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CLIMATE CHANGE: HOW THE CLIMATE FRONTIER CAN BE PUSHED

EDITORIAL BY PROF. MICHELE MOSSA

Prof. Michele Mossa
Technical University of Bari (Italy)
Editor of Hydrolink
m.mossa@poliba.it

"The huge difference between where we are now, and where we could easily be within a few generations, reveals the urgency of relieving the pressures that are pushing today's species towards extinction": these are the words used by Barnosky et al. in a recent article published by *Nature, Research Review* in 2011, referring also to the human-specific impacts on our planet, with potential repercussions also on climate change. But what is the general definition of climate change? Really, the most general definition is a change in the statistical properties of the climate system over periods of decades to millions of years, regardless of cause. In fact climate change might be caused by oceanic circulation, biotic process, variations in solar radiation on the Earth, plate tectonics, volcanic eruptions, astronomic events, such as the impact of a meteorite, and also human-induced alterations of the natural world. Sometimes, erroneously, the climate change is used to describe only the potential human-specific impacts. Concerning this last cause the recent debate "climate controversy" is well documented! In fact on this topic the scientific community is not always in agreement, but generally it has reached an overwhelming consensus - the world is warming, also as a result of human activity (see for example the news, features, research highlights, commentary and analysis of Nature Reports Climate Change on the web site www.nature.com/climate/index.html). In the just-released report "Summary for Policymakers" the International Panel For Climate Change (IPCC) states that it is 95% certain that the "human influence on climate caused more than half the observed increase in global average surface temperatures from 1951-2010."

In a recent lecture of mine (M. Mossa, *Mixing and Transport Processes in Environmental Flows - Invited Lecture*, www.lulu.com, ISBN 978-1-291-36846-8) I had the opportunity to highlight that there are many themes of interest for our community which are linked to climate change, such as the social pressure on water quantity, the sea level change, the Artic Sea ice loss, the change in type of vegetation and many others. In one of its last issues, Nature (vol. 501, no. 7467) devoted many articles on the outlook for Earth, exploring the work of the IPCC , the international body of hundreds of scientists and policy experts that regularly assesses the state of knowledge about climate changing and its potential impacts, and how nations can mitigate the problem. Now in its 25th year the IPCC has grown substantially from its early days and some experts have also investigated the progress the panel has made on the topic of rising sea levels (i.e., one of the most controversial aspects of its previous big report, published in 2007).

It is interesting to highlight that, on the contrary to public thinking, the first large scale environmental surveys are not so recent; in fact, for example, a scientific exploration of the western United States was held in May 1871. These surveys hold scientific lessons for policy, making still relevant today.

All the previous remarks make it clear why this issue of *Hydrolink* is devoted to Climate Change. In this issue we publish an interview with Prof. H. J. Fernando, who makes clearer some aspects of the controversy over global warming and its repercussions on our planet, and we also publish a series of articles written by many experts on the effects of the climate change on the rivers, floods, coastal zones, energy policy. I am sure that all these articles are of interests for our readers, and, therefore, as always, I hope that you enjoy this issue.

IAHR
International Association for Hydro-Environment Engineering and Research

IAHR Secretariat
Paseo Bajo Virgen del Puerto, 3
28005 Madrid SPAIN
Tel. : +34 91 335 79 08
Fax. : +34 91 335 79 35
www.iahr.org
iahr@iahr.org

Editor:
Michele Mossa,
Technical University of Bari, Italy
e-mail: m.mossa@poliba.it

Contact us:

Estibaliz Serrano
Publications Manager
IPD Programme Officer
tel.: +34 91 335 79 86
e-mail: publications@iahr.org

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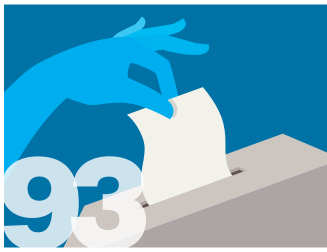

CLIMATE CHANGE SPECIAL

INTERVIEWED BY MICHELE MOSSA,
HYDROLINK EDITOR

5 QUESTIONS TO... Harindra Joseph Fernando

Harindra Joseph Fernando is Wayne and Diana Murdy Endowed Professor of Engineering and Geosciences at the University of Notre Dame, with the primary affiliation in the Department of Civil Engineering & Geological Sciences and a concurrent appointment in the Department of Aerospace & Mechanical Engineering. Among awards and honors he received are the UNESCO Gold Medal for the Best Engineering Student of the Year (1979), Presidential Young Investigator Award (NSF, 1986), ASU Alumni Distinguished Research Award (1997), Rieger Foundation Distinguish Scholar Award in Environmental Sciences (2001), William Mong Lectureship from the University of Hong Kong (2004) and Life-Time Achievement Award from the Sri Lanka Foundation of the USA (2007).

1. The first question is almost unavoidable. The global warming controversy concerns the public debate over whether global warming is occurring, how much has occurred in modern times, what has caused it, and what its effects will be. What is your opinion on this?

There is no question that the globe is warming, but the contentious issue is whether human-induced global warming is happening or not. My gut feeling is that the rapid rise of temperature from year 1991 points to some human-induced warming but the data is less conclusive because of the fluctuations. Many talk about anthropogenic warming, but the evidence mostly comes from the models (data records are not that long). People believe in models more than the model developers do, so my concern is that global warming has become a passion rather than scientific truth. Having said that, I believe that continuous pumping of greenhouse gasses must cause some perilous effects on the earth.

2. You organized a high level NATO Advanced Research Workshop in Dubrovnik, "National Security and Human Health Implications of Climate Change". What was your experience with organizing this successful event? Can you briefly give us some of the main conclusions of this event?

This brouhgt together a cadre of scientists having the same interests but looking at the problem from different angles. Warming (human-induced or not) is causing water shortages, conflicts, social injustice, and health hazards, and this meeting addressed all these issues. It was illuminating, and I think we ought to repeat such multidisciplinary exercises more often, on a firm scientific basis. Looking at data critically is a must. One of the drawbacks was the lack of modelers, and if I were to host another meeting I would have more modelers.

3. How the impact of climate change could have repercussions on water resources and projects?

The water cycle is one of the major areas that would be affected by warming. More evaporation, change of precipitation and extreme events will also affect water availability and natural disasters. While we do not have to completely rely on model downscaling, before any water project we must do some model calculation and allow some margin for climate change. For example, the 22-mile storm surge barrier in Louisiana was added extra 5 feet at a cost of millions of dollars to account for climate change.

4. The climate change could have repercussions also to national security. Can you better explain this point?

Climate change causes water and food shortages and diseases, which may lead people to migrate across the borders of countries which may lead to tensions. Naval routes toward poles may open up, causing a shift of defense strategies (US is planning on having a lesser number of ice breakers). Because of the extreme events, the security of nations will be threatened.

5. How do you think that the IAHR could help a correct future development of water projects, considering the impact of the climate change?

The only way to address this is to pay attention to the possible climate change. By conducting downscaling exercises, an estimate can be made on the magnitude of climate change and take steps to ameliorate it. Perhaps, during such exercises, the safety margins can be unacceptable or uneconomical, when we will have to pay more attention to uncertainties. Then designs can be done using an adaptive management framework. In this case, the design can be done for a shorter time period, with lesser safety margins, with provisions for design changes or introducing corrections if the problem exacerbates.

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CLIMATE VARIABILITY AND CHANGE: A BASIN SCALE INDICATOR APP UNDERSTANDING THE RISKS TO DEVELOPMENT AND MANAGEM

MICHAEL JACOBSEN, KENNETH STRZEPEK, BRENT BOEHLERT AND JAMES NEUMANN

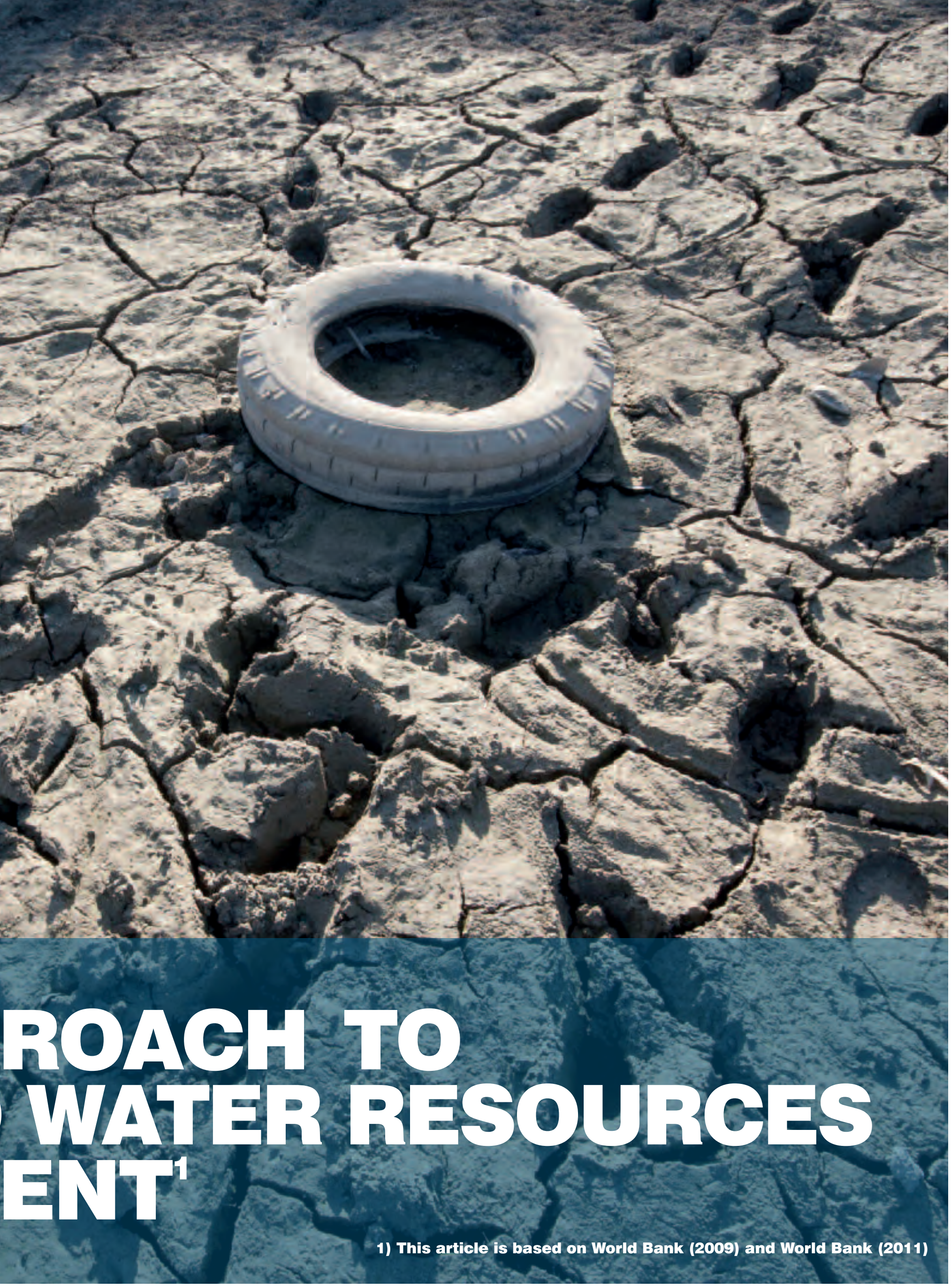
Abstract

Varying spatial and temporally, the impact of climate change is likely to have considerable implications for water resources planning as well as adding to the risks to water infrastructure systems and affecting return on investments in these systems. Attention is increasingly being paid to adaptation strategies at the regional and basin level; however, the current paucity of information regarding the potential risks to hydrological systems at this scale presents a substantial challenge for effective water resources planning and investment. The World Bank has recently developed a method to evaluate the effects of climate change on six hydrological indicators across more than 8,000 basins of the world. This work is intended to help bridge the gap between high-level climate change predictions and the needs of decision makers, whose policies and investment programs will be affected by basin and regional-level impacts of climate change on water resources and related infrastructure.

The hydrological indicators – mean annual runoff, basin yield, annual high flow, annual low flow, groundwater (base flow) and reference crop water deficit – were chosen based on their relevance to a wide range of water resource and infrastructure planning issues that face decision makers. To make the results easily accessible, the results are available on the World Bank Climate Change Knowledge Portal, http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_impacts_water&ThisRegion=Africa&ThisCcode=KEN. Here users can access graphic presentations illustrating the severity (low, medium or high) of change that is projected for the studied variable in any country or basin of interest. Users can also access tabular graphic representations of climate and hydrological projections for analyzed areas.

Introduction

Each region of the world, each country and each river basin face a unique set of climate change related water challenges. Depending on the hydrologic regime, regional and sub-regional hydrology and climate variability have a direct, but differential, impact on the various water use areas. Floods/droughts, water availability/allocation and water quality management are affected by climate change and have direct or indirect linkages to production, incomes and public welfare. Many countries are vulnerable to impacts of hydrological variability and climate change. Vulnerabilities are strengthened by poverty, weak institutions and insufficient stock of water management infrastructure. The gap between the availability of water storage infrastructure in the rich and the poor countries is wide. Africa has the largest gap between potential and actual hydropower infrastructure development, worldwide, see www.africainfra-



ROACH TO
WATER RESOURCES
ENT[1]

1) This article is based on World Bank (2009) and World Bank (2011)

structure.org Potential adaptation strategies to the impacts of climate change on production, incomes and welfare via the impact on water resources have become central to international collaboration on water management, the dialogue on national water policies and investment program in a number of countries. Conventional interventions are necessary but not sufficient. Water practitioners have long coped with and designed for variability in hydrology. Consequently, numerous examples of adaptation to hydrological variability and extreme events exist in the water sector. Implementing the "good practices" more widely (for example efficient irrigation technology, water harvesting and re-use, increased sub-surface storage etc.) would go a long way in confronting the climate change challenge. Adapting to climate change must continue to build on conventional interventions, while addressing immediate challenges, but must

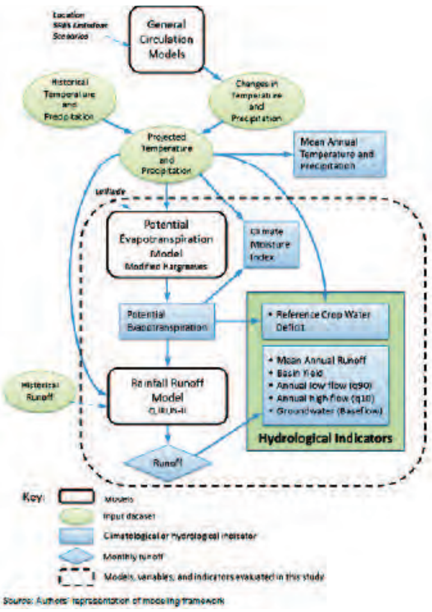


FIGURE 1: Diagram of the modeling process used in World Bank (2009, 2012) and for the web-site

> **"Each region of the world, each country and each river basin faces a unique set of climate change related water challenges."**

make a major shift in culture, planning and design of policies, programs and projects in the future. Analyses must be consistent and emphasize the consequences of uncertainty, technology and management must focus on the development of flexible and "smart" systems that can be operated to anticipate and react to changing circumstances. New design standards and criteria also need to be developed to take into account the increased uncertainty and increased variability.

The best analyses of large-scale infrastructure include consideration of future climates and sensitivity analyses, but they are typically not tied to the specific, internally consistent scenarios of future precipitation and temperature changes that have been developed for climate change assessments, do not incorporate the full range of changes that could be associated with future climates and in particular do not adequately take into consideration the uncertainty with respect to future climates which is indicated by the full suite of climate models and emission scenarios of the IPCC Fourth Assessment. It is now clear that the wide range of potential future climate and hydrologic outcomes suggest the use of planning tools such as robust decision-making (Lempert and Groves 2010), which focus on resilience to uncertain futures rather than optimization in relation to predicted futures and on methods of decision making for large-scale infrastructure that puts a very high value on flexibility.

In response to this growing need to evaluate the climate resilience of proposed development paths and related infrastructure investments, the World Bank has recently developed a method to evaluate the effects of climate change on six hydrological indicators across more than 8,000 basins of the world.

Methods

As portrayed in Figure 1, the General Circulation Models (GCMs) and the Special Report on Emission Scenarios (SRES) lie at the beginning of the analysis process. Projected changes in monthly temperature and precipitation for the 2030s (2030-39) and the 2050s (2050-59) were collected for each basin from 56 available GCM-SRES combinations used in the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC). See (World Bank 2012) for a fuller description of the methodology used.

For historical climate data, we rely on precipitation and temperature data for the 1961-1990 period from the University of East Anglia's Climate Research Unit TS 2.1 data set.

Projected changes in temperature and precipitation parameters are combined with the historical baseline to generate projections of future absolute values of temperature and precipitation for each basin for the 2030s and 2050s. This process raises two issues: 1) Which basins? 2) How to combine historic data and projected changes from GCM simulations?

For a global definition of river basins, we use the USGS HydroSHEDS definitions, based on a 1 kilometer digital elevation model. We chose a combination of Level 3 and Level 4 basins from HydroSHEDS, in an attempt to roughly match basin size to the size of a typical GCM gridbox, in order to ensure the results were not over-specified relative to the scale of GCM results.

Projecting changes in climate variables from GCM simulations has often involved downscaling approaches, but both statistical and dynamical downscaling have well-studied uncertainties (Kerr 2011), and the time and costs of these computationally intensive approaches rarely allow the use of more than a few GCMs. Therefore and to enhance policy relevance we characterize the broadest possible range of "not implausible" climate futures, as defined by the currently available set of GCM-SRES combinations. The only practical approach for a global analysis is to use projected changes in temperature and precipitation for a number of GCM-SRES combinations at their native resolutions. We have chosen 56 scenarios, which incorporate three green-house gases emissions scenarios (B1, A1B and A2) and 22 GCM frameworks. The three SRES scenarios were chosen because they are commonly used emissions scenarios for impact and adaptation assessments and the 56 scenarios reflect the large variability in possible precipitation and temperature outcomes, as well as the likely variation in spatial distribution of these outcomes.

To model changes in runoff, we employed CLIRUN-II, a hydro-climatic modeling framework with components that model: Potential evapotranspiration (PET), Snow-Water-Balance, and soil moisture. PET is a necessary input into runoff modeling as well as irrigation water requirements. CLIRUN-II uses the Modified Hargreaves method.

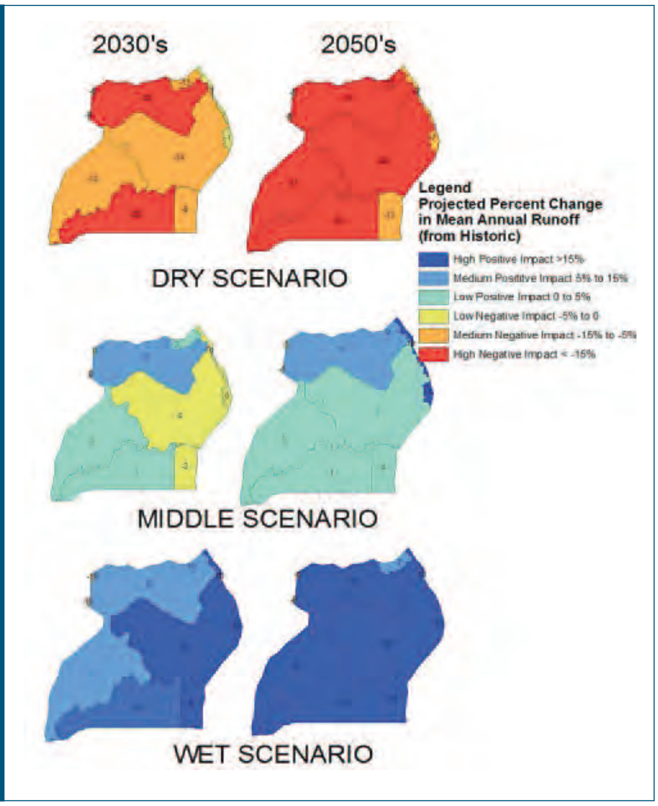
The runoff modeling component is a two-layer, one-dimensional conceptual rainfall-runoff model that simulate natural runoff with six calibration parameters. This class of model requires natural runoff data to calibrate the model over an historic period. We calibrated the model with the UNH-GRDC runoff data set (WMO 2012). CLIRUN-II produces a 30 year time series of monthly hydro-climatic variables that are used in calculation of 6 hydrologic Indicators (1) mean annual runoff; (2) river basin yield; (3) annual high flow, or Q10; (4) annual low flow or Q90; (5) baseflow or the sustained flow in a river basin resulting from groundwater runoff; and (6) reference crop water deficit, or the crop water demand that exceeds available precipitation. We employ a simplified version of the Water Deficit Index approach to estimate reference crop water deficit. For a given basin-specific growing season, this formulation reduces to the sum of monthly PET minus precipitation for those months in which PET exceeds precipitation.

Results

The analysis result is a dataset that provides six hydrological indicators for over 8,000 basins

FIGURE 2: Changes in mean annual run-off in Uganda's basins from the baseline to 2030 and 2050 for the dry, middle and wet scenarios.

Note the large uncertainty. The sign changes from large positive to large negative change depending on GCM-SRES combination.



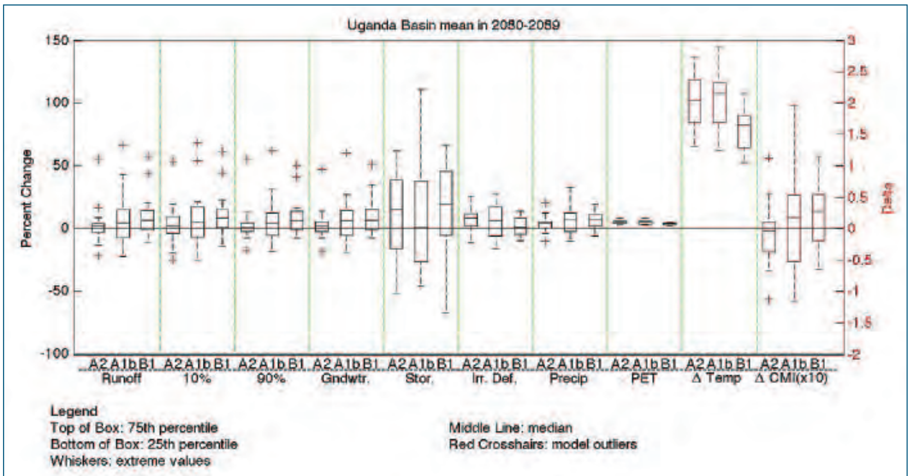


FIGURE 3: Box and whisker diagram of indicators for Uganda from the baseline across climate scenarios for the 2050s.

worldwide, for up to 56 alternative climate futures. The methodology and data set has been utilized by the World Bank in a number of cases for example for technical background papers for the Uganda Water Resources Management and Development project, a policy note on adaptation options in Botswana, a policy note on adaptation options for the Sava River Basin, and for a multi-sector investment opportunity analysis in the Zambezi River basin. A dataset of this size could easily overwhelm users, so the data also includes a user-friendly interface that allows for analysis at the country and regional level, with mapping products and statistical representations of output, such as box and whisker diagrams. The full data set and interface can be accessed at the World Bank Climate Knowledge Portal, by pointing on a map.

To illustrate how the results might be used and interpreted, we show projections for the river basins of Uganda as an example. Results for Uganda's basins are presented in two formats: as maps showing differences in severity of impact across basins for the six hydrological indicators, and as box and whiskers diagrams showing the range of projected impacts across the 56 GCM-SRES combinations for the full set of indicators. The spatial results presented on the maps (Figure 2) provide a perspective on how the indicators are anticipated to vary across basins and time as well as across climate scenarios; as such they provide a snapshot of the risks to water resources systems projected by the climate models. The box and whiskers diagrams (Figure 3), which show the statistical distribution of the results across climate scenarios, provide a complimentary perspective on the variability of the projected changes in hydrological indicators under climate change. Both figures illustrate the very large uncertainty with regard to future developments. For example for mean annual run-off it is not even clear whether Uganda will become much wetter or much drier. This underscores the importance of the use of planning tools such as (Lempert and Groves 2010), which focus on resilience to uncertain futures rather than optimization in relation to predicted futures and on methods of decision making for large-scale infrastructure that puts a very high value on flexibility.

The reader may generate similar figures using the tools available on the World Bank Climate Change knowledge portal. When doing so, it is important to keep in mind the limitations of the methodology (see next section). In particular, it must be noted that the data resolution implies that the results are not directly applicable at project level. Unfortunately, there are no quick fixes to the uncertainty at project level as the discussion in Kerr (2011) illustrates.

Michael Jacobsen is currently a Lead Water and Sanitation Specialist with the World Bank based in Sofia. He has worked on climate change, water resources and planning of environmental infrastructure for 2 decades as a consultant, government advisor and staff member of the World Bank.

Brent Boehlert is a Senior Associate at Industrial Economics in Cambridge, MA. Mr. Boehlert specializes in applied economics and policy analysis, with a focus on water resources and climate change. Drawing on his academic background in economics and engineering, he frequently employs analytical methods and tools from both fields.

Kenneth Strzepek is Research Scientist, at MIT's Joint Program on Climate Change. He has spent 30 years as a researcher and practitioner at the nexus of engineering, environmental, and economic systems, primarily related to water resource planning and management, river basin planning, and modeling of agricultural, environmental, and water resources systems.

James Neumann is a Principal at Industrial Economics, Incorporated (IEc), a Cambridge, MA-based consulting firm. Since 1993 Mr. Neumann has researched impacts of and adaptation to climate change. He is a Lead Author for the IPCC Fifth Assessment Working Group II chapter on the Economics of Adaptation.

Limitations

There are several limitations to this analysis. First are the limitations of any hydrological study relying on climate change projections. In addition, there are several uncertainties which stem directly from using rainfall runoff models in global climate change studies. Yet another issue is that because both the UNH-GRDC and CRU datasets tend to include too few extreme events (runoff and weather, respectively), there is a good chance that extreme events are under-represented in the CLIRUN-II results.

In terms of input data, both the CRU and GRDC datasets have additional uncertainties. For a fuller description of these limitations, see World Bank (2012)

REFERENCES

Kerr R 2011 Vital Details of Global Warming Are Eluding Forecasters Science 334 173-174.

Lempert R J and Groves D G 2010 Identifying and evaluating robust adaptive policy responses to climate change for water management agencies in the American west Tech. Forecasting & Social Change 77 960–74.

World Bank 2009 Water and Climate Change: Understanding the Risks and Making Climate Smart Investment Decisions. http://documents.worldbank.org/curated/en/docsearch/projects/P113213

World Bank 2011 Climate Variability and Change: A Basin Scale Indicator Approach to Understanding the Risk to Water Resources Development and Management. http://documents.worldbank.org/curated/en/2011/09/15897484/climate-variability-change-basin-scale-indicator-approach-understanding-risk-water-resources-development-management

World Bank Climate Change Knowledge Portal http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_impacts_water&ThisRegion=Africa&ThisCcode=KEN

(WMO, 2012) Global Runoff Data Centre (http://www.bafg.de/nn_266918/GRDC/EN/Home/).

FLUVIAL MECHANICS: IMPA SEDIMENT YIELD FROM RIVER

BY PREM LAL PATEL

The change in the climate due to excessive accumulation of green house gases in the atmosphere is being experienced by the whole world. The rise in temperature and subsequent variation in rainfall, vegetation cover, geological processes and runoff from the watershed has affected both the sediment erosion and sediment delivery at the catchments outlet. The changes in the water and sediment discharges in the natural rivers would affect their morphodynamics and performance of existing hydraulic structures, viz. reservoirs, weir-barrages, water supply intakes and other flood controlling structures. The presence of habitats in the natural river systems and eco-systems are also likely to be affected due to variation in sediment loads. The effect of climate change on erosion and deposition pattern of sediments in the major river basins of the world are summarised. Also, based on these investigations, a methodology has been suggested to compute the sediment yield from river basins under changing climatic scenario.

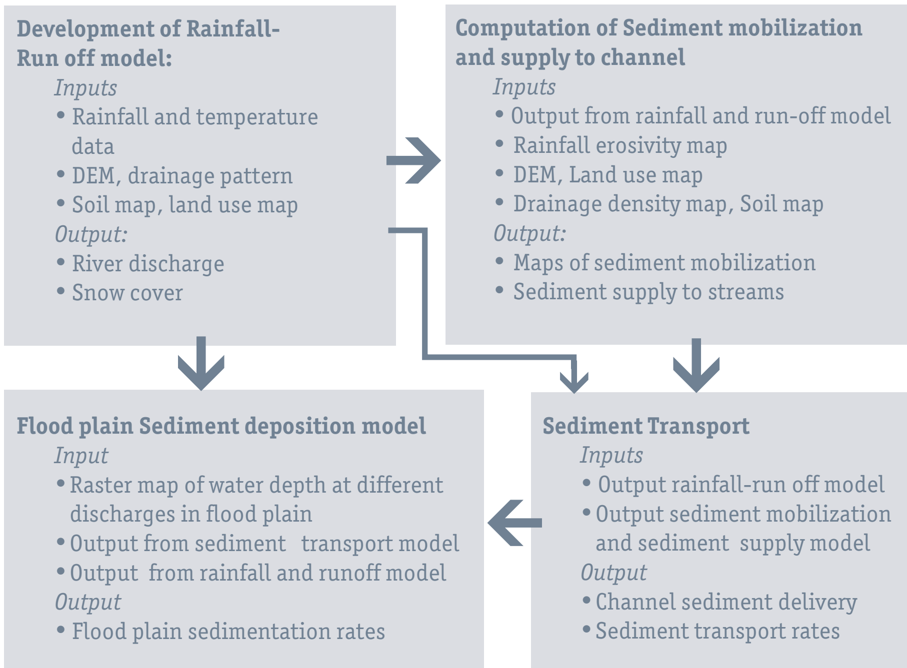


Fig.1 Conceptual model for computation of sediment yield from river basins

Prem Lal Patel **is Professor and Head of Civil Engineering Department, SVNIT Surat, India. He is also Coordinator of the Centre of Excellence on 'Water Resources and Flood Management' at SVNIT, being funded from World Bank (TEQIP-II). As well as IAHR, he is an active member of various International and National Societies like Indian Society for Hydraulics (ISH) and Indian Water Resources Society.**

Past studies on sediment yield under changing climatic conditions

Asselman et al. (2003) studied the potential effect of climate change on soil erosion, transport and deposition pattern of sediments in the Rhine river basin. For this purpose, a suite of geographical information system-embedded model was developed to simulate the erosion and transport of wash load through drainage network of the basin and its subsequent deposition on plain along lower River reaches. The model result indicated that if climate changes in accordance with UKHI climate change scenario, erosion, in conjunction with changing land use pattern, will increase by 12%, averaged over the entire basin, by year 2100.

Lawer et al. (2003) carried out study on effect of climate change on suspended sediment fluxes for three glacierized basins of southern Iceland. The effect of land use changes or any other possible anthropogenic changes are minimal on these experimental basins. The study revealed an increase in water discharge and suspended load during winter and summer seasons with corresponding decrease in autumn and spring seasons.

Yang et al. (2003) developed a GIS based RUSLE model to compute potential soil erosion rate at global scale under changing land use pattern and climatic conditions. They have estimated the present soil erosion rate to be order of 0.38 mm per year for the whole globe with South East Asia as the most seriously affected region in the world. The global soil erosion rate was estimated to be the order of 11.60 ton per ha per year by year 2090. The study concluded further that soil erosion rate, at global level, is likely to increase by 14% with 5% contribution from changes in land use pattern while 9% from climate change.

Zhu et al. (2007) studied the variation of temperature and precipitation due to climate change on soil erosion, sediment transportation and sediment flux in Lonchuanjiang catchment of Yangtze River in China. The study revealed that increase in precipitation would increase the

CT OF CLIMATE CHANGE ON BASINS

sediment flux while the increase in temperature would decrease the sediment flux in the said streams. The changes in precipitation and temperature have more influence on sediment flux in wetter months than dry months.

Proposed Model for Computation of Sediment Yield from River Basins

The past studies described as above, reveals clearly the effect of climate change on sediment yield from the different river basins in the world. The morphology of alluvial river is decided based on water discharge, sediment discharge, sediment size and river slope as describe with well known Lane's balance analogy (Garde and Ranga Raju, 2000). The expected variation in discharge and sediment load in the river due to climate change would depend upon the possible variation in the rainfall and vegetation cover and geology of the catchment. The alluvial river which is already in equilibrium condition may try to attain new equilibrium condition due to possible changes in the water and sediment discharge.

A conceptual model to compute soil erosion, transportation and deposition in the river basin can be developed as per the study taken by Asselman et al. (2003). The conceptual model can be represented as shown in Fig.1

This article has been extracted and adapted from "The Mid-term Report of A State of Art on Climate Change in IAHR" published by the IAHR Climate Change Working Group

REFERENCES

Asselman Nathalie E M, Middlecoop H. And Dijk Paul M. (2003), The impact of changes in climate and land use on soil erosion, transport and deposition od suspended sediment in the River Rhine, Hydrological processes, 17, pp.3225-3244.

Garde R. J., and Raga Raju K.G. (2000) Mechanics of sediment transportation and alluvial streams problem. New Age International (P) Limited, Publishers, New Delhi, India.

Lawler D M, McGregor G R and Phillips I D (2003), Influence of atmospheric circulation changes and regional climate variability on river flows and suspended sediment fluxes in Southern Iceland, Hysrological Processes, 17, pp.3195-3223.

Yang D., Kanae S., Oki T., Koike T. And Musiake K. (2003), Global potential soil erosion with reference to land use and climate changes, Hydrological processes, 17, pp.2913-2928.

Zhu Yun-Mei, Lu X X and Zhou Yue (2008) Sediment flux sensitivity to climate change: A case study in the Longchuajiang catchment of upper Yangtze River, China, Global and Planetary change, 60, pp 429-442.

INFLUENCE OF CLIMATE CHANGE
AN OVERVIEW OF SOME TYP

BY ANDRE PAQUIER

What will be the conveyance of the river during next flood?

Are the levees dimensioned for future conditions?

Factors influencing Floods

The origin and the main processes concerning floods permit to distinguish various types of floods. Thus, the key factors that can strongly influence one flood vary a lot. Most of the corresponding parameters can be modified by climate change or more directly by other anthropogenic changes.

For flash floods typical of steep beds and high intensity rainfalls, a direct link with the structure of rainfall events is obvious and then a clear connection with climate change can be set.

More generally, if the cause of the flood is an overflow over the banks of a main channel, a lot of parameters control the quantity of water provided to the hydrographical network and other ones the conveyance of the main channel. All these factors can be linked with climate change more or less directly: rainfall at various scales due to the change in atmospheric circulation; runoff depending on vegetation, land use, surface structure, all connected to the rise of temperature; groundwater elevation mainly related to infiltration rate and precipitation chronic. For the conveyance of the hydrographical network, the relation with climate change of parameters such as vegetation, sediment load, bed morphology, hydraulic structures (design, operation, failure), wind, sea (or lake) level, …sometimes seem obvious but often need to be detailed as, for instance, here below.

If stationary conditions are applied, a riverbed will reach equilibrium (with small variations around) depending of the geology (available material), the hydrologic regime (including both water and sediment) and the vegetation (that itself depends on the two previous factors and the maintenance of the bed). A change in these latter conditions will imply a change in bed morphology that can lead to a long destabilization. A decrease of sediment inputs can lead to a deepening of the main channel (such as downstream from a newly built dam), which means less overflows upstream but flow acceleration with further consequences downstream. Bed morphology itself will impact hydraulic structures: efficiency will be reduced by sediment deposition while stability can be reduced by bed erosion.

Failures of structures such as earthen embankments can be linked to excess flow, damages created by animals, cracks (linked with drought, for instance), local bed erosion, etc. Levee failures can cause catastrophic floods because they are often associated with high discharges and can hit people that are not prepared both because the flow can come very quickly and because people believe be protected face to any flood event. The first consequence of climate change will be a modified probability of reaching the water level for which the safety of the levee can be questioned. However, the local climatic features can also impact the stability conditions of the levee and thus the real degree of protection for the population.

In mountain areas, the changes can be stronger because of the higher sediment transport rates and the influence of the temperature gradient with altitude, which can enhance the effects.

Studies about the Influence of Climate Change at Regional Scale

Thus, connections of floods with climate change can be multiple. Generally because of the high variations in flow discharges from one year to the other one, only a statistical analysis can bring a real answer to a question of evolution in floods. The answer can be different for "usual" floods or for "catastrophic" floods; the first ones will depend on a general trend that can be observed while the latter ones require longer observations periods (not often available) and depend on flow processes that may be different because of sediment entrainment, failures of structures, etc. Because of the difficulty to downscale future climate change scenarios and

ON FLOODS:
ICAL QUESTIONS

Andre Paquier **is Head of the Hydrology Hydraulics Research Unit in Irstea, Villeurbanne, France. He has worked for more than 20 years on research in fluvial hydraulics, mainly modelling floods and their associated sediment transport.**

Is evolution of land use the main factor for change in flood risk?

to integrate all these processes, one can try to learn from the past and to detect trends from historical long series. Uncertainty on measurements of higher discharges including changes in measurement techniques as well as works (on the river itself or more upstream) that change hydrological regime (dams for hydropower, irrigation, etc) imply that the task is not an easy one. After a selection of the more trustable hydrometric stations in France and application of various statistical tests, (Renard et al., 2008) concluded that only in the North East part of France, a significant trend can be detected for annual maximum flow. This difficulty to determine a clear trend does not mean that a historical trend does not exist but variability (and uncertainty) is too high. Trend (but with similar degree of uncertainty) was also obtained for future conditions on basis of simulations using global climate models and hydrological models: for instance, on Seine basin at Paris, the 10-year peak flow decreases slightly while the 100-year peak flow remains constant. For exploring future trends, understanding of the main processes and particularly of potential feedback effects should be improved to integrate this variability (for instance, seasonal effects).

Challenges to Cope

One central question is downscaling from meteorological parameters at regional scale to rainfall at local scale. It means that not only a trend for the amount of the highest rainfall events is necessary but also a description of how is evolving the structure of the rainy events. The structure is essential for the smaller basins with risk of flash flood but also to detect trend in the rivers downstream in larger basins (for instance, because of the concomitance of high flows from two tributaries).

> **“Connections of floods with climate change can be multiple”**

Passing from rainfall to discharge implies taking into account the land use that will govern runoff parameters. This land use depends on climate (selection of plants, plant growth, etc) but also on economic activity (agricultural choices, urban development, etc). Once land use is described, a hydrological model for river basin is required. It can be physically based or not but, in any case, will depend strongly on the calibration data set. In this respect, the analysis of previous periods is required.

Special care should be for urban basins in which the drainage network is dense and surface structure quite complicated. In these cases, rainfall intensity is a key factor because the mainly artificial drainage network has a limited conveyance, which means often local flooding; then urban planning that can favour local storage or infiltration is essential.

Estimating conveyance of the river is also obviously a basic issue. Often, at hydrometric stations, discharge is estimated through a relation with water elevation and water elevation is measured continuously. But it remains essential that discharge can be measured accurately and enough often to deal with a large range of discharges and other influencing factors such as seasons. Flood plain conveyance will depend on land use, hydraulic structures and interaction with the main channel. Sediment transport and morphological changes will also make difficult the estimate of the conveyance of the main channel.

The possibilities of adaptation of the (structural and non-structural) measures to mitigate floods (Paquier et al, 2009b) should be evaluated considering that reference events will change because of climate change. For instance, levees designed to resist up to one return period cannot be easily adapted to resist to a slightly higher flow that can create a generalized runoff over the whole downstream side.

Methodologies: Key Issues for Future

As written here above, the first objective consists in defining the trend for the intensity of various flood events. Simple cases require to determinate extreme events either for flow discharges in rivers or for rainfall intensities (Paquier et al, 2009a) or for sea levels. More challenging is the combination of the various climatic factors: for instance, tide, waves, wind and atmospheric pressure are essential to forecast sea level in coastal areas.

Damages can increase drastically because of local circumstances such as in case of failure of protection structures such as dikes or if high rainfalls are combined with high water level in the river of the sea, which hinders proper evacuation of excess runoff waters. The definition of combined probabilities due to climatic forcing or the early detection of the combination of risky situations (essential for efficient warning of populations) should be enhanced.

For urban areas in which damages are concentrated, methodologies to assess potential damages in advance are necessary. Another way consists in evaluating priorities for evacuation of risky areas with the various steps corresponding to the progressive improvement of the forecasts as time is marching. Understanding of the processes met during an urban flood is also required to link all the mitigation measures to an accurate assessment of hydraulic parameters both in streets and in built-up blocks.

Hydraulic tools to be used still rely on numerical models based on 1-D and 2-D shallow water equations (El kadi Abderrezzak et al., 2009) and their improved developments (Proust et al., 2009) but they should be coupled with uncertainties assessments. The evaluation of scenarios consequences pass also by the use of dike failure models and sediment transport models (particularly in steep slope areas or extreme events) that provide results with intrinsic uncertainty even after appropriate calibration.

Conclusions

Floods are local events that depend on local conditions, often linked with anthropogenic factors. Estimates of the deviations (due to climate change) in rainfall amounts or even, in peak discharges are often not enough to evaluate future flood extents because the transformation from discharge to flood is a local one; more over, other parameters are impacted: for instance, roughness cannot be considered any longer as constant. Understanding of the main flood processes at the right scale is necessary to forecast the changes in flood risk. In the past centuries, changes in flood conditions were mainly due to anthropogenic factors that were not directly connected to climate variations; such an assumption may remain true in the future.

References

El Kadi, K., Paquier, A., Mignot, E. – 2009. Modelling flash flood propagation in urban areas using a two-dimensional numerical model. Natural Hazards, vol. 50, p. 433 - 460

Paquier, A., Pons, F., Leblois, E., Rodriguez, F. – 2009a. Influence of rainfall distribution on urban flood: a case study. 33rd IAHR Congress: Water Engineering for a Sustainable Environment, 09/08/2009 - 14/08/2009, Vancouver, CAN. Proceedings of 33rd IAHR Congress p. 2383 - 2390

Paquier, A., Tachrift, H., Riviere, N., El Kadi, K. – 2009b. Assessing the effects of two non-structural flood mitigation measures using laboratory and real cases. Road map towards a flood resilient urban environment, 26/11/2009 - 27/11/2009, Paris, FRA. Proceedings Final conference of the COST action C22. 8 p.

Proust, S., Bousmar, D., Riviere, N., Paquier, A., Zech, Y. - 2009. Nonuniform flow in compound channel: A 1-D method for assessing water level and discharge distribution. Water Resources Research, vol. 45, n° W12411, p. 1 - 16

Renard, B., Lang, M., Bois, P., Dupeyrat, A., Mestre, O., Niel, H., Sauquet, E., Prudhomme, C., Parey, S., Paquet, E., Neppel, L., Gailhard, J. - 2008. Regional methods for trend detection: assessing field significance and regional consistency. Water Resources Research, vol. 44, n° W08419.

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CLIMATE CHANGE AND ITS EFFECT ON COASTAL ZONES

BY GREGORY DE COSTA

The coast even though being one of the most serene and enjoyable place for humans, it has also been a hazardous location. These hazards each having different degrees of risk, degradation of coastal aquifers, coastal flooding (extreme tides, storm surge), coastal erosion and shoreline stability are the well-known, recently Tsunamis adding to it. It is well known that new Zealanders love their coast and take pride in the maritime heritage, ocean resources, recreational opportunities, and beach holidays.

A United Nations report has warned that, coastal degradation will put at risk ecosystems which support over half the world's economies, unless coastal management strategies are implemented. It goes on to say that "terminal" disaster looms in many coastal areas "unless we introduce much more effective management immediately." "Coastal marine ecosystems

Gregory De Costa, **originally a graduate of Civil Engineering from the University of Moratuwa, Sri Lanka, went on to do a Masters in Environmental Engineering and then a PhD in Hydraulic and Hydrology from Hiroshima University Japan. He was Head of the Civil Engineering and Associated Professor at the Open Polytechnic of New Zealand for the past 10 years and now currently works for Unitec Institute of Technology in Auckland. He is a charted professional Engineer, member of Institute of Professional Engineers New Zealand and a Fellow of the Institute of Engineers Sri Lanka. He has conducted extensive research on climate change, its impact on coastal zones and mitigation strategies.**

Traditional Management style.

have declined progressively in recent times due to the increase in human populations and their accompanying development of coastal regions. This, accompanied by increasing climate change, is putting enormous pressure on the coastal ecosystems" say the authors of the report. "By 2050, 91% of the world's coastlines will have been impacted by development," It says that, "We believe that use of scientific and traditional knowledge, together with better understanding of the economic value of healthy coastal ecosystems, can help change the political discourse that eventually determines societal pressures"

Currently numerous methodologies are employed to combat and manage changes relating to coastal aqua systems,
However, today, Climate change is bringing in a new dimension to the hazard, particularly with global warming comes, sea level rise or fall, and an increase in extreme weather events resulting

Wellington, New Zealand

Queenstown, New Zealand

Wellington, New Zealand.

in possible greater coastal disasters. Hence with climate change coming into the fray we need to adopt and change from the traditional management systems.

Traditional Management Style

Coastal hazards could be broadly classified as follows with each having different degrees of risk:

1. **Climate impacts, sea-level rise & salinity intrusion to coastal aquifers**
2. **Coastal flooding (extreme tides, storm surge, rivers)**
3. **Maritime activities (navigation hazards, search & rescue)**
4. **Coastal erosion and shoreline stability**
5. **Oil or chemical spills**
6. **Tsunami impacts**

Given that our major cities are like the ones in the photo graphs below, it is imperative that we urgently develop strategies to manage climate change impacts on coastal zones, two major areas of impact being salinity intrusion to coastal aquifers and coastal flooding.

Most New Zealand cities are situated on the coast and many of these are beside rivers. Therefore, they are at risk from flooding, either from the sea itself, or from rivers discharging into the sea. Yet, a major contributor to coastal flooding around New Zealand is high tides, which are deterministic and able to be forecast well in advance. Nevertheless with climate change the risk is further exacerbated.

Whaiwetu Aquifer, Wellington New Zealand and Salinity Intrusion

The Waiwhetu aquifer is located beneath the Hutt Valley and extends well into the Wellington harbour. Greater Wellington extracts 40% of its water requirements from ground water. The risk of salinity intrusion is emphasized by the level of abstraction from the Waiwhetu aquifer, and the degree of risk could be significantly enhanced due to climate change and possible sea level rise. A study on the variation of Conductivity at Somes Island indicated minor increase in conductivity over a period of time

Control of abstraction to manage the levels recommended by different studies is the traditional method to control seawater intrusion in Waiwhetu Aquifer. Other models as well have been adopted to develop a three dimensional model in the study area. The model is used to understand the ground water movement and the risk of saltwater intrusion. The newer models have a more detailed layer structures and redesigned boundaries. The information and analysis on the aquifer system has been used to review the critical level for hydraulic heads on the aquifer. Donaldson, I.G. and Campbell, Cussins and Phreatos studying the aquifer's flow under different stresses calculated a critical level for hydraulic heads on the aquifer. Based on the results, control of abstraction to manage the levels was recommended.

A research funded by the Asia Pacific Network, dealt with artificial recharging of the unconfined part of the aquifer. Natural replenishment of aquifers occurs very slowly. Therefore, withdrawal of groundwater at a rate greater than the natural replenishment rate causes declining of groundwater level, which may lead to decreased water supply, contamination of fresh water by intrusion of pollutant water from nearby sources, seawater intrusion into the aquifer of coastal areas, etc. Artificial recharge may be defined as an augmentation of surface water into aquifers by some artificially planned operation. Possible adverse effects of the excess recharging may lead to the growth of water table near the ground surface and causes several types of environmental problems, such as water logging, soil salinity, and may affect natural aquifer storage and recovery systems. Nevertheless this is technique that could be adopted to manage salinity intrusion particularly which could increase due to climate change.

Construction of underground dams is another technique that is adopted in technically and economically advanced countries to combat salinity intrusion. This is a surer and safer way with a higher degree of certainty managing and combating climate change impacts on salinity intrusion.

The major problem with respect to climate change and coastal disasters is the general agreement on sea level rise, and if so the rates of change of sea level rise. Coast being directly related to sea, requires a consensus on variation of sea levels at the relevant locations under consideration. Once this is established it is possible to identify its impact on other elements such as coastal aquifers. As data even if available is very sparse and relates to shorter time scales, it becomes difficult to directly relate climate change to variations in coastal elements.

The climate is slowly but surely changing towards a warmer world. That means sea level is rising, and will increasingly affect coastal zones. At the same time global warming will also alter several other drivers that will impact on coastal areas, such as sediment runoff from land, change in wind and wave patterns, altered ocean currents, warmer sea temperatures, and the expectancy of more intense storms. Hence, there needs to be collaborative integrated research in the above mentioned areas as they are interrelated, particularly the effect of sediment runoff from land, effect of altered ocean currents, the expectancy of more intense storms, and its effect on coastal aquifers, when dealing with salinity intrusion and climate change.

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THE 2011 FLOODS IN THAILAND

BY JAAP KWADIJK AND HESSEL WINSEMIUS

Persistent monsoon rains in autumn 2011 led to catastrophic flooding in Thailand, putting the lives and homes of millions of people at risk. Almost eight hundred people lost their lives. The economic damage to the country's modern industrial sector was enormous and reached out far beyond Thailand itself.

This event functioned as a wake up call for all flood prone regions particularly those currently facing a booming economy. It also attracted the attention of large investors in these areas. Flood risk might be more severe than anticipated before. And finally our experience in Bangkok has put us on a new hydraulic research and development track.

At its peak, the flow in the Chao Phraya river upstream of Bangkok was almost 5,000 m3 per second. In this river such a situation occurs only once every 100 – 200 years. The long period of extreme rainfall upriver rapidly filled the upstream reservoirs. Once filled the remaining surge deluged the surrounding land. As the reservoirs were filled before the peak flood occurred, the surplus water had to be drained into the river at a time of extreme river outflow, which only exacerbated the situation. More than 30 provinces (of the 77 in the country) were directly affected by the flooding. The worst affected was the province surrounding the former capital Ayutthaya, a World Heritage site, which was flooded by a metre and a half of water.

The main cause of the flooding was the extreme rainfall in July, August and September in large parts of the Chao Phraya catchment. This lead to large river flows, something that cannot be avoided. However, the consequences were more devastating than necessary because there was a lack of preparedness to flood events of such magnitude. Flood prevention structures were in place, but were too small to avoid flooding from river flows of this volume. However, such an extreme event cannot be considered completely uncommon. Even in strongly defended floodplains and delta's a flood exceeding the design flood, may occur sooner or later.

In rapidly growing economies the risk of these events can easily grow for three reasons, (a) the increasing wealth and population densities leading to a larger potential damage in case of a flood, (b) the required improvement of the existing local flood protection systems does not keep up pace with the growth of the cities and the urban sprawl. There will be a lot of housing and economic activity in more hazardous or less protected areas than those where the original centres of activity were located. (3) climate change and sea level rise are leading to higher water levels, occurring more often, meaning an increase of flood frequency and magnitude in these flood prone areas. Low lying areas, such as delta's in the world are among the regions having the most booming economies and urbanisation. Here the risk is often even further exacerbated by local subsidence which rates are much often greater than the rate of the rise of the sea level.

These trends will mean that unexpected large flood events will occur more often in the near future. In a perfect world flood prevention should keep up pace with all these developments, but unfortunately in practice this is not the case.

Realizing these trends, it is essential that the authorities have immediate access to reliable information on the timing of the floods, the potential flooded area and the water depth once a flood is expected to exceed the design protection levels. This is vital because the information is needed to take precautionary measures to avoid casualties and mitigate the most severe damage.

It was this type of information that was lacking in Thailand at the time of flooding. Asked by the Minister of Science and Technology, three Dutch flood experts from Deltares and Royal HaskoningDHV were cooperating during the flood event with the Thai responsible authorities

Jaap Kwadijk **has been working at Deltares since 1997, moving here from Utrecht University. He was one of the first scientists to focus on climate change and the consequences for large rivers and delta areas. His doctoral thesis in 1993 covered this topic. When he submitted his research plan five years earlier, the subject was dismissed by one of the reviewers as irrelevant (!). He has been engaged in numerous studies and projects in the same area, both in The Netherlands and at international level, and he has an impressive number of publications to his name.**

Hessel Winsemius **is an expert in large-scale hydrology and hydrological modelling. In September 2009, he obtained his PhD degree Cum Laude. Since 2012 he is a member of the first Young Scientific Board of Deltares.**

to develop rapidly response strategies to fight the incoming water. The Dutch were playing an essential role in the Flood Relief Operations Command centre. In this well organized centre there were representatives from all the relevant ministries, the Bangkok Metropolitan Authority and the army. Also the press and a large number of volunteers were present. It was the coordination and implementation headquarters.

However, the head quarter faced a substantial lack of essential information. For example, the Thai authorities had initially underestimated the problem because their forecasting system assumed that the drainage capacity around the city was sufficient to drain off the large amounts of rainwater that had fallen upstream. Possibly once this had been true, but due to land use changes and narrowing of the river system this was no longer the case in 2011. Another problem was the lack of consistent information. The one day the water was predicted to reach Bangkok very quickly; the next day, the assessment was that it would take another week. This is obviously a nightmare for any decision-making on evacuation let alone in a in a city as big as Bangkok.

The main activity of the Dutch was to develop a reliable flood forecasting model that enabled to map out the situation.This was done in close interaction with the Deltares office in The Netherlands. In this way, all data could be processed quickly which enabled the set up of a sound 1D2D SOBEK inundation model. Also the involvement of additional expertise was vital to guide the situation. However, for the small group of foreign experts in Bangkok it was also a very exceptional event.

The model appeared a lot more pessimistic than the one used before, but at the end it proofed much more realistic. It allowed to show clearly that the problem was more substantial than earlier anticipated.

The forecasts using the new model were discussed with the Thai prime minister, as the overall coordination was the responsibility of the prime minister. Every opportunity and all the assistance was provided that was needed to respond appropriately.

The actual work on the ground was generally done by the Army. An important factor here was that the model results also helped them to prioritize the dike inspections and directed them to those locations where improvements were urgently needed. This had little priority initially, but appeared essential for undertaking the precautionary dike improvements using sand bags in order to protect the most hazardous areas.

In addition, a lot of international companies were provided with valuable information to support the right measures to be taken. Using the model, a good indication of the flood extent and the water depth was provided to them. With this information, businesses could take appropriate steps at the right time. This also prevented a lot of economic damage.

Finally the sound forecasts produced by the SOBEK flood model made it possible to provide better information for the public. The communication with the media was streamlined and reliable consistent messages were sent out. That made it possible for the people in Thailand to take preparatory action.

This all resulted that the flood, although still devastating became better manageable as the risk of flooding was reduced at various places and delayed in others.

Such events are not exceptional for Thailand. There are many regions where comparable conditions appear and where such floods can occur with equally devastating results. And the trend is that this will become more common in the near future. The Thai event has (again) attracted considerable attention to the risk of flooding by large internationally operating institutions such as investors, international financing organisations such as the World Bank and re-insurance companies but also by emergency organisations such as the international Red Cross. Their questions to the research community are to provide better forecasts having longer lead times to have more preparation time before the crisis. Likewisethey ask the research community to provide assessments of the (changes in) risks in these areas as these are of considerable importance for any decision making on investments

What did Bangkok Mean for us?

Research directed at the improvement of medium-range (5-14 days ahead) large scale weather and discharge forecasting is one of the developments that will enable a more timely response on extreme flood events. Over the last 15 years this research has substantially improved our potential forecasting ability. The results of this type of research are regularly presented before scientific audiences. Being an intermediary between the scientific world and the "real" world and because we have set up many forecasting systems all over the world, we discuss these developments with our clients during the annual international DELFT-FEWS user-meetings.

Based on our experiences in Bangkok we realised that advice for the crisis management during such events could be improved a lot by having rapid assessment tools available that can provide a very quick first order estimate of the things to come during a flood in areas where sophisticated forecasting models are not at hand. Needed for this is also a very large data base that can be used to feed such rapid assessment tools.

Therefore we have started, next to our forecasting research a new research and development line together with the VU University of Amsterdam, the Utrecht University, the Netherlands Environmental Assessment Agency and the TU Delft –which is involved in the e-watercycle http://www.ewatercycle.org/. This R&D line is directed on the one hand at mapping of global flood risk (so not limited to only the flood hazard!) and on the other to develop tools that enable a rapid assessment of the real-time extent and evolution of floods with more local detail in regions where the accessibility to data is poor. In these tools, we want to enable the user to interact with the simulations so that the effect of large scale interventions, such as emergency inundation areas or temporary levee strengthening can be assessed. Internationally we cooperate in networks that include the large financing bodies, such as the World Bank and Re-insurance companies such as Willis Re, AON and Munich Re, NGO's such as the World Resources Institute and the International Red Cross. We also collaborate with a number of other research centres that are undertaking comparable research such as the Joint Research Centre in Ispra, the Dartmouth Flood Observatory of the University of Colorado and the European Centre for Medium-Range Weather Forecasts. Our policy is the one of ***Dare to Share*** so as soon as we have the results ready we put these on the Internet. Also the models that are being developed will be 'Open Source'.

The first results of this research have been published in the scientific literature. We are now able to compute high resolution flood hazard for the entire globe by a combination of existing global hydrological and hydraulic models of the Utrecht University and a new inundation downscaling algorithm. This algorithm was applied for Bangladesh as a first case study application area where we demonstrated the risk assessment approach in Bangladesh based on GDP per capita data, population, and land use maps for 2010 and 2050. Current work is focussing on first global application of the method and will be published shortly. In future work, we will investigate globally how our flood risk will change due to population growth, economic growth and climate change and we will analyze how much additional flood protection can be justified globally, given the cost-benefit ratio of flood protection and avoided losses.

We have prepared a first prototype of a rapid flood assessment tool. This tool can build a hydraulic model from publicly available data sources from the internet in a very short amount of time. A very important aspect to include is obstructions due to e.g. elevated roads. We use OpenStreetMaps to include such information in areas where data is sparse. We did a deep dive in Thailand and tested whether such a rapid flood model could simulate the real flood extent and evolution.

All work is strongly directed at validation of the results. To this end, we establish close links with the Dartmouth Flood Observatory of the University of Colorado, who prepare near real-time flood maps. The Dartmouth Flood Observatory provides us with satellite-based time series of flood event extents, which we compare with our model results for validation. This was also done over our first case study in Bangladesh and the real-time case study in Thailand. We also continuously validate the resulting impacts by comparison with estimates of reported damages and affected people.

The Bangkok event convinced us that the results of this type of R&D, both data and tools can make the difference in flood risk management in the years to come. Therefore we will continue with this research and expect to provide within due time a global assessment of flood risk, meaning hazard and consequences, on such a high spatial resolution that the information will be valuable for both crisis management as well as for decisions on investments.

References

H. C. Winsemius, L. P. H. Van Beek, B. Jongman, P. J. Ward, and A. Bouwman. A framework for global river flood risk assessments, 2013, Hydrol. Earth Syst. Sci., 17, 1871-1892.

For more readinghttp://www.hydrol-earth-syst-sci.net/17/1871/2013/hess-17-1871-2013.html

CLIMATE CHANGE SPECIAL

THE NEED FOR A WATER/ENERGY SYNERGY IN A THIRSTY WORLD

BY JOSE LUIS GONZALEZ VALLVE

We are beginning to be part of a "thirsty world", reaching the point where water, or more precisely the lack of water, is becoming rapidly and unfortunately one of the key strategic factors.

Our planet contains approximately 1400 million km^3 of water, out of which only 2.5% is freshwater, the remaining 97.5% being in the oceans. That scarce 2.5% of freshwater is distributed: 68.7% as ice and snow in cold areas, 30.8% as ground water, 0.8% as permafrost and only 0.4% is in the atmosphere and surface of the Earth.

Out of that very scarce 0.4%, 67.4% is contained in lakes, 12.2% in soil, 9.5% in the atmosphere, 8.5% in humid areas, 8% in plants and animals and only 1.6% in rivers and surface currents. In other words: the total amount of potentially available water in the surface and rivers is approximately 6440 km^3.

There is not much consensus about global data regarding human water consumption, and the complexity of the calculations involved increases when novel concepts like Water Footprint and Virtual Water are taken into consideration. The figure that seems to be more agreed on by different international organisms is approximately 4500 km^3/year, which, obviously, is a reference to "water withdrawal" of the accessible water resources: 3100 km^3 in agriculture, 800 km^3 for the industry and 600 km^3 for domestic and municipal consumption.

If the actual trends of consumption and population growth continue, in the year 2030 we will need 2800 Km^3 of additional water than the water we are using today; this would imply a 40% deficit. The possibility of a significant increase of the available water resources does not seem an option, except for the desalination plans, where energy is a key issue. This highlights once again the appropriateness of the water energy nexus, or the concept of efficiency, which points in the same direction: the pressing need to rationalize and economize our water consumption. Spared water is

> **"the total amount of potentially available water in the surface and rivers is approximately 6440 km^3"**

probably the best water source. There is no such thing as "synthetic water" that can be transformed artificially and affordably. Water scarcity is clearly the most worrying constriction, even more than energy or food, (furthermore being water the main input of these two)

The development of concepts like Virtual Water, adopted in the 90s, which reflect the volume of freshwater used for the production of a good or service (a humble pepper needing more than 70 liters), and Water Footprint, an indicator of the direct or indirect water consumption for a product process or group of products or consumers (the Water Footprint of the livestock sector has been estimated at around 30000 hm^3) have contributed to establish a new perspective for water management and movement. Currently 1300 million people do not have access to water and 2400 million do not have access to sanitation. It estimates 1700 million live in drought risk areas, which involves a risk up to 22% of the worlds GDP, and by 2050 the population under risk could reach 52%, implying a GDP loss of 45%.

A global collapse seems more likely to be caused by the lack of water than by excessive heat. In other words, the importance and concern of the effects of a possible climate change is not anymore a rise in temperature, but the lack of water, although those are two sides of the same coin. Therefore It seems that before dying due to heat (CO_2), we will die first of thirst.

The Spanish Water Miracle

I would like to start this brief reflection about what I believe can be quite rightly named "The

Spanish model : good governance

- Multiplies by 10 its population in summer
- Mixed water sources: transferred, desalinization, groundwater and reutilization

BENIDORM 1960

BENIDORM, SIGLO XXI

Jose Luis Gonzalez Vallve is the Chief Executive Officer of AGA - the Spanish Association of Water Supply Companies. He has been Regional Minister of "Fomento", and Industry, Trade and Tourism and Employment, Regional Government of Castilla y Leon, Spain; Head of The Representation of European Commission in Spain, (diplomatic status), President of Tecniberia: The Spanish Association of Engineering Firms and President of Council of Foreign Promotion of CEOE: Confederation of Employers and Industries of Spain.

Spanish Water Miracle" with the memory of a "Saharawi" girl who, just after spending the summer with an Spanish foster family, was returning back home to the Algerian desert. She was asked in front of the camera: "What would you take back from Spain back home", to what she replied without hesitation: "I..I would bring a tap"

And that is why every time we open a tap and have a splendid flow of running water, suitable for drinking, of good quality and costing less than 0.015€ per liter (a thousandth part of bottled water), we should still be astonished at the miracle that brings water to our home. Even in a developed society like the Spanish, surveys carried out among households about the most valuable invention still rank as number 1 the humble washing machine (unfeasible without running water), ahead of the automobile or telephone.

Direct water consumption in Spain is approximately 40000 hm^3/year, that is, 0.88% of the world total. Our population represents 0.65%, so, proportionally, we use a 35% more than our share as a global average. In terms of GDP, being the global GDP $78 *1012 and ours $1.4 *1012 (representing 1.77%), we can conclude that regardless of Water Footprint or Virtual Water considerations, hydraulically our economic and productive system is twice as efficient as the world average.

Furthermore, used water in Spain, is carefully guided to a wastewater treatment plant where it is treated, to the point where a good portion of that water (13%-15%) can be reused for irrigation or other non consumption uses, and in any case is returned to the river or sea in good conditions and with no harm to the environment. That is an even bigger miracle, as globally 2,500 million people do not have access to sanitation, causing disease and poverty. Some of the proud BRICS: Brazil, Russia, India, China or South Africa, that overwhelm us with astonishing figures of economic growth, have not yet managed to provide sanitation to millions of its citizens, who still have to relieve themselves in the street.

Seen from the sky, Spain is a yellow- brown country, not green like most of our partners from the European Union or many other countries, with scarce and irregular precipitation, and that is why we believe we can proudly talk about the Spanish Water Miracle, the miracle that our brown-yellow country supplies water with quality, quantity and at a reasonable price, better than in most other green countries worldwide.

The Spanish Water Miracle can be understood if we consider for example the hypothetical demands of inhabitants of central and northern Europe cities of green countries, and requested their Councils 3000 hours of sun a year, like we have in Spain. Logically, that demand would be impossible to meet.

On the other hand, the achievement of supplying 300 L of cheap, good quality water per person/day to inhabitants of very dry cities in southern Spain, as the inhabitants of green countries have, is a miracle happening every day.

The miracle stretches even more if we consider the 60 million tourists who visit our yellow-brown country yearly, to whom we serve "good, nice and cheap" water (Benidorm is a good example).

We never had it easy, but we have been able to make a virtue out of need. Spain without infrastructure would make use of only an 8% of rainwater (scarce and irregular). With 1500 dams and other constructions, we are the third country in the world with more dams, which allows us to make use of 40% of rainwater. "Green" countries of central Europe are luckier in this regard, as they can directly use 40% of rainwater without having to build dams or hydraulic works. It is well known when one lives on those countries: in cities where water is simply caught from the "phreatic" stratus and taken easily home, charging three times more than in Spain. (see: WEF Ranking)

And now to fully complete the miracle, a new sophisticated technology like water desalination, is implemented in Spain, which provides water to more than 8 million people, and once again, turning necessity into a virtue, we have reached leadership positions in this technique, still emerging and with enormous potential to improve.

But the good work and expertise of the Spanish sector and the public awareness', is driven by historical reasons. Roman aqueducts, Arab

Factors of competitiveness (Word Economic Forum)

GLOBAL COMPETITIVENESS INDEX

	RANK (OUT OF 139)	SCORE (1 TO 7)
GCI 2011-2012	36	4.6
Basic Requirements	36	5.11
1st pillar: Institutions	48	4.25
2nd pillar: **INFRASTRUCTURE**	**10**	**5.92**
3rd pillar: Macroeconomic environment	104	4.17
4th pillar: Health and primary education	36	6.09

The report highlights Spanish Infrastructures as one of its strengths

SPAIN RANKS 10th POSITION

Spain make a good use of EU founds, specially on water infrastructure. It was common knowledge in the European Union that 1€ injected in the Spanish public works management system were ninety-many cents invested in water supply or a water treatment plant.

channels or Levantine Courts, where conflicts are settled without needing lawyers or attorneys, are good examples of the long standing Spanish Water Miracle. Probably for the mentioned reasons, Spanish companies manage water in more than 200 cities worldwide and supply water every day to millions of people outside our borders, exporting the Spanish Water Miracle and promoting job creation and wealth.

Spanish companies employ more than 20,000 workers, and supply water 24 hours a day, every day, 365 days a year to more than 40 million people in Spain and 100 millions outside Spain, at a cost that in Spain sums up to an average of 0,67% of the annual family budget. To contextualize the figure, the percentage of the family budget dedicated to telephone rises to more than 3%.

Our country has always managed water efficiently, and that is why we understand it is totally legitimate to talk about the Spanish Water Miracle.

The Need of a Joint Approach for Water and Energy Systems

It can be stated, using "topological" language, water and energy sets present a major intersection, whose quantification is precisely one of the issues being discussed.

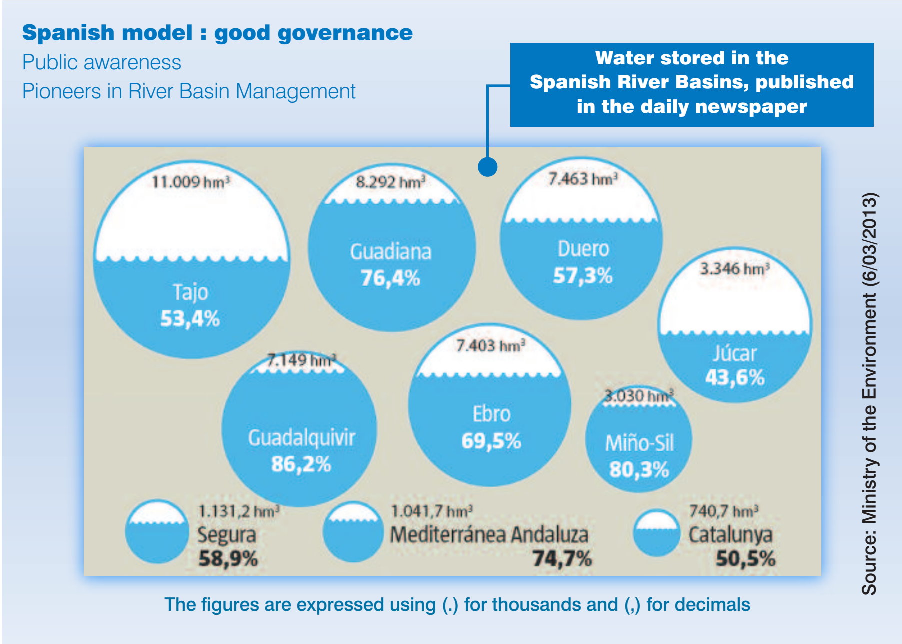
The joint tackling of water and energy emerges not only as a mere logical recommendation, but as a practical duty, given the number of common elements or intersections. Both are:

- essential elements for life quality as the economic productive system and the lack of those pose strong constrictions.
- strategic factors with high conflict potential
- key elements of productivity and economic competitiveness
- systems that require high investment in infrastructure and maintenance, high level of technical expertise and high management capacity
- systems where responsibility is very clear and public
- essential elements for the consumer

Water Uses Energy and Viceversa

Water produces energy and viceversa. There are even existing technologies that make use of peak loads with small turbines inside pipes to generate electricity. Water is, up to the date, the best energy store. Many, if not all, of the water/energy infrastructures are qualified as critical infrastructures for security purposes.

The development and application of Information and Communications Technologies (ICT) presents great potential and synergies in both fields. There is a strong correlation between energy consumption of the water systems and arrangement, from gravity of the pumping system, to desalinated water. A similar phenomena happens with water consumption: as the production of new forms of energy emerges, so does the need for water. As for example, new methods of hydrocarbon exploitation through "fracking" for the extraction of shale gas and tight gas.



The figures are expressed using (.) for thousands and (,) for decimals

> **"Water is, up to the date, the best energy store"**

As it has already been stated, for several "historical" reasons, one of which could be the different administrative ownership, up to the date both water and energy have been treated as unrelated systems, which is highlighted, for example, when attempting to know the energy consumption of water system in Spain.

The figures span between 6% and 10% of the final energy demand.

Irrigation farmers claim they have gained in efficiency and currently only use 2% of the electric demand. In California we are told management of water systems uses 19% of the electric demand. Unit consumption in water: treated, distribution, sanitation and purification, present great variation, from 0 to 4.65 Kw/m³ of water, but can reach more than 50kw/m³ for domestic use. There are many unanswered questions: for example: ¿Are household appliances or household meters included in energy consumption of water?

Experts review the possible energy savings of the water system between 5-20%, while the water consumption to produce energy can be up to 15% of the total water demand.

It can be deduced from the latter the enormous appropriateness of programs or projects aimed at the improvement of joint efficiency.

New thermal-solar technologies can reduce water use by 80%

Experts in oil refining claim they can improve the hydraulic efficiency of their plants reducing consumption up to 20%.

Experts in hydroelectric energy tell us:

- there is still a potential of around 5000Mw in Spain, with around 300 public damns that are not being actually exploited
- pumping potential for reversibility of falling water is almost infinite and plants close to the coast for pumping sea water are being considered
- the improvement of small elements like impellers in turbines can increase the production of energy up to 20%.

To conclude, we get back to the first heading: water and energy have been two systems traditionally unrelated, except for hydroelectricity, out of which we currently perceive that, out of pure simple logic and from a practical point of view, it is very convenient (if not essential) a joint approach.

THE UK'S FIRST CLIMATE CHANGE RISK ASSESSMENT AND BEYOND

BY ELEANOR HALL

Eleanor Hall **is an environmental scientist at HR Wallingford. She was lead author on the Natural Environment themed chapter in the Climate Change Risk Assessment's main evidence report. Eleanor's background is in biology and nature conservation. She attended Cardiff University then Oxford University, where she earned a Masters in Biodiversity, Conservation and Management.**

The Climate Change Act 2008 required the UK Government to undertake an assessment of the risks to the UK posed by climate change and to develop an adaptation plan to help the UK cope with the consequences. Today, the UK is vulnerable to extreme weather, including severe winters, heatwaves, floods, storms and gales and it is thought that this will continue into the later part of this century, with extreme events becoming more common and severe. The CCRA identified increased frequency of floods and increased pressure on water resources as two of the most significant climate related risks facing the UK, both now and in the future. Work has since turned to understanding how we may be able to monitor such risks to improve our preparedness for climate change.

The Climate Change Act 2008 made the UK the first country in the world to have a legally binding long-term framework to cut greenhouse gas emissions and build the UK's ability to adapt to a changing climate. The Act required the UK Government to undertake a nation-wide assessment of the risks posed by climate change and to put in place a National Adaptation Programme (NAP). To develop the NAP for England, the highest order risks from the CCRA were taken and working in partnership with businesses, local government and other organisations; objectives, policies and proposals have been devised to address them. The NAP for England, published in July 2013, describes what the government considers the most urgent areas for action. There are also NAPs for devolved matters, undertaken by the respective governments of Wales, Scotland and Northern Ireland. The Climate Change Risk Assessment (CCRA) and NAP must be repeated every five years under the scrutiny of the Adaptation Sub-Committee (ASC), an independent, statutory body also established under the Act. In addition to their advisory role, the ASC reports on the progress that the UK Government is making in reducing greenhouse gas emissions and preparing for climate change.

In January 2012, the first CCRA was laid before Parliament.

Figure 1 High level overview of the CCRA methodology

The UK's first Climate Change Risk Assessment

The CCRA identified and assessed the main risks and opportunities in the UK from climate change. It provided an overview and assessment of the scale and nature of these risks for 11 sectors (see Figure 1) and enabled comparison between them.

The CCRA also provided information on limitations in our current knowledge such as with regard to:

- Future greenhouse gas emissions: The future trajectory of emissions is uncertain. The range of projections used by the CCRA indicates the spread of possible outcomes but unfortunately it is not currently possible to ascertain which scenario is most likely.
- Climate change projections: For example, UKCP09 provides information on changes in thirty year means of variables such as temperature or precipitation. However, many risks may be more sensitive to year-to-year variability, extremes or variables such as wind. These were less well represented by UKCP09.
- Socio-economic change projections: The application of bespoke socio-economic projections was regarded as too great a task for the first CCRA. There were also methodological issues with respect to how climate and socio-economic scenario are combined.
- International dimensions: The CCRA was restricted to reviewing domestic impacts from

climate change only. However, there is the potential for climate change impacts that occur overseas to influence the UK significantly. More evidence is required on these if they are to be considered for future CCRAs.

The methodology was designed specifically for the requirements of the first CCRA. A high level overview of the approach is shown in Figure 1.

The "herculean" task of synthesising and reporting on the many risks identified by the CCRA can be found in the main evidence report that was laid before Parliament. This is supported by the detailed assessments for each of the 11 sectors and a number of articles that summarise the finding for different audiences. All these reports and more can be found at http://ccra.hrwallingford.com.

Overall, the CCRA findings indicate that the weather-related risks that the UK currently suffers from are likely to continue into the future and in a many cases, the frequency and severity of these risks are likely to worsen. The assessment of risk in the CCRA assumes that in the future no new action is taken in response to risks i.e. adaptation actions are not included. For example, flood risk is projected to increase significantly across the UK, affecting people's homes and well-being, the operation of businesses and critical infrastructure systems. The CCRA analysis assumed that there are no changes in the existing flood and coastal erosion risk management measures.

"Annual damage to UK properties due to flooding from rivers and the sea currently totals around £1.3 billion. For England and Wales alone, the figure is projected to rise to between £2.1 billion and £12 billion by the 2080s, based on future population growth and if no adaptive action is taken." CCRA Summary report, 2012

Water resources are projected to come under increased pressure as a result of climate-driven changes in hydrological conditions as well as population growth.

"By the 2050s, between 27 million and 59 million people in the UK may be living in areas affected by water supply-demand deficits (based on existing population levels). Adaptation action will be needed to increase water efficiency across all sectors and decrease levels of water abstraction in the summer months." CCRA Summary report, 2012

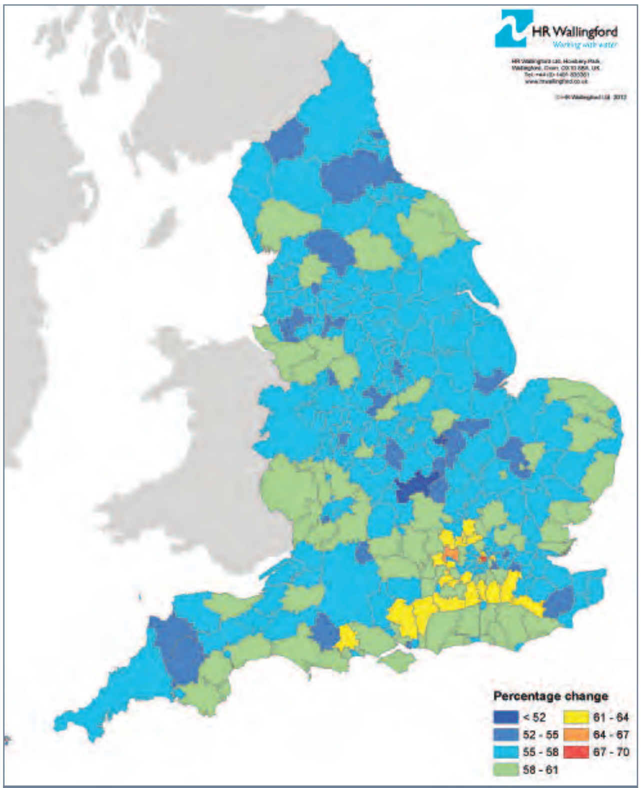


Figure 2 Percentage change of impermeable surfaces in urban gardens between 2001 and 2011.

Beyond the CCRA: Flooding

Since the CCRA, floods analysis has been undertaken for England on behalf of the ASC, using indicators to monitor change in exposure to flood risk and progress in adaptation. The objective was to provide more detailed information on specific aspects of flood risk that are of particular concern to Government. Indicators of change have been developed and spatially evaluated using information recorded in 2001, 2008 and 2011.

Approximately 8% of all properties in England lie within the fluvial or coastal floodplain. Whilst the overall growth in national property numbers between 2001 and 2011 was about 7.3%, growth in the floodplain was higher, at around 12%. Currently, one in five properties built in the floodplain are in areas of significant likelihood of flooding (1.3% or 1 in 75 years). Results indicate that climate change could almost double the number of properties at significant likelihood of flooding by 2035 unless additional action is taken. Some of the highest increases in property numbers have occurred in areas that are currently well defended against flooding, including areas of London and the fenlands. A similar picture is true for properties in areas prone to coastal erosion. As highlighted by the ASC, given a changing climate, this approach to development will leave a legacy of rising costs of flood protection. In some cases, this may outweigh the benefits of the developments.

It is estimated that around 2.3% of all properties are at risk of surface water flooding (with a depth of 30cm or more, for a rainfall event with an annual probability of 0.5%). The number of properties at risk is estimated to be increasing at around 6% per year. Compounding this problem, analysis indicated that there has also been a large increase in the area of impermeable surfaces in urban domestic gardens between 2001 and 2011, by between 50% and 70% across the country (see Figure 2).

Unfortunately, awareness of flooding and associated protection schemes is still relatively low. Installation of property level resistance and resilience measures is increasing slowly, from nearly 300 installations in 2009 to 350 in 2010. However, this isn't fast enough to reach the 200,00-330,000 properties that could benefit from the measures within the next 25 years. In 2012, the percentage of properties registered with the Environment Agency Flood Warning Direct services accounts for only 23% of those within the natural floodplain in England. It is thought that the majority of those registered will be properties in the significant or moderate bands for likelihood of flooding. Unfortunately, there are also built-up areas in floodplains where uptake is particularly poor. In areas of Hull, London and Newcastle-upon-Tyne, registration is below 20% and may leave these properties and their populations particularly vulnerable, now and in the future.

Beyond the CCRA: Water resources

Climate change and the other stressors that affect water resources have been key components of UK water resource planning for well over a decade. The latest sets of water company Water Resources Management Plans (WRMP), being prepared for 2014, will include detailed analysis of the risks to river flows and groundwater levels from climate change.

Recent post-CCRA work has explored alternative methods for using the UK Climate Projections 2009 (UKCP09) to inform water resources planning. This work has identified resources planning. This work has identified ways of projecting future climate change, using information from UKCP09, without requiring a vast amount of computing power. These latest projections are able to capture a much wider range of uncertainties associated with future changes in variables such as rainfall, temperature and potential evapotranspiration. The improved modelling approach can be used to consider future water availability, reforms to the abstraction licencing systems and the management of reservoirs within the context of climate change. Whilst the final results of the analyses for the next WRMPs are yet to be released, they are most likely to indicate a reduction in water resources available for public supply in the future. This, coupled with population increases in areas that currently have no 'spare' freshwater resources means that significant actions are required to secure water supplies and protect the water environment in the future.

Water companies are likely to continue with the 'twin track' approach of reducing demand and exploring new supply schemes. Greater use of supply scheme measures such as effluent recycling and desalination may become necessary, but they will also challenge recent progress in reducing water company greenhouse gas emissions and ultimately, the additional costs may get passed to the consumers.

The CCRA highlighted the risks of water shortages to policy makers and the UK Government has recognised that the current trajectory of water exploitation is not sustainable, particularly in the context of European environmental legislation; the Habitats Directive and the Water Framework Directive (WFD) aim to protect water bodies from such activities that may lead to environmental degradation. There is an on-going programme of research exploring abstraction reform and water trading options, including new forms of licensing and price structures to ensure sustainable abstraction while meeting public water supply and supply for other uses e.g. crop irrigation.

There are a wide range of tools and approaches developed for the assessment of climate change impacts on water resources in the UK that can readily be adapted to other sectors, industries and countries. In some countries, climate models disagree on seasonal changes in precipitation. This can lead to uncertainty related to the direction, magnitude and pace of change in the hydrological cycle due to climate change. Despite this, these countries could still benefit from adopting similar approaches to the UK for water resources planning that include consideration of climate change and socio-economic projections. This has started at a policy level, for example with initiatives developed on Water Security and Climate Resilient Development for the African Ministers Council on Water.

References

ASC (2012) Climate change – is the UK preparing for flooding and water scarcity? Committee on Climate Change, London. http://www.theccc.org.uk/
Climate Change Risk Assessment (2012) http://ccra.hrwallingford.com
Water Security and Climate Resilient Development (2012) http://www.gwp.org/About-GWP/Publications/WACDEP-Publications/
HR Wallingford (2012) Development of spatial indicators to monitor changes in exposure and vulnerability to flooding and the uptake of adaptation actions to manage flood risk in England: Results Report. http://www.theccc.org.uk/
HM Government (2013) The National Adaptation Programme – Making the country resilient to a changing climate, www.gov.uk/defra

NEW ECOSYSTEMIC AND COMPLEX PEDAGOGY FOR WATER SUSTAINABILITY

BY EMILIO A. MESSINA G.

This article analyzes the state of the global, regional and national environment and acknowledges an environmental crisis expressed in environmental degradation. It also proposes that this crisis is the result of the mechanistic paradigm of science, whose positivist educational model has been insufficient in changing patterns of production and consumption that degrade natural elements.

Emilio Messina is Coordinatior of Institutional Affairs and Projects of the Environmental Division of the Panama Canal Authority. He holds a degree in Sociology and a Phd in Public Health. With more of twenty years of experience in the Public Sector, he has been involved in several international initiatives led by the UN and UNESCO and has advised some Ministers.
He has recently published the book "Pedagogic Dialog with Nature: the Education that will save the Planet"

Due to this insufficiency, it is inferred that the environmental crisis is generated by the absence of an approach to manage knowledge in an integrated way, thus producing ecological illiteracy. Ecological illiteracy is defined as the inability of humans to work within the limits of nature, and the expression of the exhaustion of the empirical-analytical paradigm, which promotes linear conceptions of the world. In contrast, we develop an alternative paradigm from the concepts of environmental complexity and ecosystem philosophy, on which the conceptual basis of an ecosystemic education model and a complex hermeneutic court are designed. This model allows for the advancement of knowledge by identifying that the thoughts and values of the complex ecosystem paradigm cannot address the environmental crisis, as long as they are based on the positivist pedagogical models that are reductionist and fragmented; on the other hand, hermeneutic pedagogy is the platform from which it is possible to implement both the thoughts and values of the complex ecosystem paradigm. This new pedagogy will allow us to address the environmental crisis in which humanity is immersed.

Marked by new situations and problems, the world is torn between complex, integrative approaches and factual, demonstrative, and linear philosophies, stating that all cognitive approaches that emphasize the former are con-sidered mechanistic, and those which place their emphasis on the latter are considered holistic.

The environmental crisis is the product of the lack of, or insufficiency of, environmental management, which has been called *ecological illiteracy*.[1] It is an expression of the exhaustion of an empirical-analytical paradigm that promotes mechanistic and linear conceptions of the world and, furthermore, claims to be part of the problem and the solution at the same time. This imposition as the dominant paradigm has left out alternative paradigms that have the ability to explain, understand, and promote values beyond pure quantification, measurement and verification, such as the ecosystemic-complex, the historical-hermeneutic, and the critical-social one.

This world view is based on assertive values and individual and expansionist ways of thinking. These values and philosophies have the ability to permeate the vision of human development which is based on concepts of economic growth that glorify unsustainable production and consumption models. Evidence of this appears in the so-called ecological footprint indicator, which identifies a depletion and overexploitation of the planet by 30% above its regenerative capacity. This is an expression of conflicting objectives for sustainable human development that strive to create harmony among economic growth, social equality and environmental sustainability.

We understand that only through an interdisciplinary approach can we understand the essence which is not directly perceivable. A bias for the mechanical view of the world exists in this perspective; a bias that separates, isolates, and relegates the latticework of which the multiple dimensions of life are constituted, and is described in the narrative of this work under a concept we call ecosystemic. Thus, we are bounded by the fact that ecosystems contain transforming messages about the duties of human societies, which can teach us exemplary lessons on communication, information sharing, limits, flexibility, adaptation, and organization. Thus, ecosystems can be considered natural schools that teach us integral and conservationist values, incorporating both quality and cooperation, all of which are absent in human systems.

On the contrary, in human societies, we find the antithesis of these natural schools of thought is expressed in a modern rationale that incorporates elements of nature within a perverse logic that objects and exploits it beyond limits, and in addition, uses nature as a dumping ground for waste generated by this exploitation process. This view produces an increasing depletion of the earth's bio-capacity, where the form of socially organized work promotes production and consumption patterns that require an intensive use of natural elements and, therefore, is unsustainable. This rationalization of nature means that green is better represented in paper money than in the ecosystem. In this regard, Worster (2004) argued that:

> *"Whoever decided that dollar bills should be green had the right instinct. There is a deep, yet easily ignored, connection between the green money in our pocket and the green earth… Somewhere within the dollar bill there is a warning that what you have in your hand is part of a limited land and must be treated with respect." (p.109).*

What Worster denotes is simply the expression of the ecosystemic crisis that produces what we call ecological illiteracy. This classification requires us to promptly address the negative values of productive rationality and consumption patterns that promote individualism and a relationship against, instead of with, nature. When Hardin (1968), wrote The Tragedy of the Commons, about the freedom and responsibility of people using goods that belong to all, he defined the main dilemma as a situation in which several individuals, motivated only by personal interest and acting independently but rationally, end up destroying a limited, shared resource, the common good. It is as saying: "If I do not do it, someone else will."

According to the positivist view, all the philosophical and scientific activities must be carried out only in the context of analysis with facts verified by experience. These positivist and neo-positivist conceptions are characterized by a quantitative, historical, and fragmented knowledge, thus blurring the vital human process. In order for a condition to be called knowledge it must be susceptible to measurement, quantification, and verification; otherwise, it will be excluded and marginalized.

The empirical-analytical paradigm and its reductionist pedagogy are in crisis. As one of the paradigms of factual sciences today, we recognize their contributions to welfare and human progress. However, evidence reveals its inability to stop the profound imbalances in natural and social systems. With this we cannot ignore the contribution of science to the idea of human progress, but we can agree that instrumental reason and technology distort and dehumanize, with man being the perpetrator and victim at the same time.

From this distorted idea of progress, under which knowledge can be used in various forms, when referring to the use of atomic energy and the start of the so-called *Ecological Era*, Worster (2004) states that the absurdity of the contributions of the science paradigm are unveiled in this quote:

> *"When that first nuclear fission bomb exploded and the color of the sky at dawn abruptly changed from pale blue to reaper white, physicist and project leader Robert Oppenheimer first felt a heightened reverence, which then gave way to a bleak phrase from the Bhagavad-Gita: I have become death" (p.7).*

A common misconception is that it is not possible to continue to think within the same paradigm that promotes breakdown, while at the same time, proposing solutions that do not alter the established order. Its assertive, rational, analytical, reductionist, and linear thought, has resulted in values that we have socially accepted through culture, with its consequent expansion in competitive, quantitative, and domination practices. Thus, the environmental crisis, which is also a crisis of perception and values (Capra, 1998, p. 26), is the result of a reading of the world that moves at a different pace than our reductionist technical-scientific possibilities, and runs under an expansive, rational, and instrumental vision of life (deep ecology).

Environmental sustainability requires incorporating new conceptual basis in order to develop a pedagogical model that allows educating for life and not for the mechanical reproduction of the world. It is a commitment to serving the most sublime of human aspirations: to reunite nature and neighbor. We are committed to the transformation of a pedagogy that allows the assertive, expansionist, and linear vision of the world and the life within it. We are committed to strive for an integrated, conservationist, cooperative, associative, and qualitative pedagogy that permits us to reverse the intensity of ecological damage and to ensure the needs of those who walk the world of tomorrow.

Finally, we observe that complexity points to fully totalizing and worldly holistic considera-

Table 2 The new alternative paradigm and integrated management approaches in tackling complex problems.

Problem	Contributions from the alternative paradigm	Integrated Management	Results
Crisis of the paradigm of science that promotes values of modernity of the assertive type and produces ecological illiteracy, which promotes degradation of the elements of nature and environmental unsustainability	Principles of ecology Ecological interdependence (networks) The cyclical nature of ecological processes (recycling) Cooperation (partnership rather than competition) Flexibility (networks fluctuating and flexible to changing environmental conditions) Diversity (allows adaptation to changing environmental conditions) **The ecological inter-dependence** **Economic system:** Relationships with: agriculture, industries, trade, transport, energy, communications, fishing **Social system:** Relationships with: education, employment, housing, recreation, community participation, security, trust, freedom, peace, etc. **Environmental system:** Relationships with: biodiversity, climate, air, water, natural vegetation, land, seas. **Hermeneutics:** Man as a historical and contextual subject	Complexity of the ecosystem approach which supports (i) integrated knowledge management; (ii) integrated management of the territory; (iii) management of production systems and human development, and (iv) integrated management of public policy	Harmonization of the conflicting objectives of sustainable development Control of the driving forces that produce environmental unsustainability Improvement of ecological illiteracy

Source: Messina, Emilio. (2011) Panama.

tions, this being the key to the pedagogical model, while hermeneutics offers an educational platform to convey, express, and communicate such complexity. It also provides a look beyond quantitative models, which gives us the ability to place the subject in other positions from its experience and the experience of others. The dimensions of the subject: the corporeal, emotional, intellectual, and experiential, coincide with the comprehensive vision of human development and its multiple dimensions that are also addressed in the thematic content of the study (see Fig. 1).

As stated, we conclude that the environmental crisis is not a natural crisis, but rather, an ecosystemic crisis, and can only be understood as socially and historically determined, i.e., ecosystems today are the result of interactions of the past.

"A democratic, educated and fair society can only be sustainable if it is prosperous"

The mechanistic paradigm of science and its pedagogical model are insufficient to limit environmental degradation, ecological footprints, and ecological illiteracy. One cannot continue seeking solutions within the same paradigm that produces the consubstantiation problem between pedagogy and science. Alternative models can be built with contributions from ecology, complex thinking, and hermeneutics, which reveal both the instability of the paradigm of science and the ecosystemic principles and relationships in human systems. Due to this contribution we are able to rethink the problem in its complexity and interrelatedness, and thus propose innovative solutions to complex problems.

The conceptual basis for the design of an ecosystemic pedagogical model and a complex hermeneutical court are the starting points for the transformation required by the global system, the country and the region, and these are the basis for the sustainability of water.

The expression of ecological illiteracy is directly proportional to the crisis of the paradigm: higher illiteracy leads to increased degradation of natural elements. Its tangible empirical context allows us to ask: How much water is needed to sustain current rates of production and consumption? In this sense, a study published in 2010 by researchers from the National Geographic Society promoted some indicators in the context of the submission of water to the productive rationality, and made a warnings about the insufficiency of water by 2050. The indicator called virtual water (Hoekstra, 2002) facilitates the calculation of the water footprint (Aldaya, 2008). From our conceptual approach this reveals that water over-use is also permeated by values that support the idea of "common good", reducing water to just another input in the business chain, whose marginal value is set to a pure market relationship, due to its capacity to generate wealth and prosperity, but not welfare. We find that to produce a kilogram of beef requires 15,947 liters of water; a derived product such as a kilogram of sausage requires 11,535 liters; whereas to produce a kilogram of corn requires 909 liters of water. Green markets, without a holistic and integrative axiological conception, represent a threat to water sustainability, if the society continues to think within the paradigm that generates the problem.

The above stated advises society on the need of a new pedagogy that builds on the water axis around which life is sustained. This poses a problem to solve: to construct a new society, through the promotion of natural and human resources; a new society in which we emphasize water as the natural integrating element (See Fig. 2). We must understand that our greatest assets are our own people, water, and ecosystem biodiversity, which are provided naturally, and that the key area of interaction between these resources consists of watersheds that define the natural structure of a territory. In this sense, a sustainable society must be created by its own citizens. Society must be educated to be democratic and can only be fully educated and democratic if it is equitable. A democratic, educated and fair society can only be sustainable if it is prosperous. Prosperity based on inequality is a sure route to environmental disaster.

1) Term coined by Dr. Rodrigo Tarté during discussions about the project: knowledge and health management, conducted by the ACP with the University of South Florida (USF) and the International Center for Sustainable Development (CIDES). 2010.

REFERENCES

Aldaya, Maite. (2008) Water footprint analysis for the Guadiana river basin. Papeles de Agua Virtual, No.3. Fundación Marcelino Botín, Universidad Complutense de Madrid (UCM) Departamento de Geodinámica, Spain.

Capra, Fritjof. La trama de la vida, una nueva perspectiva de los sistemas vivos.

Hardin, Garret. (1968) The Tragedy of Commons. In: Science, v. 162: 1243-1248.

Hoekstra, A.Y. (editor). (2002) Virtual water trade: Proceedings of the International Expert Meeting on Virtual Water Trade, IHE Delft, The Netherlands.

Worster, Donald. (2004) Transformaciones de la Tierra. Universidad de Panamá. Colección Agenda del Centenario. Instituto de Estudios Nacionales. Panamá.

NEW IAHR COUNCIL ELECTED FOR 2013-2015

"Thank you to all IAHR members who have voted in the recent council elections; the results were announced during the General Members Assembly on 13th September, on the last day of our highly successful World Congress in Chengdu, China. I would like to introduce to you the new council team which I will lead as President from 1st October to September 2015.

I especially wish to welcome the new Members of Council and our new Vice President - Arthur Mynett, head of the water science and engineering department at UNESCO-IHE the Netherlands. Arthur joins the Executive Committee and the association will benefit from his many years of industrial experience and his international contacts gained whilst working at Deltares (formerly Delft Hydraulics), as well as his current links through UNESCO-IHE in Delft. I also wish to welcome our new Council members, including Anton Schleiss of EPFL, Switzerland, and Silke Wieprecht of Stuttgart University, Germany.

Finally, I would like to express my sincere appreciation for the support and dedication that the outgoing members of Council, including Bruce Melville, New Zealand, and Massimo Greco, Italy, and, in particular, Vice President Jean Paul Chabard of EDF, France, have given IAHR over the past two years and more. Jean Paul has completed two terms as VP of four years, and has served a grand total of ten years as a council member.

A full report on the Chengdu Congress and the IAHR Council Meeting will be published in Issue 4 of Hydrolink!"

Roger Falconer; IAHR President

President
Roger Falconer
IAHR President, CH2M HILL Professor of Water Management, Director Hydro-environmental Research Centre, School of Engineering, Cardiff University, UK

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Jing Penng
Division of International Cooperation of the China Institute of Water Resources and Hydropower Research, China

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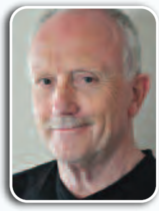
Professor of Hydraulic Engineering and Head of Water Science and Engineering Department at UNESCO-IHE Institute for Water Education, Delft, The Netherlands



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Director of the Maritime Experimentation Laboratory of the CEDEX "Centro de Estudios de Puertos y Costas"

IAHR COUNCIL 2013-2015

SECOND INTERNATIONAL WORKSHOP ON GEO-SYNTHETICS AND MODERN MATERIALS IN COASTAL PROTECTION AND RELATED APPLICATIONS

MARCH 2013, MADRAS, CHENNAI, INDIA

BY THE COORDINATORS OF THE WORKSHOP

The second workshop in a series was inaugurated by Prof. R. Ramesh, Director, National Centre for Sustainable Coastal Management, Ministry of Environment and Forests, Govt. Of India. The workshop had about 100 registered delegates, among whom, 3 from Mexico, 1 each from Sri lanka, USA, Belgium, Germany and 2 each from The Netherlands and Taiwan. The 26 lectures were delivered by 23 speakers. The proceedings were brought out in the form of printed proceedings covering all the 26 presentations.

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The workshop started with a lecture on an overview on Coastal erosion and protection as well as a number of case studies. This followed with presentations on the aspects of geo-synthetic products, their material characteristics like strength and durability, installation techniques and problems. The case studies on the design, installation and sustainability of geo-synthetic material mostly consisting of geo-tubes particularly in India, Mexico and Europe were presented that I am sure has given the delegates a good deal of exposure on the status of geosynthetic products in marine environment. The lectures covered, laboratory testing of materials as well as the protection measures, installation of geo-tubes in Mexico and India along with other products and a few papers were on numerical and stability of the protection measures. Apart from discussing the positive aspects of geo-synthetic products, the negative aspects such effects of UV rays as well as the effects on marine life were presented and discussed.

Recommendation of the workshop which needs further investigations:

A few of the specific recommendations of the workshop is listed below.

- Selection and specification of geo-synthetic properties for various applications (revetments, shore protection, breakwaters, geo-systems, etc.).
- Influence of fill-ratio on performance on design and performance of geo-systems is one of the most important parameters in dictating its effectiveness.
- Influence of fill material on performance (sand, mud, silt materials, clay, coarse materials, saturated, unsaturated, etc.). It is learnt that still there is considerable amount of work to be done.
- It is understood that the hydraulic interactions; reflection, transmission, permeability, roughness although quite clear still needs further input in refining the hydrodynamic behaviour of the geo-synthetic products.
- Scour prediction and protection
- Stimulating research in field of geo-systems which there has been wide experience in Mexico.
- Clear definition of applicability of woven and non-woven materials and proper guidelines still unclear and the accuracy of placement of geo-systems in the field is of paramount importance.
- Review of construction techniques (uniform pumping geo-tubes, anchoring, filling and releasing geo-containers-stacking units, etc.) as well as techniques for the removal of damaged units.
- Although the geo-systems as soft protection measures is found to be satisfactory on fulfilling all basic requirements, its cost effectiveness compared to conventional structures still needs more clarity.
- There need to more interaction between material manufacturing companies, consultants, research Institutes in carrying out research and systematic monitoring.

Future

It was decided during the that the 3rd workshop is proposed to be held 2015 in Merida, Mexico coordinated by Dr. Jaime ZALDÍVAR RAE (Coordinator for the Comprehensive Coastal Management program (Universidad Anáhuac Mayab; Mérida, Yucatán, México) and Mr. Enrique of Axis Engineering. Further, Prof. Amarjit Singh of University of Hawaii has expressed his interest in holding the fourth conference in Honolulu, Hawaii, USA in 2017.

PEOPLE & PLACES

New Chair and Vice Chair of the IAHR Industrial Flows and Energy Exchange Committee

Chair
Dr. Sofiane Benhamadouche
Expert Research Engineer at EDF R&D on Computational Fluid Dynamics and at LaMSID. Lecturer at Ecole des Ponts ParisTech and at Ecole des Ingénieurs de la Ville de Paris (EIVP). EDF R&D, Fluid Mechanics, Energy and Environment Department, France

Vice Chair
Dr. Chul-Hwa Song
Director and P.M. of the Thermal Hydraulics Safety Research Division
Korea Atomic Energy Research Institute (KAERI)
Daejeon, Korea

Philip Liu has been appointed ASCE Distinguished member

Philip Liu former chair of the IAHR Coastal and Maritime Hydraulics Technical Committee has been appointed a distinguished member of the ASCE.

A sad moment

Dr. Garry Tong (1945-2013)

Garry completed a Bachelor of Science in Mathematics and Natural Sciences from the University of Melbourne. He received his B E (Civil) from Monash University in 1972. After his postgraduate studies at the Delft University of Technology continued his research in hydraulic engineering and finite element modelling at the University of Wales, Swansea leading to his PhD in 1981.
He founded Computational Fluid Mechanics, an engineering company based in Australia with a wide international client base.
To read full obituary go to www.iahr.org under About IAHR/obituaries.

Two New Institute Members from Panama

Hydraulics Research Center

WRU was established in 1959. Currently WRU is a premier university in VN, in the field of Hydraulic- Hydro-power and Water Resources for industry, agriculture and socio-economics and rural development.
For more information visit the website http://en.wru.edu.vn/

Panama Canal Authority

One of the most interesting hydraulic engineering projects in the world the third Set of Locks project is now about 50 percent complete. The new lock complexes in the Pacific and Atlantic sides will feature three chambers, three water-saving basins per chamber, a lateral filling and emptying system and rolling gates.
An article describing the design by Dr. Lucas Calvo is included in the first Issue of our new practice-oriented Journal of Water Engineering and Research (JAWER) which has been launched at the Chengdu Congress
If you are interested in the project you can watch:
http://www.youtube.com/watch?v=-KyFdvAaRbU&feature=youtu.be

IAHR AIRH
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IAHR Secretariat
Paseo Bajo Virgen del Puerto, 3
28005 Madrid SPAIN
Tel. : +34 91 335 79 08
Fax. : +34 91 335 79 35
www.iahr.org
iahr@iahr.org

Contact us:

Christopher George,
Executive Director
tel.: +34 91 335 79 64
e-mail: christopher.george@iahr.org

Estibaliz Serrano
Publications Manager
IPD Programme Officer
tel.: +34 91 335 79 86
e-mail: publications@iahr.org

Maria Galanty
Communications and
On line Media Officer
Hydro-environment Division
Programme Officer
tel.: +34 91 335 79 08
e-mail: office@iahr.org

Elsa Incio
Membership and subscriptions
Hydraulics Division Programme Officer
tel.: +34 91 335 79 19
e-mail: membership@iahr.org

Carmen Sanchez
Accounts
tel.: +34 91 335 79 48
e-mail: accounts@iahr.org

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Nominations open online
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