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# Reports of the workshops:

## The future of water:
## Availability, Distribution and Provisioning - Pisa 2016

WG WATER

Science and Technology Foresight: from society to research

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# REPORT on the 1st EXPLORATORY WORKSHOP

## "THE FUTURE OF WATER – availability, distribution and provisioning"

## Pisa – April 12th – 13th

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**Science and Technology Foresight Project**

**National Research Council (CNR ) of Italy**

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*This report presents the exchange of ideas among all participants and the consensus reached by the audience. Participants agreed to appoint the organisers as the official rapporteurs of the workshop: the draft report was circulated among all participants and the final report was approved by all experts. To make it available to all interested parties, its publication on the S&T Foresight Group webpage http://foresight.cnr.it/working-groups/wg-water was also agreed.*

*Image at page 3: the God of water, basalt basin from the temple of Ashur, 704-681 B.C., Pergamon Museum, Berlin.*

# THE FUTURE OF WATER

## SUMMARY

# 1. THE BACKGROUND

## 1.1. THE S&T FORESIGHT PROJECT VISION

The "Science and Technology Foresight" (Foresight) is a CNR multisciplinary interdepartmental project aimed to define a medium to long term vision (5-30 years) of coherent research strategies in key sectors, with the scope of answering socially relevant needs as environment, food, health, security and transportation.

The challenges that society poses to these issues need to be faced with an open minded and holistic approach, keeping the central focus on the societal needs and not on the scientific research outputs and technologies *per se;* answering to the key question on how the development of knowledge, science and technology can contribute to build a sustainable future society.

For achieving these goals, the CNR Foresight project promotes face-to-face meetings and preliminary exploratory workshops, inviting international experts and researchers to an open discussion about the knowledge and the scientific and technological advances needed to address main societal needs. The thematic working group (WG) on water organised a first exploratory workshop in April 2016, gathering together about 30 international experts and researchers in the field of water cycle analysis, water management, provision and distribution. This document reports about the workshop and its outputs and it suggests the roadmap for following face-to-face (F2F) workshops.

In particular, we aim at organising one F2F workshop in late 2017, followed by the publication of a special volume containing the main results, as well as a green paper that will constitute a first step towards formulating practical proposals to policy makers.

The members of the executive board of the project are:

**Project Coordinator**: Ezio ANDRETA
**Scientific Director**: Giorgio EINAUDI

**Members of Executive Board:**
Antonino ARICÒ
Cecilia BARTOLUCCI
Ruggero CASACCHIA
Caterina CINTI
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## 1.2. CHALLENGES IN WATER MANAGEMENT

Water is the essential and crucial resource that living beings need for their survival. Life on Earth is not sustainable without water and any human activity is subject to its availability. In addition to ecosystems, all human societies have to adapt to the availability of water.

According to the UN, the world's population is expected to grow by almost a third to over 9 billion people in the next 40 years, resulting in increased water usage, and increased demand for food and

products. The amount of available freshwater resources, however, will not increase. Over the period to 2050 the world's water will have to support the agricultural, industrial and energy systems that will feed and create livelihoods and food for an additional 2.7 billion people.

Since the Industrial revolution, and in particular in the last decades, pressures on water availability and quality increased exponentially, due to many concurrent driving forces: the increase of world population, the sudden changes in all sectors of economy and the related increase of total and per capita consumption, pollution, climate change. "Global Changes", as those numerous changes are often referred to, and their effects on water resources and their use need to be addressed with a global vision. Conflicts and social inequalities also enhance the problem of water provisioning for a large part of the population, especially in developing countries and in case of transnational resources. The World Health Organization estimates that worldwide some 2.2 million people die each year from diarrhoeal disease (3.7 per cent of all deaths) and that over half of the world's hospitals beds are filled with people suffering from water related diseases.

Fresh water needs to be considered a finite resource, and a change in paradigm related to the relationship between humankind and nature is urgent. Water, called the "blue gold" of the world, is going to be a major cause of discussion, confrontation and possible conflict between different user groups and countries in the decades to come. As such, water is perhaps the main "foresight" question for humankind, as the great majority of other issues and challenges become irrelevant if clean and usable water is not available. Water is at the base of food production, agriculture, industry, health, and human well-being in general.

To cope with water scarcity, scientific research and advances in technology can contribute a great deal of solutions. As for seawater desalination, even though it is an already well assessed technology that is operated at affordable costs for developed countries, for the less-developed countries it would be beneficial new and more efficient management and distribution systems together with low-cost technologies and affordable energy cost in order to guarantee water resources of proper quality. Monitoring and assessing water quality and quantity, as well as the ability to model and predict the future availability taking into account global change, will also be of paramount importance.

While analysing the possible solutions, it is necessary to take into account the ongoing debate on public versus private water management, on the best approaches to technology transfer to developing countries, and on the contrast between the needs and views of different stakeholders, as well as the social and political implication of the several possible choices and scenarios on water management. The issue of future water quality, quantity, availability and management is a complex arena where science, technology, policy and ethics meet each other, not without clashes. It is to the scientists to develop indications on the best strategies to address these problems, helping to build the future we want.

## 2. THE PISA EXPLORATORY WORKSHOP

To prepare a knowledge-based view about water resources, and as a preparation for future research and dissemination actions, we organized a two-day exploratory workshop on the theme of future water quality, quantity and management on 11-13 April 2016 in Pisa, Italy.

### 2.1. THE WORKSHOP PARTICIPANTS

About 30 international experts, members of the Foresight project and CNR researchers and associates took part to the workshop. Participants were invited to provide two or three slides highlighting major topics and questions to be discussed. The complete list of participants and the contributed slides are reported in the Annex to the report.

Among the participants, 10 invited speakers of this workshop were asked to present a talk of 10-15 minutes on a topic of their interest, related to the main issues concerning the future of water. The talks given invited speakers talks were the following:

**Radhouane Ben-Hamadou** (Qatar University and UNESCO): "Integrated Water Resources Management in arid and semi-arid regions, challenges and opportunities"

**Martin Beniston** (University of Geneva, Switzerland): "Hydrological change under conditions of retreating mountain snow and ice in a warming climate: challenges for lowland water supply"

**Jerome Benveniste** (ESA): "The ESA Earth Observation Programmes in Support of Inland Water Monitoring"

**Douglas Cripe** (GEO Secretariat, Geneva, Switzerland): "Water challenges in the vision of the Group on Earth Observations"

**Ghada El Serafy** (DELTARES, The Netherlands): "Making decisions under uncertainties in environmental assessments"

**Klaus Fraedrich** (MPI Hamburg, Germany): "Changes along the rainfall-runoff chain"

**Glenn C. Miller** (University of Nevada, USA): "Water quality impacts from historic and current mining projects"

**Patrick Monfray** (ANR, JPI Climate, Belmont): "Transdisciplinary challenge in environmental research for sustainable development"

**Andrea Rinaldo** (EPFL, Lausanne, Switzerland): "Will large-scale water management plans include biodiversity protection?"

**Rosina Salerno** (Pan American Health Organisation, Washington D.C., USA): "Water and Health: Fighting neglected diseases with intersectoral interventions".


*The workshop participants at the Domus Comeliana in Pisa, April 12th 2016*

## 2.2. THE WORKSHOP PROGRAMME

***Monday 11 April 2016***
19:30 Registration

***Tuesday 12 April 2016***
Presentations: 15 minutes + 5 minutes of specific questions
Moderators: Antonello Provenzale (morning), Giorgio Einaudi (afternoon)

9:30 **Martin Beniston**, "Hydrological change under conditions of retreating mountain snow and ice in a warming climate: challenges for lowland water supply"

9:50 **Klaus Fraedrich**, "Changes along the rainfall-runoff chain"

10:10 **Radouane Ben Hamadou**, "Integrated Water Resources Management in arid and semi-arid regions, challenges and opportunities"

10:30 **Glenn C. Miller**, "Water quality impacts from historic and current mining projects"

10:50 **Rosina Salerno**, "Water and Health: Fighting neglected diseases with intersectoral interventions"

*11:10 Coffee break*

11:30 General discussion: Future scenarios for water quantity and quality

*13:00 Lunch break*

14:30 **Jerome Benveniste**, "The ESA Earth Observation Programmes in Support of Inland Water Monitoring"

14:50 **Ghada El Serafy**, "Making decisions under uncertainties in environmental assessments"

15:10 **Andrea Rinaldo**, "Will large-scale water management plans include biodiversity protection?"

15:30 **Douglas Cripe**, "Water challenges in the vision of the Group on Earth Observations"

15:50 **Patrick Monfray**, "Transdisciplinary challenge in environmental research for sustainability development"

*16:10 Coffee break*

16:30 General discussion: Managing future water resources - how science can respond to societal needs?

*18:15 End of the working day*

***Wednesday 13 April 2016***

9:30 - 16:30 (lunch break from 13:00 to 14:30)

General discussion on the main scientific and technological challenges for the future of water, with the goal of identifying the major themes for future research activities (including F2F meetings on specific topics). Moderator: Steven Taylor

## 3. THE WORKSHOP DISCUSSION

Ample time was devoted to the discussion, with the aim of identifying the major issues for further research and analysis. Vision for the future must be visionary and realistic at the same time. Themes discussed focused on the main scientific and technological challenges for the future of water, with the goal of highlighting the major themes for future research activities, identifying the knowledge gaps and keeping in mind the key question on how science can respond to societal needs for improving the management of future water resources and improving equality and sustainability.

There has been consensus on the need to develop future scenarios for water quality, quantity and use, driven by global changes and focussing on three main types of environment: **large urban areas including megacities**, **arid/semiarid regions**, and **coastal areas**, because of their recognised geo-political importance in the future as the most critical socio-ecological systems and for their relevance to the Mediterranean region. The need of developing a vision at global, regional and local scale has been widely recognised. A sound estimation of the many uncertainties in data, user needs, models and responses to management strategies will represent a further challenge to be properly addressed.

The discussion touched upon many relevant questions and it included an ample variety of topics on water technologies, research and societal needs and their interconnections. The several topics and concepts discussed were strongly linked to one another. An attempt was made for representing such challenges in a comprehensive scheme that links the main concepts in a web of interconnections and relationships, focused on three main aspects:

- Knowledge
- Future projections
- Technologies.

Knowledge is of course the central and key factor for understanding phenomena and taking information-based decisions. Acquiring data and information is the first step but it is not enough: information must be interpreted for producing knowledge. Within the *Foresight* perspective, knowledge means also analysing and understanding societal (economical, political and cultural) drivers and needs. Knowledge is the base for **informing** predictions of future needs and for understanding how scientific research and technologies can contribute to a better future.

### 3.1. INFORMING DECISIONS: MAJOR ISSUES AND CHALLENGES

a) ***Availability / access to safe water***

The major concern is the availability of fresh water for all uses, taking into account the different water quality needs of different types of use (for example, highest quality for drinking water, lower quality of water used for industrial purposes).

The main issues to be addressed in this framework are:

- Conflicts among several uses / users: water as common good – how to guarantee equality – technologies, management and governance are not neutral.

- Quality: availability of clean water: protecting from pollution / preserve health.
- Quantity: availability in environments and ecosystems subject to major (and increasing) climatic and demographic pressures: arid and semi arid climates, coastal areas (focus on the Mediterranean) and mega-cities.
- 70% of water is used for agriculture: develop and adopt solutions for saving water in agricultural practices.
- Groundwater resources: drinking water is coming for a large (and increasing) proportion from groundwater (aquifers), whose conditions and responses to climate change are much less known than in the case of surface waters.

Availability is more and more compromised due to two main "global change" drivers:

- Demographic drivers: increase of population / urbanisation / per capita consumption: provision for all – reuse / reduce / increase resilience of societies and cities.
- Climate change drivers: increase of extreme events – both droughts and floods induce a decrease of water availability for both natural and anthropic ecosystems with largely unknown effects on groundwater resources.

### *b) Knowledge*

Knowledge needs to be developed in the following areas:

**Filling the knowledge gaps in assessing water resources**: there is the need for new technologies (e.g., remote sensing, wireless data transmission, new sensing systems etc.) for acquiring more complete information, reducing monitoring costs and increasing reliability – access to remote areas – widen the monitored areas – increase the frequency of monitoring. Similarly, there is the need for developing low-cost in-situ monitoring networks.

**Developing future scenarios and projections** in several fields for at least the next 30 years:

• Effects of climate change on water resources (both surface and groundwater)

• Demographic changes and population distribution / migration

• Economic/societal needs (agriculture - food, health, energy, cities, industry and, more in general, land use)

**Improving relevance of information**: a large amount of information is collected by public institutions and private companies ("Big data"). At the same time, such information may not be easily available for many different reasons, e.g. the fragmentation and scarce connectivity of data bases, lack of metadata, no open access, necessity to improve data-mining technologies, necessity to homogenise indicators, poor quality of data. Data mining is a promising technique for developing decision support tools for water management (and a relevant wealth of literature is available) – existing and new techniques must also be made available. The obstacles that prevent new available technologies to be applied must be removed: among those, the lack of dissemination of knowledge about available technologies is of paramount importance.

**Extracting information and promoting analysis of big data:** data availability needs to be organised into information and transformed into knowledge. Contemporary society needs to understand better how to organise and understand the too much information available. Earth observations from ground and satellite technologies increase the availability of data and present a great opportunity for increasing knowledge and prediction capabilities. The most advanced research in Information Technologies about "big data" is developing tools for the analysis of data that can be useful for improving the knowledge on water use and needs both at local and global level.

**Working on future projections:** the capability to predict the evolution of future scenarios must be enhanced in several aspects. Predictions imply the ability to understand the future evolution of both

physical aspects (climate, ecological and environmental) on the one hand and, on the other hand, socio-economic aspects (demographic evolution, also regarding migrations, as well as socio-economic modifications) that imply changes in habits and uses of water (e.g. modifications in rural and urban structure). Climate and global changes, including land use change, are strong drivers regarding future water availability because of the effects on land structure and on the water cycle. Especially, the increase of demographic pressure may induce very strong effects. Scenarios must be developed for water quantity, water quality and use, keeping into account global changes and including uncertainties, focussing on three main types of environments: arid/semiarid, coastal and urban, and considering socio-ecological systems as a whole. Water balance is strictly linked to economical aspects and globalisation of agriculture, goods productions and trade, as well as migrations, cause shifts in water use.

Extreme event scenarios (droughts, floods, intense precipitation, erosion) must be taken into account and must inform predictions on water needs as well as management strategies and policies at local and global levels, also for resolution of conflicts on water use.

**Making knowledge available**: communication and capacity building must be improved for enhancing a more effective management of water resources able to respond to societal needs and to protect ecosystems. In this context, areas to be addressed include:

- ***Disseminate the information:*** the existence of novel approaches and technologies must be communicated to the relevant stakeholders (policy and decision makers, international organisations, water resources managers, civil society, social scientist, teachers, etc). Scientists should attend strategic events as well as policy makers should be invited to scientific meetings. More effective communication channels should be created.
- A more efficient way to ***enhance technology transfer*** should be identified, abating the obstacles for new and more efficient solutions to be adopted.
- ***Capacity building*** must be improved, forming a new generation of scientists on water management with a holistic approach.

c) ***Technologies / solutions***

Water availability for human use depends on technologies for water uptake, storage, treatment, transportation, monitoring and efficient use aimed at reducing consumption, increasing availability prevent contamination and preserve quality. Global changes cause modification of ecosystems and human habitat: the increase of population pressure on urban environment, semi-arid and coastal areas poses technology challenges in all those aspects. Resilient agriculture to global change will permit a wider portion of the population to be able to overcome extreme events as droughts and also to be able to cultivate using less water in the long term, but for its achievement a technological advancement is necessary, also in different fields as biotechnologies and a better understanding of traditional agriculture practises. Promising agricultural land uses are worldwide foreseen in revising the complex and efficient rural systems adopted in the past, towards multifunction and resilient agroforestry systems to be adopted in the future. Considering that 70% of water use is for agriculture (source: AQUASTAT, 2016) and that the growth in population needs to increase agriculture production, optimising water consumption in agriculture will represent a big step towards sustainable use.

Desalinisation will be more and more needed for guaranteeing water availability in densely

populated coastal areas. The high costs of energy need developing low-costs desalinisation technologies as well as coupling desalinisation to green energy production. Also, the employment of municipal wastewater reuse for agriculture as well as for groundwater recharge will be more and more used and accepted. The development of mega-cities and the increase of urbanisation in general demand designing "resilient cities", optimising distribution, diminishing consumption, reusing "grey" water, building "artificial aquifers" as water reservoirs, as well as developing economic models for infrastructure management.

Quality of water is often low in many countries, with great impacts on health. Water can also be a vector for epidemic disease. The need of clean water and the lack of technologies for reusing grey water bring an overexploitation of groundwater resources causing environmental impacts and diminishing the availability of the resource. Quality of groundwater needs to be protected from contamination. Monitoring systems for early warning, as well as cost-effective remediation technologies, must become of wider use.

The development of novel scientific knowledge should inform the development of technologies for water management, aimed at building a resilient society / environment – including resilience to extreme events (in particular for arid and semi arid environments and mega-cities).

Such technologies should have the following goals:

• **Save water** (in all uses: agriculture / industrial / civil): research aimed at decreasing the consumption of water needs to be improved in several domains: Agricultural practices (agronomic procedures – selection of most suitable cultivars – biotechnologies aimed at increasing the resilience of crops to droughts); adoption of industrial technologies with a lower water footprint, including the development of new materials and devices for reducing domestic consumption.

• **Reuse water**: increase reuse through the adoption of management strategies and treatment technologies.

• **Treat water** (desalinisation / special uses / reuse / wastewater treatment / remediation): lower the costs and the energetic needs of water treatment, especially for emerging countries.

• **Make water available**: exploitation of water resources is particularly intense and potentially unsustainable for underground water: one of the great challenges is artificial recharge of aquifers, aimed at restoring exploited aquifers or creating artificial ones as water reservoirs to guarantee sustainability of exploitation and increase resilience to droughts. More research is needed for improving understanding and modeling of aquifers and of their response to climate change.

• **Understand social needs on water management**: the introduction of technological solutions must be calibrated taking into account many aspects regarding social needs and traditional uses. Equal access in water resources distribution is a key aspect that needs to be guaranteed. Water is a common good and the control of water resources has an enormous geo-political and economic importance. Access to water must be guaranteed to communities, developing adequate governance strategies aimed to the resolution of conflicts. Social and health studies must be integrated with the development of technological solutions aimed to guarantee fair access to water resources.

***d) Assess, restore and manage ecosystems (e.g. wetlands / grasslands / forests / savannas):***
a better understanding of terrestrial ecosystems and their dynamics, as well as the role of water in sustaining ecosystem processes and the delivery of ecosystem services will improve the enforcement of effective conservation and restoration measures. The value of the "natural capital" of ecosystems must be recognised and brought to the attention of policy makers. The "ecosystem service approach" can be used to let policy makers understand that the preservation of ecosystems fulfils also societal needs.

***e) Communication: creating a new culture of water***

Scientific knowledge and technological advancements must be shared with stakeholders, policy makers and the general public to create a "culture of water".

In this framework, the need is connecting science and policy: how scientists can inform policy makers about the need for scientifically based water management strategies and the existence of innovative solutions?

At the same time, we need end-user empowerment: transfer of knowledge and technologies requires the ability to reach local communities and the need of new governance paradigms.

Along these lines, water issues can be tackled only through a trans-disciplinary framework.

## 4. INTERDISCIPLINARITY AND LINKS WITH OTHER ACTIONS OF THE SCIENCE AND TECHNOLOGY FORESIGHT PROJECT

Water is closely connected with the total environment, with agriculture, food, energy, health and settlement development.

Social, economic as well as technological enhancements in these sectors influence water use, and water availability has strong consequences on their development. The need for more knowledge is also related to a deeper understanding of the social and cultural aspects related to the use of water both in developed and developing countries, especially regarding traditional uses, agriculture, health.

A crucial issue concerns Social Equality: Water scarcity, or water poor quality can be the main cause of infectious diseases but is also in some cases responsible for non communicable diseases such as cancer and maternal mortality. In this sense, poor water availability detracts human resources from development and increases public health budget of countries. Water use must be guaranteed to all communities. This means guaranteeing both quality and quantity of water and access to water resources. Whole technological advancement can physically improve the availability of water resources, at the same time the socio-economical aspects of water management must be addressed and fully understood at local as well as at global level.

Technology and knowledge can be used to aid social equality on the use of water resources.

The main contacts with other areas of the Science and Technology Foresight concern Food and Health issues.

More generally, contacts have to be created and maintained with the Belmont Forum, the European Climate Research Alliance, GEO/GEOSS, CLIVAR, and other international programmes and projects.

## 5. CONCLUSIONS AND FUTURE STEPS

In the coming decades, water availability, distribution, management and use will be one of the main challenges faced by humankind. The proper management of water resources is a key point for guaranteeing the equality of access to natural resources as well as the sustainability of economic growth and human well-being.

Only a global vision taking into account future projections of global changes, the structure of socio-ecological systems, as well as the need to fill the knowledge and technology gaps will be able to contribute to creating a resilient society ensuring a sustainable use of water resources. At the same time, water issues are often local in nature: another challenge will thus be the ability of cross-scale approaches to link needs and technologies from the local to the global scale.

Global vision, local applications and multidisciplinary approaches are the guidelines to follow for the development of any water management strategy.

As a result of the exploratory workshop, and given the research mission of CNR, we propose to focus on the following topics:

A) Improvement of knowledge:
- improve monitoring solutions for water quantity and quality and develop data distribution and analysis methods capable to support the governance of water, based on Information and Communication Technologies;
- develop a system of predictions / projections on future water scenarios, including resource availability and societal demand and with specific attention for groundwater, able to provide information on the future state of water resources and estimating uncertainties;
- analyse the links between water availability and ecosystem dynamics, with focus on defining and improving water-mediated ecosystem services and benefits;
- make knowledge available to a wide audience, contributing to create a culture of water.

B) Create a resilient society:
- create a complex and interconnected system of management of water resources able to act on the several aspects: reuse – reduce – preserve quality
- contribute to guarantee equal access and distribution
- spread information to support informed decisions.

Overall, the main areas where such endeavours can be attempted are:

- Large urban aggregates
- Arid/semi-arid regions
- Densely populated coastal areas

with a specific focus on the Mediterranean region.

Discussions held at the workshop and in the following months indicated a specific importance of the effects of extreme events on the water cycle, on water availability and distribution and on water-related ecosystem services. Often, extreme events (such as droughts, intense rainfall, wind storms, large fires, floods but also earthquakes and volcanic eruptions) have long-term effects on ecosystems and on environmental processes, including the water cycle and the provisioning of water, with different intensities according to the vulnerability and the adaptive capacity of the socio-economic system. Effects can be particularly severe especially when combined with high population density and/or overpopulation. We propose that a specific future direction for the water working group is the **analysis, using novel and refined statistical and dynamical-systems-based methods, of the impact of extreme events on the socio-ecological systems, on the water cycle and on water availability and distribution, with specific attention for densely populated regions such as (mega)cities and coastal Mediterranean regions.** Such analysis should be accompanied by the identification of new technologies and land-use strategies able to mitigate the effects of extreme events.

# ANNEX 1 – LIST OF PARTICIPANTS

**Invited Speakers:**

| | |
|---|---|
| Radhouane Ben-Hamadou | Qatar University and UNESCO, Qatar |
| Martin Beniston | University of Geneva, Switzerland |
| Jerome Benveniste | European Space Agency, Italy |
| Douglas Cripe | GEO Secretariat, Switzerland |
| Ghada El Serafy | DELTARES, The Netherlands |
| Klaus Fraedrich | Max Plank Institut für Meteorologie, Germany |
| Glenn C. Miller | University of Nevada, USA |
| Patrick Monfray | Agence Nationale de la Recherche, JPI Climate, Belmont Forum, France |
| Andrea Rinaldo | Ecole Polytechnique Federale de Lousanne, Switzerland |
| Rosina Salerno | PAHO-WHO, Washington, USA |

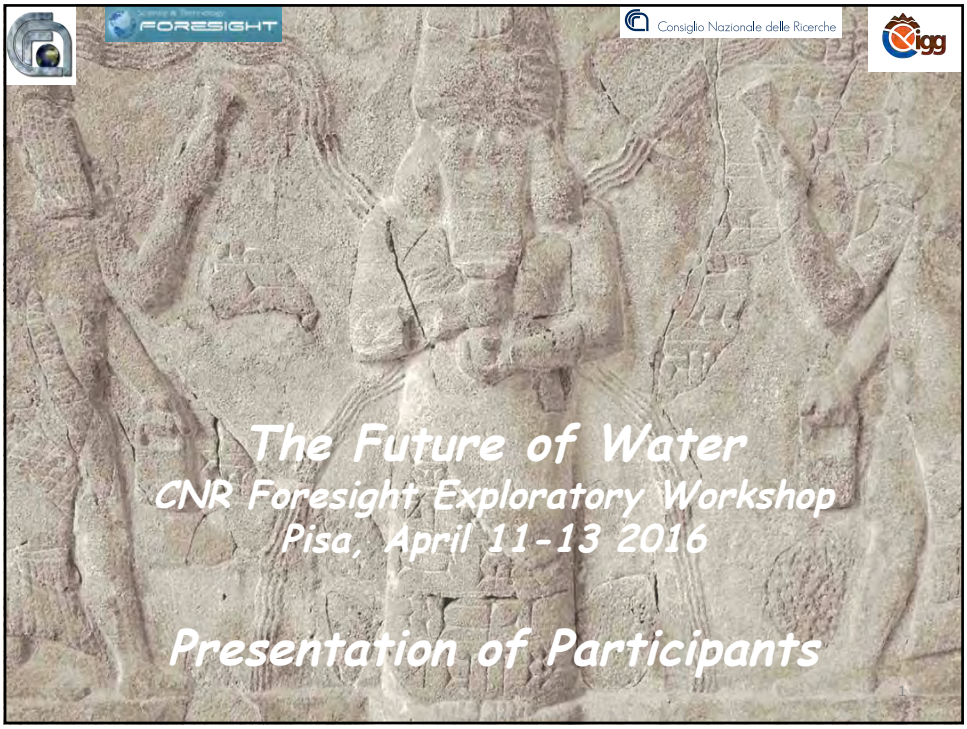
**Members of the Foresight project participating in the discussion:**

| | |
|---|---|
| Ezio Andreta | CNR Science and Technology Foresight |
| Cecilia Bartolucci | CNR-IC |
| Ruggero Casacchia | CNR |
| Caterina Cinti | CNR-IFC |
| Augusta Maria Paci | CNR |
| Stephen Taylor | Trieste Area Science Park |
| Luisa Tondelli | CNR-ISOF |

**Participants to the discussion:**

| | |
|---|---|
| Daniele Biglino | CNR-IC |
| Elisa Brussolo | SMAT Torino |
| Marco Doveri | CNR-IGG |
| Stefano Ferraris | University of Torino and CNR-IGG |
| Sandro Fuzzi | CNR-ISAC |
| Silvia Giamberini | CNR-IGG |
| Licia Guzzella | CNR-IRSA |
| Marco Lauteri | CNR-IBAF |
| Giuseppe Mascolo | CNR-IRSA |
| Barbara Nisi | CNR-IGG |
| Elisa Palazzi | CNR-ISAC |
| Maddalena Pennisi | CNR-IGG |
| Ivan Portoghese | CNR-IRSA |
| Brunella Raco | CNR-IGG |
| Francesco Russo | Italian Society of Hydrothermal Techniques |
| Andrea Scozzari | CNR-ISTI |

# ANNEX 2 – DISCUSSION HINTS AND INPUTS FROM THE WORKSHOP PARTICIPANTS




# Aim of the workshop

Main aims are:

***Identifying the topics that will become the foresight priorities in water and the related research.***

*Proposing a road map for the following face-to-face workshops.*

*Fostering an open discussion about the relevant social, economic, political and related scientific and technological issues regarding water resources to be tackled in the coming years, as well as the possible strategies to address them.*

Ample time will be given to discussion so as to analyse the important issues, prioritize them and unravel their interactions.

The discussion will be preceded by talks given by a group of experts representing different sectors, who are asked to introduce their view of future challenges related to water resources. The expert contributions should NOT concern specific research results.

2

## Some hints for topics of discussion

Frontier enabling and converging technologies in the next 10 years and new applications that could derive from their use.
Relevant themes with specific frontier topics potentially having a strong impact on economy, society and policies.
Current cutting-edge technologies with present relevant investments for each theme.
Perspectives, needs, risk assessment and public acceptability for each technology and/or management strategy in the next 5-30 years.
Top-level researchers in the world, relevant industries and international initiatives active in the topic.
Case studies of special geographical and/or social and/or geopolitical relevance where actions on water quality, quantity and management are under way or planned.

Look at the problem not only from a scientific perspective, but including relevant social, economical, technological and geopolitical perspectives.

3

## Participants

**Scientific committee: Antonello Provenzale (CNR-IGG), Enrico Brugnoli (CNR-DTA), Giorgio Einaudi (CNR Foresight Group)**

**Invited Speakers:**
Radhouane Ben-Hamadou (Qatar University and UNESCO, Qatar)
Martin Beniston (University of Geneva, Switzerland)
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Douglas Cripe (GEO Secretariat, Switzerland)
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Patrick Monfray (Agence Nationale de la Recherche, JPI Climate, Belmont Forum, France)
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Rosina Salerno (PAHO-WHO, Washington, USA)

**Members of the Foresight project participating in the discussion:**
Ezio Andreta, CNR Science and Technology Foresight
Cecilia Bartolucci, CNR-IC
Ruggero Casacchia, CNR
Caterina Cinti, CNR-IFC
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Elisa Brussolo, SMAT Torino
Marco Doveri, CNR-IGG
Stefano Ferraris, University of Torino and CNR-IGG
Sandro Fuzzi, CNR-ISAC
Silvia Giamberini, CNR-IGG
Veronica Giuliano, CNR-DTA
Licia Guzzella, CNR-IRSA
Marco Lauteri, CNR-IBAF
Giuseppe Mascolo, CNR-IRSA
Lorenza Meucci, SMAT Torino
Barbara Nisi, CNR-IGG
Elisa Palazzi, CNR-ISAC
Maddalena Pennisi, CNR-IGG
Ivan Portoghese, CNR-IRSA
Brunella Raco, CNR-IGG
Francesco Russo, Italian Society of Hydrothermal Techniques
Andrea Scozzari, CNR-ISTI

4

## Radhouane Ben-Hamadou
## Qatar University

- Oceanographer and Ecohydrologist
- Engineer: Fisheries and Aquaculture (1998)
- M.Sc. & Ph.D. Biological Ocean. and Marine Env. (1999 & 2003). UPMC, Sorbonne Univ. Paris 6.
- UNESCO-ODINAFRICA national representative and Marine Observatory manager (2004)
- UNESCO advisor for DSS on estuarine ecohydrology (2005-2006)
- Senior researcher and Assistant Professor (2006-2013). University of Algarve, Portugal
- EU-ERASMUS Mundus on Ecohydrology – Managing board
- Deputy-Director UNESCO - International Centre for Coastal Ecohydrology (2009-2013)
- President SETAC Arabian Gulf Branch (2014-2016)
- Vice President International Society of Ecohydrology

5

Radhouane Ben Hamadou

# Preliminary Thoughts

6

Radhouane Ben Hamadou

## First message: WHAT?

*Humans are changing the global water system in a globally-significant way*

*without…..*
*adequate knowledge of the system and thus its response to change*

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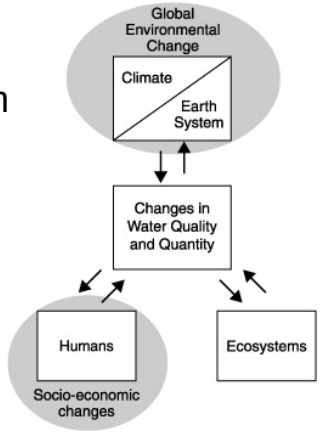
Radhouane Ben Hamadou

The Global Water System



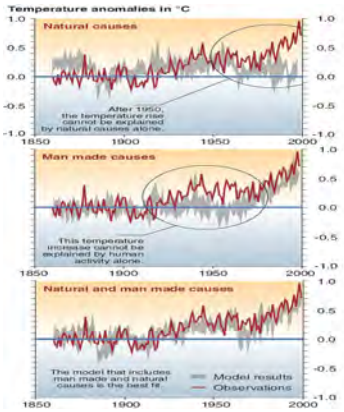

## Second message: WHY?

- Water ***Cycling*** Deeply Embedded in Earth System
- Interconnections are Strong
- Change to One Part Reverberates Throughout

8

Radhouane Ben Hamadou

Climate is changing



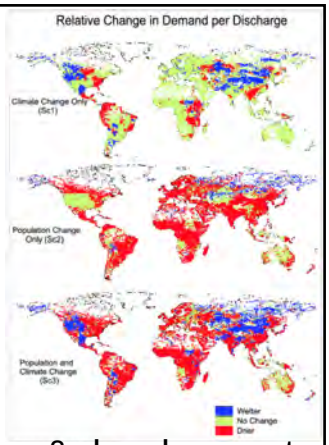

## Third message: WHY?

- There are many factors leading to changes in the rate of climate change
- Whatever the main reason is, the climate variations prompt for developing the water management strategies that take climate uncertainties into account

9

Radhouane Ben Hamadou

Water Stress Changes to 2025 (scenario)



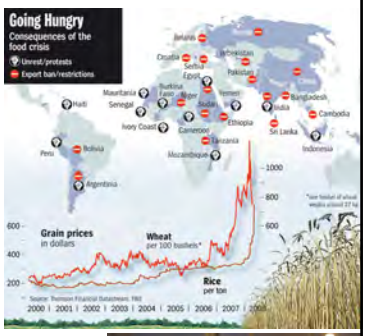

## Fourth message: WHY?

- 80% of future stress from population & development, not climate change!
- Correct Priorities?

(e.g. 85% US global change research funding to climate and carbon)

10

Data is Priceless to design water management plans




## Fifth message: HOW?

*"There is no sustainable development without adequate information about the state of the Earth and its Environment"*

*Statement at WSSD*

11

Radhouane Ben Hamadou

The challenge we all have

## Sixth message: HOW?

*How to put water in the minds of people?*

12

# Martin Beniston

- Since 2006, full professor + director of the Institute for Environmental Sciences at the University of Geneva, Switzerland (www.unige.ch/climate)
- Atmospheric physicist by training (Universities of East Anglia and Reading, UK; Ecole Normale Supérieure, Paris; and ETH-Zurich)
- Previous employments: CNRS, Paris 1978-1980; University of Quebec (80/81); Max-Planck-Institute, Hamburg (81-85); Swiss Federal Institutes of Technology in Lausanne (85-90) and Zurich (90-96); full professor and head of the Geography Institute, University of Fribourg, Switzerland (1996-2006)
- Vice-chair of IPCC from 1992-1997 (Second Assessment Report) and lead/contributing author for IPCC AR2, AR3, and AR4
- Close to 180 publications in the international literature
- **Links to water & hydrology:** Coordinator of EU/FP7 «ACQWA» large integrated project from 2008-2014, on issues related to changing mountain water resources and use in a changing climate (www.acqwa.ch)

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Martin Beniston

# Inputs for discussions - 1

- Issues of water availability, use, and quality have very different contexts (region-specific; source-specific – e.g., glacial-nival, pluvial, ground-water; water management – e.g., basin-wide, local, transboundary, etc.)
- It is difficult to address current and future problems of water resources in a homogenous manner without acknowledging these differences in complexity arising from the natural and socio-economic sciences
- Water from mountains (20% of land-surfaces; 60% of surface water source regions) is a particularly interesting case of current and future water issues, where the upstream-downstream links are often poorly understood or taken into account in water management strategies

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Martin Beniston

# Inputs for discussions - 2

- In looking at shifts in hydrological patterns in a future climate, it will be necessary to consider not only the physical aspects but also socio-economic issues that may result in conflicts of interest between agriculture, energy (hydropower; water for cooling of nuclear power stations), industry, mining, and tourism, if water supply declines below the demand of one or more of these sectors at critical times of the year
- Links from Science to Policy are often difficult to establish (e.g., how many EU project results have really guided policy?). How many scientists improve this dialog in order to push through ideas that could genuinely improve water governance and the adaptation strategies that certainly will be necessary for the «future of water»
- Some of these ideas were addressed in a rather preliminary form in the www.acqwa.ch project (downloading of full report or summary for policymakers in pdf format can be accomplished from this site).

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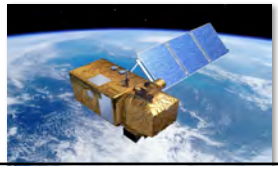
Jerome Benveniste

# Introduction

- a short presentation of yourself and your expertise in water:
  - **Dr. Jérôme Benveniste**
  - PhD in Space Oceanography (1989)
  - Post-Doc at MIT, USA
  - Joined ESA in 1992, Senior Advisor since 2008
  - Developed the RIVER&LAKE Expert System to exploit Radar Altimetry over Inland Water
  - Developed the exploitation of Altimeter SAR-mode (delay-Doppler) over coastal zone and inland water bodies
  - Preparing of Scientific Exploitation of Sentinel-3 mission
  - Editor of a Springer book “Inland Water Altimetry” (in progress)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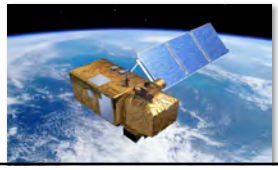
Jerome Benveniste

## EO for Sustainable Development

- a very brief summary of your main perspective, ideas, questions, comments and/or suggestions for inputs / points of discussion for the workshop:
  - EO information is essential for environmental monitoring at national to transboundary to continental scale
  - Mature tools & EO products are available for consistent & transparent assessment of water resources
  - Capacity building is constantly required for successful uptake of EO for water management
  - **Sentinels are operational and provide free & timely data => essential for water management and sustainability**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Jerome Benveniste

opernicus

## Managing water resources

Water is essential for life. The need to grow more and more food places huge demands on available freshwater. With water scarcity an increasing issue, it is important to manage this precious resource.

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**Elisa Brussolo – elisa.brussolo@smatorino.it**
**Società Metropolitana Acque Torino S.p.A. – Turin, Italy**
**Research Center**

**Background**

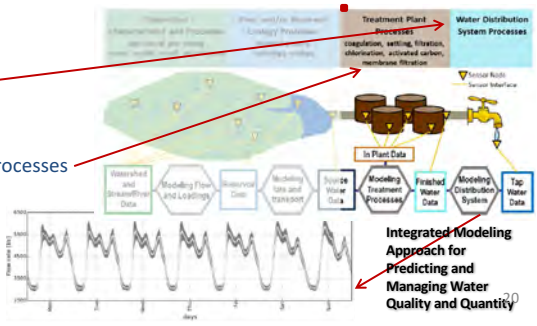
- Master degree in Environmental Physics
- PhD in Environmental Monitoring
- Post-doctoral researcher at ISAC-CNR

Stochastic rainfall downscaling, hydrometeorological prediction chain, time series analysis, atmospheric science, fluid dynamics, impacts of climate change on rainfall field

**My work**

- Researcher at SMAT S.p.A.

Water demand forecasting
Innovative drinking water treatments
Water balance
Models for drinking water treatment processes




20

Elisa Brussolo SMAT Research Center

**Specific questions of interest**

**Climate change and Integrated Urban Water Management**

**Regional and near-term climate projections are required**

- **Water supply** → mpacts of c mate change on quant ty and qua ty of surface and groundwater resources (acqu fer recharge, r ver f ow decrease, water ava ab ty and storage, …)
- **Drinking water treatments** → mpacts of c mate change on water resources qua ty (cyanobacter a a ga b ooms, natura organ c matter, n trates, emerg ng po utants, po utants concentrat on, suspended sed ment, …)
- **Water distribution** → mpacts of c mate change on water demand
- **Sewage system** → mpacts of hav er ra nstorms on sewage system

- New des gn cr ter a for sewer, san tat on and wastewater treatment nfrastructures to ncrease res ence and adaptat on to qua ty and quant ty var at ons
- D vers fy ng water sources and mprov ng reservo r management

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# Douglas Cripe Expertise

- MSc n atmospher c sc ence
  T es s ves ga o of GCA E quas -equ b um e m d- a udes
- PhD n phys ca geography (c mato ogy)
  D sse a o NA/NAO Te eco ec o s a d G ea Lake effec s ow
- WMO hydro ogy d v s on
  Integrated Global Water Cycle Observations (IGWCO Community of Practice
- Sen or sc ent st – Inst tute for Env ronmenta Sc ence (ISE), Un vers ty of Geneva
  o ec ma age € 6 5 m Assess g C ma e mpac s o e Qua y a d qua y of WA e (ACQWA) 7 o ec
- Sc ent f c off cer for Water SBA, Group on Earth Observat ons (GEO)
  As a a d Af ca Wa e Cyc e a ves
  La Ame ca Wa e Cyc e Capac y Bu d g
  GEOSS Wa e S a egy
  Mo o g f amewo ks fo Wa e SDG
  G oba D oug Mo o /G oba D oug fo ma o Sys em (GD S)

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Douglas Cripe

# Perspectives

**GEO's Vision:**

GEO, a global partnership of governments and organizations, envisions a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations.

**GEO's Mission:**

To realize its Vision, GEO works to connect the demand for sound and timely environmental information with the supply of data and information about the Earth that is collected through observing systems and made available by the GEO community. In doing so, GEO works to unlock the power of Earth observations by facilitating their accessibility and application to global decision-making within and across many different domains.

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Douglas Cripe

# Perspectives

- ***Advocate*** importance of EO as irreplaceable resources that must be protected, rendered fully and openly accessible, and integrated to provide maximum value in support of achieving national and international calls for resilient societies, sustainable economic growth, and a healthy environment worldwide.
- ***Engage*** with stakeholder communities and foster strategic partnerships to address global and regional challenges, by increasing the understanding and use of Earth observations available in support of science-based and data-driven decision and policy-making.
- ***Deliver*** data, information and knowledge enabling stakeholders to improve decision-making processes and inform policy requirements, promote the exchange of best practices, enable the uptake of new technologies, and create new economic opportunities while leveraging public sector investment through standardization, collaboration and innovation.

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Douglas Cripe

# Perspectives

**GEO Societal Benefit Areas (SBAs):**

*Water Resources Management*: supporting management of water resources, including the cryosphere, while fostering and maintaining water quality; in order to ensure the availability and sustainable management of water and sanitation through sound science-based public policies informed by Earth observations, modelling and data integration.

25

**Marco Doveri**

S nce 2008 he works as Researcher at the Inst tute of Geosc ences and Earth Resources (IGG)-P sa (Nat ona Research Counc of Ita y).

He ded cate most of research act v t es to hydrogeo ogy, hydro-geochem stry (chem stry and sotopes) and mode ng of aqu fer systems.

He be ongs to the IGG-mu t d sc p nary research group that works on the ssue *Aquifer Systems: Sustainability and Global Change*:

- study of processes and mechan sms (natura and anthrop c) that affect the hydrodynam cs, the water-rock nteract on and the qua ty of groundwater bod es;
- deve opment of pred ct ve mode s to prov de resu ts usefu for a susta nab e use of the water resource

***Possible point of discussion during the workshop***

The mportance of groundwater for g oba water demand under c mate change/var at on and strateg es of groundwater management to guarantee safe water supp y ng for the next generat ons

26

## Dr. Ir. GY El Serafy

- C v Coasta Eng neer ng n 1990
- MSc n Hydro nformat cs at the nternat ona nst tute for nfrastructura , Hydrau c and Env ronmenta Eng neer ng, De ft, The Nether ands
- Ph D at the Un vers ty of Techno ogy n De ft, Facu ty of App ed Mathemat cs, n Data ass m at on
- Jo ned the Roya Dutch Meteoro og ca nst tute and the App ed Geosc ences nst tute of the Nether ands, she deve oped her sk s n the f e d of hydro nformat cs and data ass m at on
- S nce 2001, she s a spec a st n De tares n the f e d of data sc ences (hydro nformat cs) n aquat c ecosystems and an expert n nformat on ecosystem serv ces She s act ve y nvo ved n the strateg c research and deve opments w th n De tares and s an ass stant professor n data ass m at on and opt m zat on n the Techn ca Un vers ty of De ft
- She has a broad exper ence n uncerta nty ana ys s, sens t v ty ana ys s and data ass m at on re ated to mar ne env ronmenta qua ty and ecosystem hea th as we as ntegrated mon tor ng and assessment methods
- She superv ses severa doctora degrees and master of Sc ence students She eads severa nat ona , EU and nternat ona pro ects n data ass m at on app cat ons, ecosystem mode ng, ecosystem serv ces and the use of Earth Observat on (VECTORS, COB OS, CLEANSEA, MERMA D, ECOSTRESS, FAST, Ecopotent a )

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Ghada El Serafy

## Making Decisions under Uncertainty

- The process of making decision is normally fed by information and governed by experiences from the past.
- Wrong decisions might have a dramatic effect on health and safety.
- It is confusing the terms risk and hazards for policy makers
- Do their mind work with causalities and possible scenarios?
- Present Information is certain (with a certain degree of error) but what about the possible future
- Probability of occurrence and sources of uncertainties

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Ghada El Serafy

## Making Decisions under Uncertainty

- Does that mean that uncertainties and disaster management (prevention, mitgation, preparedness) contradict
- How to train them to deal with the concept of probability?
- Which part of the probability density function should they consider?
- How to teach them to take decisions under uncertainty?
- Would that improve their ability?
- what is the role of scientists and information providers?

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**Stefano Ferraris,** Assoc ate professor,
Po tecn co and Un vers ty of Tor no, TALY
A so at GG, P sa

Hydrau c eng neer, Po tecn co d Tor no ( )
Ph D Geosc ences, Un v Grenob e (F)

## My work

1. Effects of global warming on soil moisture, actual evapotranspiration, snowmelt
2. Daily rainfall, snowfall, soil moisture, grass greenness interannual variability
3. Wheat growth modeling
4. Runoff in vineyards
5. Soil moisture and snow water equivalent measurements

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Stefano Ferraris

## Scientist's role

Warming ---> acceleration of the hydrological cycle
and
drought risk increase

Point and regional scale

**What inputs for our models: need to know the different sites ?**

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Stefano Ferraris

## Social role

Everybody talks about climate change, water as the new driver of world politics, and ecology

**About these three main issues, is science today just one of the many opinions ?**

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**Klaus Fraedrich** ***The Future of Water*** **(in Pisa – 2016)**

*Research* (water re ated on y)
Reg ona (1970 es): N e's source ? (c rcu at on over Lake V ctor a); water reservo rs n warm-dry c mates
G oba (1990-2010): drought/wetness; ong-term memory (so mo sture); argest po nt ra nfa sca ng; user-fr end y free GCM h erarchy nc . uncerta nty emu ator and AO-GCM (w th Open Un vers ty)
Ecohydro ogy (now): ra nfa -runoff cha n mode ng, attr but on ana ys s (c mate vs human), b o-d vers ty based on remote sens ng nfo
German Adv sory Counc on G oba Change (WBGU member 1996-2000); water re ated reports:
Susta nab e Management of Freshwater Resources (Spr nger 1999, 392pp)
Strateg es for Manag ng G oba Env ronmenta R sks (Spr nger 2000, 359pp)
Conservat on and Susta nab e Use of the B osphere (Earthscan 2001, 451pp)

*The Future of Water* (P sa – 2016)
1. Attr but on: Cr t ca ty approach (from WBGU), c mate versus/p us human mpact
2. Ecohydro ogy: B o-geograpy/d vers ty, re at ng sca es, c mates, and (endangered) spec es
3. Water reservo rs: Change ocat ons to reduce water oss ?

The fo ow ng s des prov de a b ased scan through the 'WBGU'-reports,

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## 1. Fresh water criticality: an index approach

Klaus Fraedrich

Cr t ca ty ndex: from reg ona sca e upwards

$$K(r) = \frac{\text{water withdrawals}}{\text{water availability} * \text{problem-solving capacity}}$$

*Withdrawal*: nat ona , rr gated area 0.5º x 0.5º, ndustr a , domest c, popu at on s ze, per cap gross domest c product (GDP)

*Problem solving capacity*: econ. strength per cap GNP, know-how, nfrastructure (supp y, d str but on, (waste) water treatment), eff c ency-stab . of po t. nst tut ons

*Water availability*: c mate/var ab., vegetat on, so , hydrography and topography, water resource deve opment projects

*Future*: Scenar os, nc . uncerta nty est mates by emu at on of under y ng mode s

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## A World Water Charter

Klaus Fraedrich

A key recommendat on (to German Government) for prevent ng a wor dw de freshwater cr s s

From Beese, F. O., K. Fraedrich, P. Klemmer, . Kokott, L. Kruse Graumann, C. Neumann, O. Renn, H. . Schellnhuber, E. D. Schulze, M. ilzer, P. Velsinger, H. Zimmermann, 1998 *World in Transitionn:* Sustainable Management of Freshwater Resources (Springer 1999, 392pp)

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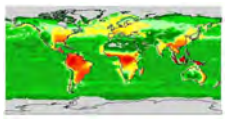
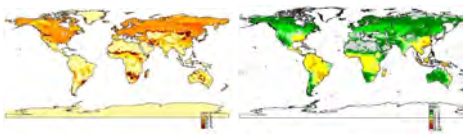
## 2. Bio geographic criticality: a climate metabolism approach

Klaus Fraedrich



**Goods**: product on of p ant mater a etc

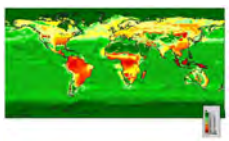
*Map-1*: NPP ε (0,1)



**Services**: ma ntanance & d str but on

*Map-2*: ΔI ε (0,1); net so . rad Su - W

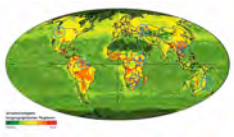
*Map-3*: Evap ***and*** LAI = m n(E, LAI) ε (0,1)



**All Goods & Services:** comb ne = max(A,B) = A ***'or'*** B

*Map-4*: map-1 ***or*** map-2 ***or*** map-3

**Sensitivity**: *Map-5*: $[\delta n(NPP) / \delta(c\ mate)]^{-1}$ ε (0,1)



**Bio-geographic criticality**: map-4 ***or*** map-5

Or b osphere affect on c mate

NW-Ame ca; coas a Amazo ; ce a As a; S- do-C a; E-Aus a a; ce a Af ca;

p a e, op fo es , sub op sava a-s eppe, ag cu /fo es ,

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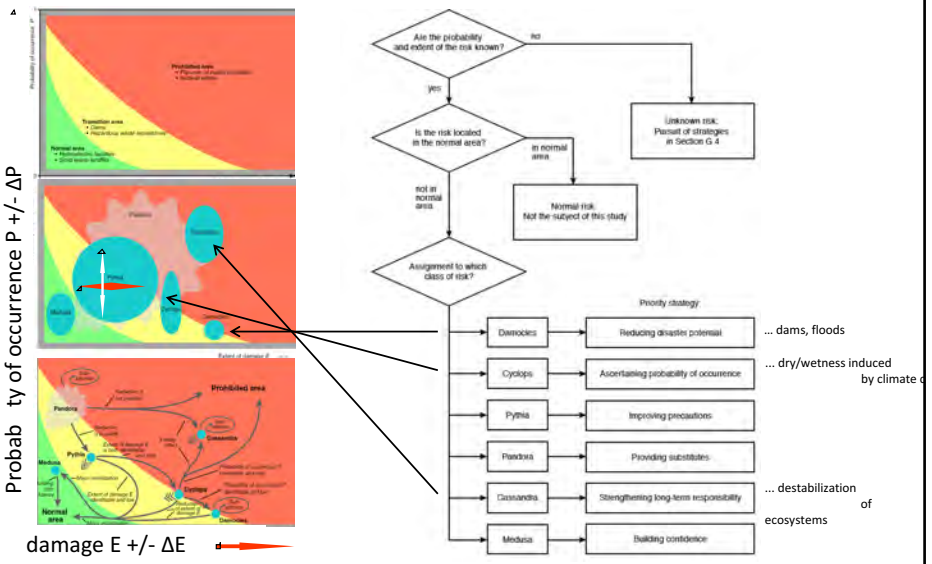
From Conservation and Sustainable Use of the Biosphere (Earthscan 2001,451pp), and Schellnhuber, Knop, Fraedrich (unpubl ms)

## 3. Global risk state space: water related

Klaus Fraedrich

Dynam cs: from 'R sk-Ana ys s' v a 'Po cy Adv ce' towards 'Res ence'

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*From: Strategies for Managing Global Environmental Risks (Springer 2000, 383pp*

## Sandro Fuzzi
## Institute of Atmospheric Sciences and Climate

General expertise

- Main field of research are the changes in atmospheric composition and their effects on global change, climate, ecosystems and human health. On these issues is also actively involved in the international efforts to transfer the research results to the policy makers responsible of environmental management

Specific expertise concerning "water"

- Atmospheric aerosol-clouds interaction and effects on global change and climate
- Functioning of the biogeochemical water cycle
- Air-sea exchange of trace atmospheric species and effects on cloud formation
- Air quality and precipitation deposition, effects on terrestrial, surface water and marine ecosystems

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Water and its phase transitions are the driving force of the hydrological cycle supporting life on Earth. Water is a vital factor in all issues connected to the functioning of our societies: energy, food, human and environmental health. Below some issues that, in my opinion, deserve special attention

**Scientific issues**

- The effects of human activities perturbing the hydrological cycle are largely unknown: understanding these is key to any action for wise policies of water management
- Weather modification (i.e. stimulation of precipitation, hail prevention, etc.): is it effective? Is it worth studying? Does it pose ethical problems?

**Technological issues**

- Agriculture worldwide uses ca. 70% of available freshwater. What's the way out in a scenary of water scarcity? Genetically modified plants or nanotechnological methods to feed the plants with the strictly necessary amount of water and nutrients?
- Recycling water for human consumption is a reasonable and viable action to pursue? Which techniques are foreseeable (Advanced Oxidation Processes, fito-remediation, etc.)

Sandro Fuzzi

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National Research Council of Italy

**Mariasilvia Giamberini - giamberini@igg.cnr.it**
**Institute of Geoscience and Earth Resources**
**National Council of Research – Italy**

Background:
- Master degree n Chem stry, Un vers ty of P sa
- Master degree n Env ronmenta Management, Scuo a Super ore Sant'Anna – P sa
- 15 years as env ronmenta consu tant n major Env ronmenta Eng neer ng compan es and un vers ty sp n-off compan es as pr nc pa nvest gator and project manager

Major nterests n water: **anthropogenic contamination of water**: assessment and remed a .

Projects re ated to water management I have been work ng n:
- **Technology transfer from research to industrial applications**: reverse osmos s membrane p ants des gn and test ng for the remova of non-b odegradab e COD from andf eachate and wastewater from tanner es (a m: reduct on of s udges'product on and mprovement of water qua ty) (severa EU and Reg ona funded app ed research projects)
- **Underground water monitoring** and des gn of severa remed at on p ans for contam nated aqu fers from andf eachate
- **Water management plans** a med to the reduct on of water use for ndustr es, waste treatment p ans and oca author t es (comp ance w th ISO 14001 standard)

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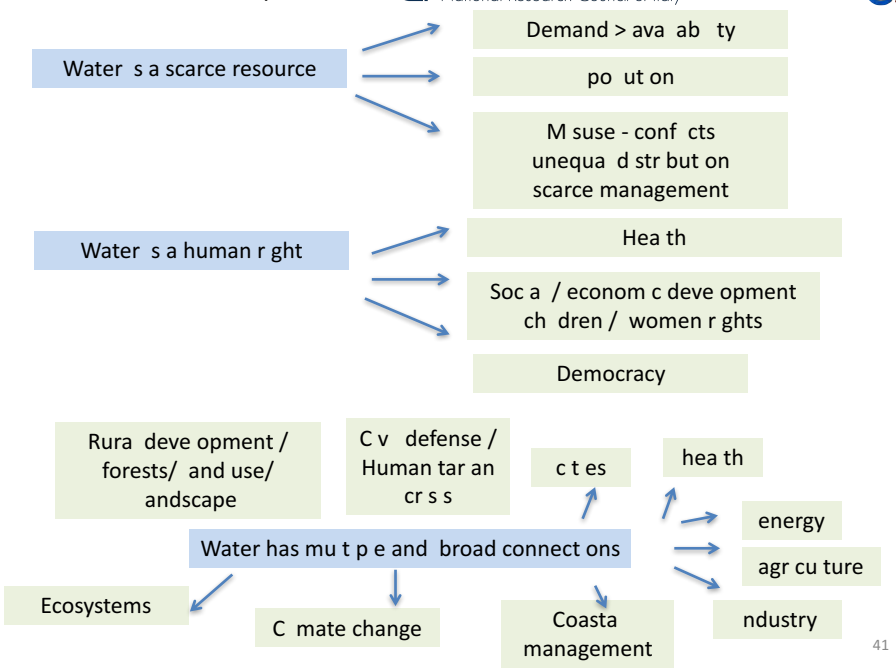







**How can research help?**

**What is needed:**
- **reduce human footprint on water**
- **Improve planning an management**
- **Increase equality in availability for the population (access to clean water)**

**How to increase knowledge and awareness within policy makers, population, stakeholders and the scientific community itself? – need of a wide perspective – understanding of the social dimension of water also for hard scientists – understanding the complexity of the problem**

**What are the priorities?**

**Areas to be developed:**
- **Reduction of water use / pollution in agriculture / industry / domestic use**
- **Assessment of water resources: monitoring / modelling**
- **Protection of sensitive areas**
- **Water desalinization**
- **Safe provisioning – improve health**
- **Reduction of energy / chemicals demand in water treatment**

## Licia Guzzella

**Actual Position** - She is principal manager and scientific coordinator of Brugherio Unit from July 2015

**From Dic 2001 to now** – Senior Researcher at CNR with assigning the profile of level II

**From 1989 to 2001** - Scientific Researcher, professional level III, at the CNR-IRSA

**Web of science (2015) 66 published paper with IF - H-index 19**
**Sum of cited papers without self citations: 1124 -Average citation per item: 17,91**

She is expert on: *ecotoxicological and genotoxicological effects* of *organic emerging compounds* and of POP pollutants in freshwater, underground waters and sediments; *water/sediments and water/soils ripartition processes* in lakes and rivers; *long range transport* of organic pollutants in remote areas; climatic effect on lacustrine environments; *bioaccumulation on food web*; *bioavailability in sediments and waters*; *passive samplers*; monitoring assessment plan; *risk assessment* evaluation in aquatic ecosystem; quality control and quality assurance in analytical laboratory.

43

Licia Guzzella

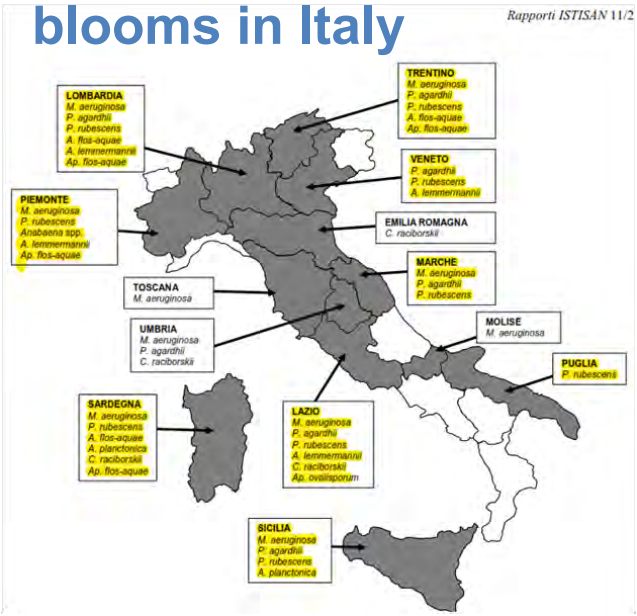
Cyanobacteria algal blooms are increasing in number of events and involved lakes all over Italy.
Which are the conditions that actually advantage their iffusione?
Climate changes? Low nutrient content of lake water? Warmer condition of surface lake waters?

Algal toxins represents a huge risk for human health and aquatic organisms.
Which are the conditions that favourite their production?

44

Licia Guzzella

# Cyanobacteria algal blooms in Italy




45

Licia Guzzella



## Passive samplers and BENTHIC ORGANISMS

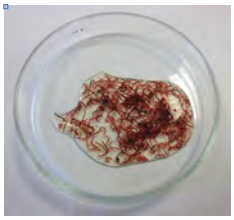
In conventional sediment studies, collection of sediment samples provides a **"snapshot"** photo of pollution conditions at **one specific time** that may not be representative of the **average situation** to which native organisms are exposed (US-EPA 2012).

46

Licia Guzzella

# European Directive n.2013/39/UE

The use of **passive samplers** and of other **bio-indicators** is advised by the European Directive n.2013/39/UE that cited ”New methods of monitoring water and sediment such as the use of **passive sampling** and/or of other **biological instruments** appear promising for future applications, therefore their development and application should be encouraged” (EC 2013).

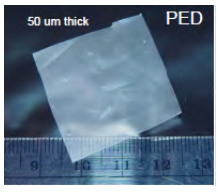


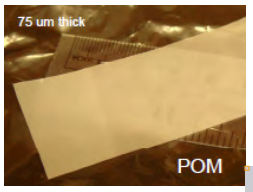
47

Licia Guzzella

# Passive samplers allow the evaluation of bioavalabilty of a pollutant in a lake or river

The use of passive samplers limited the process to physical adsortion of pollutants from water, but the role of suspended material can not be evaluated. Is that a limitation?





Bioaccumulation on native benthic macroinvertebrates may depend on specific metabolism of different taxa?



48

**Marco Lauteri** s sen or researcher at CNR BAF n the f e ds of p ant phys o ogy and eco ogy He has a ong ast ng exper ence n P ant Phys o ogy and Eco ogy of ab ot c stresses Ma n top cs concern acc mat on mechan sms to Med terranean env ronmenta constra nts: seasona drought, sa n ty, ate frost, energy excess He entered v ews of adapt ve phys o ogy str ct y nked to evo ut onary eco ogy, espec a y concern ng forest tree spec es Bas c nvest gat on methodo og es: expert se on gas exchange techn ques and on stab e sotope methodo og es ( RMS) n the study of p ant carbon water economy and so p ant atmosphere hydrau c cont nuum Deep nterest about eva uat on, conservat on and restorat on of b od vers ty, eco og ca networks, desert f cat on processes and susta nab e management of ecosystems and eco og ca andscapes Co aborat on w th genet cs research groups to oca se the genet c determ nants of phys o og ca tra ts of adapt ve s gn f cance Extens ve exper ence n nat ona and nternat ona research pro ects 47 peer rev ewed papers on a tota of 87 pub shed works

EU contract FP7 KBBE 2013 1 2 01, **"Agroforestry that will advance rural development (AGFORWARD)"** 2014 18

EU contract FP7 NCO 2013 9, R21 ENP **"Fostering partnerships for the implementation of best available technologies for water treatment & management in the Mediterranean (FP4BATIW)"** 2013 16

B atera pro ect CNR/FCT ta y – Portuga **"Evaluation of phenotypic plasticity within invasive species of the genus Acacia under Mediterranean conditions"** 2011 12

EU contract EVK2 CT1999 00006, 2000 2004, ***"Securing gene conservation, adaptive and breeding potential of a model multipurpose tree species (Castanea sativa) in a changing environment (CASCADE)"*** 2000 03

UE FA R1 CT95 0781 ***"Genetic, Molecular and Physiological Determinants of Water use Efficiency and Drought Resistance in major Forest Trees (DELTA)"*** 1996 99

Address: Cons g o Naz ona e de e R cerche, st tuto d B o og a Agroamb enta e e Foresta e (CNR BAF), V a Gug e mo Marcon 2, 05010, Porano, ta y Te +39 0763 374935 e ma : marco auter @ baf cnr t

49

Marco Lauteri

## *Water – a vertex of the crucial nexus with food and energy*

- Global changes and water resources: present situation and perspectives
- Soil use and soil consume in relation to the optimization of the water resource
- Relevance of the waste-water treatment sector for optimization and conservation of the water resource
- The role of research within the Knowledge and Innovation Community (Water-KIC)

50

# Giuseppe Mascolo

- e-mail: giuseppe.mascolo@ba.irsa.cnr.it
- Institution: Water Research Institute (IRSA) of the National Research Council (CNR)
- Research within your group: Degradation of persistent organic pollutants (pesticides, dyes, pharmaceuticals, endocrine disruptors, flame retardants) by advanced oxidation processes (AOPs), alone or coupled/integrated with biological treatments.

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Giuseppe Mascolo

- Personal research interests
  - Identification of degradation products during water and wastewater treatments;
  - Mechanisms of by-products formation during organic pollutants degradation;
  - Determination of organic pollutants in wastewater, sludge and soils;
  - Thermal decomposition of hazardous materials by incineration;
  - Understanding formation of products of incomplete combustion (PICs) during sewage sludge incineration;
  - Process modifications for sewage sludge incineration to minimize PICs emissions.

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Giuseppe Mascolo

**main perspective, ideas, questions, comments and/or suggestions for inputs / points of discussion for the workshop**

- Improving the quality of receiving water bodies by controlling/removing contaminants of emerging concern (CECs) that can cause long-term ecological effects. The relevance of addressing the problem of organic pollutants was taken into account by the Directive 2013/39/EU and further with the Decision 2015/495 on March 20, 2015.
- Managing in a proper way the treatment and disposal of sewage sludge whose disposal of to lands that can affect the quality of soil and groundwater.
- New advanced technologies for improved the quality of wastewater effluents.

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## *Transdisciplinary challenge in environmental research for sustainability development*

**Patrick Monfray**

- ANR Deputy Head on Environment, French Research Funding Organisation
- CNRS Research Director, INSU, Paris
- Co founder of International & European initiatives on environment and sustainable development:

futureearth
research for global sustainability

BELMONT FORUM

JPI Climate

ERA4CS European Research Area for Climate Services

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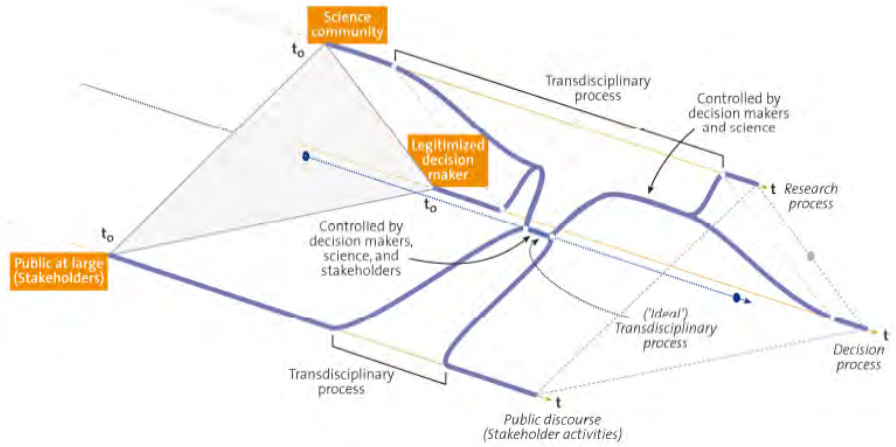
Patrick Monfray

# What are transdisciplinary processes ?




*Environmental Literacy in Science and Society, From Knowledge to Decisions*
*Roland W. Scholz, Cambridge, 2010*

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Patrick Monfray

# Some challenges to promote inter- and trans-disciplinary

- **Identify common object of interest**… but often lack stakeholder inputs
- **Build consortium of funders**: by early co design… but need time
- **Attract new research consortium**: *Research Matching system* for BF call… but not enough for incubation and maturation
- **Evaluation** : need ad hoc criteria and balanced panel… but difficulties with stakeholders participation
- **Social Sciences** involvement … but lack of Humanities
- **Ad-hoc education and scientist career** … but still disciplinary based
- …

***> Risk to attract usual suspects under cosmetic adaptation!***

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Patrick Monfray

## Need diversity of approaches and instruments

- Inter/trans disciplinary starts with **two** disciplines/actors
- Capacity building both North **&** South
- Early career scientists (e.g. **co-**supervision)
- Communication **beyond** science arena
- Brainstorming **fora** with targeted stakeholders (public, private, communities…)
- Not avoid **conflict reality** between transformation actors (≠Disney world)
- Capture **cultural** diversity with local **languages**
- …

***> Promote/teach trans-disciplinary processes ?***

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## Transdisciplinary themes supported since 2012 *(in red with some water issues)*

*12/**Coastal** **Vulnerability**, joint with G8HORCs & aligned **FP7***
*12/**Freshwater Security**, joint with G8HORCs*
*13/**Food** **Security and Land Use Change**, joint **JPI FACCE***
*13/**E-Infrastructures and Data Management**, foresight with **DG R&I***
*14/**Arctic** **Observation and Sustainable Research,** with **NordForsk***
*14/**Scenarios of Biodiversity and Ecosystem Services**, link **BiodivERsA***
*15/**Mountains** **as Sentinels of Change***
*15/**Climate Predictability** **and Inter-Regional Linkages**, with **JPI Climate***
*16/**Sustainable** **Urbanization**, with **JPI Urban Europe + SC5 ERANET***
*16/**Transformation to Sustainability**, with **NORFACE + SC5 ERANET***
***17+ more to come***

➢***Much more at www.belmontforum.org***

Patrick Monfray 58

Glenn C. Miller – gcmiller@unr.edu
Professor, Dept. of Natural Resources
and Environmental Science
University of Nevada Reno, USA

Background:

- Ph.D. in Agricultural and Environmental Chemistry at UC Davis,
- Have worked with the U.S. regulatory agencies and industry on mining and pesticide issues
- The focus of my recent research has been on the impacts and restoration of mining on surface and groundwater.

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Glenn Miller

## *Four major issues associated with past and present mining*

1. Uncontrolled drainage from historic mining, particularly acidic drainage

   Genera y few resources to remed ate the dra nage, and the cost of c eanup s the respons b ty of pub c agenc es

2. Catastrophic releases of mine waste, generally from tailings facilities.

   Sp s n Br t sh Co umb a, Mex co and Braz have caused extens ve env ronmenta and prope ty damage n the ast two years

3. Surface and groundwater discharge of contaminated water from current operating mines, particularly in wet climates.
4. Creation of pit lakes: Large scale open pit mines that penetrate the groundwater table will fill when mining is complete, leaving lakes that often contain degraded water.

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Glenn Miller

## *Research and Regulatory Programs Needed*

- Accurate methods to predict water quality draining from mines
- Accurate methods to predict and manage water quality in open pits
- Better regulation and understanding of the risk of catastrophic failure in tailings facilities
- Improved and cost effective methods for treating contaminated water from mines
- Funding sources for remediation of historic mines, for which there is no current operator or responsible party.

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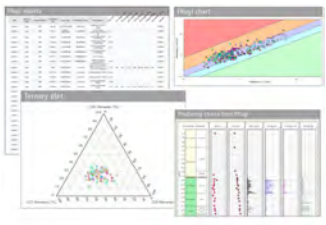
## Barbara Nisi – Researcher at CNR-IGG Pisa

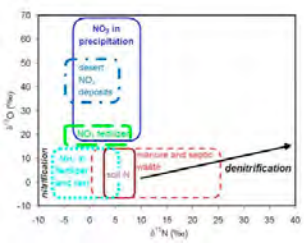
PhD: River geochemistry

Pre- and post-doc contracts:

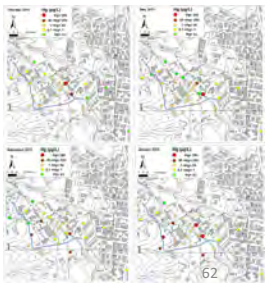
Water geochemistry databases



Dissolved $NO_3$ isotopes




Mercury pollution



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Barbara Nisi

What do we know about water availability from densely inhabitated countries?

What do we know about the quality of water in densely inhabitated countries. Can this affect population migration?

What do we know how the quality of water can affect population migration from developing and third world countries?

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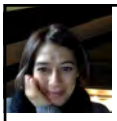

## Elisa Palazzi

*Institute of Atmospheric Sciences and Climate*

- Laurea degree in Physics (2003) and PhD in "Physical Modeling for the Environmental Protection" (2008), University of Bologna
- **ESA fellowship** from 2009 to 2011 and PI of the project DIMITRI (Diagnostics of Mixing and Transport in the Atmospheric Interfaces)
- **Researcher at ISAC-CNR since 2011**. Study of the Climate system and Earth-System processes, hydrological cycle in the mountains, precipitation, elevation-dependent warming, climate models and downscaling
- **Co-coordinator of the ECRA** collaborative programme "Changes in the Hydrological Cycle"
- **Italian member of the Belmont Forum** Collaborative research action "Mountains as sentinels of Change"
- **GEO-GNOME Initiative**: GEO Global Network for Observation and Information in Mountain Environments

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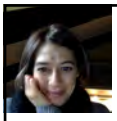

## Elisa Palazzi

*Institute of Atmospheric Sciences and Climate*

**Current research interests**

- Changes in the hydrological cycle in the mountains with a particular focus on precipitation (Himalayas)
- Use of precipitation downscaling methods in the context of modelling frameworks connecting large-scale GCMs/RCMs to smaller-scales impact and assessment models
- Study of the Elevation Dependent Warming, i.e., the mechanisms by which warming rates are amplified with elevation (Alps, Himalayas)

**Points for discussion**

- Uncertainties in observations and model simulations of the hydrological cycle components especially in the high-altitude regions
- Global versus regional models/downscaling methods: reliability of the GCMs projections?
- Modelling chain and the propagation (and communication) of uncertainties
- Changes in the hydrological cycle (particularly wed and dry extreme events) and their impacts
- Possible loss of ecosystem services related to changes in the hydrological cycle

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**Maddalena Pennisi**, IGG-CNR, P sa

I'm **graduated in Geology** and **Doctor es Sciences of the University of Paris XI**. S nce 2005 I'm a **CNR Senior Researcher**

My expert se s n **geochemistry** and **isotope geochemistry**, app ed to **hydrology, geothermal and volcanic fluids.** A s gn f cant ro e s a so p ayed n my exper ences by f e d act v ty and ana yt ca work (mass spectrometry, ma n y)

The projects I carr ed out for IGG were supported n t me by EU (DESCRAMBLE s ongo ng), Governmenta Agenc es (MIUR, INGV), and Pr vate Comm ttees

Concern ng water, my *preferred project* s the EU f nanced **Boremed**. Its goa was to assess and to manage sa n ty and boron content anoma es n water resources from the Med terranean (2001-2004, coord nated by BRGM)

I am teacher and part of the Organ z ng Comm ttee n the Short Course on Isotope Hydro ogy year y organ zed by IGG-CNR

**Finally: I'm very happy to be part of this FORESIGH on Water!**

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**Water & isotopes:**

Maddalena Pennisi

**origin and processes of the water molecule and associated dissolved elements**



| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | | | | | | | | | | | | | | | | | He |
| Li | Be | | | | | | | | | | | B | C | N | O | F | Ne |
| Na | Mg | | | | | | | | | | | Al | Si | P | S | Cl | Ar |
| K | Ca | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr |
| Rb | Sr | Y | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I | Xe |
| Cs | Ba | La* | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |
| Fr | Ra | Ac** | Ku | Ha | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lanthanides | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| **Actinides | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr |

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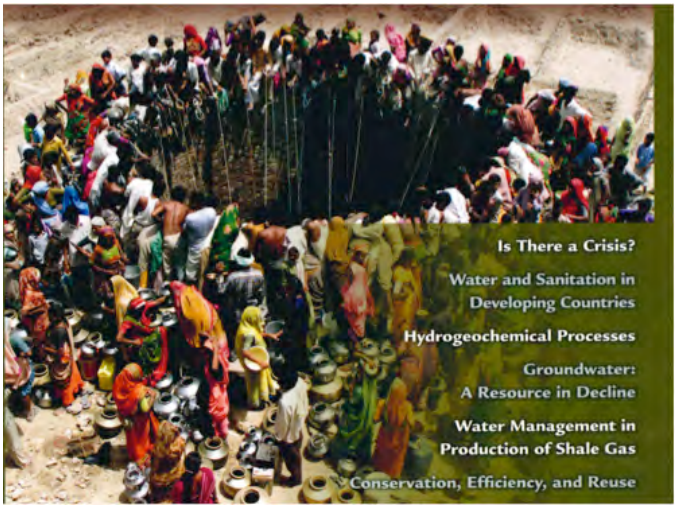
Maddalena Pennisi

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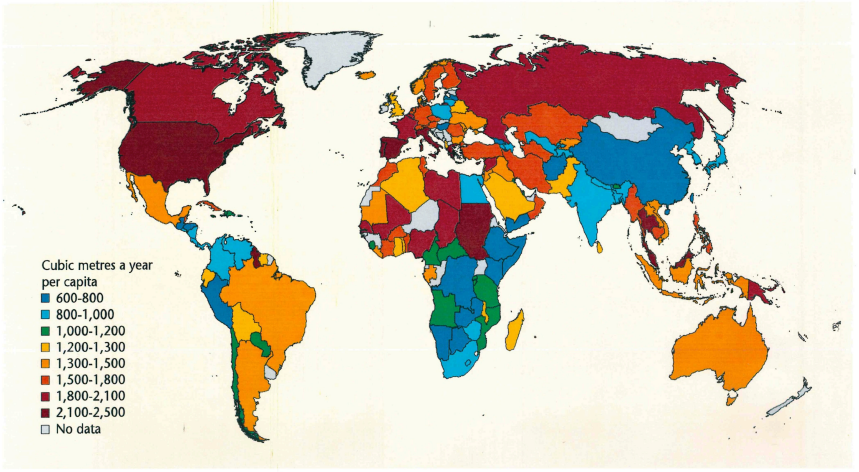
Maddalena Pennisi

## Water consumption for food, m³/y per inhabitant




De Mars y, 2015

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IRSA CNR

**ISTITUTO DI RICERCA SULLE ACQUE**

**PhD Ivan Portoghese (ivan.portoghese@cnr.it )**

Research Sc ent st at the CNR RSA s nce 2005

Ma n research nterests addressed to the hydro og ca catchments' ana ys s under c mate var ab ty and anthrop c d sturbances

Mode too s for the assessment and management of water resources w th emphas s on groundwater exp o tat on ssues

Groundwater exp o tat on susta nab ty and po cy eva uat on

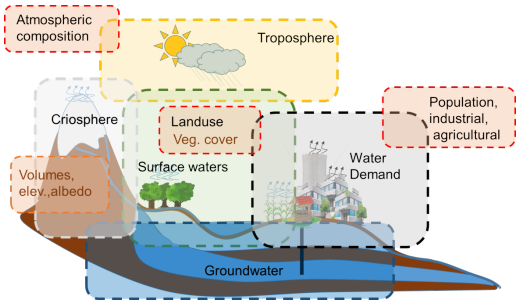
Assessment of bas n sca e hydro og ca response under c mate change cond t ons and the poss b e adaptat on strateg es n water resources management

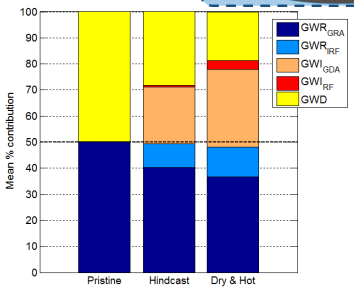
Act ve n pro ects for c mate mpact research, transboundary WRM, c mate-re ated r sks ( n Med and MENA reg ons).

Ivan Portoghese

## TRANSDISCIPLINARITY of WATER MANAGEMENT:

### Physical/ Environmental/ Social/ Economic/ Cultural/ Ethical




**Sustainable GW exploitation (GW-B approach):**

**Pristine =** before GW exp o tat on
**Hindcast =** present GW deve opment
**Dry&Hot =** d rect and nd rect mpacts

Figs courtesy of Guyennon et al. (CNR IRSA)

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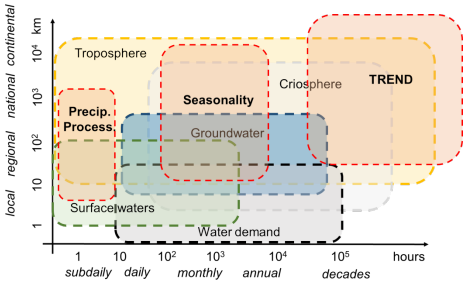
Ivan Portoghese

## Future of WATER: GLOBAL PROBLEMS

**main perspective, ideas, questions**




**1) Agriculture** accounts for **70 percent of total freshwater** w thdrawa s (g oba y).

**2) Water use data** are most y unknown.

**3) 50% more energy** consumpt on by 2035 (IEA 2010) need ng more water.

**3)** Huge prob em of **producing more food (+60% by 2050) with less water**.

**4) Large-scale water projects and Bioenergy crops** may mprove energy supp y but may **increase competition for land and water** w th mpacts on food secur ty.

**5)** A good **PROBLEM STRUCTURING is best** to dea w th c mate adaptat on. Water mang.t are typ ca **complex, messy problems** (d fferent actors hav ng d fferent prob em percept on).

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Ivan Portoghese

**COMMENTS AND SUGGESTIONS FOR INPUTS/ POINTS OF DISCUSSION (an example taken from a similar exercise):**

It s of the greatest mportance to acqu re a **good knowledge of people's problems** and **attitude to change** accept ng the com ng cha enges re ated to c mate change.

**Inefficient communication between the policy makers and the population** mpedes po cy mp ementat on.

**Governments and populations often not taking the responsibility** to react n the d rect ons **suggested by the technical experts**.

There s w de consensus on bu d ng successfu and robust adaptat on po c es based on re ab e est mat ons of c mate change mpact wh ch nc ude:

) downsca ng c mate scenar os to the sca e of the prob em so v ng and

) uncerta nty ana ys s of the methods necessary steps to frame future prob ems dea ng w th water nfrastructures.

Under h gh uncerta n scenar os the so ca ed **no-regret options** are often nvoked: **increasing population resiliency** demonstrated to be v ab e.

**Effective adaptation in the water** sector s more **viable in urban areas** (deve oped court ers).

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Antonello Provenzale
Institute of Geosciences and Earth Resources
National Research Council of Italy

General scientific interests:
**Geosphere-biosphere interactions**
**Climate change and water resources**
**Climate and ecosystem dynamics**
**Geophysical and geological fluid dynamics**

Specific questions of interest:
**Quality and quantity of future groundwater resources**
**Probability of droughts and/or extreme precipitation**
**Soil-vegetation-atmosphere water exchanges**
**Climate change and extreme impact events**
**Climate and water security**

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Antonello Provenzale
Institute of Geosciences and Earth Resources
National Research Council of Italy

Coordination of ongoing projects on climate-water-ecosystems

EU H2020 Project
***ECOPOTENTIAL: Improving Future Ecosystem Benefits through Earth Observations***
Focus on Protected Areas, make best use of Earth Observations

National Project of Interest ***NextData***:
A national system for the collection, conservation, Analysis and dissemination of climatic and environmental data in mountain and marine areas

GEO-GEOSS:
**GEO-GECO – the Global Ecosystem Monitoring Initiative**

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**Brunella Raco**

From 2001 to present she works as permanent researcher at the Inst tute of Geosc ences and Georesources of the Nat ona Research Counc of Ita y (CNR), P sa, where she carr es out researches on the env ronmenta mon tor ng of d fferent natura matr ces, espec a y water po ut on, nc ud ng ac d dra nage n dere ct m ne areas and near ndustr a fac t es w th a h ght env ronmenta mpact.

In the ast years my act v ty research has been focused to the protect on of water resources and to the f ngerpr nt ng techn ques to dent fy the or g n and the fate of contam nants.

She be ongs to the IGG-mu t d sc p nary research group that works on the ssue Aqu fer Systems: Susta nab ty and G oba Change

**Possible point of discussion during the workshop**

"Protect on of water resources". How to draw up a p a n for the determ nat on of the natura geochem ca base nes.

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Rosina Salerno
Global Health International Advisors,
PanAmericanHealth Orgnization, Washington DC

Genera sc ent f c nterests:
Econom c eva uat on,hea th po cy ana ys s, techn ca cooperat on n advanced sc ences, nternat ona hea th sector reform, g oba hea th, env ronmenta hea th, deve opment, partners network ng n deve op ng countr es.

Quest ons of nterest:
Susta nab e econom c deve opment and hea th equ ty
Us ng of m xed methods of e uat on ana ys s
System c approach to hea th
Cost ng hea th r sks and consequences of act on nert a.

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Rosina Salerno

# Main areas of work

- Universal access to primary healthcare
- Burden of diseases and suatainable ecnomics
- Safety standards
- Applied research and techical innovation
- Community participation and governance

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Andrea Scozzari

**Foresight Workshop:**
**The FUTURE of WATER: AVAILABILITY, DISTRIBUTION AND PROVISIONING**

**Background: electronic/telecommunications. PhD in information engineering.**

*… So? What do I have to do with water?*

**Here's a brief list of my main "contact points" with the water sector:**

- **Study of non-conventional water quality sensor systems, focusing on signal processing and feature extraction from electrochemical and optical signals.**
- **Investigations on remote sensing techniques (mainly optical and radar altimetry) for the observation of surface water bodies, focusing on the inland and coastal water contexts.**
- **Contribution to the organisation of a few interdisciplinary water-related events.**
**Maybe the most relevant to our meeting is a NATO-SPS funded workshop about water security in the Mediterranean region (2010). The following book was one our main outputs:**
**http://link.springer.com/book/10.1007%2F978-94-007-1623-0**
- **Investigation on data-driven techniques for the modelling of flow and transport phenomena in groundwater. In particular, system identification techniques are explored as complementary techniques to the physical modelling based on geological/geochemical information.**
- **Membership in the Action Group CTRL+SWAN (http://www.eip-water.eu/CTRL_SWAN) in the frame of the EIP-Water initiative.**

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Andrea Scozzari

**Main perspective, ideas, questions, comments and/or suggestions for inputs / points of discussion for the workshop**

**Main perspective**: enjoy listening to the key-speakers.
The multidisciplinary coverage is really impressive.

**Questions and comments**: they will come on the way…

**Suggestions for inputs / points of discussion**: the workshop proposal document poses challenging objectives. It's my first participation in a foresight exercise, thus, I do not know if there's a pre-defined method for the discussion phase.
In my currently limited view, I imagine that a preliminary phase, to determine the logical path (or method?) for the more technical exchange may be useful.

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