sub-project: 161,700 USD

Research Team: Dr. SEAK Sophat (Principal investigator), Dr. SPOANN Vin (Co-investigator), Mr. Khan Lyna (Member) and Mr. Phat Chandara (Member)

This project will conduct a comparative study of urban resilience and mitigation in the cities of three provinces in Cambodia including Phnom Penh, Siem Reap and Preah Sihanouk. It aims to address the knowledge gap in mainstreaming climate resilience and mitigation measures into the planning and implementation of development projects used for the protection of urban ecosystems in Cambodian cities. This research will use participatory approaches as part of the Hazard, Infrastructure, Governance, Socio-economic characteristics (HIGS) framework.

This project will draw upon best practice approaches to achieving urban resilient measures for infrastructure, water resources, and governance; and propose new adaptation and mitigation planning and implementation modalities. Knowledge products such as policy briefs, posters, booklets, manuals and TOT materials on urban climate resilience will be developed for policy makers, urban planners, academics, researchers, and practitioners to build sustainable and resilient cities. More significantly, this research will provide specific recommendations to assist in the responses to climate

change. These recommendation may be used by concerned ministries as a baseline for developing specific adaptation and mitigation plans—that are linked to the current climate hazards in Cambodia. Beyond this general research objective, the study also aims to meet three specific objectives:

Objective 1: To identify the city areas that are most vulnerable to climate change impacts and disaster risks, with respect to urban ecosystems of Phnom Penh, Siem Reap and Preah Sihanouk;

Objective 2: To assess climate change impacts on urban ecosystems in the urban areas of three provinces in Cambodia and develop adaptation plans to better cope with these impacts; and

Objective 3: To identify appropriate adaptation and mitigation mechanisms and provide policy recommendations that response to climate change impacts on urban ecosystems.

Research Project 3

Research Topic: Monitoring seasonal variation in metal (As, Cd, Cu Fe, Pb and Zn) concentrations in vegetables, rice and their relation to surface water and soil along the Mekong River, Cambodia

Duration of the Sub-project: 4 years

Total Cost of the Sub-project: 354,118 USD

Research Team: Dr. Proum Sorya (Principal investigator), Mr. Sean Vichet (Member) and Mr. So Viccheka (Member)

Normal fertilizer and pesticide application practices used to improve agricultural products, may contribute to the accumulation of metals in soil-water systems and agricultural products in Cambodia. These concentration levels depend on the geological characteristics of soils and amount of inputs

used. The general objectives of this study to examine the metal concentrations of As, Cd, Cu, Fe, Pb, and Zn in rice and vegetables, as well as in soil and surface water resources along the Mekong River. These results will be analyzed to better understand current pesticide and fertilizer application practices and their effect on the environment, aligned with informing sustainable management strategies for agricultural products and soils. The aim of this project is to provide atypical technical support to the Rural Entrepreneurship and Market Inclusion in Cambodia (REMIC) project; and Japan Farm Products Cambodia to assist with the safe development of sustainable products. The research team will work on analytical techniques to monitor the effect of metal levels on the environment; especially as this relates to food and agricultural products and the application of fertilizer and pesticides. It intends to determine the degree of certainty related to safe levels of human consumption for specific agricultural products.

As part of implementing this assessment, the project will provide product safety certification to companies on the basis serial laboratory analyses, which may be used to promote public confidence about the quality of agricultural products for marketing purposes. The research team will provide at least one training event per year linked to the results of these analyses. These will be presented as scientific seminars transferring science to farmers in communities to provide advice about the status of metal pollutants in surface water and soil resources; how this affects agricultural products, and best practice pesticide and fertilizer application procedures to ensure long-term product sustainability. The research has three main specific objectives:

Objective 1: To establish a national baseline of novel metal baseline levels that monitors the environmental impact of pesticide and fertilizer application along the Mekong River and whether this demonstrates local or seasonal variation. This will enable a better understanding of impacts of agricultural practices on ecological communities. This date will be used as a primary reference point for future research on the complexity of metal biomonitoring in South East Asian riverine systems;

Objective 2: To assess the safety levels of these metals with respect to permitted WHO/FAO/National Guidelines and better understand current pollution levels and the potential consequences with respect to human consumption and environmental degradation

Objective 3: To understand the effect of current practices of pesticide and fertilizer application on agricultural land and how to improve recommended land management practices.

Research Project 4

Research Topic: A multiscale Heston's stochastic volatility model with a stochastic interest rate

Duration of the Sub-project: 3 years

Total Cost of the Sub-project: 41,330 USD

Research Team: Dr. Sotheara Veng (Principal investigator), Dr. Sony Chan (Member), and Dr. Ji-Hun Yoon (Member)

In this research, we extend the multiscale Heston stochastic volatility model outlined in Fouque and Lorig (2011) by incorporating a stochastic interest rate. This will be used to study European option pricing and portfolio optimization problems. To this end, the specific objectives are as follows:

Objective 1: To formulating a multiscale Heston's stochastic volatility model with a stochastic interest rate in which analytic tractability is retained for European option pricing and portfolio optimization problems;

Objective 2: To seek approximate solutions of partial differential equations for European option prices under the proposed model using asymptotic analysis;

Objective 3: To apply a Monte-Carlo simulation to obtain an actual option price, which will be used as a benchmark for comparison purposes;

Objective 4: To analyze the error between an approximate solution and the actual option price, resulting from the Monte-Carlo method;

Objective 5: To calibrating the theoretical price to real market data, through implied volatility fitting to see whether the formulated model really outperforms the existing one;

Objective 6: To seek an approximate solutions for the value function for portfolio optimization, under the proposed model by using asymptotic analysis;

Objective 7: To obtain explicit optimal control for the value function. Our multiscale Heston's stochastic volatility model with a stochastic interest rate is expected to outperform the constant interest rate model of Fouque and Lorig (2011) in terms of implied volatility fitting, particularly, for short time-to-maturity European options.

Another expected result is that the tractability in Heston's model is retained to a certain level. In other words, the closed forms for approximate solutions for European option prices and value functions will still be available in the stochastic interest rate setting. One of the main outcomes of this

research is the scientific publication of two to three papers. Another is the graduation of two master students in financial mathematics. Finally, the results of this study will be helpful for the Cambodia Securities Exchange (CSX) in terms of the expansion of traded products in the near future.

Research Project 5

Research Topic: Strongly coupled field theory from the point of view of holography

Duration of the Sub-project: 3 years

Total Cost of the Sub-project: 44,040 USD

Research Team: Dr. Sunly Khimphun (Principal investigator)

The application of string theory is an important for the study of Physics as it is a promising candidate for explaining quantum gravity. One approach to support such a theory is to construct a model to investigate physical phenomena. Thus, this project is related to model simulation. Despite the novelty of our model, results will be simulated with conditional inputs and real data constraints, particularly with respect to Objective 3 below, relating high energy physics, to low energy physics. The simulation will test the Holographic principle, which is one of the applications in String theory postulated to explain the unification between gravity and quantum theory, via existing physical phenomena and real cosmological observation. The construction of this model is essential to understanding and fulfilling the theory, which is academically important for the advancing fundamental scientific concepts.

Objective 1: To study a model of interest, such as Einstein-Maxwell-Field, Massive Gravity, and f(r) gravity theory in an (an)isotropic medium. These

three models will be investigated in terms of their background solutions to equations of motion. The solutions will be produced numerically, then compared and analyzed.

Objective 2: To study the transport coefficients associated with the models of interest. Most of the results for transport coefficients will be numerically computed using a computer simulation. The results will be analyzed based on physical grounds to justify the numerical reliability and physical interpretations.

Objective 3: To compare optical properties as a consequence of the model of interest, with experimental results. The results of this framework will be based on a non-conventional picture, but are expected to play some role in depicting the qualitative behavior of some physical phenomenon as part of a real experiment.

Objective 4: To apply five-dimensional gravity theory and AdS/CFT correspondence to construct a holographic cosmology to study the expansion of the universe. The model constructed will be tested against the real observable data. A good agreement between the model and this data is expected.

Research Project 6

Research Topic: Elaboration of mixed oxides (TiO_2-M_xO_y) for photocatalytic applications

Duration of the Sub-project: 3 years

Total Cost of the Sub-project: 110,270 USD

Research Team: Dr. Cheng Khley (Principal investigator)**,** Dr. Long Solida (Member)**,** Dr. Tieng Siteng (Member)**,** Dr. Chey Chan Oeurn (Member), Ms.

Seng Samphors (Member), Ms. So Vichheka (Member) and Ms. Houy Laingsunh (Member)

According to Yale and Columbia University researchers, Cambodia's Environmental Performance Index demonstrates poor results for water and air pollution, as well as bacterial outbreaks. These problems need to be addressed. An inexpensive photo-catalyst, TiO_2, which possesses good photo-stability, nontoxicity, and high reactivity may lead to potential solutions. Recently, mixed metal oxides of $Zr_xTi_{1-x}O_2$ of different compositions ranging between 0 and 100% Zirconium (Zr) concentrations were tested by Cheng et al. at both the nanoparticle and crystalline stages. Following this comparison, selected compositions were used as photocatalytic materials to decompose ethylene in a gas phase, resulting in results that were up to two times better. Other applications of this photo-degradation process may be applied to the liquid phase for killing bacteria. Thus, it is important to conduct further studies on these material to demonstrate whether improved catalyst efficiency may be realised.

The research will be conducted by synthesizing mixed metal oxide nanoparticles from precursors, then investigating the nucleation-growth kinetics using hydrodynamic light scattering techniques. The prepared nanoparticle powders will be characterized using AAS, ICP, thermal analysis, X-ray diffraction and electron microscopy. The results from characterization will determined the real compositions, homo- and heterogeneities and morphologies of the synthesized materials. TiO_2-M_xO_y in the form of a powders and film may be coated onto substrates such as glass beads and used

to decompose of model pollutants in liquid and gas phases using photocatalysis to kill bacteria. Thus, the project has the following objectives:

Objective 1: To synthesize, analyze, and characterize TiO_2-M_xO_y prototypes with different metal oxides (Zirconium, Vanadium, Copper, Iron, and Tungsten)

Objective 2: To compare the decomposition capacity of TiO_2-M_xO_y nanoparticles on model pollutants

Objective 3: To compare the decomposition capacity of TiO_2-M_xO_y nanoparticles on pollutants in controlled matrix conditions and real conditions (waste from food factories and hospitals)

Objective 4: To compare the antibacterial capacity of TiO_2-M_xO_y nanoparticles on selected priority pathogens such as *Escherichia coli* and *Salmonella* spp.

Objective 5: To develop substrate prototypes required for commercial applications of nano-materials such as coated substrates (glass beads, glass plates, or aluminum) in the long term.

Objective 6: To test the photocatalytic activity of substrate prototypes on representative organic and biological wastes in liquid phase from selected sites.

Research Project 7

Research Topic: Biodiversity research for sustainable development in particular reference to bats

Duration of the Sub-project: 4 years

Total Cost of the Sub-project: 16,000 USD

Research Team: Dr. Ith Saveng (Principal investigator), Mr. Samorn Virak (Member), and Mr. Sin Sopha (Member)

Bats are the second most diverse taxa after rodents, comprising 18 families, 202 genera and more than 1,116 species worldwide (Simmon, 2005). Bats play a very important role in the ecosystem and greatly benefit humans. Fruit bats are seed dispersers. Insectivorous bats control insects that can dramatically reduce the number of crop pests. The cave nectar bat is the main pollinator of high value fruit and other important plant species. Bat guano functions as a source of energy for invertebrate diversity in caves, contributing to their ranking as significant biodiversity hotspots in terms of its endemism and threats (Whitten 2009). Moreover bat guano is used as fertilizer in many highly profitable plantations in Cambodia.

Despite this, only limited research has been conducted on bat conservation in Cambodia, especially when compared to neighboring countries such as Vietnam, Thailand and Laos. This Cambodia possesses only limited knowledge on bat diversity, ecology and ecosystem services. This project aims to build an up-to-date species database; developing a research culture and capacity bat conservation awareness; as well as developing strategies for the conservation of bat species in Cambodia.

Objective 1: To conduct a Cambodian bat diversity assessment

Objective 2: To produce a valid bat checklist and bat species distribution map

Objective 3: To build capacity and promote bat conservation awareness

Objective 4: To identify bat conservation priority areas and propose a sustainable development framework for bat conservation in Cambodia

Objective 5: To initiate ecological questions and experimental designs on ecosystem services for bats for future studies including, pest control and pollination.

Research Project 8

Research Topic: Develop a highly sensitive, speed, resolution, and compact interferometer for precision optical sensor applications

Duration of the Sub-project: 3 years

Total Cost of the Sub-project: 82,104 USD

Research Team: Dr. Eang Seang Hor (Principal investigator), Prof. Kyunman Cho (Member), and Mr. Hang Sim (Member)

In Cambodia, there is no interferometer devices for the precise measurement of refractive index changes, surface irregularities, topography and weight; for extensive application in all branches of science, technology and medicine. Most material characterization, biosensor and surface topography devices in Cambodia are imported. Additionally, there are few experts in the country capable of using these devices and only limited knowledge of high sensitivity optical sensors such as interferometer devices. Thus, the general objective of this research is to develop new interferometers for super resolution optical scanning microscopy, high-sensitivity fluidic channel readouts, and high sensitivity weight measurement for use by laboratories and industry.

This includes checking chemical and bacteria concentrations, low weight measurement, and 3D surface structure characterization. This will also contribute to strengthening and improving scientific research capacity within higher education institutions in Cambodia and equip graduates with transferable skills and knowledge that may be applied to other technical challenges. This technical capacity may also be transferred to the private sector through training, workshops, and conference presentations. With a

view to achieving general objective above, we will focus on the list of specific objectives below.

Objective 1: To design three new interferometer devices to be used for scanning standard samples to measure concentration, and microscale weights and improve the resolution quality, sensitivity, and precision or measurements previously possible in scientific research using results from commercial devices.

Objective 2: To transfer this technology to the private sector through presenting this research workshops and international conferences. The private sector participate in these events to examine our research findings with the purpose of identifying the potential opportunities for research collaboration and/or commercialization. The private sector may opt to send their staff to support the installation of a photonics laboratory at RUPP and provide internship opportunities for students within our research team.

Objective 3: To use these new devices as prototype optical sensors for research purposes within the university to better understand surface topography, refractive index detection, low concentration solution sample detection, bio-material reaction detection, and very low weight measurement.