



**UNESCO-IHE and  
climate change:  
finding solutions  
through adaptation  
and mitigation**



**UNESCO-IHE**  
Institute for Water Education



To mark the signing of the historic United Nations climate agreement in New York on 22 April 2016, UNESCO-IHE Institute for Water Education has compiled a showcase of recent work. Given that almost all our activities relate in some way to climate change, whether addressing drought, flooding, erosion or other issues, we have selected only those that have climate change as their main focus.

Here we highlight some selected activities from our three main focus areas: Education, Research & Innovation and Capacity Development. In some cases, the work spans more than one of these areas.

Our water experts support governments, cities, private sector organizations, development agencies, research and education institutes worldwide in tackling issues caused by climate change. As part of the UNESCO Water Family we are conscious of the pressing need to contribute to achieving the UN Sustainable Development Goals by 2030.

**Rectorate**

**UNESCO-IHE Institute for Water Education**

We have been working with governments for almost 60 years, addressing their varying needs for tackling climate change vulnerabilities in their country. If you are committed to addressing climate change risks by signing the COP21 Paris Agreement and you are now looking for a partner to help you achieve your goals, please do not hesitate to contact Ms. Vanessa de Oliveira, Liaison Officer - International Relations at UNESCO-IHE via [v.deoliveira@unesco-ihe.org](mailto:v.deoliveira@unesco-ihe.org).

For references to publications and online materials, please visit:

**[www.unesco-ihe.org/climate-change](http://www.unesco-ihe.org/climate-change)**

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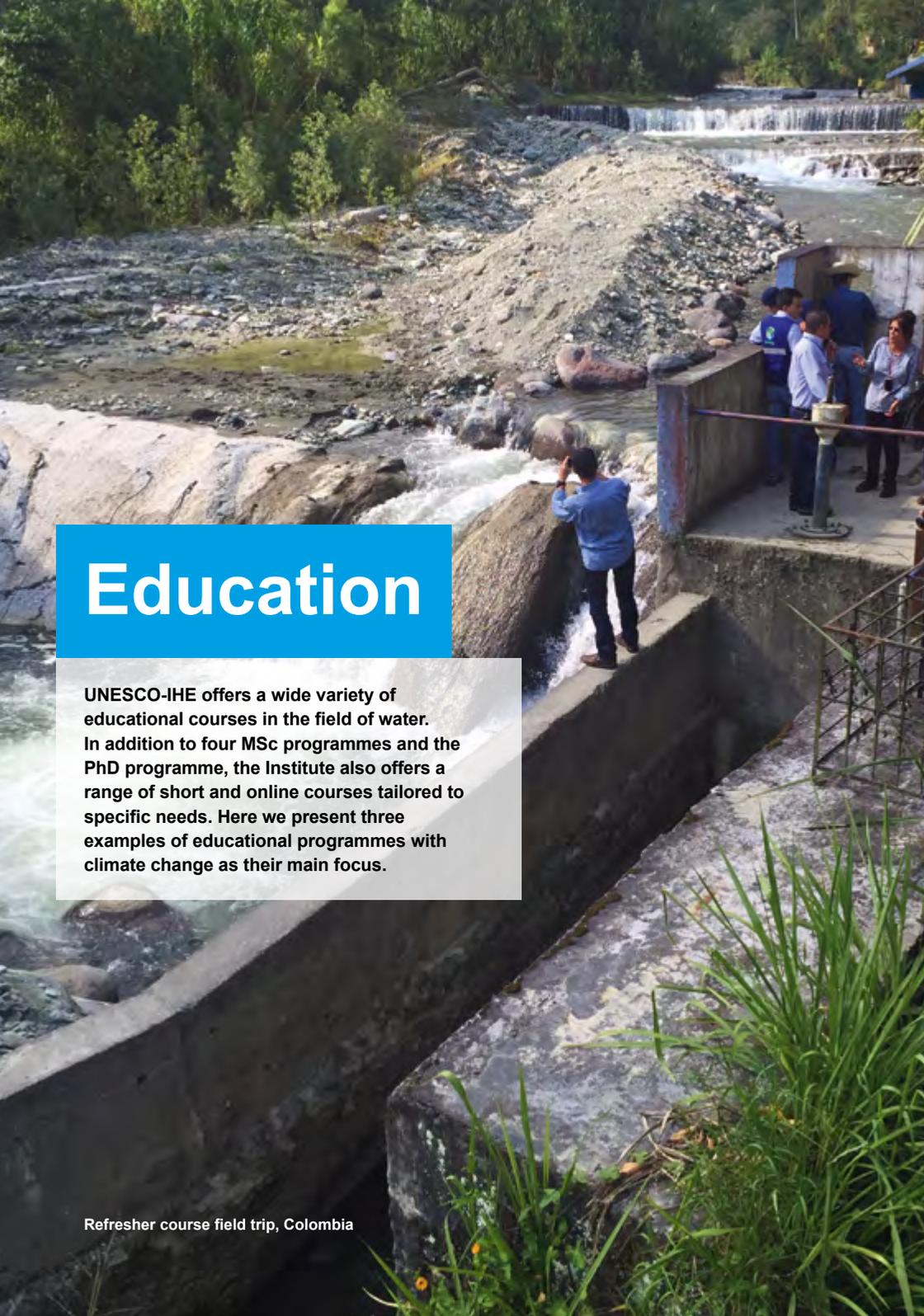
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# Education

UNESCO-IHE offers a wide variety of educational courses in the field of water. In addition to four MSc programmes and the PhD programme, the Institute also offers a range of short and online courses tailored to specific needs. Here we present three examples of educational programmes with climate change as their main focus.

# Programmes with a climate change focus

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## **Joint Master programme 'Groundwater and Global Change'**

Groundwater can play a pivotal role in adaptation to climate change. The Erasmus Mundus Joint Master programme 'Groundwater and Global Change - Impacts and Adaptation' (acronym GroundwatCH) offers a distinctive curriculum built on the cornerstones of hydrogeology, hydrology and climatology, within a framework of human pressures, climate and global change, feedback and adaptation. With this curriculum, the programme aims to address the current gaps in higher education with regard to the understanding of the interactions between groundwater, surface water, climate and global change, and how we need to consider and can benefit from these interactions when dealing with adaptation.

[www.groundwatermaster.eu](http://www.groundwatermaster.eu)

## **Short course on Integrated Water Resources Management as a Tool for Adaptation to Climate Change**

This three-week short course aims to give professionals in the water and climate sectors an understanding of the relation between climate change and water resources. Topics include: environmental impacts of climate change, adaptation strategies for water use sectors, modelling water allocation and institutional aspects including stakeholder participation.

More information: [www.unesco-ihe.org/iwrm-tool-adaptation-climate-change](http://www.unesco-ihe.org/iwrm-tool-adaptation-climate-change)

## **Refresher course on Integrated River Basin Management under Climate Change**

A one-week refresher course for UNESCO-IHE alumni was recently organized in Bogota, Colombia. The aim of the course was to update their knowledge on integrated river basin management, with a focus on the impacts that extreme climate and climate change have on the planning of water resources at a basin level in the Latin American context.

UNESCO-IHE organizes refresher courses in Europe, Africa, Asia, Latin America and/or the Middle East, primarily for our alumni. The courses cover themes that are of direct relevance and importance to the region and the participants.

[www.unesco-ihe.org/refresher-courses](http://www.unesco-ihe.org/refresher-courses)

[Link to video documentary](#)



# Research & Innovation

The Institute's demand-driven research activities focus on and contribute to the knowledge base concerning water & development. Examples of research into climate change impacts, policy, governance and mitigation are listed here.

**Beach erosion Gold Coast, Australia**

# Climate change impacts and risk quantification

## Agriculture & water resources

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### Estimating the local effect of weather on field crop production

Agriculture is a key sector critical to global food security. It is also commonly considered highly exposed and vulnerable to climate change impact. To what extent does crop production depend on weather and climate? How will climate change affect cropping systems? Adaptation strategies and climate policy cannot be determined until the above questions have been clearly addressed.

UNESCO-IHE and the Center for Agricultural Policy and Trade Studies at North Dakota State University have developed a bio-economic framework considering cropping systems as a managed ecosystem and integrating crop science and economics to identify the role of weather in crop production and to simulate the impact of climatic change. The modelling approach can be applied to different crops or regions.

#### Reference

Jiang, Y., Koo, W.W. (2014) Estimating the field effect of weather on crop production with unobserved producer behavior: a bioeconomic modeling framework. *Environmental Economics and Policy Studies* 16(3), 279-302. DOI: [10.1007/s10018-014-0079-9](https://doi.org/10.1007/s10018-014-0079-9).

### Climate change and socio-economic development as drivers of freshwater availability

In this research paper by Stigter et al. (2015), a combined assessment of the potential impacts of climate change (CC) and socio-economic development (SED) on water resources is presented for the most important aquifer in the south of Portugal. The goal is to understand how CC and SED affect the major current pressures from water-consuming and contaminating activities, predominantly agriculture. Short-term (2020-2050) and long-term (2070-2100) CC scenarios were developed and used to build aquifer recharge and crop water demand scenarios, using different methods to account for uncertainty. SED scenarios were developed using bottom-up and top-down methods, and discussed at workshops with farmers and institutional stakeholders in the water sector. Groundwater use was quantified for each scenario.

#### Reference

T.Y. Stigter et al. (2015) Combined Assessment of Climate Change and Socio-Economic Development as Drivers of Freshwater Availability in the South of Portugal. Springer. *Water Resources Management*, 1-20.

<http://link.springer.com/article/10.1007%2Fs11269-015-0994-y>

### Impact of climate change on water resources and crop yields in Nepal

The purpose of the study was to develop a tool to investigate the effect of prospective climate change (up until 2100) on hydrology and the productivity of rain-fed crops (wheat *Triticum L.*, maize *Zea Mais L.*, and rice *Oryza L.*) in the Indrawati river basin, Nepal, Himalaya. The study was carried out under the scope of the UNESCO-IHE-led project on Adaptation to Global Change on Agricultural Practices (AGloCAP). The researchers used climate projections from three global circulation models. Wheat was found to be more vulnerable than maize and rice to climate change.

#### Reference

Palazzoli I., Maskey S., Uhlenbrook S., Nana E. and Bocchiola D. (2015) Impact of prospective climate change on water resources and crop yields in the Indrawati basin, Nepal. *Agricultural Systems*, 133:143-157.

<http://www.sciencedirect.com/science/article/pii/S0308521X14001498>

[Link to final project report](#)

# Climate change impacts and risk quantification Coasts

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## **AXA Research programme on Climate Change impacts and Coastal Risk (CC&CR)**

The overarching objective of the CC&CR research programme is to generate new fundamental scientific knowledge and formulate ground-breaking theoretical and modelling concepts, which will enable the development of innovative CC-driven coastal risk assessment methods that are underpinned by state-of-the-art interdisciplinary science.

The programme comprises three main research lines:

- Climate change impacts on coasts: the science;
- Probabilistic, scale-aggregated modelling of CC-driven coastal hazards, and
- Innovations in coastal risk assessment.

The main research methods adopted include process-based, scale-aggregated, and probabilistic numerical modelling; field data analysis; and risk modelling. The research undertaken within this programme is highly inter-disciplinary and spans the fields of coastal engineering, climate science, hydrology, ecology, applied mathematics, physical geography, risk modelling, and oceanography.

## **Climate change impact assessment for inlet-interrupted coastlines**

The anticipated rise in sea levels due to climate change will result in coastlines receding worldwide through erosion. This is a known phenomenon that can in principle be calculated and predicted based on a given sea-level rise. However, coastline change near the thousands of coastal inlets around the world will not only be affected by sea level rise but also by CC-driven variations in terrestrial phenomena such as rainfall, river flow and fluvial sediment supply.

Until now science has lacked a model that takes these terrestrial effects into account in the calculation of the future development of inlet-interrupted coastlines.

UNESCO-IHE has succeeded in developing a new model that is able to produce predictions within a few minutes of how the coastline will develop in the vicinity of inlets as a result of climate change-driven variations in both oceanic and terrestrial phenomena.

The first results of this research were published in the prestigious journal *Nature Climate Change* in 2013.

### **Reference**

[R. Ranasinghe, T. Duong, S. Uhlenbrook, D. Roelvink and M. Stive \(2013\). Climate Change impact assessment for inlet-interrupted coastlines. \*Nature Climate Change\*, Vol. 3, 83-87.](#)

## **Coastal hazard and risk assessment of Narrabeen Beach, New South Wales, Australia**

This research project, funded by the Australian Commonwealth government, focussed on developing a modelling framework to integrate geomorphological, engineering and economic approaches to assess risk for the Australian coast. Coastal land use planning and management need an indication of the degree of risk.

### **Reference**

[R. Ranasinghe, T. Duong, S. Uhlenbrook, D.J. Wainwright, R. Ranasinghe, D.P. Callaghan, C.D. Woodroffe, R. Jongejan, A.J. Dougherty, K. Rogers, P.J. Cowell \(2015\). Moving from deterministic towards probabilistic coastal hazard and risk assessment: Development of a modelling framework and application to Narrabeen Beach, New South Wales, Australia. \*Coastal Engineering\*, Vol. 96, 92–99.](#)

# Climate policy

## Short-term impact of a domestic cap-and-trade climate policy on local agriculture

To combat climate change, governments have to control greenhouse gas emissions effectively and at low cost. Market-based approaches such as cap and trade or carbon pricing are often considered with strong policy interest, which allows the achievement of greenhouse gas emission reduction targets in a flexible, cost-effective way. Governments, however, need to understand the possible impact of different policy instruments for climate change mitigation before making decisions. UNESCO-IHE has constructed a policy simulation model based on production economics for assessing the economic impact of a cap-and-trade climate policy on agriculture. The modelling approach can be applied for policy appraisal in order to inform climate policy design.

### Reference

Jiang, Y., Koo, W.W., 2013. The short-term impact of a domestic cap-and-trade climate policy on local agriculture: A policy simulation with producer behavior. *Environmental and Resource Economics* 58(4), 511-537. DOI: [10.1007/s10640-013-9737-9](https://doi.org/10.1007/s10640-013-9737-9).

# Governance

## Climate change governance: history, future, and triple-loop learning?

The international climate change regime started out very constructively, but although there has been progress over the last 25 years, this progress falls short of what is needed to address the climate change problem. The paper by Joyeeta Gupta (2016) presents the regime evolution in terms of the concept of single-, double-, and triple-loop learning, and its relationship with participatory processes and trust, emphasizing the more recent developments and prospects for the future. The issue is whether, at this stage, we will be able to combine bottom-up initiatives with top-down legally-binding goals and align Northern and Southern perspectives. The aim is to create a global consensus on the restructuring of society so that the problem can once more be seen as structured and manageable.

### Reference

Gupta, J. (2016), Climate change governance: history, future, and triple-loop learning? *WIREs Clim Change*, 7: 192–210. DOI: [10.1002/wcc.388](https://doi.org/10.1002/wcc.388). Edited by Karin Bäckstrand, Domain Editor, and Mike Hulme, Editor-in-Chief.

<http://onlinelibrary.wiley.com/doi/10.1002/wcc.388/pdf>

## The history of global climate change governance

What has happened globally on the climate change issue? How have countries' positions differed over time, and why? How are problems and politics developing on an increasingly globalized planet and can we find a solution? This book by Joyeeta Gupta explores these questions and more, explaining the key underlying issues of the conflicts between international blocs. The negotiation history is systematically presented in five phases, demonstrating the evolution of decision-making. The book discusses the coalitions, actors and potential role of the judiciary, as well as human rights issues, in addressing the climate change problem. It argues in favour of global constitutionalism, which could provide the quantum leap needed to address the problem of climate governance.

This book won the Atmospheric Science Librarians International (ASLI) Choice Award for 2014 in its history category, which was awarded in the US in 2015.

### Reference

Joyeeta Gupta (2014). The history of global climate change governance. Cambridge University Press. ISBN: 9781107040519.

[www.cambridge.org/us/academic/subjects/earth-and-environmental-science/environmental-policy-economics-and-law/history-global-climate-governance](http://www.cambridge.org/us/academic/subjects/earth-and-environmental-science/environmental-policy-economics-and-law/history-global-climate-governance)

# Mitigation

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## **Estimating the regional agricultural supply of greenhouse gas abatements**

Agriculture holds the potential for mitigating climate change through biomass production and management to sequester carbon from the atmosphere. Yet a critical question remains: to what extent are land owners or farmers willing to manage their land for sequestering carbon? How can governments assess the carbon sequestration potential of regional agriculture with farmers' own production decisions? Can a carbon market give sufficient incentives to induce agricultural supply of greenhouse gas emission reductions by carbon sequestration, in addition to crop production? The study developed a sampling-based approach that can simulate, in a market setting, land-based carbon sequestration by regional agriculture. The approach is flexible enough to be applied in different regions with minimum information required, while accounting for spatial heterogeneity of both farmer preferences and production.

### Reference

Jiang, Y., Koo, W.W., 2013. Estimating regional agricultural supply of greenhouse gas abatements by land-based biological carbon sequestration: a Bayesian sampling based simulation approach. *Journal of Environmental Economics and Policy* 2(3), 266–287. DOI: [10.1080/21606544.2013.806041](https://doi.org/10.1080/21606544.2013.806041).

## **Producer preference for land-based biological carbon sequestration in agriculture**

While agriculture can play an important role in mitigating climate change through land-based carbon sequestration, its potential, however, depends on the preference of the farmers who manage the land and make their own decisions. Are farmers willing to devote their land to carbon sequestration? Can a carbon market stimulate land-based carbon sequestration through agriculture? What are the potential costs for farmers adopting different carbon sequestration activities? UNESCO-IHE conducted a survey to examine farmers' preference for carbon sequestration. A quantitative modelling of farmer preferences revealed factors affecting decisions about participating in carbon sequestration, including the costs for farmers of adopting different carbon sequestration activities.

### Reference

Jiang, Y., Koo, W.W., 2014. Producer preference for land-based biological carbon sequestration in agriculture: some implications from a sample of North Dakota farmers. *Journal of Soil and Water Conservation* 69(3), 231–242. DOI: [10.2489/jswc.69.3.231](https://doi.org/10.2489/jswc.69.3.231).

# Selected projects

## Preparing for extreme and rare events in coastal regions (PEARL)

Coastal floods are regarded as one of the most dangerous and harmful of all natural disasters. Rapid urbanization in coastal areas, combined with climate change and poor governance, can lead to a significant increase in the risk of local pluvial flooding. Should this coincide with high water levels in rivers and high tide or storm surges from the sea, it will pose a greater risk of devastation to coastal communities.

UNESCO-IHE is leading a five-year project that combines 24 leading partners, funded by the European Union's Seventh Framework Programme, aimed at developing innovative adaptive flood risk management strategies for coastal communities. The project focuses on extreme hydro-meteorological events, with a transdisciplinary approach integrating social, environmental and technical research and innovation.

More information on [www.pearl-fp7.eu](http://www.pearl-fp7.eu)

## Training courses, research and capacity development

Tailor-made courses have been developed for Colombia, presenting ways to use global hydrological model results to evaluate catchment basin problems. The global models used are explained and scenarios from the IPCC are tested in a case study in the Magdalena river basin.

Similar tailor-made courses on the application of models and tools for climate change impact research in the Mekong Basin was offered in June 2015 to the Khon Kaen University in Thailand. This course was designed to transfer knowledge and skill gained in the UNESCO-IHE-led [PRoACC project](#) to young researchers in Thailand and Vietnam.

The research being developed in a PhD research project aims to build spatial and temporal hydrological drought indicators from global climate models and climate change scenarios. This is expected to contribute to the assessment of risk and how to forecast drought. Case studies for this project will be carried out in Colombia, Mexico and Brazil.

In the capacity development project 'ClimaCol', adaptation measures for climate change are being developed using the

tipping point methodology. Training was provided for a number of organizations in Colombia.

[Drought indicators Latin America](#)

### Reference

Project report 2014: Climate adaptation Colombia. Climate data scaling and analysis for the Magdalena basin. Project partners: FutureWater, UNESCO-IHE, Deltares, SarVision, Waterschap Hunze en Aa's, IDEAM, DNP, CorMagdalena.

An aerial photograph showing a village in Bangladesh that has been severely affected by a cyclone. The image is split into two horizontal sections. The top section shows a cluster of traditional houses with thatched roofs, many of which are damaged or partially collapsed. The ground is dry and dusty, with some debris scattered around. The bottom section shows the same area after flooding, with murky water covering the ground and surrounding fields. The houses are partially submerged, and the water reflects the sky. The overall scene depicts the devastating impact of natural disasters on rural communities.

# PhD Research highlighted

A large part of the research agenda at UNESCO-IHE is implemented through our PhD fellows from all over the world. In this section we present three examples of PhD research in the field of climate change that is still ongoing, as well as an example that was completed in 2015.

Flooded village after 1991 cyclone in Bangladesh

# Research in progress

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## **Quantifying environmental risk due to coastal flooding**

By PhD Fellow  
Seyedabdolhossein Mehvar  
(Iran)

There is a growing demand from the environmental policy and decision makers to have a better overview of the economic value of coastal environments. Many studies have shown that considerable ecosystem degradation and lost services have been experienced worldwide, driven by natural hazards and the impact of climate change.

The objective of this PhD research is to develop a framework to quantify the monetary value of environmental losses and risks caused by climate change-driven episodic and chronic flooding in coastal areas. The outcomes of this research will present a generic framework for valuation studies of environmental losses and risks that can be broadly applied to a variety of coastal wetlands.

## **Holistic modelling of catchment-estuary-coastal systems at macro time scales**

By PhD Fellow  
Janaka Bamunawala  
(Sri Lanka)

The world's coastlines, estuaries and nearshore coastal morphology are shaped not only by oceanic processes such as tides, waves and mean sea level, but also by terrestrial processes such as river flows, fluvial sediment supply, land use pattern, land management, etc. Although scientists, engineers and managers have known this for decades, the inherent divisions between traditional disciplines such as hydrology, geography, geology, oceanography and coastal engineering have resulted in fragmented approaches when assessing the anthropogenic and environmental impacts on the long-term evolution of estuarine and coastal morphology. This research aims to fulfil this enormous knowledge gap, by developing a holistic modelling approach that can simulate contemporary and future estuarine-coastal morphological evolution at 50-100 year time scales, including catchment sediment erosion processes.

## **Socio-hydrological dynamics in Bangladesh: understanding the interaction between hydrological and social processes along the Brahmaputra floodplain**

By PhD Fellow  
Md Ruknul Ferdous  
(Bangladesh)

The advanced understanding of the complex web of interactions between dynamic physical and social processes will help to improve current policies for disaster risk reduction in Bangladesh. As socio-hydrology is related to short-term and long-term dynamics, understanding system dynamics should be of major interest to governments that are dealing with strategic and long term-decisions about responses to climate change.

# Finalized research

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## **Climate change impacts on the stability of small tidal inlets**

By Trang Minh Duong, PhD  
(Vietnam)

This research, supported by the DGIS-UNESCO-IHE research program UPARF, focused on small tidal inlets (STIs), thousands of which can commonly be found in tropical and sub-tropical regions of the world. STI environments are heavily utilized for navigation, sand mining, waterfront developments, fishing and recreation. Their occurrence in developing countries, socio-economic relevance and low community resilience, and high sensitivity to seasonal forcing makes STIs potentially very vulnerable to CC impacts. This study resulted in the development of innovative process-based and reduced-complexity modelling approaches and obtained predictions of CC impacts on the stability of STIs. Results show that CC is likely to decrease the stability of STIs and that the main driver of change is future variations in wave direction; not SLR as commonly thought.

### **Reference**

[Associated journal paper: T. Duong, R. Ranasinghe, D.J.R. Walstra and D. Roelvink. 2015. Assessing climate change impacts on the stability of Small Tidal Inlet systems: Why and How? \*Earth Science Reviews\*, Vol. 154, 369-380.](#)

[Thesis \*Climate change impacts on the stability of small tidal inlets\*, by Trang Minh Duong, PhD \(Vietnam\)](#)

# Selected projects

## **Holistic approach to flood risk assessment in areas with cultural heritage: a practical application in Ayutthaya, Thailand**

The historic city of Ayutthaya, inscribed on the World Heritage List in 1991, was subjected to an extreme flooding event in 2011, the worst flooding Thailand has experienced in decades. Under the project, UNESCO-IHE and partners undertook a flood risk assessment, combining quantitative and qualitative aspects and then developed a risk mitigation plan. A new flood-prevention approach that combines a 1.6 metre-high permanent wall, dykes, and a new road elevation and floodway is proposed to save the ancient World Heritage city of Ayutthaya Island from future flood events. The province has sought an allocation of 550 million Thai Baht from the government to support the project, which involves building over 12.5 kilometres of dykes surrounding Ayutthaya Island.

### Reference

Vojinovic, Z., Hammond, M., Golub, D., Hirunsalee, S., Weesakul, S., Meesuk, V., Medina, N., Sanchez, A., Kumara, S., Abbott, M. (2016) Holistic approach to flood risk assessment in areas with cultural heritage: a practical application in Ayutthaya, Thailand. *Natural Hazards*, Vol. 81, Issue 1, 589-616.

<http://link.springer.com/article/10.1007%2Fs11069-015-2098-7>

## **AfriAlliance: Africa-EU Innovation Alliance for water and climate to enhance the Climate Change preparedness of Africa**

The ambitious AfriAlliance project aims to prepare Africa for future climate change challenges, by facilitating the cooperation of African and European stakeholders in the areas of water innovation, research, policy, and capacity development. UNESCO-IHE will coordinate the project, which runs from 2016 to 2021 and is funded by the EU Horizon 2020 programme.

Specifically with respect to water, Africa is one of the regions most in need of innovative solutions for tackling climate change-related challenges. The fruitful interaction among relevant stakeholders in water management is of central importance when trying to generate, increase and exchange knowledge and innovation that address the demands of workable, effective solutions with a tangible impact.

While a broad range of networks already exists, interactions about water and climate could be further enriched and strengthened within Africa and between Africa and Europe.

AfriAlliance will therefore support existing networks in working together and sharing innovative solutions for key water and climate change challenges.

More information on [www.afrialliance.org](http://www.afrialliance.org)



# Capacity Development

UNESCO-IHE strives to strengthen the programmes of universities and research institutes as well as the knowledge and capacity base of government ministries and other water sector organizations in Africa, South America and Asia/Pacific. We do this by training water professionals on the job, creating water education networks, joint research, policy advice, distance & e-learning, participation in innovative projects and facilitating knowledge sharing. A few examples on climate change adaptation in coastal and urban areas are listed here.

# Adaptation Coastal areas

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## **Coastal risk assessment along the East coast of Sri Lanka**

This project constitutes the first on-the-ground application of coastal risk modelling approaches developed by UNESCO-IHE.

The Asia Development Bank-funded project assesses the economic and environmental coastal risk and subsequent determination of economically and environmentally optimal coastal setback lines along the fast developing East coast of Sri Lanka. The aim is to facilitate risk-informed, sustainable coastal zone management of high-growth coastal areas by the Coast Conservation Department (CCD) of Sri Lanka.

## **Climate change-driven variations in the wave climate and potential sediment transport along the coast of Vietnam**

Vietnam has been identified by the International Panel on Climate Change (IPCC, 2007, 2014) as one of the countries to be most affected by climate change. In particular the Mekong and the Red River deltas with their extremely high population density in low-lying areas are severely threatened.

Changes in regional wave climate and sediment transport rates, in response to climate change-driven variations of atmospheric circulation, are of particular interest in the field of coastal zone management and decision making. Changes in alongshore gradients in longshore sediment transport (even small gradients) could result in chronic impacts such as coastline recession, inlet migration, ebb/flood delta depletion/accretion.

At present, there is no clear indication about projected future wave climate data and the resulting sediment transport rate along the Vietnam coast, and therefore this study focused on providing this information. UNESCO-IHE and partners have analysed the future offshore wave conditions along the coast using a third-generation

numerical wave model.

The future projected wind data from selected Global Circulation Models (GCMs) are used as the input for the wave models. Subsequently the offshore wave climate is translated into nearshore and finally the potential longshore sediment transport rates in different coastal stretches along the coast of Vietnam are calculated. Results show that the central coast of Vietnam is likely to experience enhanced erosion in the coming decades.

### References

[Project report 1: Climate Change Driven Variations in Future Longshore Sediment Transport Rates along the Coast of Vietnam.](#)

[Project report 2: Climate Change Driven Variations in the Wave Climate along the Coast of Vietnam.](#)

# Adaptation Urban areas

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## **Managing urban water systems with significant adaptation deficits – a unified framework for secondary cities**

Debate on how to address climate change impact has brought adaptation to centre stage in the discussions on urban development. UNESCO-IHE has developed a conceptual framework with the case study of Can Tho, the largest city in the Vietnamese Mekong Delta. The framework addresses the potential conflict of two drivers for adaptation, by unifying adaptation into a directed force that addresses both domains: adaptation gaps and adaptation deficits.

UNESCO-IHE's focus with regard to urban areas is the so-called secondary cities (non-capital cities with a population of less than several million). 80% of the urban population in Asia lives in secondary cities, many of which are poised to undergo explosive economic growth and population increase. It is very likely that such growth will result in severe stress on the environment and challenge the liveability of inhabitants due to e.g. urban flooding and water pollution.

## **More adaptation activities**

Other adaptation activities can be found on [www.mare-asia.net](http://www.mare-asia.net) where UNESCO-IHE is carrying out a number of climate risk evaluation/adaptation projects in Indonesia in the cities of Batam, Malang and Kendari and in Vietnam in the cities of Can Tho, Soc Tran, Tra Vinh and Ho Chi Minh.

# List of selected references

## Climate Change Impacts publications

Agarwal A., Babel M.S., Maskey S., Shrestha S., Kawasakia A. and Tripathi N.K. (2015) Analysis of temperature projections in the Koshi River Basin, Nepal. *International Journal of Climatology*, URL: <http://onlinelibrary.wiley.com/doi/10.1002/joc.4342/abstract>

Agarwal A., Babel M.S. and Maskey S. (2014) Analysis of future precipitation in the Koshi River basin, Nepal. *Journal of Hydrology*, 513: 422–434. URL: <http://www.sciencedirect.com/science/article/pii/S0022169414002327>

Bhatt D., Maskey S., Babel M.S., Uhlenbrook S. and Prasad K.C. (2014) Climate trends and impacts on crop production in the Koshi River basin of Nepal. *Regional Environmental Change*, 14: 1291-1301. URL: <http://link.springer.com/article/10.1007%2Fs10113-013-0576-6>

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## Videos

[Video documentary of refresher course 'Integrated River Basin Management under Climate Change'](#).

[BBC interview on the AXA Climate Change & Coastal Risk research program](#)

## Links to educational programmes

Short course [Integrated Water Resources Management as a Tool for Adaptation to Climate Change](#)

Joint Master programme ['Groundwater and Global Change'](#)

## PhD thesis

<https://www.unesco-ihe.org/news/climate-change-impacts-stability-small-tidal-inlets>

## Project reports

Climate Change Driven Variations in Future Longshore Sediment Transport Rates along the Coast of Vietnam. Project partners: AIT, UNESCO-IHE. [Download pdf here](#).

Climate Change Driven Variations in the Wave Climate along the Coast of Vietnam. Project partners: AIT, UNESCO-IHE. [Download pdf here](#).

Climate adaptation Colombia. Climate data scaling and analysis for the Magdalena basin. Project partners: FutureWater, UNESCO-IHE, Deltares, SarVision, Waterschap Hunze en Aa's, IDEAM, DNP, CorMagdalena (2014). [Download pdf here](#).

Approaches to risk assessment on Australian coasts. University of Wollongong. [Download pdf here](#).

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