WATER AND CLIMATE CHANGE

Building adaptive capacity through innovative climate services for water resource managers

Executive summary

Water is one of the most fundamental resources for human and natural life on Earth and its sensitivity to climate change is expected to have a great impact on ecosystems and socio-economic development. Agreements and plans have been recently implemented aiming at fighting climate change as well as ensuring good quality of water bodies. At the European level, the Water Framework Directive (WFD) steers a legal framework for protecting water resources on the long-term perspective, while the European Green Deal defines the role of water within a prosperous society, with a modern, resource-efficient and competitive economy. Copernicus Climate Change Services (C3S) provides innovative and freely available data to base development of Climate Services upon. Climate services are powerful tools to support long term decision making in sustainable management and governance of water. The co-generation approach helps to frame the innovation to capitalize stakeholder's experience and respond to users' needs boosting their knowledge on climate science. Targeted marketing strategies are needed for harnessing the economic value of climate predictions for the private and the public sectors. Grant schemes need to be proposed to support climate services and ensure their scalability and further development also in the private sector.

Introduction

The role of water is fundamental for human and animal life on Earth. Water quality and its availability are critical factors affecting socio economic development, ecosystems and food security. Water quality and quantity are strictly linked to land use and water use; at the same time, this resource is highly affected by climate changes and it is also considered as the main means through which these changes are felt by society.

Aiming at tackling the effect of climate change on social and natural development strategies, agreements and plans have been stipulated in the past recent years. In 2015, countries adopted the **2030 Agenda for Sustainable Development**. The Agenda consists of 17 Sustainable Development Goals (SDGs) to end hunger and poverty, fight inequality and face climate change. SDG 6 "Ensure availability and sustainable management of water and sanitation for all" is specifically focused on water- and ecosystem-related targets while supporting society's health, economic development and better water management and governance.

The **Paris Agreement** (2016) brings all nations into a common cause for combating climate change and adapting to its effects. The Agreement's objectives include mitigation to reduce emissions and adaptation actions for natural and man-made catastrophes. According to the **UN Convention on Biodiversity (2013)** the growing impacts of climate change, calls for actions to increase ecosystem resilience, including adaptive water management.

The **Water JPI (2014; 2020)** declares that Climate change, groundwater over-abstraction and diffuse pollution strongly influence water availability, with impacts on health and the environment. Research is needed on safe water systems for citizens, competitiveness in the water industry, water cycle gaps. At the European level, the European Commission stipulated the EU **Water Framework Directive (WFD)** which establishes a legal framework to protect and restore clean water in the EU for ensuring its long-term sustainable use aiming at achieving good environmental status for all waters. River Basin Management Plans (RBMP) are drawn up from the Member States with

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specific programs of measures to achieve the objectives of the WFD together with an estimation of the impacts of human activities on the current status of the water. These plans take into account the impact of climate change and are drafted to be climate-proofed.

The WDF highlights the importance of all interested parties to be involved in the discussion related to the RBMP. To this end, adaptive co-management solutions are supported to bring together stakeholders at different levels and local communities for enabling a shared decision process that looks at a sustainable use of resources. This strategic approach puts research into action in a flexible framework able to cope with uncertainties.

Involvement at all levels in water-related matters are reflected in the first ever **European Citizens' Initiative "Right2Water"**, which urged the EU and the Member States to ensure (i) the right to water and sanitation to all citizens, (ii) the independency of water supply and water management from internal market rules and (iii) exclusion of water services from liberalization measures.

Due to the pressure on water availability from different uses in a variety of sectors, the Commission launched in 2012 the **Blueprint to Safeguard Europe's Water Resources.** This long-term strategy aims at ensuring the availability of sufficiently good quality water for all the legitimate needs.

Approach and results

Climate services for water resource management developed in CLARA

AQUA provides daily updated 10-day and climatological seasonal forecasts up to six months ahead on groundwater level and inflow. The service supports management for drinking water producers by giving information on future water availability depending on different water usage strategies.

PWA is a knowledge service based on water quality, habitat evaluation, sediment transport and water allocation models. PWA is able to compare different scenarios deriving from simulations driven by land, hydrologic, and climate information, forecasts and projection, useful for supporting water design, planning and management.

ROAT is a service using real-time hydro-meteorological modelling of the river basin and seasonal forecast (6 months) for the operational assessment of a multipurpose reservoir. ROAT supports the decision-making process by providing the most likely state of the reservoir and the degree of compliance with demands given some user-defined management scenarios.

FLOODMAGE is a DRR Climate Service which provides a comprehensive outlook about the potential economic and financial losses inflicted by flood hazard. Three types of flood phenomena are covered: coastal, pluvial and fluvial. The service is oriented to a variety of users and can be tailored to specific needs.

Moreover, two horizontal services were developed in CLARA for providing climate forecast data: **CLIME** for climate projections and **PPDP** for decadal predictions.

What are the key elements for good climate services towards water resource managers?

User involvement has been the key element throughout the development of the Clara services. The process of cogeneration enables the interaction of service developers, data providers and users from the early stages of design for the climate service. In this way, the users' needs and priorities can be fully addressed. As a result of this enhanced communication approach, climate services become efficient tools to facilitate the decision making process for water management in the long run. By actively participating in the development, each of the involved actors can contribute with her/his own competence and expertise, adding value to the service. At the same time, this process reduces

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the number of iterations needed in the design of a new service, proving to be more efficient in resource allocation and in terms of satisfaction degree from the users. Making sure that climate services are available and accessibility adapted allow decisions to be done timely.

Integration of local data - at proper spatial and temporal scales - in the hydrological models critically improves the quality of the results. Even if large scale hydrological modelling has proven reliability in simulating streamflow in ungauged areas, availability of observed data from measuring stations allows a better calibration of the model and spatial downscaling. This not only improves the simulation of the hydrological dynamics at the local scale but also enables to include expert knowledge from the users who have experience in the area of interest. Therefore, plans for establishing new hydrological station networks and improving data acquisition should be promoted. In addition, investments in data assimilation of Earth Observations as well as weather data would significantly improve the quality of forecasts.

Conclusion

Lessons learnt, challenges and opportunities

One of the main milestones achieved by the Clara project has been the dramatic improvement in understanding and use of the **seasonal forecasts**. Water managers built awareness around SF and received them enthusiastically, both for the possibility of anticipating what may happen a few months in advance and also for supporting their decision based on scientific results. The provision of **scenarios based on different management strategies** through the year gives an added value in terms of knowledge and preparedness for the dry season, when water scarcity affects several sectors. For example, a sustainable planning of water exploitation from different sources (lakes, surface or groundwater reservoirs, desalination facilities and natural small water retention measures) can be carried out avoiding negative impacts on society, environment and infrastructures. Information provided by running hydrological models with climate scenarios allows investigating long term availability of water as well as its quality for humans and ecosystems until the end of the century. Despite the scepticisms in trusting the uncertainty intrinsic of climate projections, these **results certainly give a good reference for design, planning and investment actions for the long term perspective**.

The current lack of knowledge represents one main challenge in the employment of climate services. To this end, activities addressed to **capacity building in climate science and climate information** should be promoted. The CLARA project has been a positive example in this sense, by bringing users from the water management sector together to discuss their problems and frameworks at the local, national and international perspective within the Multi User Forum. In addition, the use of serious games as the "Call4Water" developed within the CLARA project proved its usefulness to make the users in water resource management more aware of concepts such as reliability and uncertainty in the use of seasonal forecasts. The process of cogeneration opens the doors to **innovative ways of presenting scientific results**, finally providing effective tools in bridging the gap between technical knowledge and decision making. Access to this knowledge by users who generally have a good technical background strengthened their trust in these products. As a result, information supported by the climate services can be easily accepted and used to inform the public and apply restrictions, management or emergency plans depending on the forecasted situation.

Activities carried out by the CLARA project and the CS developed in its framework offer a clear example of integration between public data and forecasts provided by Copernicus C3S and implementation for needs at the local scale.

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Implications and recommendations for a successful CS for Water and Climate Change

Feedbacks and comments collected from the users perspective show that **the Clara project has produced powerful climate services for the water resource management sector**. Provision of tools displaying the current and the future water situation is of great importance to water managers for securing water availability in the following months, or to make big investments that require knowledge for the next 20 to 50 years. These operational advantages not only confirm the enormous **economic value generated by climate services** but also validate the need to base the development on tailored business models.

Climate services provide not only data and modelling results but most importantly they give **access to information that is valuable to water management operations**. Data is processed and then delivered in a way to facilitate communication and understanding of results to non-expert users and to the public. Thanks to the interactive approach between users and services providers enabled by the cogeneration process, the valuable information is identified from the early stage of development, while innovative solutions are drawn to design services often supported by intuitive and user-friendly online presentation systems.

The customization of hydro-meteorological and climate information represent the nucleus of the economic potential upheld by climate services, which should therefore be **supported for commercialization**. Different marketing strategies shall be applied for the commercialization of CSs in water management, whether it is addressed to the public of the private sector. Availability of funding from the governments could allow smaller authorities such as municipalities, regions or county boards to set up and employ the use of climate services in their operational activities. At the same time, competitive grand schemes could be implemented to support existing projects and their maintenance in the early stages, until the CS is self-reliant and self-sustaining.

From a regulatory perspective, one of the main issues related to water management arises because of socioeconomic drought, which occurs when different sectors dependent on the same water body or river basin use more water than sustainably available. Effective multi-risk decision support systems already exist within the European framework of flood prevention. In a scenario of climate change and water use where water is becoming increasingly scarce, flood forecasting interacts with medium-term water management, since the water that is "wasted" due to an incorrect flood forecast cannot be used later for irrigation in the critical dry periods of the following months. **A better defined regulation for improving water governance during periods of drought is hence needed for guaranteeing an even distribution of water** between the involved actors. In some of the European countries that are already strongly affected by droughts (mainly in the Mediterranean region) this is already a key factor, and in the future it may become a conditioning factor on the Northern region too.

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