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WATER & SUSTAINABLE DEVELOPMENT

WATER AND SUSTAINABLE DEVELOPMENT WM 3 - 2015

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EDITORIAL

Water and sustainable development? Is that the question? And sustainable living? Sustainable living requires health and dignity. And health and dignity need both water and development. Water is a limited resource whose amount on the planet is constant, but its availability depends, beyond the natural conditions of its location, on our technological capabilities. Therefore, sustainable water management becomes *sine qua non* for sustainable living, but that sustainable management is not a moral category, but an activity dependant of the technologies available in every place and time, modifying the quantity of resource available and the achievement of higher health and development standards.

The first steps towards sustainable access to safe drinking water and sanitation are the most important to achieve an adequate healthy life expectancy, worthy to the name. Such steps are costly and difficult, not so much economically but because of the difficult implementation of capacity building or the political blindness to accepting that sustainability and dignity in both rural and urban environments may have differing solutions.

Water sustainability will define the conditions for sustainable development. And such water sustainability will be determined by the water technologies available.

The body of knowledge made available to the sustainable management of water brings health through improved access to water and sanitation. Water needed by people, for food production and as a power source for development, providing in return access to education as a fundamental source of dignity, transformed into independent life through access to knowledge. Thus, the circle for sustainable living becomes closed.

The incorporation of the eradication of poverty as a basic objective of mankind and the acceptance of climate change has brought back our focus on uncertainty, which had been forgotten, but never disappeared, and that, will bring back knowledge to the core of the experience of the human species.

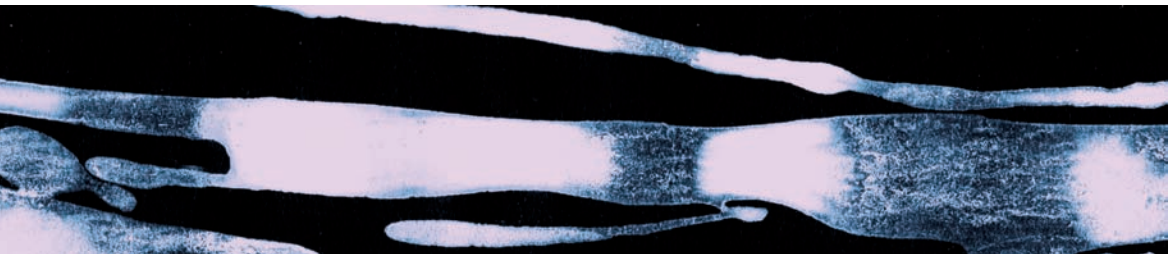
Ramiro Aurín

Cutting the umbilical cord while making our life compatible with that of Mother Earth. (© Illustration: Hiroshi Kitamura)

WATER AND SUSTAINABLE DEVELOPMENT:

IMPLEMENTING THE WATER RELATED SUSTAINABLE DEVELOPMENT GOALS. THE RELEVANCE OF TECHNOLOGY

Josefina Maestu



KEYWORDS:
SDG
SANITATION
WATER MANAGEMENT
TECHNOLOGY

With the conclusion and appraisal of the Millennium Development Goals in 2015, a new post-2015 development agenda will build on the lessons of the last 15 years. This new agenda will comprise 17 new Sustainable Development Goals (SDGs), representing an expansion and a more ambitious plan of action to help end poverty by 2030.

Goal 6 is a dedicated water goal – to "Ensure availability and sustainable management of water and sanitation for all". The agenda will be adopted by Member States at the Sustainable Development Summit in September 2015.

Moving to action is tackled by Goal 17 for about the different Means of Implementation for the achievement of the objectives. This includes Capacity Development, Financing, Institutions, Policies and Partnerships and Technology as a catalyst for change. Some key challenges for implementation in relation to the different aspects of the water related sustainable development goals are:

- *WASH:* there is a need for increased and locally appropriate WASH financing, institutional capacity, political support and management of inconsistencies in the enforcement of legislation. There is a need to scale up appropriate technologies and improve capacity to deal with inequalities and tackle the problems of open defecation, WASH in schools and health centres.
- *WRM:* there is insufficient financing and a need for improved financing in water resources management. Many countries already suffer an infrastructure deficit. Without a major increase in investment for infrastructure many countries will struggle to meet targets. Little progress has been made on payment for water resource services and ecosystem services. There are also challenges for implementing appropriate technologies. Water efficiency is in some countries not integrated into water resources management. Few countries have advanced implementation for improving irrigation and rainwater harvesting. "Technology divides" could be addressed to ensure technology becomes an effective means to attain socially and ecologically sustainable development. Insufficient capacity is also an issue. Typical problems relate to lack of human capacity both in numbers and knowledge, to plan and manage.
- *Water Quality:* there are many challenges in implementing water quality and protection of ecosystems,

involving, among others, the need for improved financing of soft and hard infrastructures, development of institutional capacity for development of standards and regulations and their monitoring and enforcement, limited information and experience on accounting for water quality and ecosystem protection (scale, data, ground-truthing and relevance, coverage and representativeness, added value for decision making, monetary valuation), and disconnection between water and land use regulations.

- *Risks:* implementation challenges with regards to risk management are mostly felt by the world's poorest communities. These include improved financing, lack of access to financial resources, insufficient new technologies, lack of capacity and limited use of traditional knowledge, improved water governance with increased focus on water, ensuring involvement of all relevant national sectors in climate actions, lack of discussion of institutional barriers and how to overcome them hindering adaptation strategies, lack of capacity, skills, and time to access resources by local governments, untapped knowledge of women and incomplete, unreliable, inaccessible or lack of hydrological information.

Fig. 1. Voices of progress.
@ Natalia Dejean-ORMAX.

THE RELEVANCE OF TECHNOLOGY TO DRIVE ACTION

The Post 2015 Agenda recognizes the critical importance of knowledge as a drive of human development and sustainability. As such, technology plays, and will play, a vital role in implementing the water related Sustainable Development Goals to 2030.

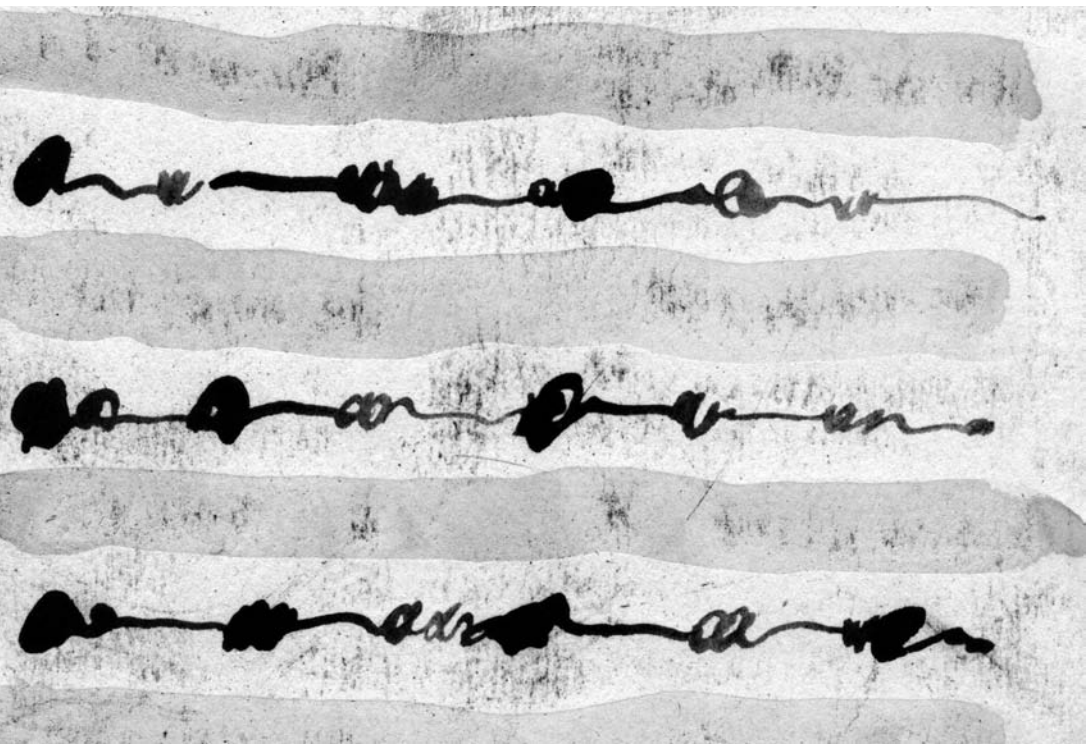
An innovative technological solution creates a domino effect that can transform lives. In Tanzania, women couldn't realize their full potential because they were marginalised, invisible, denied a voice. The necessary transformation would have to involve sweeping societal change – empowering these women and seeing them assert their rights at community, district, national levels. The women were also hampered by the fact that it was the female duty to manage water. The issues were so culturally ingrained it seemed hopeless to expect change within a short timeframe.

The first domino was a growing grant making mechanism – this was the technology innovation. The innovation was the realization that while women might be easy to marginalize, successful business people are less so. The second domino was thus economic empowerment. The third domino came with a voice, organising to demand better capacities for water and sanitation rights.[1] Since 2006 –just nine years– the situation for women in Tanzania has become much more hopeful. And it began with a technological innovation.

TECHNOLOGY?

For the purposes of development, technology is the "collection of techniques, methods or processes used in the production of goods or services or in the accomplishment of objectives, such as the SDGs". It includes knowledge of techniques and processes, often embedded in machines. This can mean software that is very sophisticated but that can be embedded in machines, computers, devices, infrastructures and thus can be used by people without detailed knowledge of its workings.

It is hard to overestimate the importance of technology for economic development. Despite recent advances, for developing world countries, foreign technology sources may account for as much as 90% of domestic productivity growth. In general, technology opens the following development opportunities.



- *Economic development* – The spread of technology is a strong catalyst for economic growth, job creation, human capital accumulation, and efficiency.
- *Environmental improvement* – Resource efficient technologies enables societies to reduce their environmental impacts, reducing the risks, degradation or collapse, and enabling adaptation.
- *Poverty alleviation* – Many innovations bring crucial social benefits as well, such as better access to water, improved sanitation, reduced energy poverty and lower health risks as a result of replacing polluting products and processes with cleaner technologies.
- *Competitiveness* – Technologies allow meeting stringent social and environmental requirements and acceding to markets with stringent water related requirements.
- *Resource productivity* – Environmental technologies enable societies to improve their resource productivity resulting in real cost savings to the economy and the environment.

- *Social capital* – Technology development and dissemination typically adopts a multi-stakeholder approach that must build trust and legitimacy.

The "knowledge era" initiated in the Industrial Revolution and the Enlightenment has already led to the accumulation of a vast repository of human knowledge, and provides convincing demonstration examples of how this knowledge can be put to the service of human development. Beyond that, the experience with the Millennium Development Goals –MDG– shows that fixing a set of well-defined priorities is a means to foster innovation and steer innovation towards commonly agreed goals. Though recent history can serve to support technological optimism it is also clear that the technological challenge coming from the SDGs is different to that of the MDGs. While the MDGs focused mostly on poor countries and provided an opportunity to advance towards poverty reduction by implementing mostly existing technologies, the SDGs call for a change in current practices and then for the development of new innovative solutions to curb current unsustainable development paths so as to make achieving the objectives of WASH possible while improving water quality, managing current and future risks and preserving water providing ecosystems.

When it came to fulfilling the MDGs and the elimination of poverty, the critical pathway consisted often in expanding the reach of crucial basic technologies (wells, latrines, water harvesting, water purification for water provision and sanitation, etc.) from high-income and middle-income economies to low-income economies, and to adapt these techniques to local circumstances. The SDGs will expand the range of existing technologies to be used and adapted for human development via the fields of water quality, water resources management and risk management.

In an important sense, meeting the SDGs will be different. The world will need new technologies and new ways to organise human activity to combine improving human development standards and environmental goals. And to fulfil the new post 2015 development agenda, technological change will be paramount, in both rich and poor countries alike.

Nevertheless, the technological challenges are not the lack of know-how nor even only the lack of innovation, they mostly consist in putting technology effectively at the service of fulfilling the human development goals. And this implementation challenge consists in bridging the gap between knowledge and action. See the box below for more information on green technologies.

As defined above, technology refers to what is feasible, and even "which are the best technical ways to cope with particular challenges?" But when going from knowledge to practice, the set of options available narrows down to those that are socially acceptable and even more, if the engagement of business and people is required, the set shrinks to those that are economically profitable or that can be made financially sustainable in the longer term.

Besides fostering innovation and know-how, the main SDG implementation challenge for technology

Green technologies have the potential to create new business opportunities, markets and jobs. They can also increase the amount of water available for drinking, agriculture, and manufacturing; boost resource efficiency; and contribute to achieving development goals. This can be done by technologies in areas such as water resources assessments, reduction of water losses, wastewater treatment, efficiency of water utilities, bio technologies, and others. Technology development – if combined with public awareness – can also contribute to increased conservation, reuse and recycling, and greater efficiency in most water using sectors.

While water use efficiency is a priority in a majority of countries, it is clear that introduction and implementation of water efficiency measures lags behind, particularly in low Human Development Index –HDI– countries. In the lowest three HDI categories water efficiency is not perceived to be integrated into water resources management, while less than 50% of very high HDI countries have advanced implementation or full implementation. Few countries have advanced implementation for irrigation and rainwater harvesting, and many lack sufficient or appropriate equipment, and several mention the need for advanced technology transfer.

While the North-South divide in access to technology remains a central issue that must be tackled based on global equity, equally important "technology divides" must be addressed to ensure technology becomes an effective and equitable means to attain socially and ecologically sustainable development: 1) Traditional versus new technologies, 2) Gender and technology, 3) Beyond technology transfer: Technology assessment, 4) Ownership and control of technology and innovation, 5) Intellectual property rights.

See UN-Water Zaragoza Conference: Water and the Green Economy in Practice:
http://www.un.org/waterforlifedecade/green_economy_2011/index.shtml

consists in finding ways to make socially possible what is already technically feasible. In this context the discussions have focused on accelerating the development, transfer, adoption and dissemination of appropriate, in particular environmentally sound technologies.

For this reason, the SDGs require a coordinated effort to find the way through new critical pathways towards sustainability. In many development areas, but particularly for water, this implies an unprecedented mobilisation of know-how operating across many sector and regions. Governments, international institutions, private business, academia, and civil society will need to work together to identify the pathways to success, in ways that combine technical expertise and democratic representation.

The so called "advantages of backwardness" (the advantage of relying on the experience of now developed countries) allows better decision making between traditional and new technologies, and going further than mechanical technology transfers by embedding gender issues, local knowledge and intellectual property rights in making the right social choice. In addition, green technologies, that increase the amount of water available boost resource efficiency and contribute to achieving development goals, may be converted into opportunities to create new business opportunities, markets and jobs. Technology, science and innovation development when combined with public awareness can make a real contribution to efficiency and sustainable growth in most water using sectors.

MONITORING

Mobile to web platforms have emerged as a key asset to aid in the long-term sustainability of water services. Mobile technologies collect data on water point type, location and functionality, and in real-time map the distribution and monitor the status of water infrastructure at country level. The information collected can provide valuable insights as a basis for informed decision-making, programme planning, and strengthen transparency and accountability. Yet, transferring technology requires both local knowledge and local capacities to make these options meet local conditions. The effective adaptation and use of these technologies depends critically on knowledge, the human and social capacities in place and the existing institutions and policies.[2]

Presently, there is a range of innovative and low cost technologies and behaviour change approaches for sanitation and water supply and management as well as technical alternatives to increase efficiency in water provision and water use. There are also many alternatives for adapting to climate change and reducing the risks derived from water extremes such as floods and droughts.

Global problem-solving oriented networks for sustainable water development will therefore become crucial new institutions in the years ahead.

SOCIAL MEDIA AND SHARING

TICs and social media represent a real opportunity to reduce the transaction cost of screening among existing alternatives and making technology choices. Scientists, technologists, civil society activists and others are increasingly turning to online networks for collaboration, crowdsourcing, group problem solving, and open-source solutions such as for software and applications. The pathways to sustainable development will not be identified through a top-down approach, but through a highly energized era of networked problem solving that engages the world's universities, businesses, non governmental organisations, governments, and especially young people, who should become the experts and leaders of a new and profoundly challenging era.[3]

Sharing knowledge, through Global Technology Platforms, is a means to improve water decisions, this includes not only the dissemination of techniques but also to the enabling conditions that may favor their transfer and adaptation and of the capacities required to make them work.

CHOICES

Technology choices are an integral part of water policy. They imply complex decisions based on non-technical criteria. Smart technologies choices require comparing between conventional technologies and new ones, balancing traditional infrastructures with green alternatives, mixing local and global knowledge, adapting alternatives from abroad to local conditions, dealing with environmental and social impacts of the alternative

technologies, etc. All these decisions require technology evaluation and assessment tools and good water governance so as to insure transparency and inclusiveness.

Besides the divide between developed and developing countries, to ensure technology becomes an effective and equitable means to attain sustainable development goals, social choices must consider some important trade-offs.

BARRIERS

This includes those initiatives intended to ease or remove barriers that inhibit the adoption of water technologies everywhere –such as weak market demand, uncertain return on investment, and technological lock-in to current infrastructure– as well as other barriers that are more specific to some developing countries, such as lack of technical skills and capacity. Patents policies may need to consider facilitating the use of technology in developing countries. Competition, policies may be examined under the lenses of its potential to foster or inhibit the adoption and dissemination of new technologies.

Fig. 4. Voices of hope.
@ UNICEF.

FINANCING INNOVATION AND ADOPTION

The post-2015 development agenda may require a significant increase in investment in infrastructure in a significant number of countries. Particularly there is a need for country-specific investment for water resources management and the control of water and wastewater quality, as well as for operation and maintenance necessary for the sustainability of services from both existing and new infrastructure, not forgetting funding of related governance functions.

Apart from the development of new infrastructures, important investments will be required to upgrade and maintain the existing ones in order to avoid them becoming obsolete and insecure.

Countries will have to find the financial capacity to undertake all this by working on strategies to attract financing for water projects, making an early approach to potential funders and making appropriate provisions in their own budgets.

Innovations in environmentally sound technologies, which are not already in the market, are often more expensive than incumbent technologies, without the necessary supportive infrastructure. This lack of infrastructures make easy for incumbents, including *"unsustainable technologies"*, to compete. Such challenges are relevant to water quality, WASH and WRM. Many innovations in sustainable water management are still perceived by private business as high risk and with uncertain return. Governments financing and policies, implemented by public private partnerships, can be purposely designed and implemented to reduce risks and promote development and diffusion and transfer of technologies on mutually agreed terms.

The introduction of environmental technologies in new markets usually requires significant and sustained funding, whether for research and development, adaptation, licensing, installation, training or operations. In some developing countries and economies in transition, the private sector's ability to pay and government's ability to support are often weak.

Governments can play a key role to foster innovation by creating the conditions to transform good knowledge and sustainable technologies into feasible and profitable business opportunities. The development and diffusion of environmental technologies significantly benefit from policy incentives in the form of tax breaks, subsidies, tariff protection, preferential terms of trade or government endorsed promotional programs. Where these policies are weak, or uncertain, or where perverse subsidies for unsustainable industries exist, the chances of success are much lower.

The possibility of water related innovations to find their way through its implementation depends on the existing market opportunities which in their turn are heavily dependent on markets prices, particularly for water but also for energy, labour and other resources. If water prices do not reflect current scarcities then market gains from resource savings in the water sector will be a poor driver to trigger the adoption of water efficient technologies.

In the same sense, the financial risks of innovations is higher for early adopters and reduces as well as the innovation is disseminated. Pilot or demonstration projects are means to trigger innovation and to speed up their diffusion as they can help reducing innovation risk and costs of scaling up.

Adoption risks and dissemination costs can also be reduced by global business solutions like the certification schemes are also efficient means to motivate business to act in the right direction of technology, science and innovation development. Further investments in science, and particularly in applied science, will help speed the innovation curve and the translation of new tested solutions into the ground.

ENABLING INSTITUTIONS FOR INNOVATION AND ADOPTION

Successful environmental technology adoption requires well-functioning public and private sector institutions, with good governance, efficient administration, an effective legal system, strong management skills and investment in R&D.

Lack of good governance can specifically hinder the opportunities of Small and Medium-sized Enterprises –SMEs– to participate in the implementation of water related solution. The creation of enabling and flexible institutional setups is a clear pre-condition for technology development and innovation.

Institutional inertia often favors technology inertia: rules are shaped to routinely approve traditional and well established technologies while increasing the costs of adopting innovations that may not find an easy way through red tape.

High transaction costs for SMEs, in the position to use low scale and better adapted innovation, may play in favor of big firms facing less uncertain regulations and having better access to public authorities.

BUILDING CAPACITIES

By their very nature, new technologies require specialized knowledge and skills, which are often lacking in countries where education levels in science, engineering and technology can be low, and emerging areas like environmental engineering, biotechnology or clean energy are underdeveloped and not supported in universities. This is stressed in the case of WASH and dealing with water risks.

Capacity to respond to water risk, for instance, may be strongly hindered by the lack of understanding of the interdependence of disasters with development, climate change, disaster risk and adaptation are the fundamentals of a culture of risk reduction.

As regards the technological aspects of water quality and WASH, professionalization of the water technology related practices is key. Codes of Practices may offer a relevant solution to this challenge.

EMPOWERMENT BRINGS DOWN BARRIERS

Innovative environmental technologies are prone to be perceived as a challenge to cultural traditions. This challenge is very important in all water themes, and especially for those activities that call for a significant engagement of local communities. It is worth recalling the importance given to local community participation in water management in the current Post 2015 Agenda.

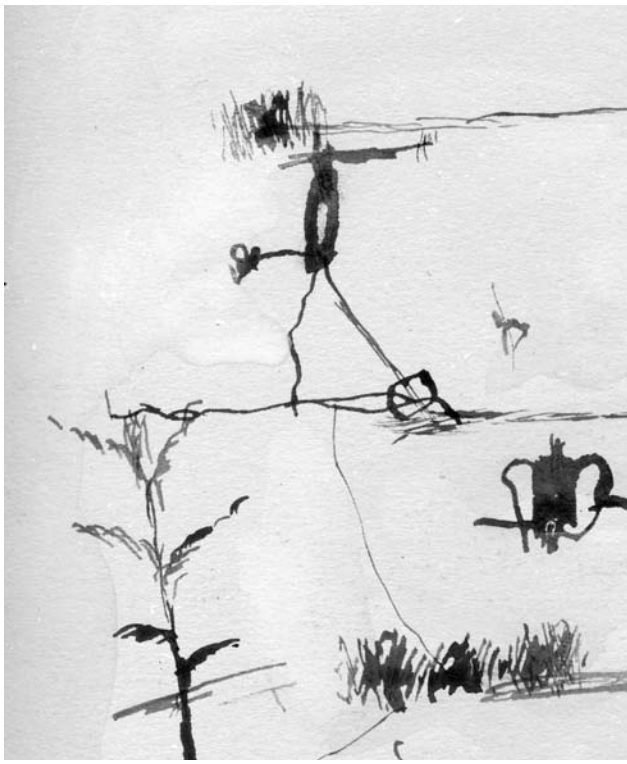
Empowering local communities and providing them with access to technical knowledge can be a powerful instrument to avoid the risk of technology project failures due to the inability of countries to absorb the technology into their infrastructure, culture and society.

In addition to favouring innovation this can support technology screening and adaptation to local conditions as well as to avoid going further with options that are not properly aligned with the host country's political and social priorities.

In the same sense empowerment can help identify existing gaps that could potentially make promising technologies fail in the end. Fluent social dialogue helps identify and tackle barriers to do with skills, insufficient financial support, market barriers and mismatches with existing infrastructures.

Technological interventions are not a panacea for all ills. But it has been shown time and again that one small technological change can create a ripple across myriad seemingly loosely connected areas, having an effect on social conditions, empowerment, visibility and beyond. When something as simple as piped access to water can transform lives, particularly of women and children, by freeing them to engage in more meaningful activities than gathering water, we owe it to ourselves to support, promote and search for better technological solutions where necessity brings us.

Josefina Maestu
Director, United Nations Office to Support the International Decade for Acction: Water for Life 2005-2015



Footnotes

[1]. http://www.un.org/waterforlife decade/waterandsustainabledevelopment2015/pdf/Mary_Rusimbi_BMCase.pdf

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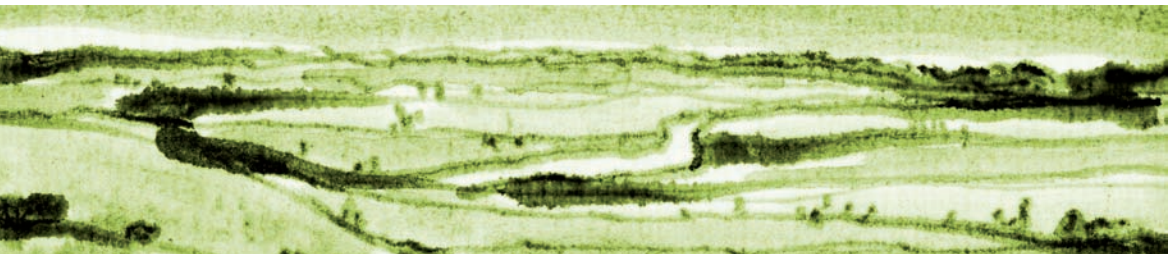
WATER AND AGRICULTURE FOR SUSTAINABLE DEVELOPMENT

Olcay Ünver



KEYWORDS:
SUSTAINABLE AGRICULTURE
RESOURCES
CLIMATE CHANGE
SUSTAINABLE LAND MANAGEMENT

CHALLENGE

The challenge of agriculture today is sustainably produce adequate and nutritious food for a growing, sophisticating, and increasingly mobile global population while preserving and preferably enhancing the resource base.

This is a multi-faceted challenge that goes beyond the ability to produce more food. Agriculture is a major employer, provider of livelihoods in multiple ways and a buffer in population mobility. Changes in the broader landscape including external drivers and how we deal with these have far-reaching implications.

The challenge today is greater than ever due to the fact that the drivers of change for agriculture and for water in agriculture have accelerated. These are population growth and mobility, economic development, changing consumption patterns and diets, and social and technological change, all exacerbated with the impact of climate change. These drivers create largely negative pressures not only on agriculture and water resources but also on the other elements of the resource base, while interacting among themselves, complicating the ways and means for us to properly deal with them.

Providing for the estimated 60% increase in the global food demand by 2050 will need a careful combination of closing yield gaps through intensification, increased water productivity, expansion of irrigation where viable, and reducing waste and loss in the food chain.

CONTEXT

The societal, macro goal of achieving a world free from hunger and malnutrition, where food and agriculture contribute to improving the living standards of all, especially the poorest, in an economically, socially and environmentally sustainable manner establishes the framework within which the issues and options for societal response (FAO, 2013) take place.

Within this framework, the agriculture sector, from policy to practice, can be sustainable when the following five principles, developed by FAO in collaboration with the member state governments and partners are properly addressed (FAO, 2014a):

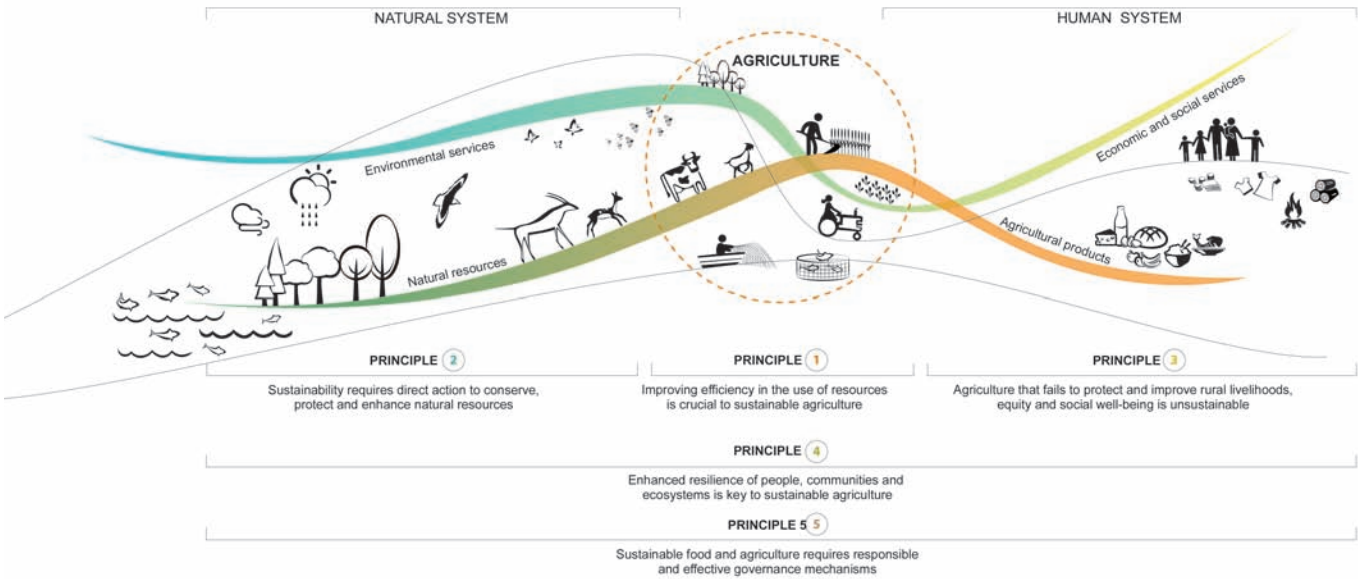


Fig. 1. The Five Principles of Sustainable Agriculture (FAO, 2014a, Fig. 3 pp. 18-19).

1. Improving efficiency in the use of resources is crucial to sustainable agriculture;
2. Sustainability requires direct action to conserve, protect and enhance natural resources;
3. Agriculture that fails to protect and improve rural livelihoods and social well-being is unsustainable;
4. Enhanced resilience of people, communities and ecosystems is key to sustainable agriculture; and
5. Sustainable food and agriculture requires responsible and effective governance mechanisms.

As agriculture as a sector does not operate in isolation, sustainability in food and agriculture is determined by the success with which the interactions involved are balanced and the trade-offs managed between the natural system and the human system. Figure 1 depicts how the elements of the natural system in the form of environmental services (e.g. climate, nutrient cycling, biodiversity, water cycle, coastal protection, filtering and buffering, purification, physical stability and support) and resources (e.g. land, soils, oceans, freshwater, genetic resources, forest resources, aquatic systems, nutrients, and energy) are linked to the human system in the form of economic and social services (socioeconomic development, poverty reduction, employment, stability, health, nutrition, shelter and clothing) and agricultural products (i.e. food, feed, fiber, and fuel). Agriculture accomplishes this through crops, livestock, forestry, fisheries, and other agriculture-related functions.

The five principles of sustainable agriculture are closely interlinked, mutually supportive and form a holistic conceptual framework. The environmental, economic and social dimensions of sustainable development are addressed in this continuum, with the first two principles referring to the environment, the third to social and economic aspects and the fourth and the fifth underpinning all three. Proper governance structures cuts across the continuum and forms the fourth dimension of sustainability in this conceptualization.

The actions in the human system, including increased levels of consumption, have grown towards the bounds of the Earth.[1] Interactions and trade-offs involved are complex and across the board and must be managed with utmost care.

Chart 1
Trade-offs in the natural system-human system domains through agriculture
Trade-offs occur most anywhere with limited resources; and when economic, social and physical decisions are involved. They occur in the domain of the respective systems, space and over time. The latter are trade-offs where immediate benefits are traded for future costs or immediate costs (investment) bring future benefits. Trade-offs occur in space when a land use decision is taken between agriculture, recreation or conservation. Inaction, like actions, also comes with benefits and costs, depending on the specific circumstances at hand, such as leaving an ecosystem intact and letting a problematic practice drag on. Examples of trade-offs involved in functioning of the natural system and the human system (FAO, 2013):
• In the allocation of use or access rights, in favor of small or large holders, and top-down versus bottom-up governance;
• In increasing production efficiencies, for example, by granting right of access to land or fishing grounds in the hands of large operators but undermining smallholders' livelihoods;
• In choosing between production of food/fiber or biofuel;
• In increasing crop production and reducing land use through intensification, at the cost of increased water use;
• In intensification of production on cultivated land, sparing large areas of forest, but increasing pollution and use of energy and nutrients;
• In over-allocation of water with water scarcity decreasing food production capacity and human benefits within a very short time frame; and
• In conservation of natural resources which often entails immediate costs for future benefits.

On an average day, agriculture produces 23.7 million tons of food, of which 19.5 million tons are cereals, roots, tubers, fruit and vegetables, 1.1 million tons meat, and 2.1 billion liters milk. On the same day, capture fisheries and aquaculture harvest over 400 000 tons of fish, and forests provide 9.5 million cubic meters of timber and fuelwood. Agriculture, on an average day, uses 7.4 trillion liters of irrigation water and 300 000 tons of fertilizer for crop production. The total value of the production of this one day of agricultural activity is estimated at USD 7 billion (FAO, 2012a; FAO, 2013a; FAOSTAT, 2013; World Bank, 2007).

There are more than 570 million farms in the world, 90% of which are run by an individual or a family and rely primarily on family labor. Family farms occupy over 70% of the global farmland and claim more than 80% of the global food production (in value terms) (FAO, 2014). They are a key element of a food-secure world and to sustainable rural development. They are also instrumental in closing yield gaps (see Chart 2) and labor productivity gaps as well as conserving the natural resources.

Agriculture, in addition to meeting our basic needs for food, feed, fiber and fuel, gives jobs to more than one in three of the world's workers, and provides rural livelihoods for 2.5 billion people (FAO, 2013a). It is also related positively to social stability, preservation of local cultures and traditions, and makes important contributions to landscape and wildlife, water management and water quality, and flood management. Agriculture, on the other hand, is a major contributor to greenhouse gas emissions through soil management practices and livestock-related activities and offers opportunities to mitigate climate change.

FAO (2015), and Lundqvist *et al.* (2015) however, reports that while the current levels of food production are more than adequate, the distribution and social, economic and cultural circumstances are failing to serve the entirety of the global population. Despite a decline of 167 million over the past decade, 795 million people are undernourished globally, counterbalanced, in a negative way, by an overweight and obese population of 2 billion. Hundreds of millions in the bottom one billion go to bed hungry; the same vulnerable group who also lack access to adequate water, sanitation, energy and hygiene. The prevalence of undernutrition in the developing regions is estimated at 14.3 percent (FAO, IFAD and WFP, 2013), where the primary cause of hunger and malnutrition is people's inability to buy. The situation has also a gender dimension: 60 % of the undernourished are women, who correspond to 43% of the agricultural labor with major disadvantages in terms of access to resources and services (Asian Development Bank, 2013) as well as in managing these resources.

Large losses, on the other hand, occur along the entire food chain. Approximately one third of all food produced for human consumption is lost or wasted, amounting to 1.3 billion tons per year. The loss or wastage occurs at the consumption stage in the medium to high-income countries and in earlier stages such as transportation and storage in low-

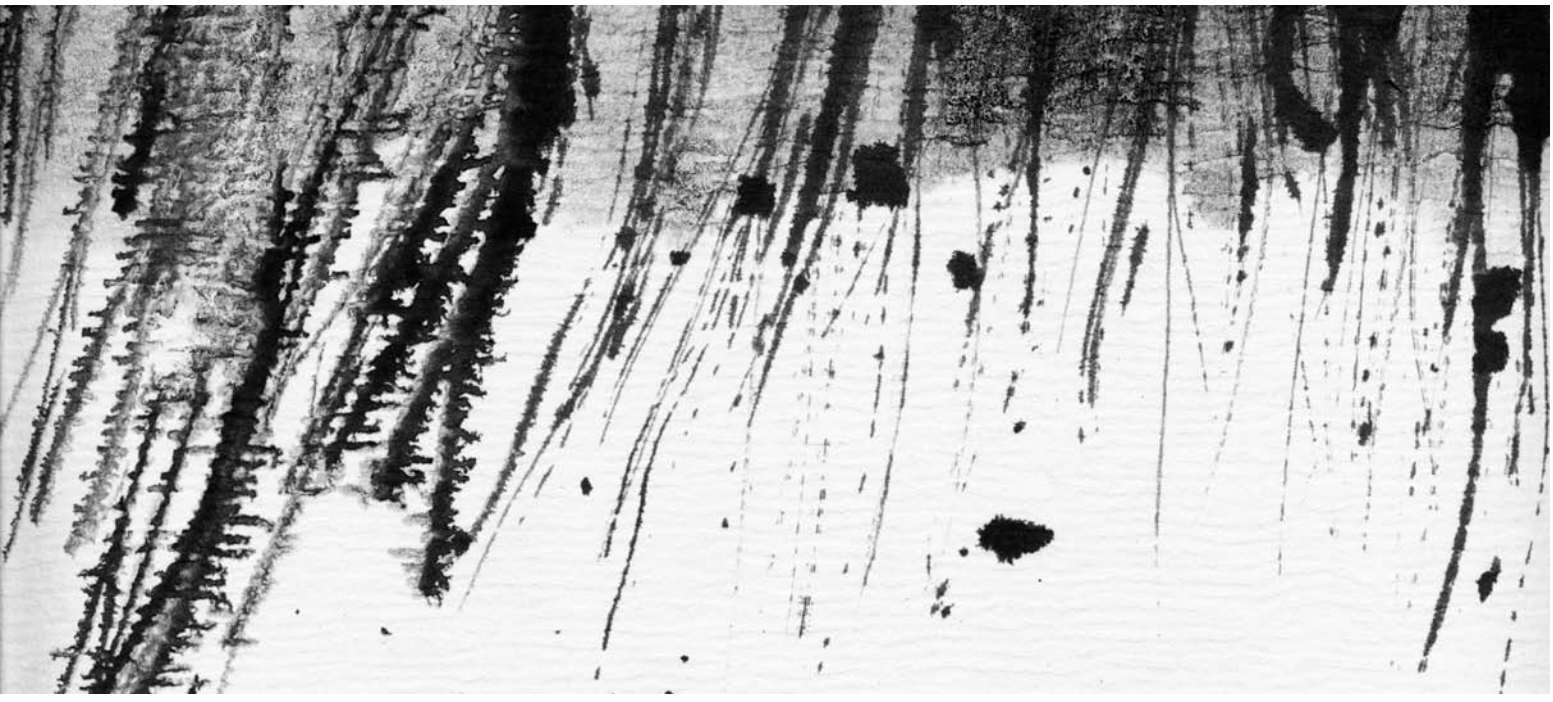


Chart 2

Estimated yield gaps (FAO, 2011b)

Estimated yield gaps (percentage of potential) for cereals, roots and tubers, pulses, sugar crops, oil crops and vegetables combined

	Actual yields in 2005 compared with potential yield (%)	Yield gap (%)
Region	**Year 2005**	
Northern Africa	40	60
Sub-Saharan Africa	24	76
Northern America	67	33
Central America and Caribbean	35	65
Southern America	48	52
Western Asia	51	49
Central Asia	36	64
South Asia	45	55
East Asia	89	11
Southeast Asia	68	32
Western and Central Europe	64	36
Eastern Europe and Russian Federation	37	63
Australia and New Zealand	60	40
Pacific Islands	43	57

Source: Adapted from Fischer *et al.*, 2010.

Chart 3

Area equipped for irrigation (FAO, 2011b)

Area equipped for irrigation (percentage of cultivated land and part irrigated groundwater)

Continent / Regions	Equipped area (milion ha)		As % of cultivated land		of which groundwater irrigation (2006)	
Year	**1961**	**2006**	**1961**	**2006**	**Area equipped (milion ha)**	**As % of total irrigated area**
Africa	**7.4**	**13.6**	**4.4**	**5.4**	**2.5**	**18.5**
Northern Africa	3.9	6.4	17.1	22.7	2.1	32.8
Sub-Saharan Africa	3.5	7.2	2.4	3.2	0.4	5.8
America	**22.6**	**48.9**	**6.7**	**12.4**	**21.6**	**44.1**
Northern America	17.4	35.5	6.7	14.0	19.1	54
Central America and Caribbean	0.6	1.9	5.5	12.5	0.7	36.3
Southern America	4.7	11.6	6.8	9.1	1.7	14.9
Asia	**95.6**	**211.8**	**19.6**	**39.1**	**80.6**	**38.0**
Western Asia	9.6	23.6	16.2	36.6	10.8	46.0
Central Asia	7.2	14.7	13.4	37.2	1.1	7.8
South Asia	36.3	85.1	19.1	41.7	48.3	56.7
East Asia	34.5	67.6	29.7	51.0	19.3	28.6
Southeast Asia	8.0	20.8	11.7	22.5	1.0	4.7
Europe	**12.3**	**22.7**	**3.6**	**7.7**	**7.3**	**32.4**
Western and Central Europe	8.7	17.8	5.8	14.2	6.9	38.6
Eastern Europe and Russian Federation	3.6	4.9	1.9	2.9	0.5	10.1
Oceania	**1.1**	**4.0**	**3.2**	**8.7**	**0.9**	**23.9**
Australia and New Zealand	1.1	4.0	3.2	8.8	0.9	24.0
Pacific Islands	0.001	0.004	0.2	0.6	0.0	18.7
World	**139.0**	**300.9**	**10.2**	**19.7**	**11.9**	**37.5**
High-income	26.7	54.0	6.9	14.7	26.5	49.1
Middle-income	66.6	137.9	10.5	19.3	36.1	26.1
Low-income	45.8	108.9	13.1	24.5	50.3	46.2
Low-income food deficit	**82.5**	**187.6**	**16.6**	**29.2**	**71.9**	**38.3**
Least-developed	**6.1**	**17.5**	**5.2**	**10.1**	**5.0**	**28.8**

Source: FAO (2010b,c).

income countries. Per capita food waste is 95-115 kg/year in Europe and North America, and 6-11 kg/year in sub-Saharan Africa and South/Southeast Asia (FAO, 2011a). Food lost or wasted represents wastage of labor, energy, water, land, and other inputs used into the production of that food. This is 250 km^3 of water wasted (equivalent to the annual flow of Russia's Volga River, or three times the volume of Lake Geneva year in, year out); and 1.4 billion hectares of land cultivated in vain. It also causes 3.3 billion tons of CO_2 equivalent of Green House Gases –GHG– released into the atmosphere per year and an economic bill of USD 750 billion every year.

On the production side, the net cultivated area on a global scale has grown by 12% over the past 50 years, more than often at the expense of forests, wetlands and grassland. During the same period, the irrigation area has more than doubled, and water withdrawals for irrigation have increased by some 80% (FAO, 2011b). The scope of further expansion is not great, with the most potential in parts of South America and in sub-Saharan Africa. Out of these two regions, South America has succeeded in improving yield from rainfed agriculture, e.g. tripling rainfed maize yield from 1 ton per hectare to 3 ton per hectare since 1960s, sub-Saharan Africa has shown little progress. Chart 2 lists the estimated yield gaps for major crops for different regions in the world, and Chart 3 shows the areas by region equipped for irrigation as compared to the cultivated land. Sub-Saharan Africa stands out the least irrigated region globally.

The projections about the increase in the global food supply falling below the population growth have so far been proved wrong, largely thanks to the increase in productivity. Crop intensification resulted in increased yields and saved large areas to be converted to farmland. It has also avoided release of an estimated 590 billion tons of CO_2 into the atmosphere (Burney *et al.*, 2010). The prospects for agriculture to respond to the increasing food demand by 2050 are supported historically but if and how this is to be accomplished is yet to be established given the state of the associated resources, investment policies, and equity issues that surround them. And all that has to be done by preserving the ecosystems whose services are essential for all life on earth.

The availability of land and water resources and healthy soils in the provisioning of the demands for food has been on the top of the development agenda for governments and communities. Pressures which can take the form of shocks at times, be it impacts of price volatility on the poor and the impoverished, or hydrologic extremes all relate to the resource. These play varying roles. For example, global agricultural markets are able to absorb supply shocks when land and water systems continue functioning. The impact of climate change, along with its resource-related impacts, points to increased uncertainty on the part of farmers in terms of predicting harvests, while moving the boundaries of agriculture with new possibilities in the northern hemisphere, and rendering lower latitudes increasingly vulnerable to changing temperatures, humidity and new stress levels. Overall, cumulative results of the physical and economic external drivers is further degradation of land, soil and water resources and deterioration of associated ecosystem goods and services.

Chart 4

Share of world's cultivated land suitable for cropping under appropriate production systems

Regions	Cultivated land (Mha)	Population (milion)	Cultivated land per capita (ha)	Rainfed crops (%)		
				Prime land	Good land	Marginal land
Low-income countries	441	2.651	0.17	28	50	22
Middle-income countries	735	3.223	0.23	27	55	18
High-income countries	380	1.031	0.37	32	50	19
Total	1.556	6.905	0.23	29	52	19

Source: Adapted from Fischer *et al.*, 2010.

Chart 5

Irrigation water withdrawals and pressure on water resources (FAO, 2011b)

Annual long-term average renewable water resources and irrigation water withdrawal

Continent Regions	Precipitation (mm)	Renewable water resources* (km^2)	Water-use efficiency ratio (%)	Irrigation water withdrawal (km^3)	Pressure on water resources due to irrigation (%)
Africa	**678**	**3.931**	**48**	**184**	**5**
Northern Africa	96	47	69	80	170
Sub-Saharan Africa	815	3.884	30	105	3
America	**1.091**	**19.238**	**41**	**385**	**2**
Northern America	636	6.077	46	258	4
Central America and Caribbean	2.011	781	30	15	2
Southern America	1.604	12.380	28	112	1
Asia	**827**	**12.413**	**45**	**2.012**	**316**
Western Asia	217	484	47	227	47
Central Asia	273	263	48	150	57
South Asia	1.602	1.766	55	914	52
East Asia	634	3.410	37	434	13
Southeast Asia	2.400	6.490	19	287	4
Europe	**540**	**6.548**	**48**	**109**	**2**
Western and Central Europe	811	2.098	43	75	4
Eastern Europe and Russian Federation	467	4.449	67	35	1
Oceania	**586**	**892**	**41**	**19**	**2**
Australia and New Zealand	574	819	41	19	2.3
Pacific Islands	2.062	73	-	0.05	0.1
World	**809**	**43.022**	**44**	**2.710**	**6**
High-income	622	9.009	45	383	4
Middle-income	872	26.680	39	1.136	4
Low-income	876	7.332	50	1.191	16
Low-income food deficit	**881**	**13.985**	**48**	**1.813**	**13**
Least-developed	**856**	**4.493**	**28**	**190**	**4**

* Refers to internal renewable water resources; it excludes "incoming flows" at the regional level.

Agriculture uses 11% of the world's land surface for crop production, and accounts for 70 percent of all water withdrawn from aquifers, streams and lakes. The land suitable for cropping is skewed against those countries that are in bigger need to increase agriculture production. Chart 4 lists the distribution of cultivated land in terms of extent, per capita use and quality by income groups (FAO, 2011b).

On per-capita basis, high-income countries cultivate twice the area as low-income countries. The availability of prime land for cultivation is higher in high-income countries by some 13%, compared to low-income countries. In most developing countries, there is little room for expansion of arable land, especially in South Asia and in the Near East/ North Africa region. Land is available for expansion in sub-Saharan Africa and Latin America but over 70% of what is available have serious soil and terrain limitations.

As for water resources availability and withdrawals, the geographic distribution is uneven. Withdrawals in Europe account for 6% of the continent's internal resources with

only 29% used for agriculture, while Asia withdraws 20% of its water resources, to allocate over 80% of it for irrigation. Chart 5 lists irrigation water withdrawals for regions and sub-regions, and according to income levels, and the pressure on the resource emanating from irrigation.

The chart shows the extent to which irrigation is stressing the existing resource base in certain regions while existing resources can avail themselves for increased use in others.

Water scarcity, be it physical, capacity-related, or economic scarcity, is a major barrier for agricultural production, and a challenge for intensification. Withdrawals in regions such as the Middle East, Northern Africa and Central Asia are already beyond critical thresholds and large regions in the Indian sub-continent and northeast China are highly stressed. Figure 2 shows the extent of water scarcity in the world based on the consumptive use in irrigation.

The figure also indicates that sub-Saharan Africa and the Americas, with the exception of the western United States are lesser-stressed for physical reasons. Sub-Saharan Africa has lower water resources development levels due to constraints emanating from capacity and financial reasons.

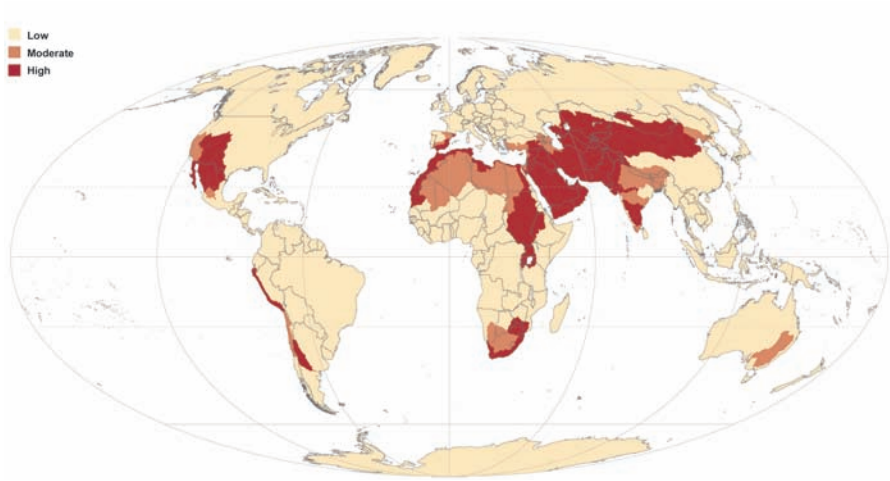


Fig. 2. Global distribution of physical water scarcity by major river basins (FAO, 2011b).

CLIMATE CHANGE AND AGRICULTURE

Climate change is a major stressor interacting with, and impacting on, most of the drivers involved in water and agriculture scenery. The entirety of the water cycle is vulnerable to the impacts of climate change and the consequences, current and future, are well explained elsewhere. Adaptation needed in the water domain to tackle with climate change has a strong agriculture component. The land use and soils bring in a strong mitigation component that complements the picture (see, for example, IPCC, 2014). Agriculture activities from crop cultivation to livestock contribute to emissions in multiple ways. These range from nitrous oxide emissions due to reasons such as fertilizer use, irrigation method and tillage to methane emissions in cattle breeding and manure management. Land use and land use changes can lead to carbon dioxide emissions. Agriculture, however, can also be a part of the response to climate change as holistic practices can provide both adaptation and mitigation benefits (see Chart 6). The increasing (and variable) use of climate-smart agriculture practices is a good example how a sector can move from a problem status to the side of the solution.

Chart 6
A landscape approach for policy making, planning, and monitoring in the Kagera river basin*
The Transboundary Agro-ecosystem Management Project for the Kagera River Basin, funded by the Global Environment Facility and implemented by FAO, aims to adopt an integrated ecosystem approach in this basin, shared by Burundi, Rwanda, Uganda and Tanzania. The project helps restore degraded lands, sequester carbon, adapt to climate change and use agricultural biodiversity in a sustainable way while improving agricultural production, rural livelihoods and food security.
One of the farmers living in Kiruhura District, Uganda was inspired to take on the new way of herd management to improve his income after being introduced to better farming methods that enabled him to keep a small, high productivity herd while combining this activity with agricultural cultivations. He sold 150 heads of cattle to keep only 10 animals and managed to increase his income from milk while planting about 10 000 trees, one acre of fruit trees, pastures and leguminous fodders whose seeds he supplies to other farmers. In addition, his family benefits from gardens of maize, cauliflower and carrots in addition to 20 beehives. He attributes the quick adoption of the new land management ways to Farmer Field School activities that promote farmer-to- farmer learning. Other farmers have benefited from the introduction of fruit trees by improving their nutrition and diversifying their income generating opportunities. Additional activities include communal tree nurseries which have enabled farmers to plant on bare hills over 150 000 trees in the area, both for timber and fruits.
A participatory multi sector process to assess and map land degradation and Sustainable Land Management (SLM) was carried out for the entire basin. The assessment provided the baseline information and a harmonized territorial estimation of the tangible elements of the ecosystem's good and services such as the impacts of land use and management practices on soil, water, biomass and biodiversity as well as its social and economic implications.
Decision makers in the four countries are assisted in analyzing what type of land degradation processes are occurring, including those exacerbated by climate change, where they are happening, what are the trends and why and what are the expected ecological and socio-economic impacts. The data and maps are used to devise the best project intervention strategy, identify best SLM practices for scaling up and guide effective and responsive interventions at various scales.
A comparison of maps showing degradation and SLM effectiveness allows decision makers to identify areas requiring interventions, select good practices that can be scaled up, and choose additional SLM measures that are needed to address specific degradation problems.
Information gathered allows for landscape and territorial management among sectors and contributes to achieving multiple objectives, including sustainable productivity, enhanced resilience to climate variability and change, and climate change mitigation.
* From brochure "FAO Success Stories on Climate-Smart Agriculture" dated 16 June 2014, accessed at http://www.fao.org/3/a-i3817e.pdf

PROSPECTS AND RECOMMENDED RESPONSE OPTIONS

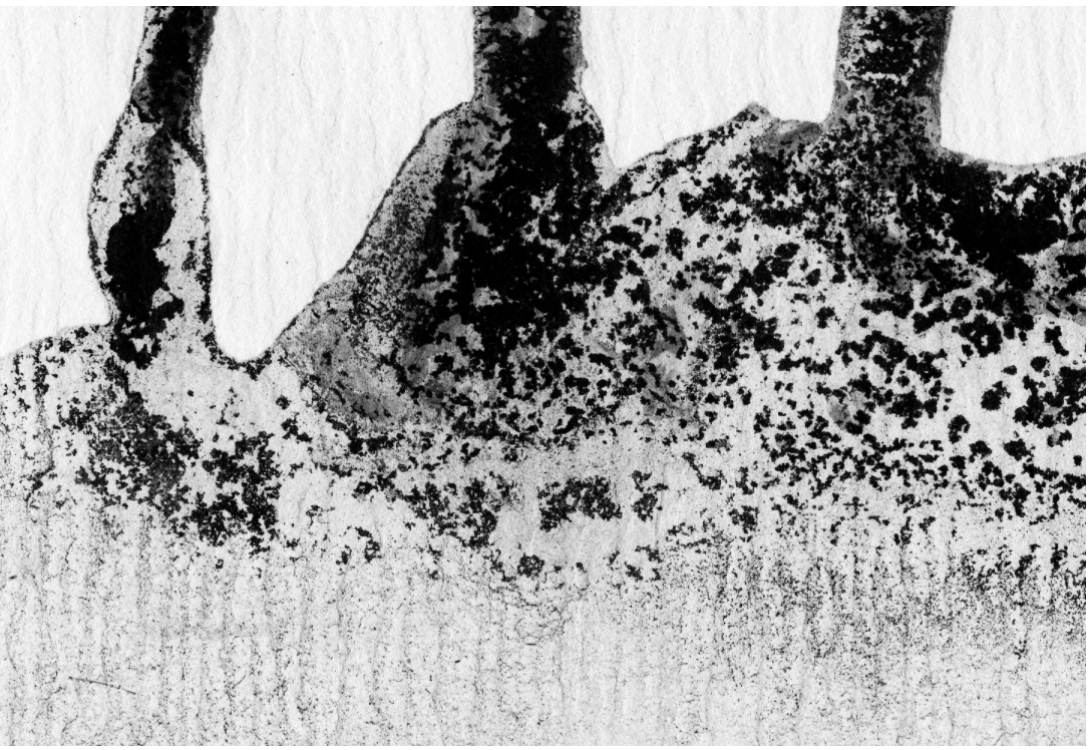
FAO projections indicate that 80 percent of the additional food required to meet demand in 2050 will need to come from land already under cultivation. There is little scope for expansion of the agricultural area, except in parts of sub-Saharan Africa and South America. One third of global land surface is degraded fro moderate to high due to the erosion, salinization, compaction and chemical pollution of soils (FAO, 2011a). Moreover, some 12 million hectares of land is added to this each year through drought and desertification (UNCDD, 2013). Much of the remaining land available is either unsuitable for agriculture, and/or the ecological, social and economic costs involved in cultivating it are prohibitively high.

Among the options available are intensification of crop production, better water productivity, increased soil health, reduction of food waste and loss from farm gate to fork, and changes in consumer behavior, implemented in a holistic, coherent manner, based on the specific circumstances from community to national scales, supported by right incentives and regulatory tools.

A white paper produced by FAO and World Water Council (2015) assesses the prospect for global food supply between now and 2050 as encouraging, albeit with caveats.

The paper states many of the poor who are currently food insecure will remain so despite the encouraging outlook. Substantial, targeted public and private sector investments will be needed to reduce poverty, increase incomes, and ensure food security for many of the world's rural and urban residents.

A similar outlook is predicted for water availability in support of meeting the demand for food production at the global level, accompanied by an increase in the number of regions facing water scarcity. This will require better governance arrangements and investment in water technologies and infrastructure. They will also need well planned food security strategies to deal with supply shortages and trade arrangements to protect them from price volatilities in food supply.



Much of the expected population growth between now and 2050 will occur in the urban areas of developing countries. The resulting competition for water and land resources will have to be well managed so agriculture can support the needs of an increased urban populace and remain viable. This will need innovation and synergetic solutions such as recycling and reuse of water and nutrients embedded in municipal waste products.

As agriculture will continue to support rural livelihoods and provide jobs for a substantial number of people in developing countries, investments will be needed in rural infrastructure and security nets.

Agriculture will remain to have the largest share in water withdrawals globally and will need to be increasingly efficient, in the face of increasing urban and industrial demands and environmental flow requirements. Among the measures to be taken now, technological innovation and targeted investments in training, institution building and education to boost productivities are essential.

Climate change has already added new challenges to the water and agriculture agenda, mostly in terms of enhanced adaptation at both regional, watershed and household levels, including water storage, conjunctive use of groundwater and surface water, wastewater capture and reuse, agroforestry, and investment in research. Special attention is needed for the uplands and mountains where much of the world's water supply originates.

Overexploitation of land and freshwater resources, both surface water and groundwater, degradation and pollution must be dealt with decisively. In other places, intensive agriculture, industrial development and growing cities pollute water bodies

to the extent that it is not anymore available for domestic or agricultural use. Public policy interventions, with effective blends of economic tools and regulatory measures, should be put in place for all levels, starting from household level.

Increased investment in technologies and research to enhance smallholder crop, livestock, and fish production is essential. Incentives for farmers to increase land and water productivity and those in education, training, and outreach should be accompanied with arrangements to encourage private sector involvement and public-private partnerships in new technologies are needed. These need to be complemented with programs and support mechanisms for farmers, especially smallholders, to deal with risks emanating from spikes in input prices, low crop yields, and extreme weather events.

Access by all to safe and adequate drinking water, sanitation, and health care is essential for food and nutrition security, with specific emphasis on women and children.

Policies and investments are needed to provide off-farm employment in rural areas especially where land and water resources constrain development. This also helps relieve pressure on urban areas.

Gender roles in agriculture work largely and widely to the disadvantage of women, especially in the developing countries where women are responsible for much of the agricultural activity. Institutional reform, public policy discourse and targeted investments are needed to and yet many of the institutional settings that influence agriculture are not supportive of women's role in the sector. More appropriate institutions, supportive policies, and strategic investments are needed to rectify this situation, not only in production but also in capacity development, outreach, more equitable land tenure, access to resources and employment opportunities.

Water institutions must adapt to increasing competition for water and land in agriculture and must effectively reflect equity and efficiency concerns to deal with competition and scarcity. Security of land tenure and water rights must be ensured in transparency. This will in turn encourage farmers to invest in their land to increase productivity and close yield gaps.

Adaptive governance structures catering to the changing circumstances, including administrative, financial and judicial systems should be put in place and be allowed to evolve, with effective stakeholder participation and proper transparency and accountability arrangements.

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Footnote

[1] 2015 update to the landmark article "Planetary Boundaries: Exploring the Safe Operating Space for Humanity" by Rockström et al. (2009) states that four of the nine planetary boundaries (climate change, loss of biosphere integrity, land-system change, altered biogeochemical cycles) have now been exceeded due to human activity (Steffen *et al.,* 2015).

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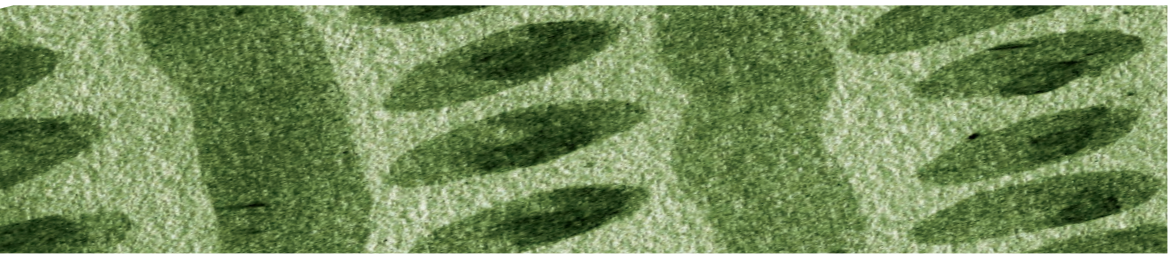
DESIGNING FOR CLIMATE CONFIDENCE:

MOVING BEYOND UNCERTAINTY IN SUSTAINABLE WATER MANAGEMENT

John H. Matthews and Guillermo Mendoza



KEYWORDS:
RISK AND UNCERTAINTY
CLIMATE CHANGE
DECISION SCALING
ADAPTATION PATHWAYS
ECO-ENGINEERING

INTRODUCTION

The desire to manage water sustainably has broad support, but defining "sustainable" water management has proven difficult for policymakers with instruments such as the Sustainable Development Goals (SDGs), but the goals are no less challenging at an operational level. An important question for defining sustainability in an operational context is the most relevant timescale for measurement: can you define sustainability over a year?, a decade?, a century?, longer?

In practice, much of our management of water occurs through the medium of long-lived infrastructure — infrastructure which can easily endure for a century or more (e.g., Li and Xu 2006), even outlasting the financing and governance mechanisms that created that infrastructure (Hallegatte 2009). At these timescales, decisions made today about design, allocation, governance, and operations may have impacts decades away, which is a timescale very relevant to the current period of climate change (Dominique 2013). Indeed, climate change has been identified as a potential risk for water managers for some decades already, but extensive disagreement exists about how to best address climate as a risk (and opportunity). Since 2008, however, the level of discussion for water managers and planners has intensified as high-profile thinkers began to question the assumption that analyzing past hydrology is a sufficient means of understanding future water conditions (Milly *et al.* 2008, Wilby & Dessai 2010).

Understanding the degree, form, and severity of climate risks facing water management and planning is necessary to achieve sustainable resource management and development goals for energy, food production, sanitation and supply, and ecosystems. Many authorities acknowledge that water is central to understanding human impacts from climate change (Sadoff & Muller 2009), but widespread disagreement remains about where, when, and how climate change is important for water management decisions. Climate change is not relevant to all water management decisions, nor are climate

change impacts equally significant when they do show an influence (Stakhiv 2011). Beyond these basic truisms, however, little consensus exists around how we identify current and projected risks and then develop adaptive strategies that are robust to those risks.

These risks do not weigh evenly on all disciplines involved in water management. For decision making on aquatic ecosystems, for instance, the tolerance for qualitative over quantitative knowledge is relatively high; an awareness of how climatic trends are proceeding may be sufficient for environmental decision makers in many cases. For infrastructure investments, however, quantifying risks is necessary for accurately meeting goals, especially if those goals have been defined through an economic or financial lens. Because water infrastructure is so necessary for meeting the demands of modern economies, much of the burden for constraining climate risks falls on engineers and engineering-informed positions.

Simply put, engineers build things. These structures are often challenging to design and construct, expensive, and difficult to move, modify, or tear down. As investments, water infrastructure will often influence ecosystems, economies, and communities for very long periods, even outlasting their own operational lifetimes (Hallegatte *et al.* 2011).

Here, an aquatic ecologist, a civil engineer, and a climate scientist describe their shared insights into how climate change influences the work of water managers and planners, some recent approaches to identifying and responding to those risks, and the means for integrating these approaches within institutional frameworks and finance mechanisms.

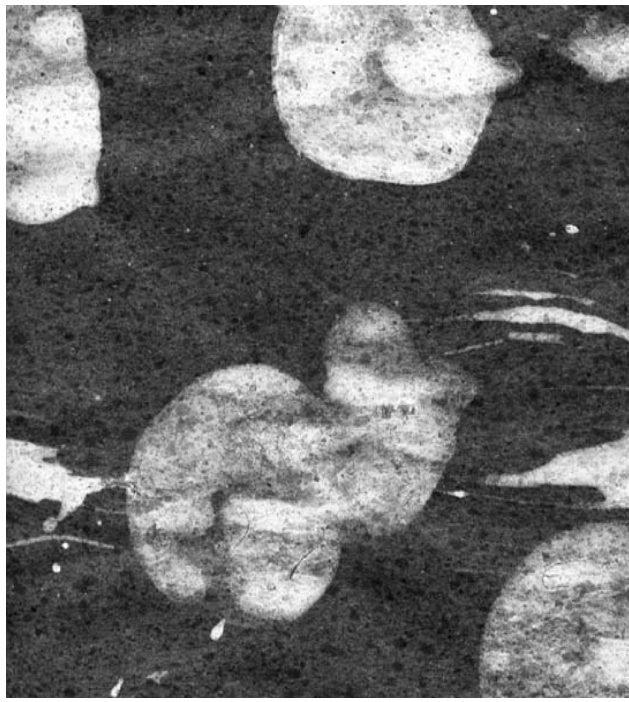
THE SIGNIFICANCE OF CLIMATE CHANGE: UNCERTAINTY AS A "NEW" RISK

Neither climate change nor uncertainty about the future are new issues for engineers or water managers. Indeed, the assumption that that past water conditions were sufficiently accurate to describe future hazards and water availability (e.g., designing a levee meet 1:100 year flood conditions based on 30 years of monitoring data) was known to be a "wrong" but useful approximation. Climate was assumed to be fixed or "stationary" (Milly *et al.* 2009, Wilby *et al.* 2009).

The water community become uncomfortable with these assumptions, perhaps as the pulse of climate change has quickened in recent decades and climate scientists have felt more comfortable attributing the role of anthropogenic forcings to particular events. Certainly, the level of awareness of a potentially disruptive connection between climate change and water management has intensified. The appearance of new hydrological conditions, apparent shifts in climate variability, and the widespread suspicion that many decades-old structures no longer match their current climate conditions appear to have fostered an increasingly wide dissatisfaction with longstanding approaches to quantitative analyses to support design, planning, and operations (e.g., Lins and Cohn 2011).

Since the 1990s, climate models have been used as a tool to project the pace and extent of future climate impacts in order to inform more robust water management solutions. As a tool, downscaled climate models enabled a quantitative approximation of future climate. In many ways, these models allowed engineers to introduce new data without significantly changing how they made design and management decisions.

However, the use of these models has proven controversial given their limitations in approximating the water cycle and in providing practical, high-confidence guidance. Discussions about the wise use of climate model information have often centered on how to reduce or constrain the uncertainties within



and between models and scenarios. Technical discussions of "uncertainty" have often proven confusing and unhelpful to decision makers seeking simple, plain-language technical recommendations. Hearing that models were unable to have consensus about increases or decreases in annual water availability may have even tainted the reputation of credible methods for incorporating climate information into water management decisions (Kundzewicz and Stakhiv 2010, Brown and Wilby 2012).

While future models and scenarios are likely to improve in their resolution and accuracy, many water managers and planners have found climate models dissatisfying for decision making when quantitative long-term outputs are necessary. Moreover, climate shifts on the water cycle will not simply alter design and operating specifications for availability and variability; climate change is already shifting many aspects of water demand as well. While bleached "bathtub rings" behind aging reservoirs and overtopped flood control levees may show how large changes in water availability can disrupt managed systems, there are also responses by water users that may have a comparable or even greater influence than direct climate impacts. Shifts from rainfed to irrigated agriculture, manufacturing to service economies, demographic shifts from immigration and shifts in reproduction and health, the rise of mega-cities, and population influxes from drying to wet regions may be among the easiest trends to predict, but all of these trends will interact in complex patterns. Together, the combination of direct and indirect climate impacts and socio-economic shifts has been called "deep uncertainty" by some observers to reflect the challenge of making long-lived, high-impact decisions despite large knowledge gaps about future trends (Hallegatte *et al.* 2012, Walker *et al.* 2013).

A huge rock in the high Norwegian Arctic. Longyearbyen, Norway. @ UN Photo/Rick Bajornas.

The types of engineering approaches necessary for a well-understood, clearly defined future would be quite different than those necessary for an "untrustworthy" future or even an unknown and unrecorded past (Brown 2010). The widespread level of dissatisfaction among engineers, water managers, and decision makers around the usefulness of projected climate information has led to two general concerns:

1. How do we make long-term decisions about specific projects given deep uncertainty about the future of climate impacts in particular places?, and
2. How do we scale lessons from particular places and projects to ensure that climate information is appropriately mainstreamed within the design and operations of all engineered water management systems at an institutional level?

These two concerns differ from each other primarily in their level of analysis (individual project scale *vs* generalized decision-making processes): developing a single-project solution is not the same as ensuring that all projects initiated by a potentially large, diverse water management institution have successfully assessed and addressed climate risks. For the project scale, emphasizing the best, most appropriate, and effective practices is essential. At an institutional level, the approach should begin by examining how existing decision-making processes function and then modifying the most relevant steps in those processes to match successful project-scale methodologies.

NORMALIZING CLIMATE ADAPTATION: ADDRESSING CLIMATE UNCERTAINTY AT BOTH PROJECT AND INSTITUTIONAL SCALES

Formal engineering-based design processes for water infrastructure follow a similar structure and decision-making cycle globally. Using the US Army Corps of Engineers (2000) as a typical example, these steps usually include:

Step 1 – Identifying problems and opportunities
Step 2 – Inventorying and forecasting conditions
Step 3 – Formulating alternative plans
Step 4 – Evaluating alternative plans
Step 5 - Comparing alternative plans
Step 6 – Selecting a plan

Including climate information in a water management project should include two elements: the need to first *assess* the potential relevance of climate change to an existing or planned project in a way that realistically accounts for climate uncertainty and then to develop a strategy (or set of strategies) to *reduce* or *avoid* future identified climate risks. From a sustainability perspective, an ideal solution should also take account of ecological impacts and interactions. Recent methodological developments have identified several promising decision-centric approaches to incorporating climate information into water management processes.

Identifying Climate Risks through Decision Scaling

Developed about 2008 through the Upper Great Lakes International Joint Commission in North America, decision scaling is a systematic "bottom-up" approach to align climate change adaptation designs with traditional engineering planning (Brown *et al.* 2011, Wilby 2011, IJC 2012). Decision scaling starts by examining the decision context, defined by an explicit "problem statement" (USACE 2000), which then drives the design and planning process (Brown *et al.* 2012, Weaver *et al.* 2012). Decision scaling sets boundaries with stakeholders to guide the problem solving process, where climate is simply a stressor of (potential) major concern. In other words, future climate states are not forecast or projected to define the problem statement, since such projections have a strong tendency to limit metrics to those that can be visualized through downscaling climate models rather than the management goals as defined by stakeholders and decision makers. Decision scaling asks the planner to confront wide the full spectrum of uncertainty provided by climate models and scenarios, though other forms of climate and non-climate data can also be included, such as paleohydrological records, actual climate records, and other types of model output. Performance indica-

tors defined by stakeholders and decision makers can be "stress-tested" against climate data in order to define "breaking points," which can then be compared with the tolerance for risk and failure held by decision makers (Garcia *et al.* 2014).

Decision scaling as a technique implies that projected climate conditions should not be part of the problem statement. Instead, we should maintain traditional engineering practices where the problem statement is defined by the critical performance in service provision or risk reduction (USACE 2000). All climate states that violate these critical thresholds of performance or risk reduction can be identified through decision scaling, which are overlaid as added stressors to the planning and design process. Climate science and analysis are used at this stage to determine the plausibility of these critical climate states to inform the evaluation of climate robust engineering solutions (Weaver *et al.* 2012). The different levels of confidence for a specific climate state, as well as institutional capabilities and levels of consequence, provide a decision framework for climate adaptation designs that can be geared towards flexibility, robustness, efficiency, or some combination of evaluation techniques. Traditionally, engineering has often guided decision makers towards selecting efficient solutions as the most optimal approach, but often other institutional mechanisms exist or can be built to provide a framework for robustness, flexibility, or some combination of these qualities (such as integrating Decision Scaling with Adaptation Pathways, as described below, or through the use of multi-institution cost-sharing plans).

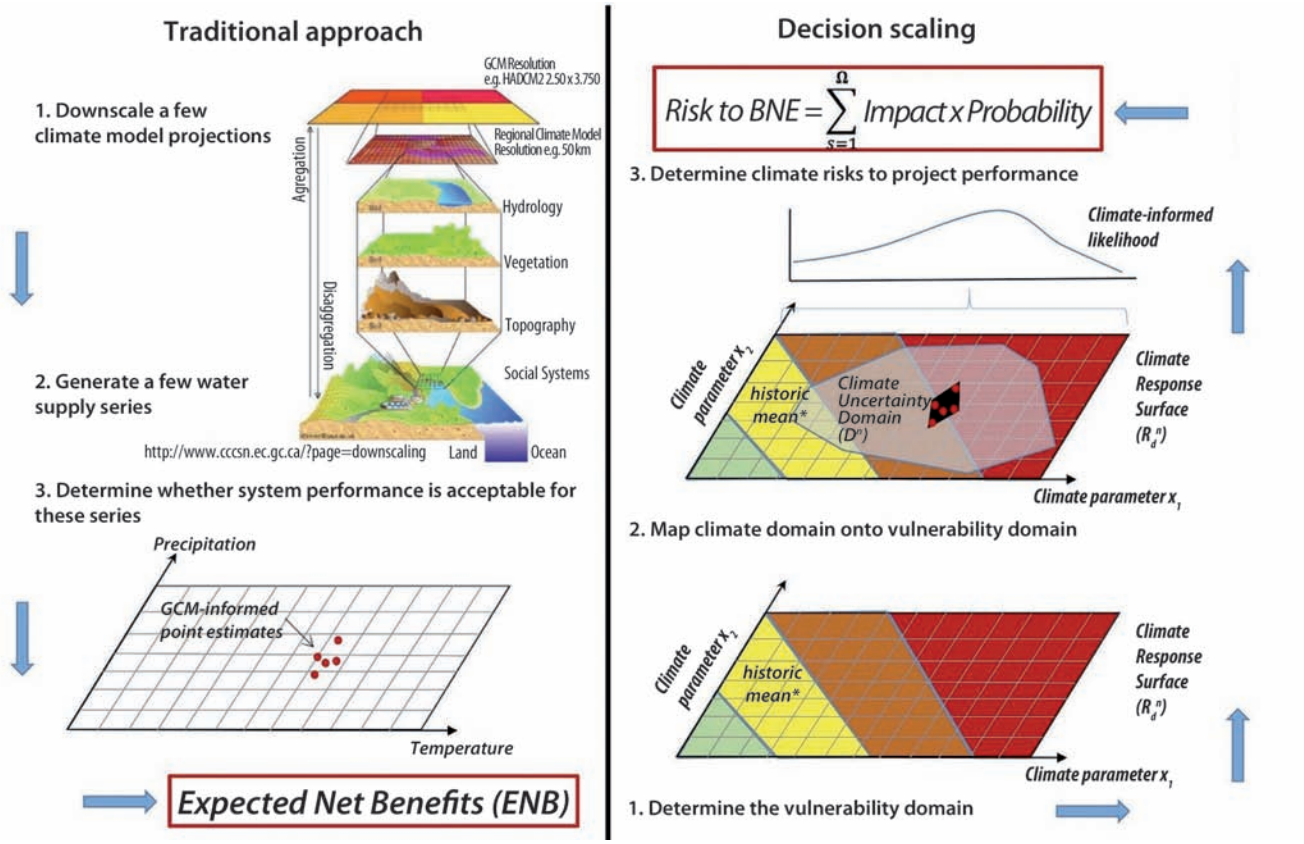
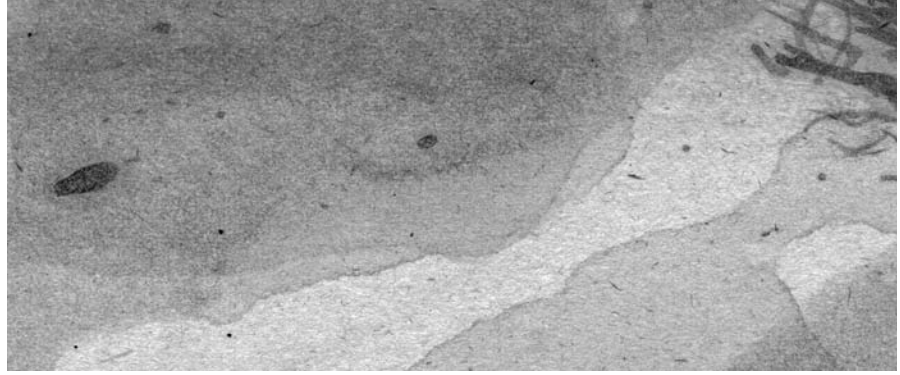


Fig. 1. Traditional approaches to assessing climate risks emphasize a top-down approach that begins with downscaling climate models to local scales, connecting these outputs to water management and water variables of interest, and the evaluating risk tolerance against some standard, such as an economic mechanism like Expected Net Benefits (ENB). Uncertainties in the projections are generally hidden, even when they are magnified through multiple model stages. Decision scaling is considered a bottom-up approach, that begins with approaching stakeholders to define a vulnerability domain ("breaking points," using criteria defined by stakeholders), mapping a variety of climate data onto that domain, and then evaluating according to external criteria such as ENB. Image courtesy of Patrick Ray.



Reducing Climate Risks through Adaptation Pathways

Decision scaling presents a powerful means to stress-test water management system, infrastructure, and operating rules using performance indicators that have been defined by stakeholders and decision makers. These performance indicators are evaluated against a wide range of conditions that is not restricted by climate projections. As a result, Decision Scaling gives water managers a good impression of the range of climate states in which a specific managed system will perform acceptably according to preset performance metrics — as well as which alternative measures will increase this performance range. As such Decision Scaling represents a "diagnosis" based on projected, actual, and hypothesized conditions as seen at one moment in time. Given the long operational lifetimes of most water infrastructure, how do we implement these decisions through time, especially when high levels of uncertainty may suggest very different successful strategies in the future, which themselves may require long lead and preparation times or may prove to be alternative, even exclusive decisions, such that pursuing one adaptation intervention may make another choice more difficult, expensive, or even impossible to pursue? What should you pursue first? Can you maximize flexibility while also minimizing risk?

Many current climate risk approaches maximize flexibility by focusing on so-called no-regrets approaches, which leave open the fullest range of options (e.g., Heltberg *et al.* 2009). Decisions about infrastructure, however, may be a challenge for no-regrets approaches given that large investments may have a high potential for "regretful" outcomes, reflecting the necessity of making many relatively inflexible decisions during the design process. Hence, Adaptation Pathways (Haasnoot *et al.* 2012) has developed as a mechanism for envisioning how sequences of decisions can be navigated over time.

In effect, when planning *consecutive* investments for a water management system, a water manager needs information on the plausibility that potential climate changes will stress the system beyond an estimate of the performance range used to judge urgency. Thus, plausible ranges of downscaled projections can be used. For planning purposes, information is needed on the order, flexibility, potential level of regret, and approximate timing of actions to take. Adaptation Pathways can provide a method for prioritizing these actions. Adaptation Pathways describe a sequence of policy actions or investments in institutions and infrastructure over time to achieve a set of pre-specified objectives (e.g., performance indicators and decision thresholds) given uncertain, hard to know, and shifting conditions.

An Adaptation Pathways diagram (see Figure 2) provides insight into the performance of actions, the sequencing of actions over time, potential decision dead-ends, and "path dependencies" (e.g., decisions that are difficult or impossible to reorder or undo once made). For instance, building a new dam may require a decade of planning, design and construction, which implies that the lead necessary for investing in that dam must be made at least 10 years before its services are needed. What decision tipping points must be met before initiating such an expensive, essentially irreversible process? What alternatives for water supply or energy generation should be considered in the meantime? Should the dam itself be built in a modular or stepwise function? What long-risks should be considered that might necessitate modifying or supplementing the dam's function and structure as the climate continues to evolve?

Decision Scaling and Adaptation Pathways are two methods that cooperate well since they both begin by testing robustness of proposed and/or actual water management solutions against a range of climate states using decision-relevant objectives to derive performance metrics and identify thresholds (also called "adaptation tipping points" [Kwadijk *et al.* 2010]) beyond which performance may fall below acceptable levels. In addition adaptation pathways add a useful planning perspective, allowing for bringing in the urgency to act, possible order actions, showing the (in)flexibility of actions taken and allowing for comparative assessment and tradeoffs for alternative possible paths based on other relevant criteria besides the primary targets. This can be done qualitatively as in the example or with more advanced cost-benefit analysis methods.

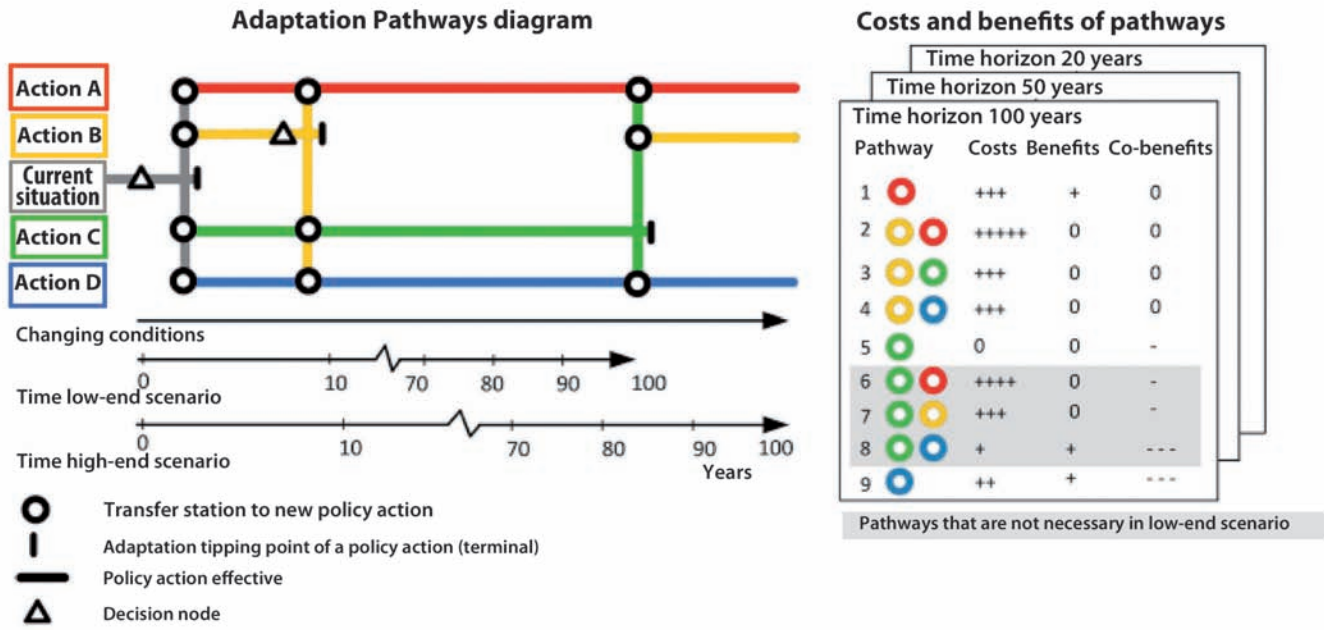


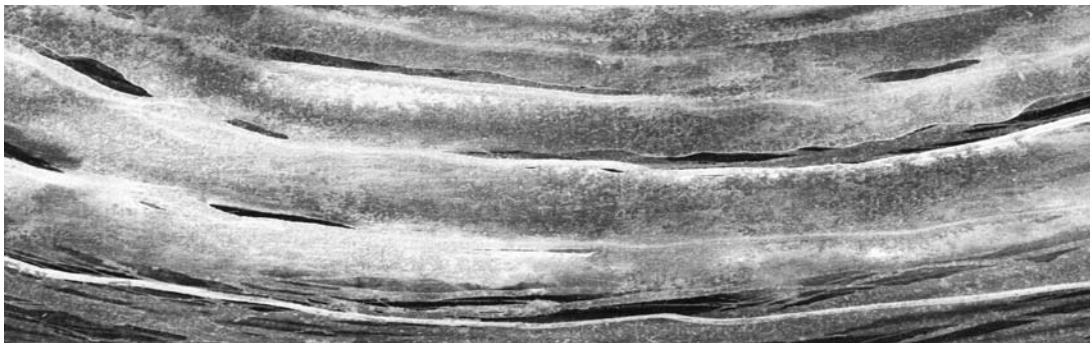
Fig. 2. An example of an Adaptation Pathways diagram and a scorecard for each of the pathways. In the map, starting from the current situation, targets begin to be missed after four years; an adaptation tipping point is reached. Following the grey lines of the current plan, one can see that there are four options. Actions A and D should be able to achieve the targets for the next 100 years in all scenarios. If Action B is chosen, a tipping point is reached within about five more years; a shift to one of the other three actions (A, C, or D) will then be needed to achieve the targets. If Action C is chosen after the first four years, a shift to Action A, B, or D will be needed after approximately 85 years in the worst case scenario (follow the solid green lines). In all other scenarios, the targets will be achieved for the next 100 years (the dashed green line). The colors in the scorecard refer to the actions: A (red), B (orange), C (green), and D (blue). The point at which the paths start to diverge can be considered as a decision point. Taking into account a lead time e.g. for implementation of actions, this point lies before an adaptation tipping point.

Integrating Ecosystems into Long-term Water Management

Any credible definition of long-term sustainability should include ecological parameters. In recent decades, ecosystem consideration in infrastructure projects has typically occurred through environmental impact assessments, which often are relegated near the end of a design and planning process. There are few standard methodologies for these assessments, and their credibility is often questioned, particularly since projects are often well developed and difficult to modify at this stage.

The gaps between the disciplines of engineering and ecology around water management issues have been significant and durable, particularly around the translation of issues of ecological concern into an operational framework that can be evaluated using engineering-oriented performance indicators. "Ecosystem services" have been the most widespread approach to integrating ecological variables by assigning monetary values to functions supplied by ecosystems that are comparable to infrastructure functions such as water purification, flood risk reduction, and water storage (Sappelt *et al.* 2011). The development and assignment of economic value to ecosystem services is often challenging and may be overwhelmed by promised investment returns on planned infrastructure services. While ecosystem services have had some partial success, they have not proven to be a panacea (Schröter *et al.* 2014).

Recently, a team of ecologists and engineers developed a framework using decision scaling (Eco-Engineering Decision Scaling, or EEDS) as a basis for facilitating trade-offs between infrastructure and ecological performance indicators (Poff *et al.* 2015). While very new, EEDS holds significant promise since the methodology facilitates trade-offs early in the design and planning process (when major changes are relatively easy to make), without reference to economic value, with ecological indicators that focus only on ecological function and resilience. Moreover, EEDS was developed with as an adaptation pathways complement, which can be used to evaluate the relative environmental impact of alternative decision pathways. For individuals and institutions already using decision scaling, EEDS should be a straightforward technique for adoption and implementation.



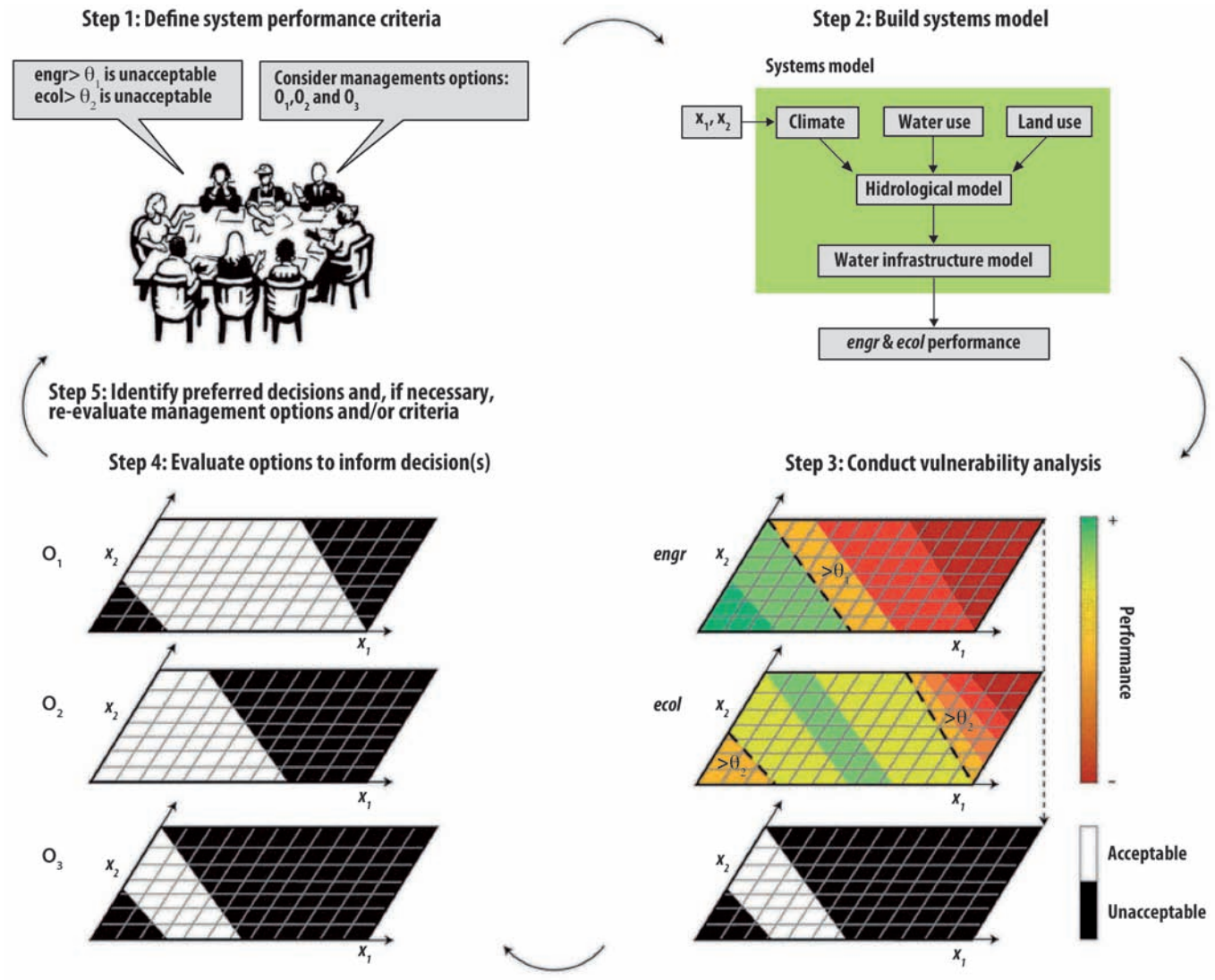


Fig. 3. An overview of the process of eco-engineering decision scaling (EEDS). The first two steps involve defining a set of ecological performance indicators in the same terms as the relevant engineering indicators, with steps 3 and 4 (and 5, if necessary) comparing and evaluating approaches to balance and tradeoff risks and opportunities between ecological and engineering concerns. Credit: Image first published in Poff, N. L., Brown, C. M., Grantham, T. E., Matthews, J. H., Palmer, M. A., Spence, C. M., *et al.* (2015). Sustainable water management under future uncertainty with eco-engineering decision scaling. *Nature Climate Change,* 1–10. http://doi.org/10.1038/nclimate2765.

Mainstreaming Climate Adaptation through the Project Design Cycle

While Decision Scaling, Adaptation Pathways, and EEDS represent emergent new approaches to assess and avoid climate risks for water managers, the challenges for implementing these methods at an institutional level require a more general reassessment of how water management decisions are defined, evaluated, and implemented globally. In most cases, making climate adaptation a consistent outcome at the institutional level requires a formal mainstreaming process (Wilby and Vaughan 2010).

Recently, the World Bank developed a stepwise process for mainstreaming decision scaling within their investment practices as a means to systematically reduce climate risks (Ray & Brown 2015). Similarly, with the support of groups such as Deltares, the Dutch Water and Environment Ministry (Rijkswaterstaat) as well as the Mongolian and Bangladeshi governments have been testing institutional-level implementations of Adaptation Pathways to develop long-term sequential planning processes.[1] As both approaches have matured and gained broader acceptance and attention, interest has grown in how to create a more unified and integrated approach to long-term water management that makes use of their complementarities.

A new initiative that started in 2014 and is led by the Dutch Water and Environment Ministry, the U.S. Army Corps of Engineers, and the Alliance for Global Water Adaptation (AGWA) is now connecting these three methodologies — decision scaling, adaptation pathways, and eco-engineering decision scaling — in a stepwise decision-making process for engineering-oriented water managers, especially those in the developing world. This project, tentatively called Climate Risk–Informed Decision Analysis (CRIDA), is intended to facilitate institutional climate adaptation mainstreaming by supplementing the standard engineering design cycle.[2]

Going to Scale: Projects, Institutions, Policies

Global climate change and sustainable development policies have a complex relationship with water management: while efforts to promote clean energy, widespread access, and effective adaptation assume that well-managed and sufficient water resources are available (and may indeed be fueling additional development and funding), neither the United Nations Framework Convention on Climate Change –UNFCCC– nor the SDGs address the gap in effective knowledge about long-term robust water resources management and design (Lexén *et al.* 2013, Lexén *et al.* 2015). The burden for developing coherent and effective operational approaches for implementing sustainable water management relies on technical decision makers and the gradual synthesis of new knowledge and expertise. Moving from project piloting to institutional mainstreaming has been an actively evolving process. Ultimately, however, national and global policymakers will need to support and enable these emerging methods to become standards, integrated within policy frameworks.

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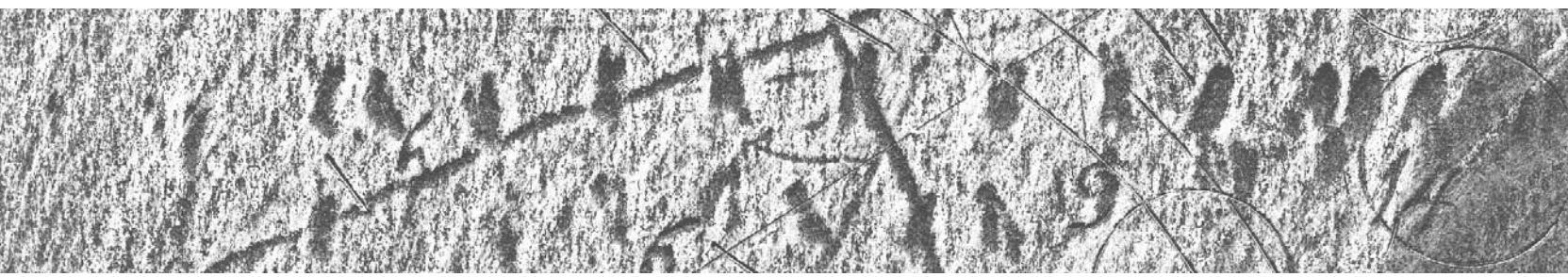

Footnotes

[1]. For instance, see https://www.deltares.nl/en/projects/climate-change-risk-assessments-and-adaptation-for-roads-the-road-apt-project/.

[2]. For more information, see http://alliance4water.org/technical/index.html.

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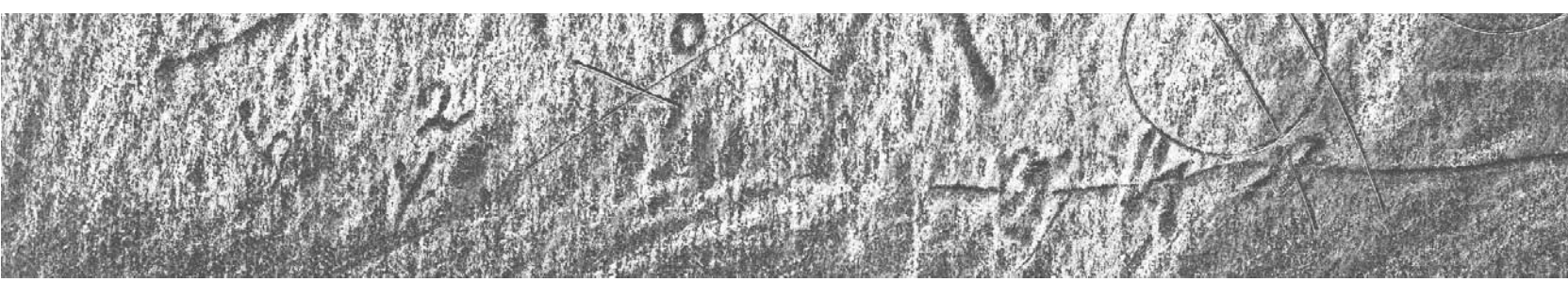
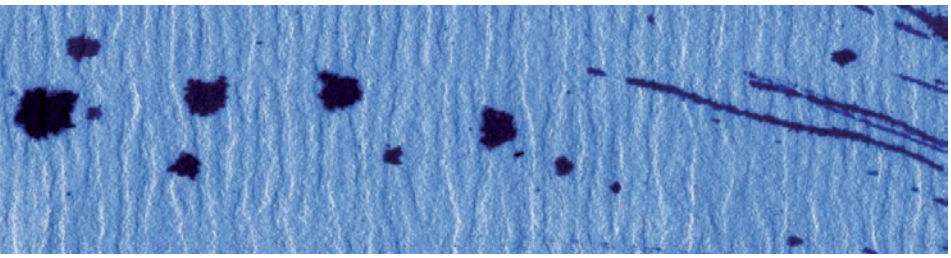


ACTING RESPONSIBLY:

BUSINESS AND THE HUMAN RIGHTS TO WATER AND SANITATION

Mai-Lan Ha



KEYWORDS:
BUSINESS
WATER RESOURCE MANAGEMENT
CORPORATE WATER STEWARDSHIP
HUMAN RIGHTS TO WATER AND SANITATION
SUSTAINABLE DEVELOPMENT GOALS

THE SUSTAINABLE DEVELOPMENT GOALS – ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL

At its upcoming United Nations General Assembly meeting in September, the global community will adopt a new set of international development goals, the anticipated Sustainable Development Goals (SDGs) that will guide the implementation of development priorities for the next fifteen years. With 17 goals and 169 targets, the upcoming Sustainable Development Goals (SDGs) are more complex than the Millennium Development Goals (MDGs) they replace. Though the MDGs provided a starting point for action, they were generally recognized to be incomplete. The SDGs strive to provide a more coherent framework for action that takes into account both the complexity and interlinkages inherent in sustainable development.

Crucial to the achievement of the SDGs, such as those related to eradicating hunger, improving child mortality, and ensuring environmental sustainability, will be sustainable management of water resources and ensuring water and sanitation for all. SDG 6, the sustainable development goal focused on water covers the interlinking nature of water including: increasing access to water, sanitation, and hygiene, addressing issues of water stress, water quality, integrated water management, and ecosystems. There is also recognition that meeting an SDG on water, and any other sustainable development goal, will require that all societal actors take action by committing resources, skills, and expertise.

Businesses will have a clear role to play given their dependency and impacts on water resources. Many companies are already doing so via corporate water stewardship practices. These practices can further be strengthened by integrating business responsibility for the human rights to water and sanitation.

THE BUSINESS CASE FOR ACTION

Wherever we look, businesses today touch upon aspects of water, either through their direct operations, in their supply chains, or in their role as water service providers.

- *Water is a non-substitutable resource:* Water itself, or the services it provides or enables, is an indispensable input for most businesses. Managing a secure access to water in the quantities needed, of the quality required, and at the right time and place is essential for the very existence of almost all businesses. This becomes increasingly important as pressures on the finite quantities of water available increase.
- *Water in the value chain:* Water plays a similar role throughout the whole value chain of industrial production and commercial activity as well as the multiple interactions with communities and stakeholders at all levels. Businesses have an interest and responsibility to understand these complex relationships and conduct their activities accordingly.

Given the importance of water, the business case for corporate action is generally based upon a number of factors:

- Ensuring the company's local legal and social license to operate in a specific location;
- Preventing or reacting to operational crises resulting from the inadequate availability, supply, or quality of water or water-dependent inputs in a specific location;
- Gaining an advantage over competitors because of stakeholder perceptions that the company uses natural resources responsibly and has a minimal impact on communities or ecosystems;
- Assuring investors and markets that business operations will continue to be profitable by securing water availability for operations and reducing water-related costs;
- Upholding corporate values based on sustainable and equitable development by contributing to the well-being of the catchments, ecosystems, and communities in which the company operates.

Businesses function at a key juncture in ensuring sustainable development policies are implemented due to the critical and active role they play in transforming resources into products and services required by societies. This case is further strengthened with the realization that business contribution specifically on sustainable development also plays a key role in businesses' long term longevity and success. The case revolves around a number of areas:

- *Ensuring Good Water Governance:* Businesses that depend upon water realize that meeting development goals necessitates addressing aspects of water sustainability more broadly including: improving water governance systems and addressing water security and water quality; all issues of importance for addressing water-related business risk.
- *Healthier employees:* Business action to ensure adequate water and sanitation in the workplace provides the opportunity for companies to ensure their employees are sufficiently cared for. Healthier employees contribute to overall long-term company productivity through less frequent sick days and absence of costs associated with the need to replace or train new employees.[1]
- *Vibrant communities:* Beyond their employees, businesses also realize that healthy communities have a positive impact on their businesses. Businesses are engaging in activities that focus on not only employees, but increasingly the families of their employees and communities at large. Healthy families ensure a high level of productivity in their workplace while

vibrant communities often serve to bolster not only a company's social license to operate, but also a healthy customer base.
- *Triple Bottom Line:* Business realize that a strong business case can be made that helping to achieve sustainable development goals offers opportunities to create innovative new products and markets.

These elements make it clear that ensuring adequate water for employees, communities, and society is needed for the long term well-being of businesses. Not taking action, on the other hand, is untenable, leading to potential greater conflict over water resources, decreased social license to operate, and increased reputational risks.

THE HUMAN RIGHTS TO WATER AND SANITATION AND BUSINESS RESPONSIBILITY

Underpinning achievement of SDG6 on water and sanitation is the recognition of the importance of the human rights to water and sanitation. In 2010, the UN General Assembly, officially recognized the human right to water and sanitation as a fundamental human right. With its recognition, governments across the world are now tasked with meeting their obligations. Today, over 80 states have recognized either explicitly or implicitly the right to water and sanitation for their citizens through constitutional amendments and national legislation, or implicitly through interpretations of provisions such as those related to the right to life, the right to health, or the right to a safe environment. (CEO Water Mandate and Shift, 2012) In tandem these governments are also passing new legislation that will have a direct impact on businesses such as those elements which prioritize water use for human consumption, public trusteeship of water resources, enhanced protection of water resources, and increased public participation and access to information in water resources management. (CEO Water Mandate and Shift, 2012)

In tandem, in 2011, the UN General Assembly and the UN Human Rights Council adopted the UN Guiding Principles for Business and Human Rights for implementation of the UN "Protect, Respect, and Remedy Framework" making them the authoritative framework for business responsibility towards human rights, including the rights to water and sanitation. The Protect, Respect, and Remedy Framework lays out the basic responsibilities of states and businesses. They rest on three pillars:

"The future development agenda must aim at universal enjoyment of the human right to water and sanitation by every single human being"

Former Special Rapporteur on the Human Right to Safe Drinking Water and Sanitation. Catarina de Albuquerque.

1) The state duty to protect against human rights abuses by third parties, including business, through appropriate policies, regulation, and adjudication;
2) The corporate responsibility to respect human rights, which means to avoid infringing on the rights of others and to address adverse impacts with which a business is involved;
3) The need for greater access for victims to effective remedy, both judicial and non-judicial. [2]

Chart 1

The right to water and sanitation covers five main areas:

Dimension	Definition
Availability	Water and sanitation facilities must be present in order to meet people's basic needs. This means a supply of water that is sufficient and continuous for personal and domestic uses, which ordinarily include drinking and food preparation, personal hygiene, washing of clothes, cleaning, and other aspects of domestic hygiene, as well as facilities and services for the safe disposal of human excreta (i.e., urine and feces).
Accessibility	Water and sanitation facilities must be located or constructed in such a way that they are accessible to all at all times, including to people with particular needs (such as women, children, older persons, or persons with disabilities). Accessibility is particularly important with regard to sanitation, as facilities that are not easily accessible are unlikely to be used and may raise safety risks for some users, especially women and girls.
Quality and safety	Water must be of a quality that is safe for human consumption (i.e., drinking and food preparation) and for personal and domestic hygiene. This means it must be free from microorganisms, chemical substances, and radiological hazards that constitute a threat to a person's health over a lifetime of consumption. Sanitation facilities must be safe to use and prevent contact between people and human excreta.
Acceptability	Water and sanitation facilities must meet social or cultural norms from a user's perspective, for example, regarding the odor or color of drinking water, or the privacy of sanitation facilities. In most cultures, gender-specific sanitation facilities will be required in public spaces and institutions.
Affordability	Individual and household expenditure on water and sanitation services, as well as associated hygiene, must be affordable for people without forcing them to resort to other, unsafe alternatives and/or limiting their capacity to acquire other basic goods and services (such as food, housing, or education) guaranteed by other human rights.

Source: CEO Water Mandate and Shift: http://ceowatermandate.org/humanrights/understanding-impacts/hrws/

The Guiding Principles look to help implement this framework by enabling businesses to develop policies and practices to show that they are respecting human rights. These include:

1. Developing and articulating a human rights policy
2. Assessing the company's actual and potential impacts
3. Integrating findings from such assessments into the company's decision-making and taking actions to address them
4. Tracking how effectively the company is managing to address its impacts
5. Communicating with stakeholders about how it addresses impacts
6. Helping remediate any negative impacts it causes or contributes[3]

Together, the recognition of water and sanitation as human rights and the adoption of the UN Guiding Principles set the baseline expectation for companies on the issue of water and sanitation.

CORPORATE WATER STEWARDSHIP AND BUSINESS RESPECT FOR THE HUMAN RIGHTS TO WATER AND SANITATION

The previous sections laid out the business case for action on water as well as growing global expectations around the human rights to water and sanitation. In response, a number of companies have taken a variety of actions to address their water risks and their impacts as related to human rights. Many have done so through implementation of good corporate water stewardship practices. Corporate Water Stewardship (CWS) is a company's progression from understanding environmental and social water risks, to improving water management in operations and supply chains, to working collaboratively with other water users and water managers to improve governance of shared water resources. Companies that commit to water stewardship broadly understand that there are two sets of risks that need attention: company-related risks that require individual company actions, and river basin-related risks that require collective action with diverse stakeholders. A foundational premise of corporate water stewardship is that businesses can take positive action to mitigate adverse impacts on communities and ecosystems, and thereby manage water-related business risks, including physical, reputation, and regulatory risks.[4]

Generally, companies can manage and implement their broad stewardship practices and policies through a corporate water management cycle which can vary from company to company. A typical process, which has been adapted from the UN Global Compact Management Model for water-related management is outlined below[5]:

1. *Commit* – Commit to drive sustainable water management.

Chart 2		
Relationship Between UN Guiding Principles and Elements of Corporate Water Management		
UN Guiding Principles Element		**Corporate Water Management Elements**
Policy Commitment and Embedding Respect	Is similar to	Commit; Define
Assessing Impacts	Is similar to	Account; Asses
Integrating and Taking Action	Is similar to	Implement
Tracking Performance	Is similar to	Monitor
Communicating Performance	Is similar to	Communicate
Remediation	No clear match but	Elements of Implement are Relevant
Source: CEO Water Mandate and Shift, *Guidance for Companies on Respecting the Human Rights to Water and Sanitation*, 2015.		

Chart 3	
Elements of Corporate Water Stewardship	
Key Elements	**Description of Activities**
Addressing operational Issues	Technical and management changes that improve water efficiency, wastewater treatment, and employee access to WAter, Sanitation, and Hygiene (WASH).
Understanding basin, context, and impacts	Awareness of how the company interacts with surrounding basin(s), including the nature and extent of local water stress, local regulation, and the company's impacts on ecosystems and communities, including any potential impacts on the Human Rights to Water and Sanitation (HRWS).
Developing a water strategy and raising awareness internally	Developing goals, strategies, and policies that integrate water risks and impacts into core business processes and decision making. Raising awareness of the company's water impacts and stewardship strategy throughout the business, from the CEO and leadership team, to facility managers, to suppliers.
Leveraging improvements in value chain	Managing water-related risks and impacts throughout the value chain from raw materials to consumers, including water use, water quality, access to WASH services in the supply chain, and other social and environmental impacts outside the company's direct operations.
Advancing water sustainability via collective action	Actions that address basin-related risks or identified collective impacts, which require proactive collaboration with others to improve local conditions and reduce water stress in the basin.
Advancing water sustainability via public policy engagement	Responsible engagement by the private sector that improves public sector capacity and advances better water governance.
Communicating with external stakeholders	Ongoing transparent reporting, disclosure and dialogue with diverse stakeholders about corporate water stewardship strategy, policies, activities, baseline conditions, and progress toward targets.

2. *Account* – Collect data on internal water performance and the condition of the basins in which the company operates.
3. *Assess* – Use the data generated in the Account phase to identify water-related business risks and opportunities and negative impacts.
4. *Define* – Define and refine corporate water policy, strategies, and performance targets that drive performance improvements and address risks and negative impacts.
5. *Implement* – Implement water strategies and policies throughout the company and across the company's value chain.
6. *Monitor* – Monitor progress and changes in performance and basin conditions.
7. *Communicate* – Communicate progress and strategies and engage with stakeholders for continuous improvement by means of corporate water disclosure.[6]

The human rights to water and sanitation have implications for all companies' water stewardship practices. By applying a human rights lens to water stewardship, a new focus on the social dimension of water is added. It focuses company's attention on understanding the impacts that company practice, in their main operations and supply chains, might have on individual's human rights to water and sanitation and requires companies to take action to mitigate or remediate those impacts. In fact, the due diligence elements of the UN Guiding Principles outlined above align well with companies' corporate water management practices as shown in Chart 2.

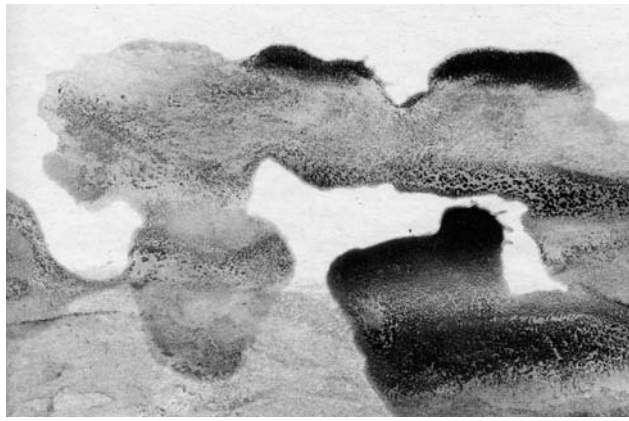
Companies that look to respect the human rights to water and sanitation will often need to build upon the work and competencies already present in their water and human rights teams as it requires the expertise of both. At a very practical level this may mean integrating elements of water or human rights

into existing systems, structures, and/or policies. For example, companies may have both standalone water and human rights policies. When they look to make a public commitment to the rights to water and sanitation, they can look to integrate water and sanitation into human rights' policies or vice versa.[7] The key here however is ensuring that the human rights lens is preserved.

In many cases, companies meeting their responsibility to respect the human right to water and sanitation will likely undertake a range of activities that also fall under existing Corporate Water Stewardship practice, described in Chart 3. Fundamental to any action related to respecting is a strong focus on ensuring appropriate and ongoing stakeholder engagement in order to develop policies, understand impacts, and respond to identified impacts.

A few examples are included below.

- *Assessing and responding to impacts on human rights:* Companies already taking action to understand their basin contexts as well as their impacts on ecosystems have a starting point from where they can look to assess impacts on communities. In many cases, impacts on the human right to water and sanitation will be dependent on a variety of actions including companies (or their suppliers') own water use, how that impacts local ecosystems, and how that in turn impacts communities. To meet their responsibilities, companies may conduct further standalone human rights impact assessments or utilize amended or revised water risk and assessment process that integrate the human rights to water and sanitation into them. Once companies understand their impacts, how they are involved, and prioritize the most pressing human rights impacts, they can take a range of actions. Often these actions are directly related to operational performance (such as limiting water use, increasing efficiency, implementing improved wastewater treatment processes) or working with others to improve water performance through collective action or engaging in supply chains.
- *Addressing cumulative impacts:* In many cases, impacts on the rights to water and sanitation are often cumulative, resulting from the actions by a variety of actors operating in a basin. Together, these actors' water use might lead to unsustainable use of local water resources or impact water quality to an extent that it impacts local communities' rights to water and sanitation. In order to both identify these impacts and take appropriate action, companies will need to work with other stakeholders in the basin. Corporate Water Stewardship's strong emphasis on collective action enables exactly this type of analysis and action via joint monitoring of local projects that leverage the resources of the private sector or engagement with policy makers.
- *Leveraging improvements in the supply chain:* In many cases, a company's greatest water-related risk does not lie in its direct operations, but rather in its supply chains. Similarly, it is often the case that the greatest impacts on the rights to water and sanitation lies in company's supply chains. Companies that recognize both their increased water risks and their water impacts and work to bring about better water performance in their supply chains are then able to both meet their responsibilities in regards to human rights and to tackle their long term water risks.



Business Case:
Company Action to Identify and Respond to Human Rights' Impacts

A company in the food and beverage industry regularly conducts human rights impact assessments in high-risk countries and has begun incorporating impacts on the HRWS into its assessments. In one country where it has a plant, the company's assessment highlighted local community members' concerns that they were experiencing reduced access to safe water and associated health problems. Local stakeholders expressed the view that the irrigation practices of local farmers (responsible for 96% of the water use in the country) and the activities of the various companies located in the watershed area were responsible for using the majority of available groundwater. This input helped the company evaluate the nature of its own involvement in the negative HRWS impacts on local communities. Following the human rights impact assessment, an independent third party-verified water resource review was completed, which concluded that the company's operations were not causing or contributing to depletion of water in the region and that the company's approach to water stewardship, and waste water treatment in particular, was effective. But the assessment also suggested that the negative HRWS impacts were nonetheless directly linked to the company's operations through its business relationships, since some of the local farmers were supplying milk to the company. In response to the linkage situation, the company committed to strengthen its engagement with local farmers about more effective use of water for irrigation purposes and responsible water stewardship, thereby using its leverage to try to mitigate the risk of the impact continuing.

To help mitigate the risk that the company's own activities might contribute in the future to negative HRWS impacts, the company also took some additional steps. The company committed to holding regular consultations with local NGOs, water experts, environmental groups and other companies located in the area about access to water issues to help evaluate whether local approaches prove effective over time. The company signed a memorandum of understanding with a major environmental NGO in order to improve water usage within the company's operations, including its supply chain, and to further implement the Alliance for Water Stewardship standard in the region and, ultimately, in the whole country.

From: CEO Water Mandate and Shift: *Guidance for Companies on Respecting the Human Rights to Water and Sanitation.*

SUPPORT FOR THE HUMAN RIGHTS TO WATER AND SANITATION

For some companies, particularly those who are UN Global Compact endorsers, there is an additional expectation that companies might go beyond respect towards supporting the achievement of the rights to water and sanitation. Supporting the rights to water and sanitation can take a number of different means including:

1. Core services through innovation and services rendered.
2. Social investment or philanthropy.
3. Collective Action and public policy engagement.
4. Partnerships.

In many cases, businesses that take steps to respect the HRWS have positioned themselves to be able to effectively support the rights. Some of the key obstacles to increased private sector engagement for activities that support access to water, sanitation, and hygiene are concerns about the long term sustainability of such projects as well as lack of clarity in regards to government versus companies' roles. Often, these projects require an array of competencies that go beyond the company's core expertise. Respect's strong focus on effective stakeholder engagement enables companies to determine what type of support would be most appropriate to local circumstances thereby increasing the likelihood of its long term sustainability. In addition, new guidance related to managing the integrity of multi-stakeholder water stewardship initiatives which would cover a number of partnerships, social investments, and

Business Case:
Respect as a Basis for Support

A company that is reviewing how to strengthen increased access to WASH in its own facilities may learn from its workers that there is a poor understanding of sanitation in the local community which may hamper the company's efforts within its factories. Via engagement with workers and others it also learns that there are existing government led programs to increase awareness around WASH in the local community. It can then decide to invest in these initiatives to both ensure that it meets its own responsibilities within its factories but also contributes to greater achievement of the right to sanitation in the local community.

From: CEO Water Mandate and Shift, *Guidance for Companies on Respecting the Human Rights to Water and Sanitation.*

collective actions that support the right, also provides guidance for how to undertake projects in a way that meets local needs and respects the role of governments.[8]

Other companies are taking a different approach, by utilizing their core businesses to directly contribute to supporting the human right to water and sanitation and achievement of WASH targets. For example, Unilever's focus on changing consumer behaviour and promoting greater access through WASH via their products such as Lifebuoy and Domestos aim at not only improving local communities' access to sanitation and hygiene but also focus on changing consumer behaviour as its relates to WASH to help ensure the long term sustainability of such interventions.

THE PATH FORWARD

Achievement of an SDG on water will require a variety of efforts by all actors. The private sector has a unique role to play in their achievement. Central to these efforts will be an alignment between companies' water stewardship practice with the rights to water and sanitation. There already exists a number of leading companies who have taken action to do exactly this, though given the extent of the challenge; many more will need to take up the call to action. By playing their roles, businesses will not only ensure their own long term viability by can play a significant role in ensuring the sustainability of this life sustaining resource.

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Footnotes

[1] For more information about the business case for sanitation in particular, please see: http://www.ceowatermandate.org/sanitation

[2] See: http://198.170.85.29/Ruggie-protect-respect-remedy-framework.pdf

[3] For more see here: http://www.ohchr.org/Documents/Publications/GuidingPrinciplesBusinessHR_EN.pdf

[4] Further details about risks can be found on the CEO Water Mandate Website and WWF websites: http://ceowatermandate.org/why-stewardship/stewardship-is-good-for-business/

[5] http://www.unglobalcompact.org/docs/news_events/9.1_news_archives/2010_06_17/UN_Global_Compact_Management_Model.pdf

[6] Please see: http://www.ceowatermandate.org/disclosure/ for more.

[7] For more step-by-step guidance on how to apply a human rights lens to corporate water stewardship please see Guidance for Companies on Respecting the Human Rights to Water and Sanitation.

[8] Please see Guide for Managing Integrity in Water Stewardship Initiatives.

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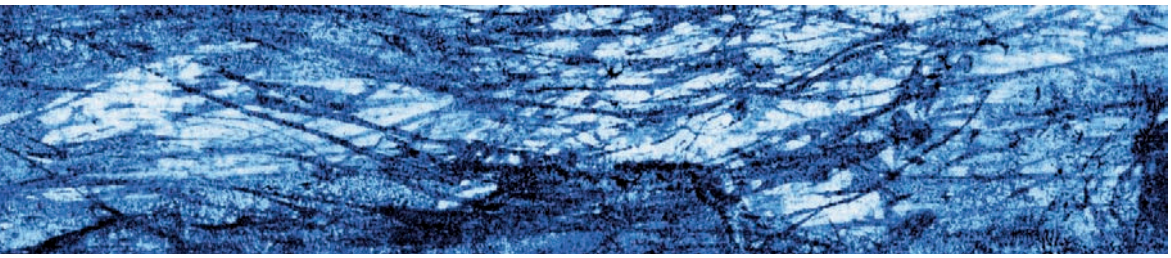
RISK ASSESSMENT

AS A TOOL TO IMPROVE WATER, SANITATION, AND HEALTH

Kyana R.L. Young and Joan B. Rose



KEYWORDS:
OMRA
SANITATION
RISK
HEALTH

INTRODUCTION

Drinking water and wastewater reuse goals and safety have advanced through the use of the Quantitative Microbial Risk Assessment –QMRA– framework and through the use of advanced diagnostic technology for monitoring pollution sources and specific hazards. Without an established framework that is inclusive of sanitation to resolve issues outside of the quality access narrative, problems will continue to amass. Therefore, it is necessary to develop a comprehensive framework that supports the concomitance of quality, access, treatment, education, and the adaption of risk assessment as a tool to improve water, sanitation, and health.

The United Nations set Millennium Development Goals –MDG– for 2000 – 2015, which included issues on wastewater treatment, unreliable energy infrastructure, maintenance capacity, and inability to pay for water and/or sanitation services, and infrastructure feasibility. However, the recommendations contained in the United Nations MDG approach were narrow or unspecified and often unachievable for regions striving for compliance; the nations in question were limited by their lack of access to financial resources particularly for sanitation. In developing regions of the world, more than 90 percent of the sewage generated in low-income countries, and more than 70 percent of sewage produced in lower-middle income countries, is discharged untreated to water bodies (Van der Bliek, 2014). Adding to these countries' situations are the fragile states of organized, well-maintained water distribution systems, sanitation management, and hygiene conditions. Investment in water and sanitation technologies is critical if global health goals are to be achieved.

Despite efforts to resolve the global issue of inadequate sanitation practices, forty percent of the global population remains without access to basic sanitation (Smith, 2002). Many people who lack access to basic sanitation reside in rural areas where open defecation is practiced. Between 1990 - 2011, the rate of open defecation decreased by nine percent globally, with the most significant change occurring in Southeast Asia. Countries such as Ethiopia, Nepal, Laos People's Democratic Republic, and Vietnam collectively achieved a greater than 30% decrease of open defecation over the 20-year analysis period (WHO, 2014).

Countries that have interest in improving their water, sanitation, and hygiene conditions are often restricted in their progress by the scarce availability of financial

resources and the mismanagement of the resources that are available. Fewer than 25% of countries with poor water and sanitation conditions have established a national sanitation plan. Lack of a management plan may also contribute to ineffective operation and maintenance of the existing technology, poor capacity building, and failure to provide education for technicians, scientists, engineers, and managers. This overview describes what is needed to use a QMRA approach for decisions regarding wastewater treatment technologies and efficiencies in the developing world, using rotavirus as the target contaminant, in order to demonstrate how prioritized and strategic investments can be translated into improved health outcomes.

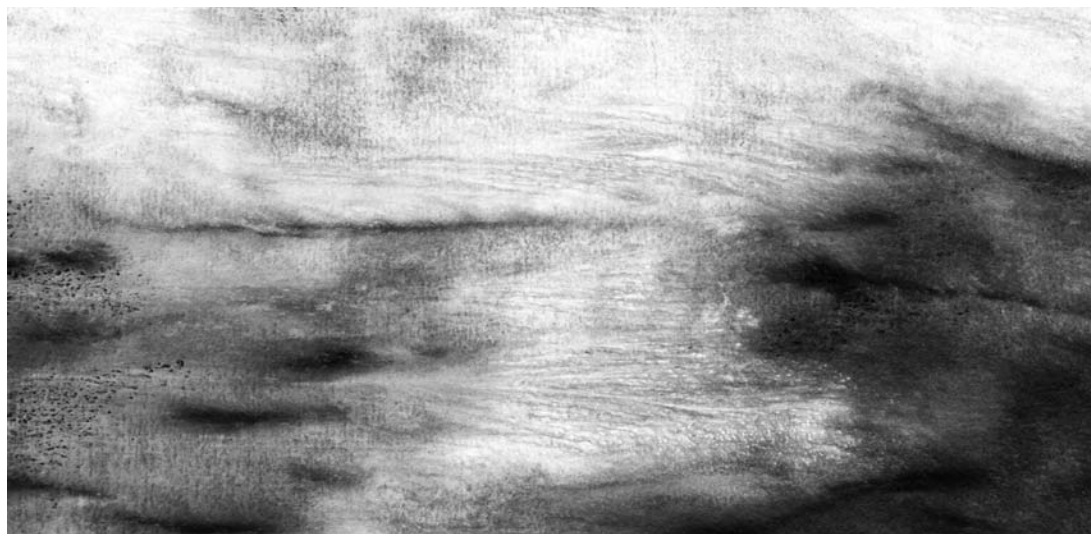
USE OF THE RISK ANALYSIS FRAMEWORK

Investments to improve sanitation and thereby protect ambient water quality for multiple purposes will require translational science and risk frameworks that improve assessment, evaluation, and resolution. Successful knowledge translation includes intentional strategies to allow for communication between multi-partied stakeholders, and the sharing of data and information from their respective perspectives. To achieve science informed decision making, the science must be written for a broad audience and information made readily accessible (Jacobs, 2005). Scientific frameworks with workable models will be imperative in communicating scientific principles and findings to policy makers (Xu, 2007).

Risk analysis, as a framework, aids in resolving the communication dilemma by translating data-intense scientific results into metrics presented as evidence-based risk estimates. QMRA has been widely accepted as a formal process for estimating human health risks from microbial pathogens and infectious disease processes related to drinking and recreational water exposure pathways (Regli et al., 1991; Haas et al., 2014; USEPA, 2011; WHO, 2011). The risk framework systematically allows for the integration of science and policy, and can be used to determine the degree to which control of water contaminants can protect water quality and health, and improve the designated uses of waterways. The framework exemplifies the translation of science into action through a staged process of problem formulation, hazard identification, dose response, exposure assessment, risk characterization, and risk management for informed decision-making.

Policymakers are rarely involved directly with scientific studies, yet they require science to make decisions regarding implementation of sound, evidence-based policies. While the methodological hypothesis-based approach –along with new tools, technology and models– allows for complex problems to be more efficiently analyzed, sanitation and water quality issues are what might be thought of as "wicked problems" (Brown et al., 2010). This phrase refers to a circumstance in which the solution to a particular problems are not fully known and the current body of knowledge is not accessible or communicated clearly to those who need the information for decision-making. With different values, interests, desired outcomes, and perspectives, the relationship between scientists and policymakers often suffers due to complexities of the problems and the lack of effective frameworks to improve communication.

Regions with limited water supply often use wastewater either inadvertently or with planning to supplement their non-potable water needs, for designated purposes such as agricultural irrigation, recreation and simply maintaining environmental flows. Depending on the access to a sewer, or sanitation facility, type of sewage treatment, water use in the community, prevalence of infection in the population (in this case we will use pathogenic viruses as our target), the final concentration in treated wastewater will vary and the loading to surface water resources will also vary. Inadequate treatment of the fecal wastes whether using dry or wet sanitation prior to final disposal or reuses only displaces the risk, these practices posing health risks to local, downstream and special populations.



QUANTITATIVE MICROBIAL RISK ASSESSMENT FOR SANITATION: A CASE STUDY

Introduction

Characterization of pathogens and particular viruses that are persistent, potent, and excreted in high numbers in feces or into sewerage systems is needed, as it is clear that fecally-polluted and sewage-dominated waters as well as wastewater reuse will be increasing in the future. Globally, waterborne diseases include hepatitis, viral gastroenteritis, meningitis, encephalitis, myocarditis (norovirus, coxsackievirus). Recently, Kuilia *et al.* (2015) produced the first global map of rotavirus emissions to surface waters. Rotavirus, one of the key causes of childhood diarrhea, was estimated at 2×10^{18} viral particles/grid/year, of which 87% is produced by urban populations (Figure 1). Key monitoring data are needed to further study pathogen concentrations in sewers, sewage systems, through various treatment processes and in discharges to surface water, and to address improved management.

A detailed assessment of the virus in both untreated and treated wastewater is imperative. The QMRA process follows the problem statement, hazard identification, exposure assessment, dose response, risk characterization, and risk management and the resulting analysis can be used for informed decision-making. Specific to this paper, for the overall assessment when using QMRA this can provide evidence based recommendations on how to improve water quality, sanitation management, for improved health conditions of the global populations.

The Problem Formulation

Increases in population growth, and the subsequent increase consumption and withdrawal of water, presents challenges in providing both adequate quantity and compliant quality of water simultaneously. With the addition of other external factors, such as climate changes, eutrophication, and fecal contaminated waters, greater health risks are present for populations who have limited access to water resources. These water resources have a variety of designated uses including the provision of safe drinking water. Vulnerable populations with limited, or no access, to improved sanitation and water supply, are also the populations of people around the world who live under water scarce conditions; they rely on polluted waters contaminated with harmful microbial and chemical contaminants.

Viruses, in particular, are a target for control as the adverse health effects can be vast and immediate; a single exposure through drinking or recreational water can cause an outbreak that widens over the course of days or weeks. The problem formulation will focus on the emission and health effects in a population once they are exposed to waters fecally contaminated with rotavirus. Management strategies that examine various efficacies of sewage treatment as a public health provide an effective approach to improving water quality.

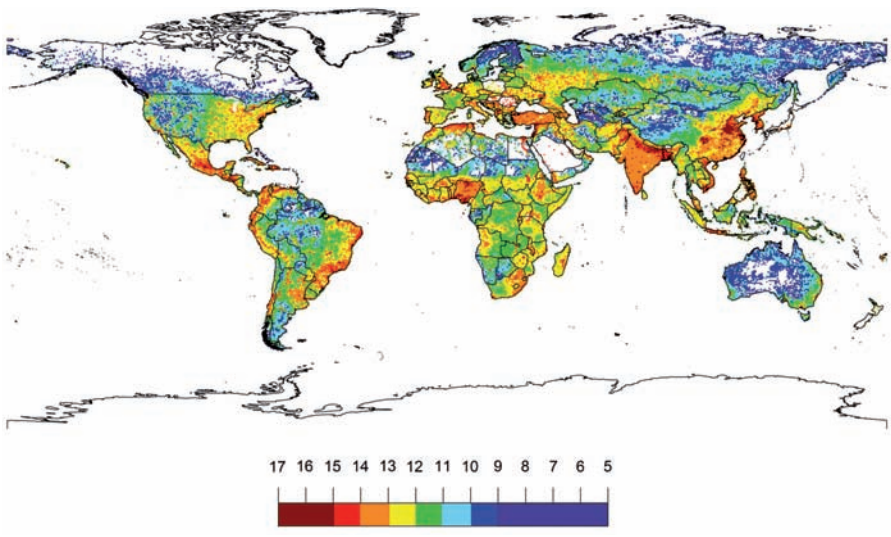


Fig. 1. Rotavirus emissions for $\log_{10}$ viral particles per grid per year

Hazard Identification

Over the last 20 years, there have been advances in water diagnostics and testing technologies, allowing greater ability to monitor pathogens at full scale. A deeper understanding of the variation in pathogen loads found in wastewater, and of the ability of secondary treatment to remove these waterborne microbial agents, has been forthcoming in water treatment advancements. Pathogen discovery has also been a critical driver in emerging concerns about new viruses and other waterborne disease-causing agents in sewage. New genomic tools have been extremely useful in identifying possible hazards. Identification of quantitative data on total culturable viruses using more standard methods (e.g. *Information Collection Rule* methods) and new methods for other viruses, including Quantitative Polymerase Chain Reaction –QPCR–, are useful for determining the concentration of a particular virus. This advanced characterization aids in providing scientific evidence and justification for delineating the appropriate log reductions required by water treatment practices. Rotavirus remains an important virus, and while a vaccine is available, uptake is poor in some areas. As this virus mainly affects children's health, a targeted effort on both the environmental and community health will assist in abating other pathogenic risks.

Exposure Assessment

Exposure assessment is extremely important as countries begin to prioritize watersheds and designated uses of their water resources for economic development (i.e. tourism, food security and water supply). The pathways from the source to the location where humans are exposed should be fully understood for each watershed. As mentioned above, Kuilia et al (2015) have produced the first global map of rotavirus emissions to surface waters. This map has the resolution to address watershed impacts with ability to estimate concentrations based on hydrologic conditions.

Three exposures are conceived for this case study: sewage discharge with and without treatment to surface waters; use of the surface waters for cleaning, washing (hygiene), or recreation; potable water source with various levels of drinking water treatment. Information that is needed for such exposure pathways include virus concentrations in sewage, reductions by sewage treatment and/or dilution in to the receiving waters; volumes associated with various uses (Figure 2).

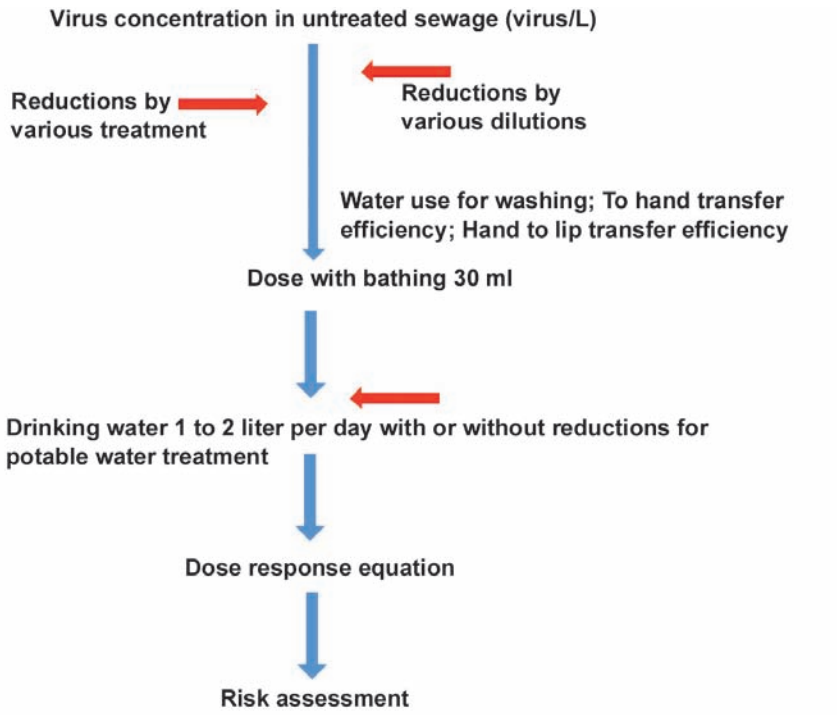


Fig. 2. Scenarios for calculating exposure and risk associated with sewage inputs to surface waters .

Dose-Response

The dose-response data and models for viruses have been developed for nine different viruses (http://qmrawiki.canr.msu.edu/index.php/Dose_Response). These models are used to determine daily infection probabilities, given a certain exposure dose. The modified beta-Poisson (Equation 1) model has been used for rotavirus as a model for one of the most potent viruses tested to date (Haas *et al.,* 2014).

The model is defined as a probability function with two host specific parameters (Equation 1):

$$P = 1 - [1 + dose \frac{2^{\frac{1}{\alpha}} - 1}{N_{50}}]^{-\alpha}$$

Where P is the probability of infection, dose is the number of microbes received; α and N_{50} are the model parameters (α = 0,26 N_{50} = 96,1) specific to rotavirus.

Risk Characterization

The single (daily) exposure risk was estimated for average rotavirus concentrations in sewage at 10,000 viruses/liter with 90 and 99% reductions by sewage treatment (1 – 2 $\log_{10}$ removal, 90 and 99%, respectively). This was done considering a 1/10 dilution by the surface water receiving the sewage and three exposures when using the water for i. washing clothes, ii. bathing and iii. drinking (presuming that the potable water plant provides 4 log removal of viruses). Chart 1 and shows the risks for the average levels of viruses with two sewage treatment efficacies.

Risks are quite high –between 10 to 40%– if using surface waters for washing or bathing with rotavirus loading into surface water systems at 10,000 viruses per liter; this is including sewage treatment reducing the virus levels by 90 or 99%. While drinking water risks are below epidemic (or detectable outbreak levels generally <20%) if the potable treatment process achieves 99.99% reduction (4 $\log_{10}$ removal) (as suggested by the *Surface Water Treatment Rule* in the United States), the risks do not approach the goal for safe drinking water. Risks between 1/100 and 1/10,000 would be achieved if 99.9% of viruses were removed by wastewater treatment. This analysis suggests that a fairly high number of endemic infections can be expected as a consequence of bathing in or drinking polluted surface waters that have received discharges of inadequately treated sewage.

Chart 1

Risk estimates for rotaviruses in surface waters receiving sewage after treatment

Average Virus Levels			
Description	**Washing**	**Bathing**	**Drinking with 4 log removal**
Exposure dose calculations			
Average sewage concentrations of rotavirus (Numbers/L) 10,000 viruses/L			
Sewage treatment removal rate (%)	90 (99)	90% (99)%	90 (99)
Surface water concentration (N/L) with 1/10 dilution	100 (10) viruses / L	100 (10) viruses / L	100 (10) viruses / L
Volume consumed per day (L)	25 ml	30 ml	2 liters
Health risk calculations			
Average dose received (N)	2,5 (0,25) viruses	3.0 (0.3) viruses	0.02 (0.002) viruses
Daily probability of infection	3.9E-01 (1.1E-01)	4.1E-01 (1.3E-01)	1.2E-02 (1.2E-03)
Annual Health Risk Goal for Drinking Water is 1.0E-04 Daily Health Risk Goal for Drinking Water is ~E-06			

Risk Management

There remains a need to bolster the management of investments in innovative water and wastewater treatment, infrastructure, resource recovery and environmental protection policies that translate into improved water quality and sanitation management. It is recommended that efforts be made to examine innovative wastewater treatment to achieve a minimum of 99.9% reductions of viruses unless hydrologic conditions can be proven to provide more than a 1/10 dilution.

Characterization of the quality of a source or ambient water system requires initial assessment, followed by continued monitoring, so that changes in that source can be observed over time. The transport and fate can be informed by geological data and sanitary surveys, and this information can ultimately be used to characterize water quality, modeling and risk maps. This will ensure a science-based approach for decisions on the development and implementation of sanitation technology and optimization of goals around cost, efficacy, training needs and long-term sustainability. The results from these studies can be used to inform policy makers of the risks involved in not providing drinking water complaint, and eliminating the search for relevant data in search of making informed decisions. With the use of QMRA, the policymakers can take decisions based

on the risks posed to their respective communities, without the intensive search to delve into science heavy publications and reports. In these situations, mathematical functions can be used to calculate the likelihood of an adverse health outcome when a person is exposed to rotavirus through water consumption. Thus, appropriate, risk-based policies for public health safety are essential.

In addition to the lack of access to basic sanitation, 768 million people do not have access to an improved drinking water source; eighty-three percent of the 768 million people (637 million people) live in rural areas. One hundred eighty-five million people rely on untreated surface water for their main water source. Between 1990 and 2012, 2.3 billion people gained access to an improved drinking water source (UN, 2013). In the next 30 years, there will be significant investment in new approaches to sanitation, wastewater treatment, and reuse. It is imperative that appropriate log reductions of various microbial sand chemical contaminants are achieved as the designs are implemented to protect public health. Otherwise, investments may provide very little incremental safety.

RECOMMENDATIONS TOWARD MEETING SANITATION GOALS

As part of the new Sustainable Development Goals (SDG) released by the United Nations, several goals for water and sanitation have been released with a target completion date of 2030. These goals include ending open defecation, achieving equal access to sanitation and hygiene, supporting communities to improve sanitation management, and expanding capacity-building for developing countries. During the next 15 years, it is imperative that scientists, researchers, and engineers participate in proactive endeavors to achieve these water and sanitation goals. Recommendations for achieving the goals include obtaining more data on pathogens of concern in feces and sewage. This will aid in creating decision support tools such as the rotavirus map presented in this paper; the information can be used for estimates of concentration and occurrences of specific pathogen in water sources. Along with obtaining more data on pathogens, it is imperative to use QMRA as a model to identify and to evaluate minimization of risk based on the available technologies for wastewater treatment of pathogens. Overall the objective would be to identify technologies to achieve, at minimum, 99.9% removal (3 log removal) of viruses. Working within the realms of these recommendations will aid in achieving the SDG's and help to improve water, sanitation and health conditions for the global population.

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THE WATER FOR LIFE AWARDS

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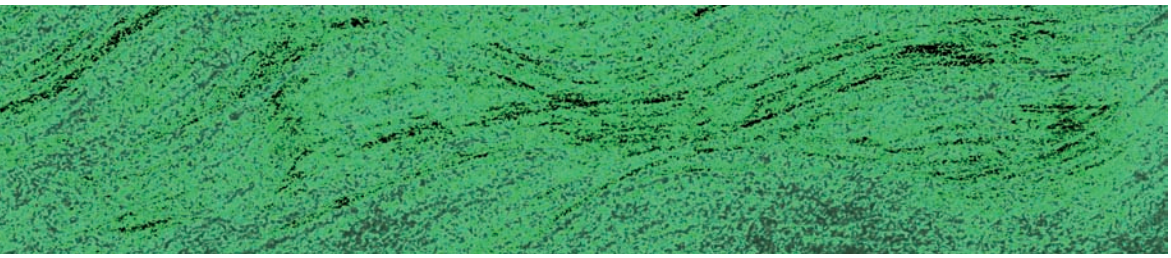


KEYWORDS:
WATER FOR LIFE AWARDS
BEST PRACTICES
WATER MANAGEMENT
PARTICIPATION
COMUNICATION
AWARENESS-RAISING
EDUCATION

Water and sanitation interventions are technical. They don't resonate with the public in the same way as disaster relief missions or the plight of hungry children. The best water and sanitation interventions often occur in less than dramatic circumstances – after all, the cumulative effects of open defecation in a water source do not create explosions or tidal waves. They stunt growth and intellectual development. They steal days of work and school. They tend to be the subject of ruminative feature articles rather than the stuff of hold the presses front page late edition all night front line reporting. Likewise the solutions that quietly condemn these issues to history.

For this reason, in 2011, the Water for Life Awards were created. They remain the only United Nations awards designed especially to recognise cutting edge water and sanitation projects and programmes around the world. And since 2011, 11 projects have taken home an award, over five editions of the scheme, and with it increased media coverage, recognition and opportunities for partnerships. No less worthy is the way in which these projects have, through the award, been studied so that their successes can be replicated in other parts of the world. For years experts on the ground have been trumpeting, for example, basic hygiene education. The winners of the Water for Life Awards, and the finalists, provide verifiable examples of such principles in action, and the increased recognition brought by the award – the awards are judged by an expert panel from among the top water experts in the world – lends these successes greater legitimacy in the eyes of decision makers.

"CULTIVANDO AGUA BOA" (winner 2015) is a systemic program based on civil society participation, where water is the backbone for a series of actions, with the objective to fight poverty and climate change. It represents a new way to substitute old habits with sustainable and participative practices focused on those territories where natural resources are threatened. It works with an awareness plan composed of 60 actions, which to date has enabled the following main achievements: recuperation of 200 micro-basins in the region, upgraded water quantity and quality, reduced soil erosion, improved life quality and social insertion of local people, reforestation of riversides, increased nature conservation and a participative water management promoting water stewardship and sustainable land management.

The awards comprise two categories. Category I awards "Best water management practices" and category II awards "Best participatory, communication, awareness-raising and education practices". This is to differentiate between two very different but equally vital interventions – ones that change the way water resources are managed and ones that change the way people interact with water. That said, many projects and programmes incorporate elements of both categories.

What type of projects demanded the attention of the juries? The variety was staggering. Winners included a civil society engagement project to promote water stewardship; two behaviour change outreach programmes – one in South America, one in India; one involving arts, the other science. There was a project that became part of a national school curriculum raising awareness of water and sanitation issues. Another winner created an advanced water treatment system to ensure predictable water quality for industry. Yet another involved educating and mobilising a population to defend their constitutional rights to lakes as commons. A European project tested water quality, and reached out to communities so the people better understood the value of the dry toilets they were being provided with, and were able to get involved in the construction and water cleaning process. An Asian winner introduced an innovative water management system across an entire river basin to ensure natural recharge of groundwater even as land use changed with the passage of time. In Africa, one winner rolled out water tanks and pipes with breathtaking speed to provide water and sanitation to a city expanding beyond its boundaries. Another project uses research and lobbies decision makers into seeing the value of scientific solutions which depend on geographical conditions – such as solar powered irrigation pumps for agriculture beyond the scope of the electrical grid. But all the winners had something in common with the very first – a river rehabilitation project. Where the river had been choked with filth, they restored it. The result was that it once again became a source of life and community. While we don't often dwell on it, where clean water and sanitation are lacking there can be no hope for a healthy community. This community health boost is something that all these diverse projects have delivered.

Fig. 1. 2011 Water for Life Awards Awarding Ceremony.

ONE DROP (winner 2015) uses water to drive change with a unique approach that empowers people to improve their living conditions. Called the "ABCs of Sustainability", it is based on 3 complementary components designed to establish a solid foundation on which communities can build and flourish: Access to Water and Sanitation ("A"); Behavior Change through Social Arts ("B"); Capital/ microloans ("C") for economic development. Project India is rooted in the "A" and "B" components. It is implemented in Odisha, which is among the seven poorest Indian states. Carried out over four years (2011-2014), it implements sustainable solutions to the problem of poverty through a WASH program designed/implemented by Gram Vikas whereby a 100% coverage/inclusion method ensures access to a toilet, a bathing room and water available 24/7.

THE DWS/WBSSA ECO-SCHOOL WATER PROJECT (winner 2015) main objective is to strengthen water education through the Eco-School's 7 step framework for Education for Sustainable Development –ESD– learning and change. These steps guide schools through a learning process which promotes water conservation and sanitation education as well as engaging learners in enquiry-based learning methods which empower them to better understand their local water context and to take action to improve this. The project has a strong inclusivity focus. emphasizing public participation, participatory learning processes and action taking for better water management and to ensure water security for the more disadvantaged communities that do not have access to potable water especially in areas where water is increasingly becoming scarce due to climate change and poor catchment management practices.

WHAT HAS BEEN GAINED?

The Water for Life Awards have been a powerful force for change. The winners have shone because they were exceptional – in the scope of their ambition, in the innovative use of new methods and approaches, in their ability to challenge perceived norms to affect change. Through the Awards, these cases and the stories behind them have been shared all over the world, replicated, improved and updated.

Bolivia is one of the poorest countries in Latin America. Extreme poverty affects 40 percent of the population. In Cochabamba, in some municipalities such as Arque, Tacopaya, Bolívar and Sacabamba, the under-five mortality rate is higher than the national average. SODIS, who won the Category 2 Award in 2012 for their Communication strategy for social and behaviour change' could not approach the situation with any kind of standardised solution. Women in Cochabamba are hit especially hard with water-related problems such as scarcity, pollution and the increasing needs of households and the community. The poverty and marginalization of women is linked with their lack of training and empowerment. This is a barrier to expressing their problems and expectations in water, sanitation and hygiene services. Any behaviour change approach needed to address these women, while also empowering them to speak out.

As project leader Elsa Sanchez said: *"It's so important that people make decisions in processes and project implementation because any initiative that wants to develop to respond to the people's needs and problems, must fit the context in which they live.*

The multiple aspects ensure that women are empowered in their ability to identify needs, prioritize, and participate in decision-making in these solutions and the administration of funds".

The Water for Life Awards have been a series of proofs showing just how much more effective water interventions are when the beneficiaries are part of the solution themselves. The SODIS project pushed this even further by making children ambassadors of the messages:

"I remember very well students in Tiquipaya; how they worked with their parents in promoting handwashing practices and safe water consumption. Children taught their own families to practice. The father of a boy said: «Thank you, my son, no one has taught me to wash my hands as you have taught me.» It was a source of pride for father and son.

Arriving to the Sursubi community of the municipality Conception for a monitoring visit and to support the implementation of the Strategy for Health, Safe Water and Sanitation (HASS), I went immediately to the school at the precise moment that children were playing in the green field.

Fig. 2. Category I awardees "Best water management practices".

I believe we arrived late, I thought silently. Just then I noticed a small, thin boy about six years old with a small bottle in one hand and a ball of cloth worn in the other and said, «Professor, professor, worms that were in my water do not move anymore because I killed them yesterday with the sun. Can I drink it now?» At that time my heart made a chuño [swelled] and the tears wouldn't wait."

The approach proved remarkably effective. Indeed, today Sanchez says: *"The most important lesson is that the sustainability of projects necessarily requires strengthening community participation and empowerment, linked to municipal management processes, while considering the issues of water, hygiene, sanitation, and health education as skills of the Gobiernos Autónomos Municipales."*

Likewise Singapore's NEWater Project has been an exemplar of superior water management, and planning for the future, can bring sustainability, and with it security, to an economy. The Project won Category 2 in 2014, and in the words of Director George Madhaven: *"Singapore may be water scarce, but our water programmes have made us attractive to business, because we can guarantee a high quality, very reliable water supply. We can't afford any interruption to this supply; the jobs of Singaporeans depend on it. So now when you see companies like Rolls Royce in Singapore, our water supply has played a major role in this and all Singaporeans are benefiting."*

Singapore's investment in its water security has been a boon to the standard of living across the city state. In the 60s water sources were toxic, with unfettered dumping of waste of all kinds. Today water management is central to citizens' well-being, and thanks to repeated public awareness campaigns, people take care of their water sources. But technology has played a part too.

"In the dry season we put NEWater back into the reservoirs to ensure levels are consistent. We use membrane technology, forcing water through a membrane that will only allow the water molecules through, so there's no chemicals involved. We are researching bio-mimicry to copy the human kidney. It's the most efficient filtering machine in nature, and we are beginning to understand how it works. We hope that in the next few years we can introduce this.

Fig. 3. Category II awardees "Best participatory, communication, awareness-raising and education practices".

NEWater will be the pillar of our water supply for the next 50 years. We have replaced the use of potable water for industry with NEWater. In Singapore we have lots of high impact industry. NEWater already provides 30% of the water they use. By 2060 it will provide 55%. This is significant because our growth will be founded on water from our own catchment."

Water for Life Award winners have not only impressed with their

Fig. 4. Category II ORMAX project award.

results, however, but also with their approaches. ESG's project to Protect Bangalore's Lakes for Posterity' faced an uphill struggle to convince a distant middle class that building floating hotels and shopping malls over traditional water sources didn't represent "progress".

""Protecting the lakes by planting trees not barbed wire, so they're not just freshwater reservoirs but wetlands, green havens. Now it is law that all lakes must be surveyed and protected with money allocated from the annual budget", said Leo Saldanha, project leader. "ANow the government can see how we can create communities invested in rehabilitating the lakes, which brings jobs as well as fresh water, and as a result better health. Now other states are watching us and learning, so these laws are influencing change not just here but Kolkata, Hyderabad."

The project won the Category 1 Award in 2012. And thanks to ESG's continually adapting approach, which has been inclusive of converts to the cause, not least the media, the project is now seen as a model for the whole of India to better develop sustainably.

"Five years ago people were very cynical, they thought protecting the lakes was a lost cause. Thanks to our protests, and the media, which has been hugely supportive, and our successful legal challenge, they can see the results. Now neighbourhoods are fighting to protect their own water sources."

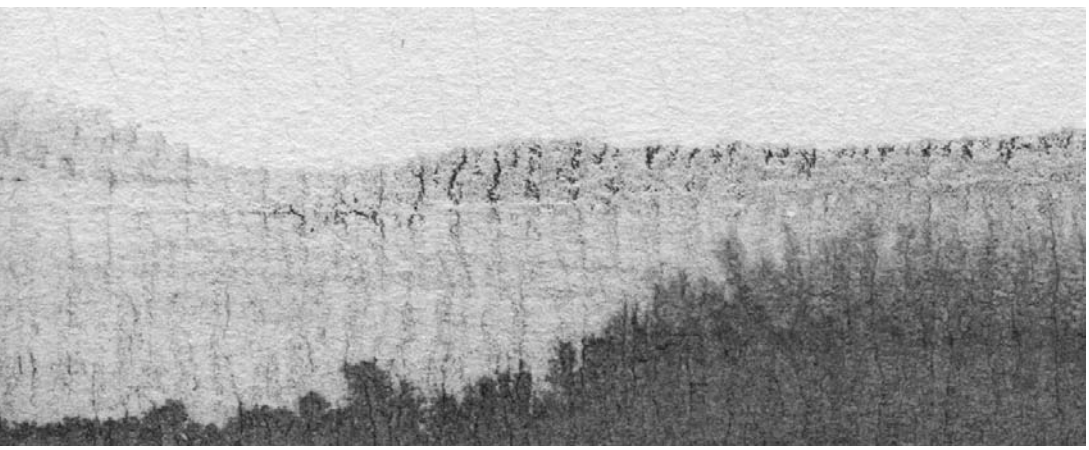
Something as simple as a toilet can spur massive change in a community, when it is supported by educational outreach and the community is involved.

Moldova is one of Europe's poorest countries, but since people have been engaged, change has been dramatic.

Says Natalia Dejean of ORMAX, *"The teachers at the schools are amazed by the reduction in absences due to sickness. They have been halved since the new toilet was installed. The children say it is better. It's not just hygiene, the old toilet was about 300 metres outside the school gates. The winter in Moldova is very long, frosty, cold, and rainy. It's better for them to have a toilet on site for many reasons."*

The ORMAX Safe Water and Sanitation for All project is not *"building roads or houses. But we empowered people to change their own lives by educating them. They have become the drivers of the work and that is very positive. I was born in Moldova. For me it is very important to see the people. Like anyone, these people don't like to be told what they should do, what is good for them. If you don't speak the language you don't see the sincerity. Something has changed in people's lives here [since ORMAX began the project in Moldova]".*

By testing the chemical composition of the water, ORMAX could begin to examine what was affecting water quality. Open defecation was one issue, as was the proximity



of livestock to water sources. But another was the level of chemical pesticides – something that had been introduced to Moldova only relatively recently.

"Moldova is famous for its fruit and vegetables. We educated the farmers about the composting properties of human and animal waste, but they already knew. Their parents used these same sustainable techniques, then people forgot. In the Soviet Union there was ready access to cheap chemical solutions, so people used those.

When the education began, people remembered their parents using the same techniques. They remembered their parents' generation was healthier. The education helped illustrate that it was the unsustainable fertilizer practices that was to blame."

Again, the project helped usher out a false progress in favour of a traditional, sustainable approach. One of the key things highlighted by Award winners has been that the 21st century approaches to sustainable development are often not novel – they were the ways in which communities sustained themselves for hundreds of years before industrialization.

"The chambers for the sewage waste in the waterless toilets are large and only two years old in many cases. The waste may not yet be mature enough to use for compost. But the farmers already collect the urine from the school and use it to help the fruit trees grow. Apples and apricots. These are old ways, now remembered."

Natalia Dejean now believes that the last generation of Moldovans were an anomaly. Future generations will value sustainability from a much earlier age: *"Three years ago we began to focus more on educating children in the schools. The next generation of Moldovans will be much more concerned about the environment. They are more sensitive towards these issues than their parents and they become great messengers in their own communities".* The ORMAX Project won the Category 2 Award in 2013.

Fig. 5. Category II IWMI-Tata project award.

One of the most inspiring things about the Water for Life Award Winners has been the way in which sustainable water management can bring communities together. Kumamoto City had no choice but to involve farmers when it was realized that water tables were dropping and becoming contaminated. As the main water users, if the farmers didn't engage with the process it wouldn't work. And what was being suggested was unorthodox. Kumamoto began flooding unused paddy fields to improve the natural water recharge.

Said Seio Utsunomiya of Kumamoto's international affairs office, *"Because of our efforts, we use less chemical pesticides in agriculture which will hopefully improve people's health. And we have been planting broad-leafed trees to encourage biodiversity. Already people know how important it is to buy local produce, both to sustain the local economy and to reduce the carbon footprint of our foods".*

The whole community has been engaged with clearing old paddy fields and planting trees. People are proud of their local produce, and are happy to involve their children to become more aware of their pure groundwater and how it must be protected. This is not a quick fix scheme – the Water for Life Awards have consistently shown that band-aid solutions are unsustainable.

"We plan decade by decade. We will complete the first decade of our project this year. The subsidies for the farmers to flood their land will continue; the whole project will continue for now, which shows how successful we have been. But each decade we will review, and see where we can improve. In the future, we will expand our efforts to neighbouring cities, more companies will come here. This will not be a burden, they can help. Our UN Best Practice Award has become a symbol and it has encouraged people to take these efforts seriously."

Fig. 6. Category II ONE DROP project award.

Kumamoto's basin wide groundwater management using the system of nature project won Category 1 in 2013.

Other Award winners have shown us how to deal with the dramatic changes occurring in urbanization. The eThekwini Water and Sanitation project in Durban, South Africa, needed to address the dramatic influx of rural people who were expanding the city faster than its water and sanitation provisions could cope.

"We couldn't look to the past even if we had wanted to. The processes were different, as were the challenges. Several hundred informal settlements had sprung up, essentially communities in transition. One million people living in shacks. As an interim solution we had to put in shipping containers with showers and toilets. This was a unique solution for a unique situation."

This was a big shift for a country which had previously focused on world class interventions for a wealthy elite while the poor were often left unserved. This approach has led to more sustainable communities.

"There is no more open defecation, so family health is better. In South Africa, we had a culture of looking after the first world people. We had to change our mindset to focus on poor communities, and to engage and talk with them. We took responsible risks to create what people really needed – through a formal process of dialogue we did things that had not been done before. Once we identified what was needed we created innovative technology to bring services to the poor."

This "Participatory and Learning Based Approach to Raising Awareness on Water and Sanitation" won Category 2 in 2011.

Working with decision makers and policy, rather than directly delivering interventions that benefit the people, IWMI-Tata's Water Policy Programme could easily have gone under the radar were it not for their Award for Category 1 in 2014. Yet their work has impacted millions of lives for the better.

In the words of Tushaah Shah, project leader, *"Due to this project, 40 to 50 million people have better access to consistent electricity and groundwater availability.*[1] *But they don't relate it to IWMI or our work. The farmers are not our target market, we speak with*

policy makers. So they don't acknowledge our work but they do benefit."

This is one of the greatest legacies of five year so of the Water for Life Awards – bringing to public prominence projects which go on beyond the public domain. And thanks to the success of this project and others like it: *"Today there is a greater appetite for science-based solutions.* [2] *Science was divorced from decision making and we have been bridging the gap. There is increased acceptance of ideas and collaboration in water systems management.*

More recently we've conducted research into improving partnership and cooperation. Ten years ago, when we began this project, we didn't understand the craft of addressing policy messages to decision makers. We are better now."

Each year projects bring fresh innovations, building on the work of previous years. The most recent winners include the dramatic eight year regeneration of the area surrounding the world's largest hydropower facility at Itaipu Binacional – with their project Cultivando Agua Boa, which took Category 1. And a curriculum enhancing school programme run by South Africa's Department of Water and Sanitation and the Wildlife and Environment Society of South Africa (WESSA), which shared the Category 2 Award (for the first time) with ONE DROP Project India, which uses circus skills and theatre to raise awareness of water and sanitation issues.

Said Jacques Rajotte, Chief Operating and Innovation Officer at ONE DROP *"In each of these villages we identify a group of artists, as well as social art tools, so depending on the issues we go to those communities knowing or having a general idea about the issues. We also run workshops, longer interventions where we feel that the challenges are greater. In these cases, project team members go to those communities for four or five days, with a toolbox of potential social art projects they can use. And they start interacting with the community and based on those conversations, and using these specifically designed art interventions they start the community dialoguing among themselves and becoming more aware of the sanitation issue, realising that if you have a divide when it comes to water it's about survival and your own community and your children."*

In conclusion, the Water for Life Awards have brought much needed recognition to vital water and sanitation projects all over the world. But even more, they have shone a beacon on best practices: in water security, hygiene, water resources management and the relationship between water and policy makers, water and cities, water and a changing world, water and sustainable development.

The case studies from these projects alone are invaluable for maintaining sustainable water management practices for a sustainable world. We look forward to seeing the life changing solutions the winners of tomorrow may bring.

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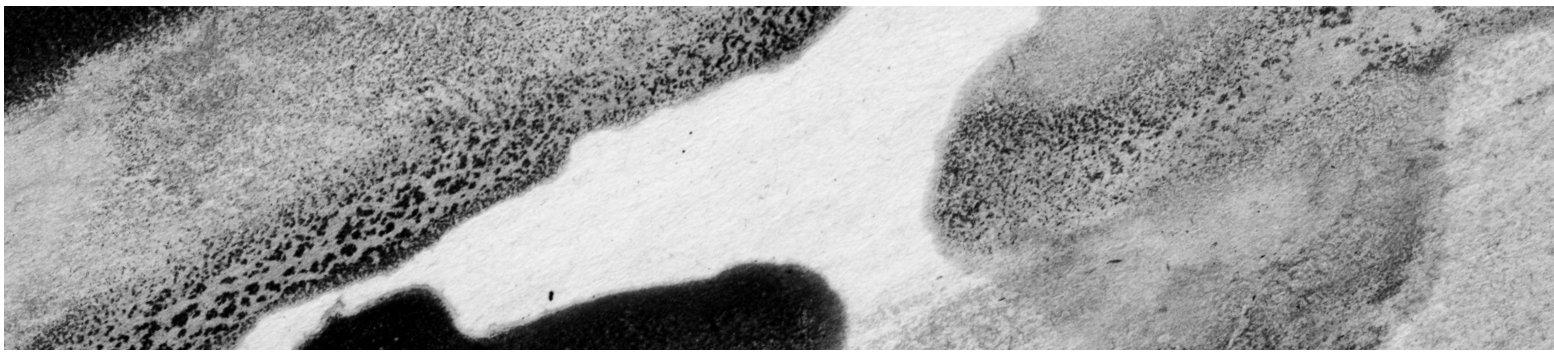

Footnotes

[1]. By providing regular and reliable power, JGY made it possible for farmers to keep to their irrigation schedules, conserve water, save on pump maintenance costs, use labour more efficiently and expand their irrigated agriculture rapidly. While GDP from agriculture grew at just under 3 percent per annum for India as a whole, Gujarat has recorded nearly 10 percent growth since the project's inception in 2003, the highest in India. The scheme has been so successful the government of India has made it a flagship scheme in its 12th five-year plan for the power sector.

[2]. This is just one instance of how ITP showed that despite a lot of potentially useful scientific research being conducted in India, it often does not reach the policy makers –who are willing and keen to learn from science– because neither the research objectives nor the research design are formulated with them in mind.

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WATER AND SANITATION THE PATHWAY TO A SUSTAINABLE FUTURE

THE NEGOTIATION OF A NEW SET OF GLOBAL DEVELOPMENT GOALS IN 2015 PROVIDES A UNIQUE OPPORTUNITY TO MAP A PATHWAY TO A BETTER FUTURE FOR THE PLANET AND ALL OF ITS PEOPLE.

GOAL 6 – ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL – IS CENTRAL TO REALISING THIS VISION

SEE BELOW HOW MEETING INDIVIDUAL TARGETS IN GOAL 6 WILL DRIVE PROGRESS ACROSS THE WHOLE SPECTRUM OF SOCIAL, ENVIRONMENTAL AND ECONOMIC SDGS.

6.1 SAFE DRINKING WATER

EVERY **15 SECONDS** A CHILD DIES FROM A PREVENTABLE **WATER BORNE DISEASE**

200 MILLION HOURS = THE TIME **WOMEN & GIRLS** SPEND FETCHING WATER EVERY DAY

6.2 SANITATION AND HYGIENE

MORE THAN **1 IN 3** PEOPLE HAVE NO ACCESS TO IMPROVED **SANITATION. 1 IN 7** STILL PRACTICE **OPEN DEFECATION**

SOME COUNTRIES **LOSE AS MUCH AS 7% OF GDP** BECAUSE OF INADEQUATE SANITATION

6.3 WATER QUALITY

OVER **80%** OF **WASTEWATER** WORLDWIDE IS DUMPED – **UNTREATED** – INTO WATER SUPPLIES

2 MILLION TONS = AMOUNT OF **HUMAN WASTE** DISPOSED IN **WATER COURSES** EVERY DAY

6.4 WATER EFFICIENCY

70% = AMOUNT OF TOTAL **WATER CONSUMPTION** USED FOR **AGRICULTURE**

85% = INCREASE IN **WATER DEMANDS** CAUSED BY RISING **ENERGY PRODUCTION** BY 2035

6.5 INTEGRATED WATER RESOURCES MANAGEMENT

2/3 OF THE WORLD'S POPULATION COULD FACE **WATER STRESS** BY 2025

ACCESS TO **WATER** POSES THE BIGGEST **SOCIETAL** AND **ECONOMIC RISK** OVER THE NEXT TEN YEARS

6.6 WATER-RELATED ECOSYSTEMS

GROUNDWATER PROVIDES **DRINKING WATER** TO AT LEAST **50%** OF THE GLOBAL POPULATION

THE EFFECTS OF **CLIMATE CHANGE & URBANIZATION** WILL IMPACT THE **WATER-CYCLE** - INCLUDING VITAL **GROUNDWATER** RESERVES

KEY:
LINKED GOALS

END POVERTY (SDG 1) · END HUNGER (SDG 2) · HEALTHY LIVES (SDG 3) · QUALITY EDUCATION (SDG 4) · GENDER EQUALITY (SDG 5) · SUSTAINABLE WATER & SANITATION (SDG 6) · ACCESS TO ENERGY (SDG 7) · SUSTAINABLE GROWTH (SDG 8)

RESILIENT INFRASTRUCTURE (SDG 9) · REDUCE INEQUALITY (SDG 10) · SUSTAINABLE CITIES (SDG 11) · SUSTAINABLE CONSUMPTION (SDG 12) · CLIMATE CHANGE (SDG 13) · SUSTAINABLE OCEANS (SDG 14) · SUSTAINABLE ECOSYSTEMS (SDG 15) · INCLUSIVE SOCIETIES (SDG 16) · GLOBAL PARTNERSHIP (SDG 17)

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UN WATER
At its 19th Meeting
(29-31 August 2013),
UN-Water confirmed
the World Council of Civil Engineers
as UN Water Partner.
WCCE
WORLD COUNCIL
OF CIVIL ENGINEERS
Committed
to human
welfare

WATER AND SUSTAINABLE DEVELOPMENT:

CHALLENGES FOR CIVIL ENGINEERING

Tomás A. Sancho Marco

KEYWORDS:
WCCE
WATER
SUSTAINABILITY
OBJECTIVE 6
IWRM
MANAGEMENT CONFLICT

INTRODUCTION

From a sustainability perspective, away from short-term strategies (seekers of ephemeral successes which are then displayed as wrong decisions and turned to mourning for the mistakes and missed opportunities), we must ask ourselves a question: *What future do we want?*

Among the media phenomena that reach people and create opinion we recently have had two examples of how to resolve with drastic measures a future which is considered as unsustainable: the bestselling novel *Inferno* and the featured film *Kingsman: The secret service.* In both examples it is shown how a few (belonging to a small elite of power) design tragic plans to eliminate a large part of humankind, as a solution to the problems of sustainability of our planet. Another large share of opinions is in line with the search for new potential colonies in space, on other planets, and so several novels and movies (*Interstellar, Gravity, Avatar, Mars* ...) approach this discussed potential, overcoming the pessimism of more apocalyptical views shown in movies such as *Planet of the Apes, Divergent, Elysium* … On other grounds, other reputed voices such as that of Pope Francis, more focused on the reality of our world, have risen to request a more rational and sustainable use of natural resources we have available,[1] addressing the concept of an integral ecology to which both human and social dimensions are incorporated.

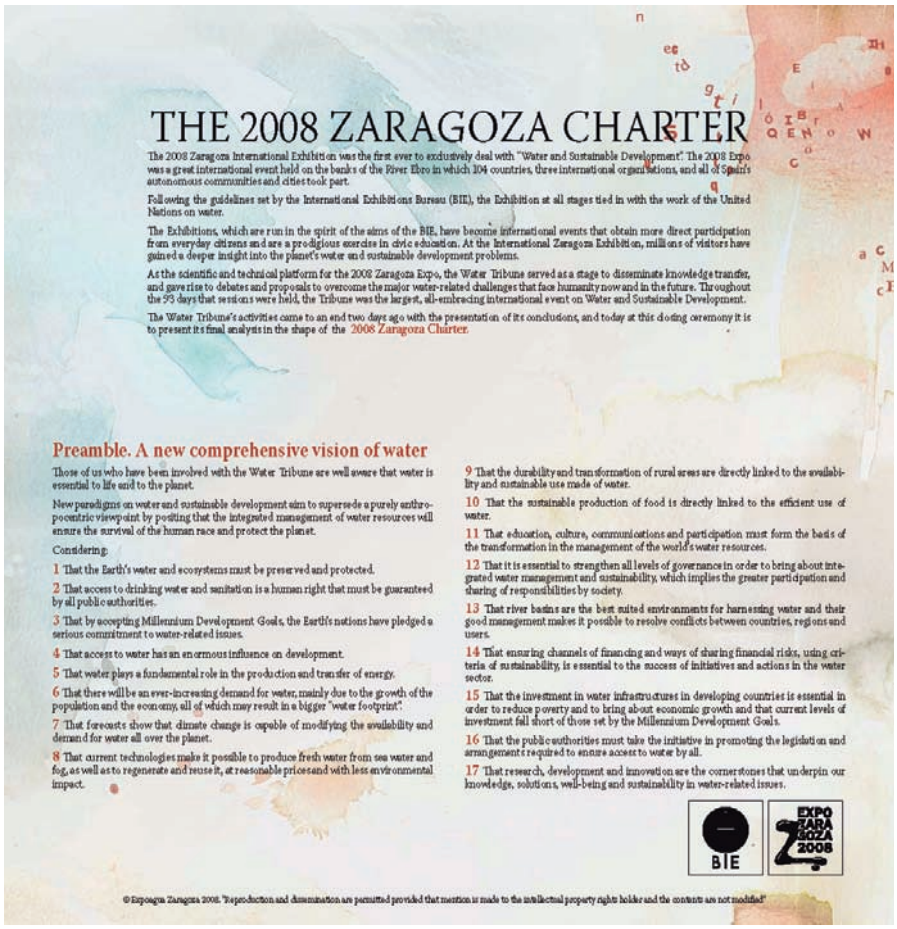
WCCE (World Council of Civil Engineers) is involved in UN's Global Compact initiative, which commits its signatories to properly manage their environmental and social impacts, including human rights, working conditions and corruption prevention. WCCE is also committed to UN's Sustainable Development Goals –SDG– approved last September by the UN General Assembly, and the actions under discussion in the Conference of the Parties, COP-21 Paris, December 2015.

We are facing an issue, which is critical to our future and hovers over many fields of activity of civil engineers. Our profession, civil engineering, is committed to the social mandate of creating a sustainable world and improve overall quality of life,[2] and such makes us contribute in a competent, collaborative and ethical manner as experts:

- Planners, designers, builders and operators of the economic and social drive of society: the built environment;
- Custodians of the natural environment and the efficient and proper use of its resources;

- Innovators and integrators of ideas and technology in the public and private sectors as well as in academia;
- Risks and uncertainty managers of natural disasters, accidents and other threats; and
- Leaders in debates and decisions that shape environmental policy and public infrastructure.

Specifically regarding with water and sustainable development, WCCE assumed the legacy of the International Exhibition Zaragoza 2008 and its Water Tribune, which was summarized in the Zaragoza Charter,[3] subscribing a partnership agreement to help this legacy contribute to the improvement of water management and sustainability in the world.



THE 2008 ZARAGOZA CHARTER

The 2008 Zaragoza International Exhibition was the first ever to exclusively deal with "Water and Sustainable Development". The 2008 Expo was a great international event held on the banks of the River Ebro in which 104 countries, three international organisations, and all of Spain's autonomous communities and cities took part.

Following the guidelines set by the International Exhibitions Bureau (BIE), the Exhibition at all stages tied in with the work of the United Nations on water.

The Exhibitions, which are run in the spirit of the aims of the BIE, have become international events that obtain more direct participation from everyday citizens and are a prodigious exercise in civic education. At the International Zaragoza Exhibition, millions of visitors have gained a deeper insight into the planet's water and sustainable development problems.

As the scientific and technical platform for the 2008 Zaragoza Expo, the Water Tribune served as a stage to disseminate knowledge transfer, and gave rise to debates and proposals to overcome the major water-related challenges that face humanity now and in the future. Throughout the 93 days that sessions were held, the Tribune was the largest, all-embracing international event on Water and Sustainable Development.

The Water Tribune's activities came to an end two days ago with the presentation of its conclusions, and today at this closing ceremony it is to present its final analysis in the shape of the 2008 Zaragoza Charter.

Preamble. A new comprehensive vision of water

Those of us who have been involved with the Water Tribune are well aware that water is essential to life and to the planet.

New paradigms on water and sustainable development aim to supersede a purely anthropocentric viewpoint by positing that the integrated management of water resources will ensure the survival of the human race and protect the planet.

Considering:

1 That the Earth's water and ecosystems must be preserved and protected.

2 That access to drinking water and sanitation is a human right that must be guaranteed by all public authorities.

3 That by accepting Millennium Development Goals, the Earth's nations have pledged a serious commitment to water-related issues.

4 That access to water has an enormous influence on development.

5 That water plays a fundamental role in the production and transfer of energy.

6 That there will be an ever-increasing demand for water, mainly due to the growth of the population and the economy, all of which may result in a bigger "water footprint".

7 That forecasts show that climate change is capable of modifying the availability and demand for water all over the planet.

8 That current technologies make it possible to produce fresh water from sea water and fog, as well as to regenerate and reuse it, at reasonable prices and with less environmental impact.

9 That the durability and transformation of rural areas are directly linked to the availability and sustainable use made of water.

10 That the sustainable production of food is directly linked to the efficient use of water.

11 That education, culture, communications and participation must form the basis of the transformation in the management of the world's water resources.

12 That it is essential to strengthen all levels of governance in order to bring about integrated water management and sustainability, which implies the greater participation and sharing of responsibilities by society.

13 That river basins are the best suited environments for harnessing water and their good management makes it possible to resolve conflicts between countries, regions and users.

14 That ensuring channels of financing and ways of sharing financial risks, using criteria of sustainability, is essential to the success of initiatives and actions in the water sector.

15 That the investment in water infrastructures in developing countries is essential in order to reduce poverty and to bring about economic growth and that current levels of investment fall short of those set by the Millennium Development Goals.

16 That the public authorities must take the initiative in promoting the legislation and arrangements required to ensure access to water by all.

17 That research, development and innovation are the cornerstones that underpin our knowledge, solutions, well-being and sustainability in water-related issues.

BIE

EXPO ZARAGOZA 2008

MAIN GOALS AND CHALLENGES

There are unmistakable signs that we have not been driven properly growth compliant with the requirements of sustainability.

The Sustainable Development Goals adopted in 2015 offer an unique opportunity for countries to promote progress in several of critical political, social, economic and environmental development issues. In particular, the current proposal for a specific objective dedicated to water (n° 6): *"Ensuring the availability and sustainable management of water and sanitation for all".*

Specific targets contained in this Objective 6 are:

6.1. By 2030, achieve universal and equitable access to safe and affordable drinking water for all.

6.2. By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

6.3. By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally .

6.4. By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the

number of people suffering from water scarcity.

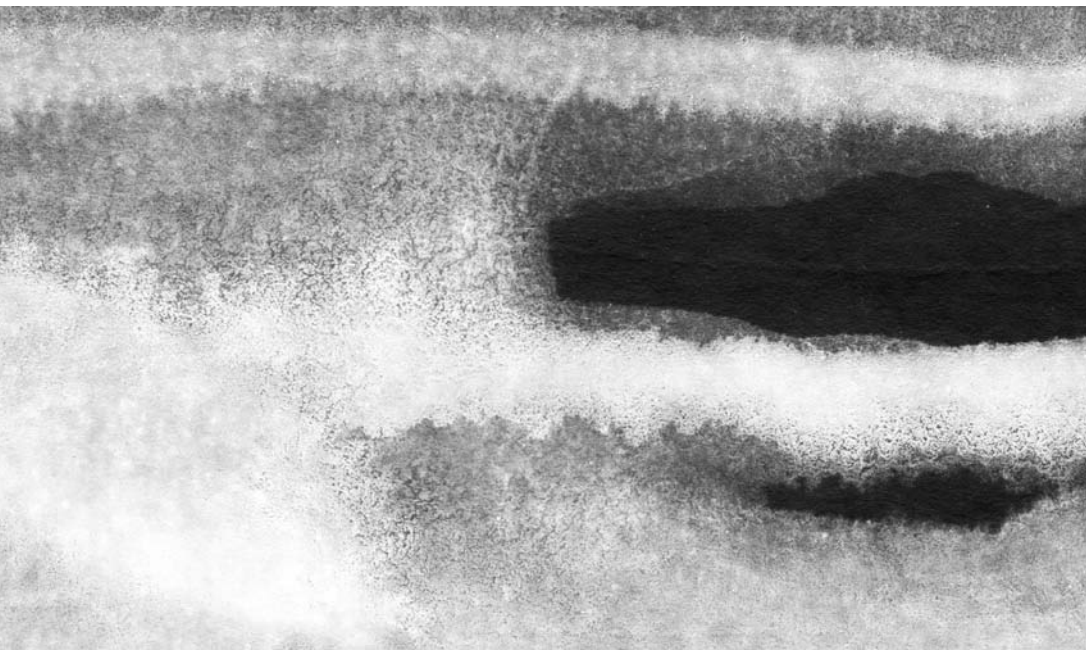
6.5. By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.

6.6. By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

6.7. By 2030, expand international cooperation and capacity-building support to developing countries in water and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.

6.8. Support and strengthen the participation of local communities in improving water and sanitation management.

All of them rely on the Integrated Water Resources Management – IWRM– (targets 6.4 and 6.5).



Public and private sectors managers will have to face difficult choices in allocating water resources, as they will have to address combined diminishing supplies of water with ever increasing demands.

Population growth and climate change increase the pressure on water resources. The traditional fragmented approach is not viable any longer, and a paradigm shift is needed: now a holistic approach to water management is essential.

The focus of Integrated Water Resources Management is now globally accepted as the way onwards to reach a sustainable, efficient and equitable development and to achieve global management of limited water resources and resolve conflicts between different demands.

So was declared by 7 Global Organizations in 2013's Chengdu Declaration on Global Security in Water,[4] which focused on the requirements posed by water scarcity and called for joint actions in the fields of politics, education, research and implementation.

Human societies are often responsible for the degradation of water resources. For example, the every day pouring of over 2 million tons of sewage and wastewater from industrial and agricultural use into Earth's bodies of water.

We must manage water sustainability so that everyone has enough water to drink and to stay clean and healthy; that food producers have enough water to meet the demands of growing populations; that industries can have enough water for their needs; and that countries may ensure a stable energy supply.

Water cannot be a limiting stakeholder to economic and social development of the regions and, moreover, cannot generate serious environmental impacts on water ecosystems. In addition to this, sustainability should be taken into account defined as long term feasibility in a context of solidarity with future generations, to which

we cannot leave them a scenario with social inequality, disproportionate economic liability or depletion of vital natural resources such as water.

Water scarcity is twofold: first, one in which due to a lack of infrastructure water available to users is not the amount which would be technically, economically and environmentally possible and second, one in which even having available all the water potential available, the water demand overrides the resource available.

Therefore, action must be driven through enabling better supply management in all its aspects (increased regulation of surface water, groundwater use and increased combined use) so that when technically and environmentally feasible, no water availability will be hindered illogically and always to the detriment of potential consumers of lower income, the first, and the environment, the second.

Developing an appropriate demand management must not be disdained. If this is not done, whatever its supply management, in the end always water will still be lacking, at least in a country with the peculiarities of Spain. This demand management is achieved, first, through regulation, followed by its effective practical implementation by all stakeholders, empowering a leading role to consumers.

In the study that Nobel prize awardee Ellinor Ostrom's carried out on 1990 on the management of fisheries, grasslands and water resources by local communities,[5] she shows that users themselves can avoid the *tragedy of the commons* at the time that they manage the resource. The *tragedy of the commons*[6] (Hardin, 1968) symbolizes the inevitable degradation of the environment when individuals use a scarce resource in a common opportunistic behavior taking precedence over the collective interest. These opportunistic behaviours fall into a spiral of increasing individual use, resource degradation and tragedy for those who live on it.

2013 Chengdu Forum of International Water Organizations

Global Water Security Declaration

Water scarcity is on the rise

Water resources, people and economic activities are unevenly distributed around the world, which makes freshwater scarce in many areas. Water scarcity in most arid and semi-arid areas is intensifying with time, due, in large measure, to population growth and economic activity. Many parts of the world face water scarcity due to the lack of adequate water resources, human and institutional capacities to adequately govern and manage water and/or the economic means to develop water resources. The Global Risks 2013 report of the World Economic Forum identifies the water supply crisis as one of the two most likely high-impact risks of current times.

Water security means minimizing water related risks

Water security can be defined as the capacity of a population to safeguard access to adequate quantities of water of acceptable quality for sustaining human and ecosystem health, and socio-economic development and to ensure efficient protection of life and property against water related hazards (floods, landslides, land subsidence) and droughts. Hence, water security is the assurance of uninterrupted water supply in sufficient quantity and adequate quality to meet the water needs of domestic water consumption, food production and water-dependent economic activities that are essential for the welfare of a community, and in conformance with the principles of sustainable development. Globally increasing demand and competition for limited water resources, including groundwater, has drawn increasing attention to water security. Climate change has also accentuated the need for managing hazards associated with extreme hydrologic events, such as floods and droughts, but also to increase the reliability of the supply for all uses, including the environment.

Water security hinges upon balancing water supply and demand, both of which change over time, and avoiding the unsustainable over-abstraction of water. The supply of water can decrease due to the depletion of non-renewable water resources or degradation of water quality, climate change, or various other anthropogenic activities such as land use changes that affect the hydrologic cycle, such as land use changes. Water supply can increase through the development of new water resources. Water demand can increase as a result of population and economic growth. It can be managed through conservation, increased water use efficiency, economic measures, and agricultural and trade policies and practices. Achieving the optimal equilibrium between water supply and water demand, without compromising future water security, is the central goal of water management. Achieving this goal requires adequate human and institutional capacities, as well as cooperation between stakeholders at the local, regional and international levels.

Demand management is essential for water security

The Integrated Water Resources Management (IWRM) approach has now been accepted internationally as the way forward for efficient, equitable and sustainable development and management of the world's limited water resources and for coping with conflicting demands. In general, water supply augmentation is challenging and often not an option. Many countries and regions, other than sub-Saharan Africa, facing water scarcity have already fully developed their water resources beyond sustainable levels, resulting in rivers running out of water by the time they reach the sea, lakes shrinking in size and groundwater wells running dry. Non-conventional ways to augment the water supply include recycling, desalination and, at a small scale, water harvesting. Theoretically, desalination offers the potential of unlimited water supply to areas near the ocean, or other saline water bodies, but its feasibility depends on the availability and cost of energy which remains high, despite technological advances in membrane technologies based on reverse osmosis. In many areas, demand management offers the only viable solution for sustainable development. Demand management aims at influencing attitudes and consumption patterns towards more efficient and cost effective water use. It is often practiced through a combination of economic, technical and administrative measures, with educational and social interventions also playing a role. Economic measures include valuing and pricing mechanisms and other incentives for reducing water use. Technical measures include conservation and increasing water use efficiency and water reuse. Adopting such measures is critical for the viability and community acceptability of new projects built in parts of the world where water is scarce.

In parallel with demand management, the sustainable use of existing and future water supply infrastructure, where reservoirs and dams play an important role, is essential for water security, especially in developing countries, and to face global challenges associated with increasing demand due to population growth and climate change. Governance, maintenance and sedimentation management are key issues for securing adequate water supply in the future.

In developing countries, the need to speed up the development of water storage and sustainable water related infrastructures is of utmost importance, to address the critical need for water supply, energy, food production and sanitation, but it must be pursued in according with the principles of sustainable development. In many countries of the sub-Saharan Africa, the real use of renewable water is less than 10% of the known potential due to a lack of investment for water storage and water supply infrastructure, which is worsened by the rural characteristic of these regions.

In 2050 the world population will reach nine billion, with a corresponding increase in the demand for water, food and energy which will double impacting on the need to speed up and augment water storage infrastructure development worlwide.

Several factors threaten water security

Several factors threaten water security or make its future status uncertain. Such factors include:

- Population and economic growth, including urbanization and land use change;
- Lack of water resources mobilization and appropriate water supply infrastructure in some developing countries;
- Unsustainable water use, often driven by poorly thought-through development goals;
- Inefficient and wasteful water use;
- Climate change.

We, the undersigned associations, therefore call for joint action to improve global water security

Policy. There is an urgent need to increase cooperation on water by working together and with other global organizations, such as UNESCO, FAO, the Global Water Partnership and the World Water Council, to inform policy makers about current and emerging threats, and promote solutions and strategies to ensure water security.

Education. Promote formal education on water issues at all levels and raise capacities among key stakeholders and the general public. Academic and association members will be encouraged to contribute to the strengthening of educational systems, including curricula and teaching materials that would serve this goal. The concepts of virtual water and the water footprint can be used to help the public better understand the impact of everyday choices on global water security.

Research. Promote thematic research (including the development of modeling techniques) in areas including climate / land / surface water / groundwater interactions, monitoring systems and methods for water management, increased water use efficiency in domestic appliances, industrial equipment and processes, and agriculture; water recycling and reclamation and management of the byproducts formed during the management of the water cycle.

Practice. Engineers and other professionals can contribute to greater water security through the design of sustainable hydro-environmental systems, including enhancing water use efficiency in agriculture and industries, such as power generation, mining, and oil and gas production and processing.

We endorse the above principles and commit to collaborating with all partners and stakeholders that share this common vision.

Approved on the 9th of September 2013 in Chengdu, China.

Signed on the occasion of the 35th IAHR World Congress by:

International Association for Hydro-Environment Engineering and Research (IAHR)

International Commission on Large Dams (ICOLD)

International Commission on Irrigation and Drainage (ICID)

World Association for Sedimentation and Erosion Research (WASER)

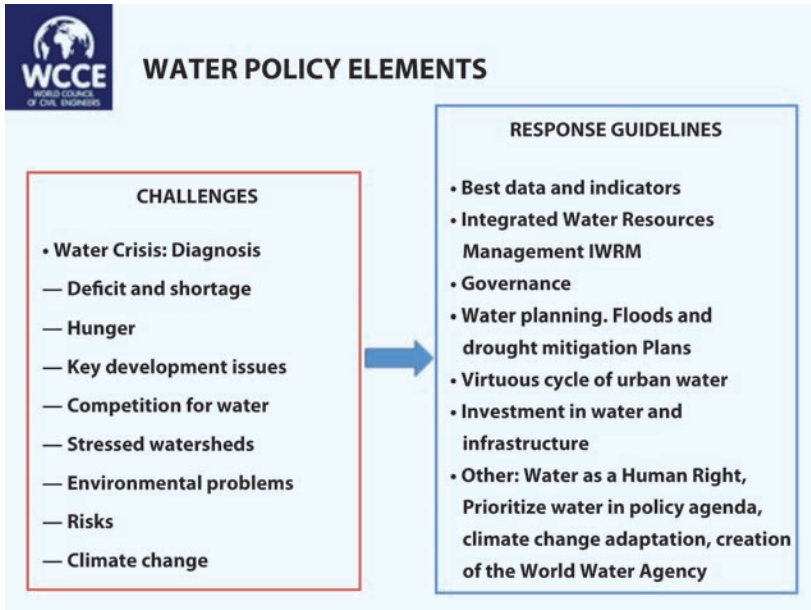
World Council of Civil Engineers (WCCE)

International Water Resources Association (IWRA)

International Association of Hydrological Sciences (IAHS)

United Nations Secretary General's Advisory Board on Water and Sanitation (UNSGAB)

In the presence of UNESCO's Natural Sciences Sector



Regarding water management, Ostrom bases its study on the experiences of Spanish Levante's orchards, the Philippines' *zajeras* and California sub-basins. In his analysis, the author shows that the users of these settlements have been able to make a proper sustainable water management through the implementation of robust and enduring institutions over time. The study concludes that the experience of Spanish orchards, where the user participates in the resource management and the degree of association holds a pyramidal shape (sub-basin user communities, general user communities and basin authorities) are success stories which may be of interest to other countries.

So, there should be more integrated supply and demand management, overcoming concepts of compartmentalized visions of both issues, promoting use of an economically efficient, environmentally acceptable resource, that would meet its demands fostering the necessary socio-economic activity in the affected regions.

CONTRIBUTION OF CIVIL ENGINEERING

We, civil engineers, are eager to apply the available tools we know and should be applied to contribute to the sustainable development during all developmental stages of infrastructure: in general planning, in water and energy management planning, urban planning, mobility and transport of goods and waste management, as well as in the design and construction stages.

I would like to highlight following five areas of specific contribution of civil engineers to sustainable development in the field of water.

Integrated water planning and management

Public action should promote strategic and participatory water planning and integrated management of water in all its aspects, as a socioeconomic and environmental resource, trying to maintain the basin unity of watersheds to prevent or mitigate the permanent shortage or seasonal excess of resource.

Water planning be should extended globally and simultaneously to a region as a whole, and needs harmonization to be integrated with sectoral planning and general economic planning explicitly. Water planning objectives' are to increase the availability of water for sustainable development, to protect its quality and rationalize its uses attuned with the environment. Water Planning addresses the quality of life and the correction of sectoral and regional imbalances. It requires a permanent approach, and continuous processes of review and update, introducing the participation of all stakeholders in the planning process. Its core must be technical, which may feed the water policy framework: other regulations will build on this framework.

Some other further reflections on water planning are:

— Water must serve all society's and human needs, properly coordinating them with special attention to food and energy.
— Planning should be a "bottom-up" process. Participatory processes are a guarantee for the effective implementation of the agreed measures. These processes should have their scope properly adjusted (subject and grade), respecting the priority role of water users, who must cooperate especially in the management and conflict resolution and problems that may arise, as well as the funding of the measures adopted.
— Planning studies and management decisions must be carried out by duly qualified, holistically-oriented interdisciplinary teams, but led by those more specifically trained professionals in water issues, hydraulic civil engineers.
— The regional scope to such studies should be river basin water systems, with its related groundwater systems, overriding any administrative and political barriers. It is noted that a large part of the world's land, population and resource are located in transboundary basins.
— Water planning should be based on a thorough compilation of available resources, existing and potential demands, and its decisions are to be taken based on models to appraise the impacts of any alternatives on development, on society and on the environment.

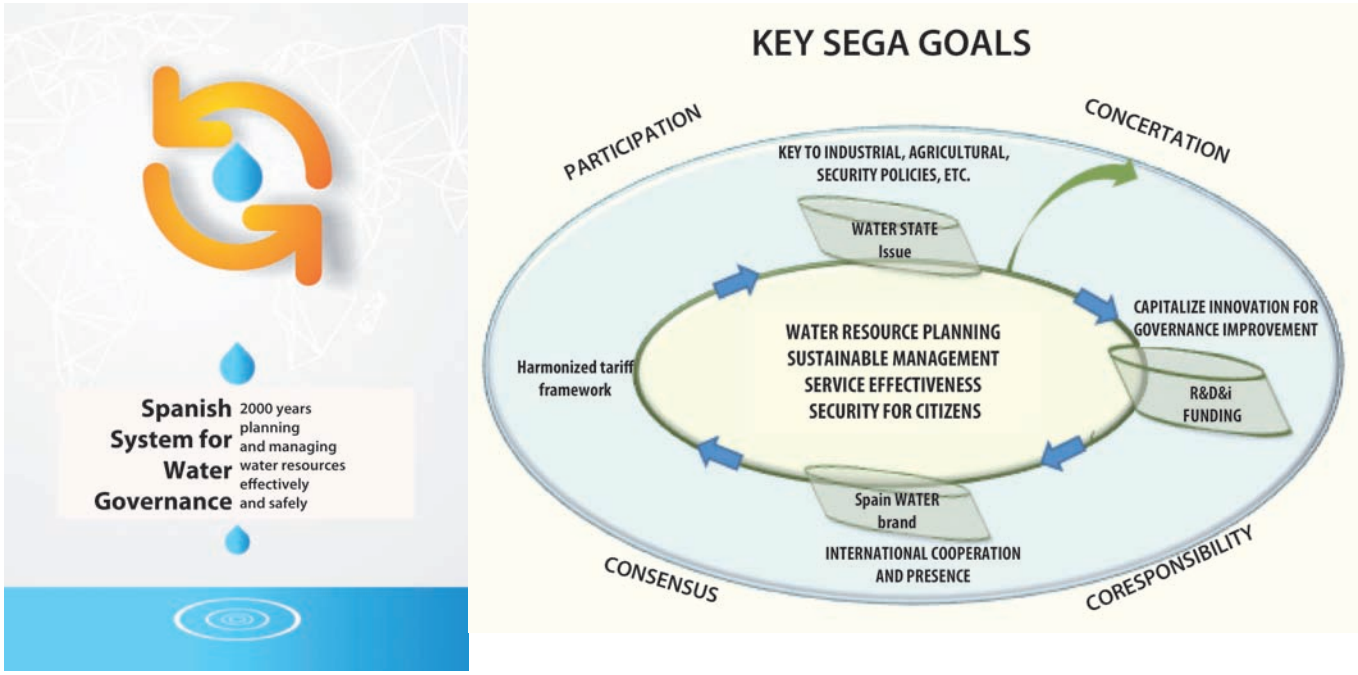


Fig. 6. The Spanish Water Governance Framework SEGA, a successful case.

It should also be noted that water initiatives are slow, and lack of long-term policies should be overcome to uphold the necessary payback of water investments. All agencies and studies state that water investments are the most profitable socially and economically, but their maturation period of definition, execution and commissioning is long, usually higher than political office mandates, making more attractive to political officers short-term investments. But it is profitable to invest in water: according to WHO, apart from the unquestionable improvement this will imply for millions of people, there is a potential economic benefit of $ 3-34 for every dollar invested in water and sanitation. In the United States, publications estimate the return of hydraulic investments, just in terms of avoiding damage to extremes, is in the order of 1-6 ratio (cost-benefit). Statistical data from show that 1 m^3 of water yields an average of 27 € compared to a production cost less than the euro.

Spain offers successful models to address the growth experienced in its twentieth century, where the population mostly became urban, quad folded, and domestic water demand multiplied by 24. Hectares of irrigated land skyrocketed from 900,000 to 3,400,000 Ha, as well as hydroelectric installed power from 200 megawatts to 17,000 megawatts, from a 296 km channel network to one holding tens of thousands of kilometers of canals, from 57 to over 1,200 large dams, 10 liters per capita daily demand to three hundred. We created basin organizations (Water Authorities) for better water management, and we transfer about 1 km^3 to ensure water security and correct imbalances ...

Spanish hydraulic engineering milestones throughout its historical development and the knowledge acquired through them, places Spain as a leading and state of the art country regarding solutions and technologies for efficient water management and water-related technologies, being a reference in planning and integrated water resources management as well as in the use of unconventional resources, reducing its energy expenditure.

This progress in the field of water technology is fuelled by a historic drive, based on Spain's geography, being a country with a delicate water balance as a result of an irregular rainfall regime. This has led, throughout our history, to stir up the wit of the professionals responsible for the exploitation of the resource and their colleagues. Among these milestones we can find the approval of the Water Act, back in 1866, and the creation in Spain of the first basin authority in the world, the Confederación Sindical Hidrográfica del Ebro, in 1926, which resulted in an administrative model for water management to be replicated in many countries.

It should also be noted that our country holds the fourth largest inventory of large dams in the world, with about 1,200 employees in charge for infrastructure operation and regulation, flood control and, less frequently, recreation usage.

On these grounds, we are technology leaders in water supply systems, sanitation and water treatment with special emphasis on desalination and water recycling. The brief summary of the historical activity of Spanish hydraulic engineering brings up evidence to conclude that Spain has achieved excellence and international recognition, not only on drinking water technologies but

also in modernization of irrigation, water treatment, in desalination, use of recycled water, etc.

The current challenge is to address the worldwide solution to the problems posed by water scarcity, conducted from a sustainable approach that would unquestionably include water planning and water management, clearly participated by the public, led by hydraulic engineering professionals to its accomplishment.

It is this moment when these practices: water planning, environmental restoration, and the design and calculation, maintenance and operation of water infrastructure from catchments to regulation and distribution networks, through purification plants and water treatment, require the performance of professionals with specific knowledge gained from previous training and subsequent experience in the field of hydraulic engineering.

Unfortunately, in these times, on many occasions the role of engineering is underestimated when it should be remembered that his former activity brought up the great development that has taken place over the past, and engineering will always be a driver for progress which has always been a cornerstone to face the present and future challenges.

The water, food and energy nexus

Humanity faces the challenge of ending hunger in a time when population growth may cause serious water stress in certain regions of the world. Irrigation (along with rules of fair international trade) is the best guarantee to address the food needs of the population, but it needs to improve its efficiency and productivity.

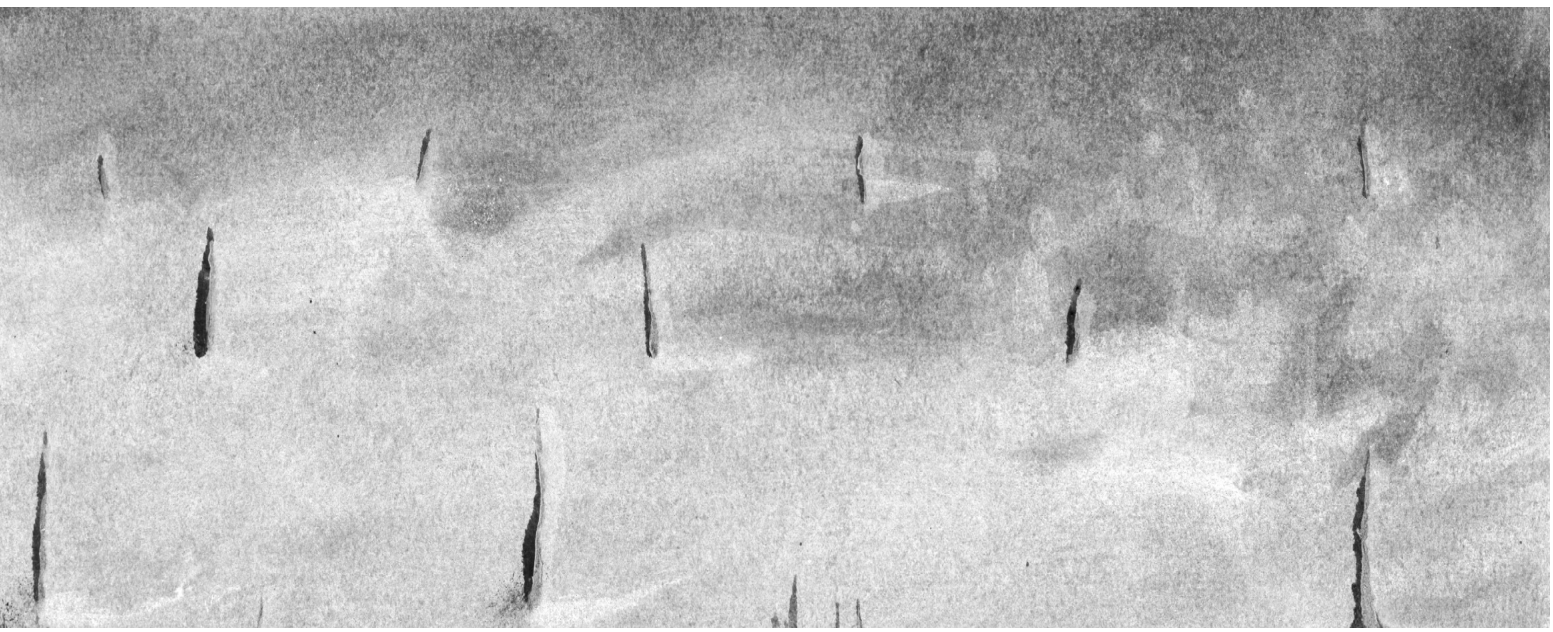
In general, the most commonly used surface irrigation technique in most developing countries is flood irrigation, having a very low implementation both localized irrigation and sprinkler irrigation.

The great advantages of localized irrigation is its efficiency, not only in saving water but by its automation capabilities and improvements to farmers' quality of life which can drive modernization of irrigation in developing countries, which engineering, with its experience and expertise, must assume as a new challenge.

Within this objective several other infrastructures necessary to ensure water for irrigation may be built such as regulation works, may them be large dams or irrigation ponds. The modernization of currently existing irrigation systems is key to the sustainability of our planet, not only through water consumption but through its quality and good condition of water bodies and their associated ecosystems.

Moreover, water and energy are strongly imbricated. Water provision processes require energy input for water catchment, transportation, treatment and regeneration, and also, many of the most common energy processes need water, as a transfer medium, coolant or in steam cycles, etc.

The water has a very important role in power generation. From hydroelectric energy power source to cooler of thermal power plants. Energy is essential for the supply and treatment of water (about 8% of world energy is devoted to water) and although there is still a long way to ensure universal access to water supply and sanitation in many coun-



WATER IS KEY

Increased agriculture production from water management will be essential to ensure food supplies in the world and achieving food security. Increasing water scarcity and more intense rainfall events will be the feature changes in the overall pattern of water availability due to climate change. These changes create a serious and continuous threat to stable agricultural production, in particular to irrigated areas in the world. A secondary threat posed is the loss of productive land due to increased barren (and associated salinity), the groundwater reservoirs' depletion and the increase of the sea level.

By 2030, it is estimated that irrigated areas will be under increasing pressure to raise productivity per water input, both to buffer the more volatile production of dry crops and respond to declining water availability. Managing this production risk caused by the increase of barren land and more variable rainfall events will require systems for dry and irrigated crops which should become more responsive and flexible in approach.

In the short term, the progressive adjustment of large-scale operation and drainage systems will be essential to ensure greater cultivation intensity to close the breach between actual and potential yields. Key adjustments for maintaining cultivated areas in irrigation schemes include:

- Optimizing operational storage and distribution through provision of on demand water services.
- Protect serviced areas from any damage caused by floods and maintaining drainage outlets.
- Introduce more water efficient farming practices and adjust institutional capabilities to ensure planning performance.

Negotiating allocations and inflows of water to agriculture across river basins among competing sectors will be an essential prerequisite for improved operating performance and productivity gains.

Well targeted investments in small-scale water control services and the improvement of services on a larger scale and institutional reforms, will become in the medium term. Other strategies that can be used to increase water productivity directly or that have indirect water-saving benefits include:

- Reducing soil evaporation through the adoption of conservation agriculture practices.
- Planting more water - efficient crop varieties.
- Improving soil productivity to increase the yield per unit of water used.
- Decreased runoff from cultivated land.
- Reduce crop water requirements by microclimatic changes and reuse of water for agricultural purposes.

Finally, in the long term, a transition needs to be anticipated towards a new irrigated agriculture more specific to areas affected by water scarcity and where commercial agriculture may be possible.as

tries, the power supply in developing countries is even lower. More than 2,000 million people in these countries do not have access to electricity.

The Water Energy Nexus is not often considered in the planning or political levels. It is essential to integrate the management of these two resources, because it improves the savings and increases water and energy efficiency. Today, this is of vital importance in a context of growing world population and therefore its demands. Improving energy systems can not only save energy but also the water used in its generation and if we improve water management, we can spare part of the energy required for its supply.

Globally, there has been a significant commitment to the development production by renewable energy sources. Its main objective is to generate energy in an efficient and environmentally friendly way, processes which also save a lot of water. Engineering, as a result of the Industrial Revolution, plays a key role in this objective.

The global energy outlook has definitely been conditioned by our present concern on climate change caused by the emission of greenhouse gases. Today the world's population is aware of the need to protect the environment and use environmentally friendly methods of energy production[7] (see Figure 7).

The global analysis of the Water-Energy Nexus assesses the significant cost that requires the integrated management of the water cycle. Each cubic meter of water collected requires an expenditure of energy that can be defined as its *energy footprint.* Even today, this concept has not been accounted enough in the analysis of investment associated with water planning, since it is assumed that it is borne by the end user or consumer.

The *energy footprint* of water in a given process can be defined considered as the sum of the water input units of each stage of the process and depends on the characteristics of the system to which it is applied. There-

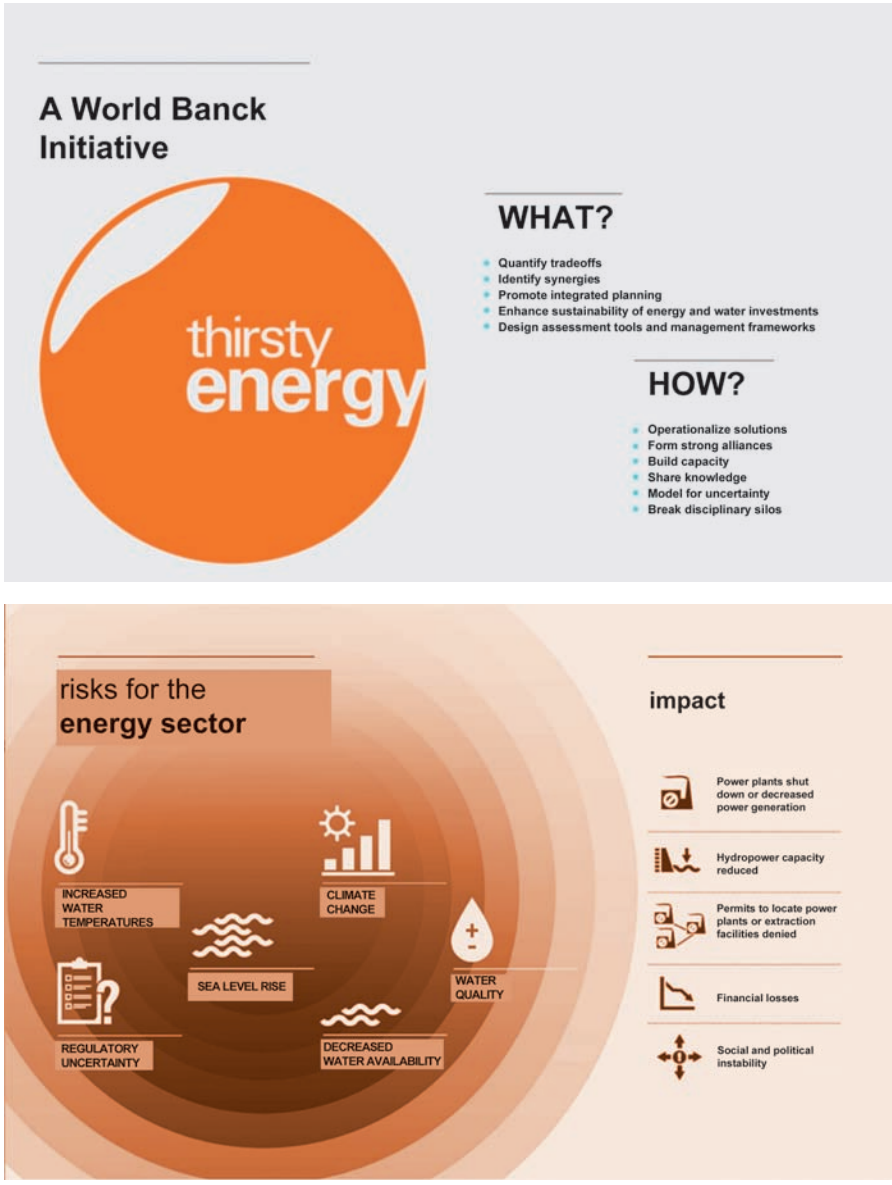


Fig. 7. The World Bank report Thirsty Energy has stressed the important role of water for secure energy supply.

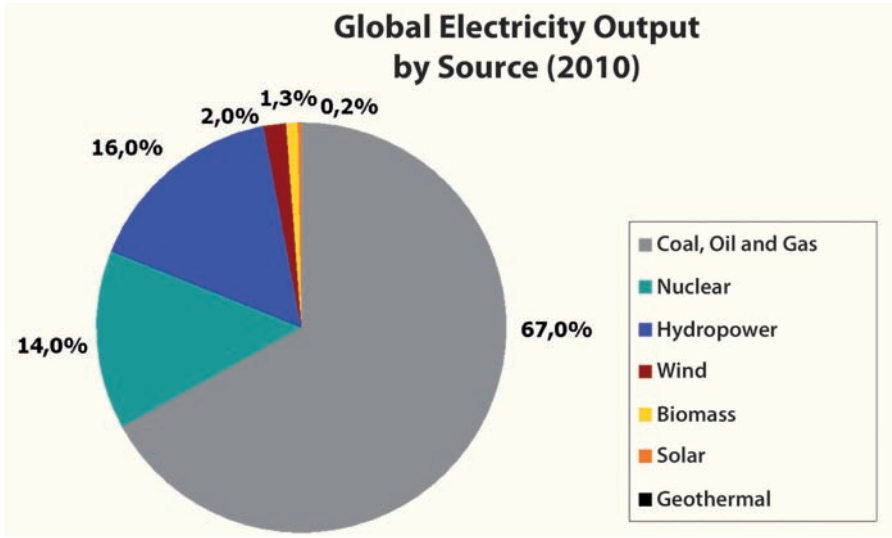


Fig. 8. Source: International Energy Agency (2011).

fore, and although it has always been sought to improve processes to save energy, potential energy savings derived from a more rational use of water are still very important and only through comprehensive approaches joint water and energy savings may be addressed.

The challenges linked to climate change can be divided into four key areas: greenhouse gases, hydrological vulnerability, mitigation of climate change and adaptation. The energy sector is a major user of water, as already mentioned, and water and energy policies should be studied in close coordination. Hydropower provides solutions in both directions in this regard. On the one hand generates clean energy and on the other, contributes to the storage of fresh water.

The market for Clean Development Mechanism –CDM– is beginning to play an important role in providing renewable energy to the developing world. It is expected that the hydropower sector continues to be one of the main contributors to the carbon credit market.

Hydropower is currently the only means through which energy from the sun, wind or water can be integrated into the energy *mix*. Enabling safe integration of renewable energy due to the flexibility of the hydropower generation technologies, which should serve as backup for the complicated management of renewable sources' energy production.

Hydropower generation technology can be described as *renewable, proven, reliable and currently capacitated to produce far more electricity than all other renewable sources* together.

Hydropower is used in more than 150 countries, with 11,000 plants built and around 27,000 generation units installed. The worldwide installed capacity is around 900 GW of power. These figures may be combined with those obtained through reversible systems (pump-turbine) in existing plants, estimated between 120 GW and 150 GW more.

The average annual production of hydroelectric power worldwide is around 2,600 TWh , representing approximately 16% of the total energy produced.

And there is still significant room for growth in hydroelectric generation, in a safe and sustainable manner.

Extreme risk management: floods

Between 1985 and 2009, 2,900 significant flooding episodes have occurred worldwide because of which more than 175,000 people have been killed, and more than 2,600 million have been affected. In 2009, property damage related to flooding exceeded 7,700 million.

In Europe, major floods between 1998 and 2004 were the cause which put into force an European Directive on the assessment and management of flood risks after the loss of more than 700 human lives and economic losses over to 25,000 million euros during the above mentioned period.

Current knowledge has highlighted the merits of conducting Adaptive Flood Management, a trend internationally accepted today. This involves the application of a series of measures to reduce the effects of flooding. Some of them are more traditional, and others more recent and in line with green infrastructures and management measures, which internationally have been named "Green Water Defense" –GWD–.[8]

The GWD approach makes full use of the role of ecosystem (in form of natural forces and processes) and seeks to balance the structural and nonstructural measures promoting an effective development and improvement of both land and water ecosystems.

For example, changes in land uses and water (in the layer of the Occupation) can impact positively or negatively on health and ecosystem

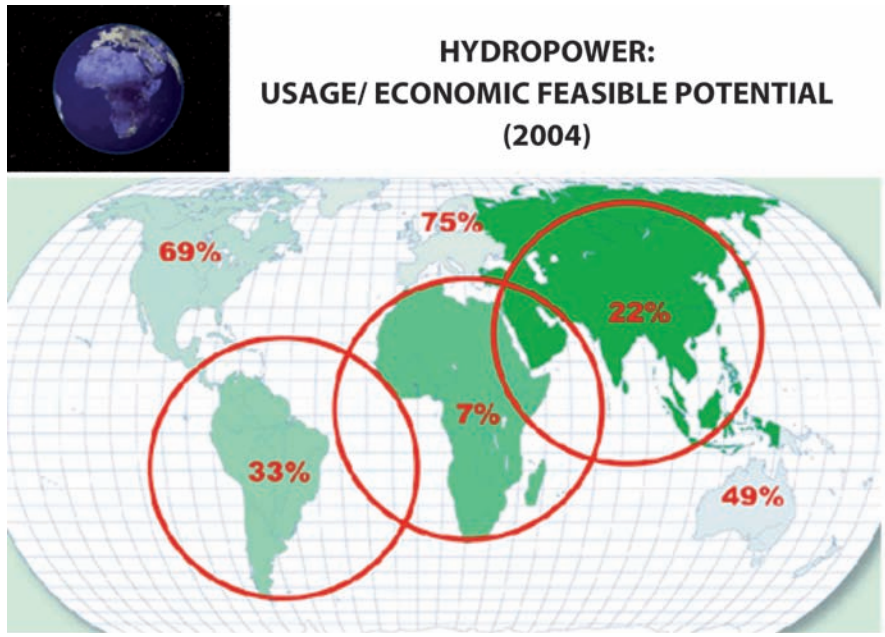


Fig. 9. Source: LUIS BERGA, ICOLD, honorary President.

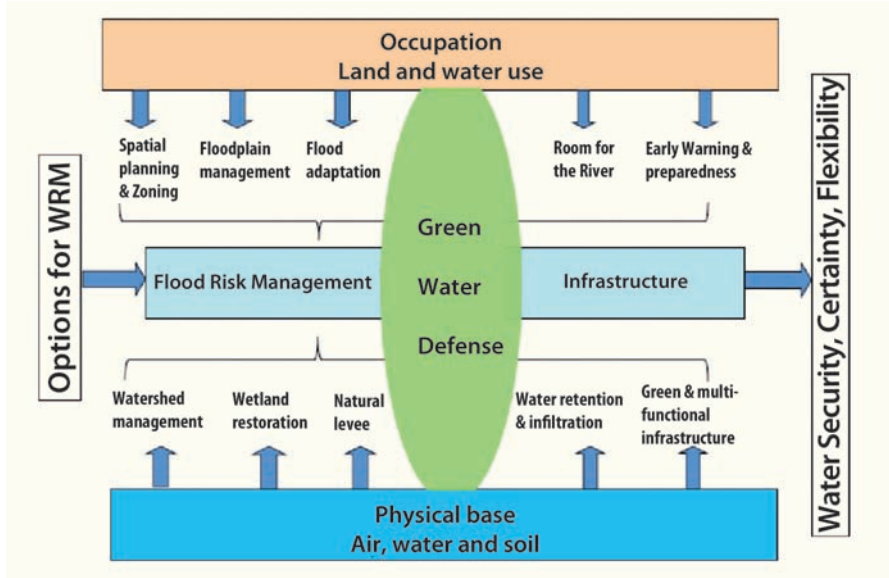


Fig. 10. Green Water Defense (GWD), conceptual framework.

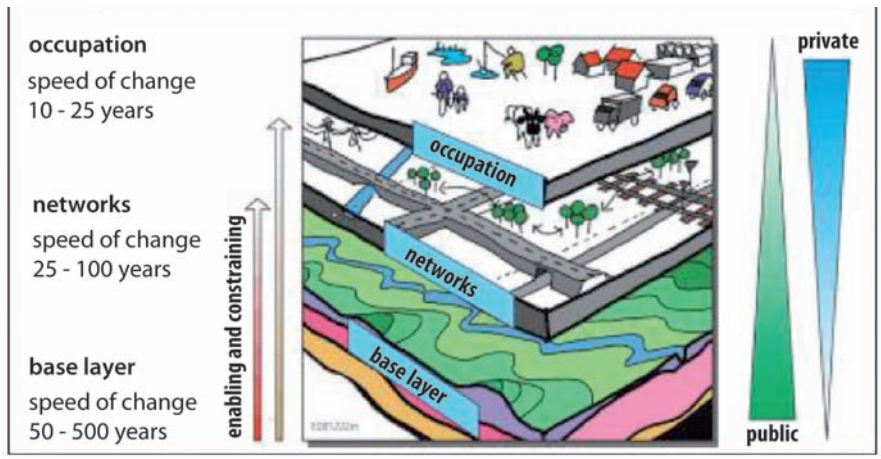


Fig. 11. The Layer Model for Deltas. Source: VROM, 2001.

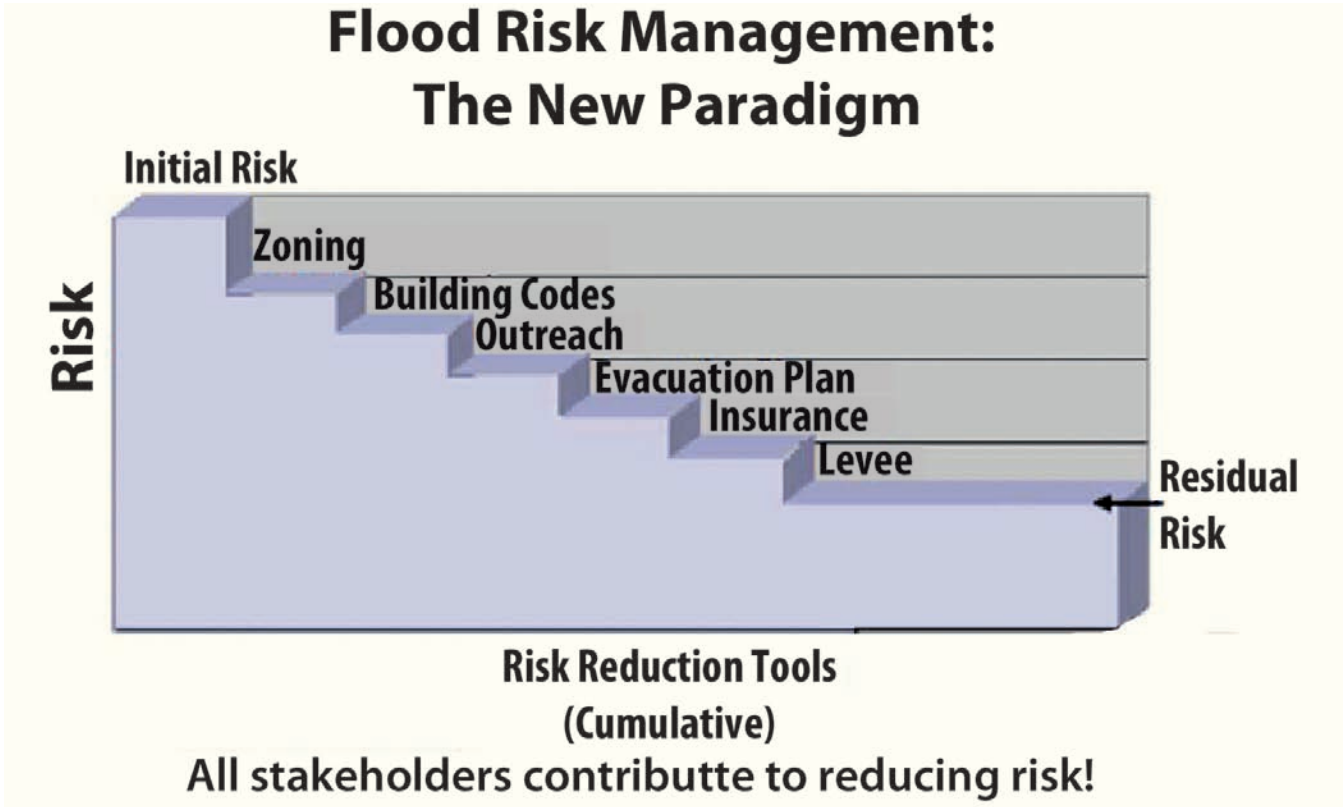


Fig. 12. Flood risk management (USACE HQ 2012).

function (the base layer) and lead to new requirements in infrastructure development and operation (the Network layer). Similarly, payment for ecological services through the protection of mangrove forests (Base Layer) allows farmers to live and grow along the coast (in the layer of the Occupation). The three spatial layers linked by GWD concept, function as a dynamic system to contribute to water security and flexibility. The GWD approach adheres to the criterion of cost-effectiveness for advice and options for the prioritization and selection of measures, based on the concept of acquisition-risk reduction 'taking into account social and environmental costs and benefits.

In the United States, to defend against the risk, it has been adopted a new paradigm in the same vein, adding to the traditional view (dams and dikes-channeling) a series of non-structural measures, and sharing its implementation among all stakeholders, both public and private.[9]

Risk reduction is clearly seen as a collaboration between different levels of government and the affected citizens. Candidates must be active participants in the process of defining, sharing, accepting and choose risk levels. In this sense, the public must move from the traditional view where it is expected that engineers or experts would "solve the problem", or the illusion that somehow infrastructure buildup would eliminate all risks to a new vision based on accepted standards of risk through processes based on informed consensus.

Smart cities

Some very important challenges lie ahead regarding water, resulting from global change:

a) Population growth and concentration of population in cities, which 50% now will happen to host 70% of the world population in 2050.
c) The increase in living standards, leading to a greater supply of water per person, and especially in developing countries.
d) The space-temporal resource variability, which is expected to increase as a result of the trends related to climate change.

Facing these major challenges we must act, applying appropriate solutions, based on successful experiences known and the search for new possibilities available today. In a recent workshop hosted in Spain, WCCE concluded the following:

General remarks

— The water required to meet basic water supply and sanitation demands:

a) Allocates, both presently and in the near future, 13% of total water demand worldwide (600 km^3 today, 900 km^3 in 2030).
b) Should be considered a basic right of the individual, and as such should be guaranteed by public authorities.
c) Must be combined into (even more due to the growing gap between available resources and demands) an integrated water resources management –IWRM–, carrying out an appropriate strategic water planning which:

1st) provides precise restrictions on environmental grounds
2nd) preserve and protect the sources of better quality for human supply as first priority

d) The true availability of these resources for a sustainable urban water cycle without inducing negative impacts requiring:

- A thorough planning within a 10 or 20 years time horizon.
- A stable development and funding in the medium and long term, with legal and financial security.
- A demanding engineering effort to build infrastructure and to manage them, prior and posterior to any urban water use.
- Legal capacity to intervene in territorial and urban planning.
- A comprehensive, proper and optimum sized action, upper than local authority, with defined powers to obtain the necessary economies of scale and scope which may provide an efficient service.
- A huge engineering effort through the water cycle: to enable the flow of water through a water tap to citizens, great engineering activity unfolds, both before –offering proper access in quantity and quality– and after –evacuating and treating it properly–.
- Transparency and public communication to citizens by water services, enabling their participation in terms of matter and their level of interest.
- Adaptation to the local circumstances, both in the decision of the management model to apply, as the amount to be provided, its funding mechanism and its education and capacity building.

Technical aspects

- The water storage amount in dams (or available in groundwater deposits) is the most closely related indicator to supply security, and must be managed hiper annually taking into account drought cycles.
- Alternative resources (desalination, regeneration and utilization) are more expensive and increase energy dependence, so they should be considered as complementary sources, not a substituting alternative.
- It is necessary to control and monitor the resource in quantity and quality.
- The benefits for *network sectorization* (consumption control, leakage control, investment planning) and *connections and distribution rings* must be highlighted.
- The importance of sanitation and treatment of wastewater is vindicated on the same level as water supply, as it affects the sustainability of the resource and the health conditions of the population. These cannot be left out of sync, to a later date, once the minimum subsistence level is exceeded.
- The modernization of systems and the provision of a "smart" factor which will enable them the best operation and management available, via R&D and knowledge transfer.

Our cities should move towards the concept of *"smart cities"*. This concept goes beyond the application of the latest technologies to the cities because they must incorporate the criteria of the Local Agenda 21 and align to the Europe's 2020 strategy 2020. Such requires, among other things, an overview in the planning, taking into consideration aspects like resource scarcity and climate change, a decentralized vision of the city, with a significant contribution of its different neighborhoods; and the involvement of the people in defining the city's future.

Improving governance

On the one hand, civil engineers want to contribute to the improvement of governance with an active prevention of corruption scourge affecting public works contracts. The alliance that WCCE has established with GIACC –Global International Anti Corruption Centre–, through the the publication of corruption prevention manuals in both Spanish and English and workshop celebration in its various member countries are in line with such initiative.

On the other hand, we have to contribute to the improvement of water governance providing new mechanisms and methodologies.

The governmental and non-governmental stakeholders can achieve its planning and water management objectives by improving the relationship between them. At a basin level, there are at least four mechanisms

that may help. Participation, transparency, fair and honest conduct and conflict management.

Participation defines the process by which non-governmental stakeholders are involved to some degree in collective action. The government decides what level of power is to be offered to those participating. This power can range from mere information, through consultation and coordination (with consultation mechanisms in stable structures) to consensus and co-decision.

Transparency is condition to genuine participation. Basically, transparency refers to the quantity and quality of information that a stakeholder makes available to others in regards to the decisions taken. These decisions can affect individuals (eg, recognition or suppression of individual rights by the authorities) or a group of individuals. Transparency is a feature especially required to the government. Lack of transparency, both in terms of the decisions that affect individuals or decisions affecting groups, influences strongly the perception that other stakeholders may have on such federal / national action.

Fair and honest conduct is also required to all stakeholders, not just the government. This principle refers to the extent that all stakeholder actions are guided by the principle of common good and do not take advantage of other stakeholders. As in the case of transparency, fair and honest conduct would be predicated not only on decisions that affect individuals but on those that affect communities. However, it seems that behaviours which are affecting individuals should the most important object of the honesty of the action. For example, it is required from a fair and honest government not to conduct initiatives or register grants which would privilege some stakeholders over others. This fair and honest conduct may also require users by requesting them not to

use more water than their granted license, for example.

Finally, *management conflict* is a mechanism that has enormous importance at basin level. The resolution of the conflict will sometimes require authority action and other times, only mediation. The conflict is part of the relations between sometimes divergent interests on how public goods are to be managed, so the ability to manage conflict is increasingly necessary if we want to achieve good governance. Conflict resolution is a shared responsibility between government and nongovernmental stakeholders.

The involvement of different stakeholders to the federal / national authorities in water management would not eliminate the fundamental role played by the authorities, but it would change them, because the power national / federal government can no longer act as sole manager or simply as authority, but should lead the basin. The changing role of leadership monopoly of the basin involves some changes. In addition, the government should still be able to intervene should other stakeholders fail to agree on targets or how to reach them. This is especially necessary when public good is considered strategic and the risk that private stakeholders may act against future generations (for example, extracting more water than ecologically sustainable) is present. As a result to this shift in emphasis from command and control to negotiation and persuasion, the governmental decision makers must acquire a new skill set. In contrast with the typical management skills (planning, organizing, staffing, directing, coordinating and budgeting), in the area of governance, the set of skills of public decision-makers are *activation, orchestration and modulation* (Salamon 2002).

The *activation* skills foster the various stakeholders to participate constructively and to engage in joint problem solving. *Orchestration* skills serve to support the networks set as orchestra conductors, directing that all musicians to play the same piece synchronously with the necessary harmonies to avoid the cacophony. In a basin, the ability to orchestrate the various interests involves the ability of enabling the alignment of individual goals with collective goals. The *modulation* set of skills defines the modulation of incentives, as rewards and punishments are necessary to encourage cooperative behavior. In the area of governance, public policy makers are constantly faced with the dilemma of deciding how much authority or how much assistance (grant) is "enough" and how much is too much. If the authority is excessive, "partners" may decide not to cooperate; if there is no authority, public goals can be obviated for the sake of private interests. If subsidies, for example, to implement new irrigation systems are inadequate, they will not be adopted; if excessive, they will run the risk of financing an investment that would in any case had been developed.

Good governance presumes users to become actively involved in the management of water resources with the authorities of other levels of government, establishing mechanisms for relations between stakeholders (mainly participation, transparency, fair and honest conduct and conflict management) and trying to find objectives that go beyond the specific outputs of particular intervention programs, but the objectives of increased water quality, improvement of the economic development and social welfare for all basin stakeholders and inhabitants.

The coaching staff (engineering and other disciplines) must make great educational efforts, also through the media, for citizens to participate and act on the basis of adequate information.

FINAL REMARKS

It's time for action. A time in which engineering is needed, where hydraulic engineering professionals are needed to lead the process and culminate it successfully. One of the lessons learnt from history should be the successful development of the twentieth century in much of our globe provided and driven by engineering. We should learned from our errors: environmental conditions that were not anticipated and managed timely, but such errors –which obviously requires effective action, and is now being addressed– should not be magnified or overruled their benefits. Another essential pillar to the solution, Integrated Water Resources Management was adopted and fostered by hydraulic engineers.

Regarding of water, engineering is essential to all: The necessary structures for its use, as well as for the following operation and maintenance, planning and resource management, water systems modeling, optimization, data collection (quantitative and qualitative), regulation, distribution and transport, purification and water treatment, flood control, determination of flood areas, dam safety, droughts special plans ... Professional activities all which require capacity and specific knowledge, and cannot and should not be relied on hands different from professionals and expert companies.

One thing is the times require new skills such as transparency and participation –and quite another (and an error to avoid)– is that leadership is relinquished from the most prepared professionals. None of the above mentioned activities may be carried out successfully without the supervision of skilled hydraulic engineers, who can also propose the most efficient actions from a holistic point of view. Our professionals remain at the forefront of knowledge, and are willing to contribute with their work to a suitable basis for the corresponding political and social processes. Hence the timeliness of the cooperation derived from our role as UN Water partner, which is bearing good fruit such as this series of *Water Monographies.*

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WCCE Past-President
World Council of Civil Engineers

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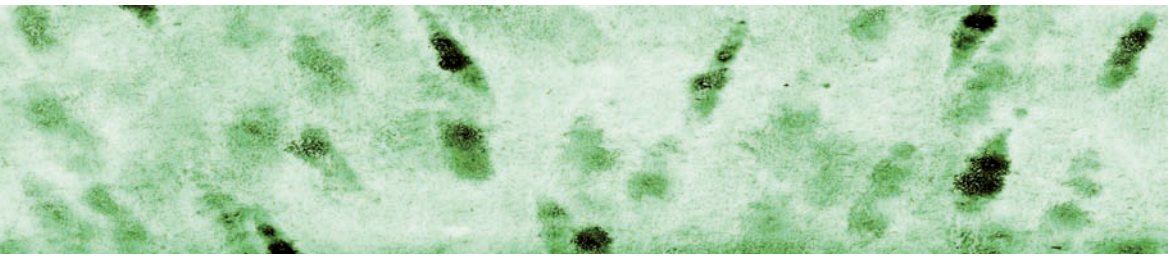
WATER FOR A SUSTAINABLE FUTURE

NEW PARADIGM, NEW VISION

Ángel Simón Grimaldos



KEYWORDS:
SUSTAINABLE DEVELOPMENT
WATER
CLIMATE CHANGE
WATER RESOURCE
KNOWLEDGE TRANSFER
COOPERATION

The debate between sustainable and/or long-lasting may be passionate in the field of linguistics. It is, however, clear that the paradigm generally accepted as sustainable development will define the new age of humanity. In this future and liquid reality, water is called upon to play a central role. Sustainability refers both to our productive model, and also to the structure of our societies and to the shaping of our cities, whose accelerated growth all over the planet represents one of the main risks for the preservation of our natural resources. The idea, the concept, is not new. It was formulated in the seventies and arose from the demographic explosion and energy crisis of that decade. Paradigm is, however, a term of Greek origin *(parádeigma),* meaning model, pattern and example. In a broad sense, it is something which has to serve as a guide or roadmap to be followed, the instructions of a group which establishes limits and determines how a person or organization should act within such established parameters. Sustainable development is, therefore, our roadmap.

The new vision, corresponding to the present time and future prospects, based on recognition of climate change and the need for a change of direction, also makes it necessary to endeavour to reduce inequalities, preserve equal opportunities and, finally, use a new toolbox which will allow us to guarantee a better future. It is no longer possible to view this future from a fortified Europe but rather, as we have seen so harshly with the migratory phenomenon and the personal drama which entails, it compels us to seek forms and formulae of global governance for an interconnected world without borders. Water again plays a fundamental geostrategic role.

Water may represent a serious challenge but, if managed efficiently and fairly, it can play a key facilitating role in strengthening the resilience of social, economic and environmental systems in the light of fast and unforeseeable changes. Technological disruption must necessarily reach a sphere such as water resource management, which represents a challenge for governments, companies, professionals and academics. Knowledge management is thus once again the key to a great leap forward in solving the problems raised.

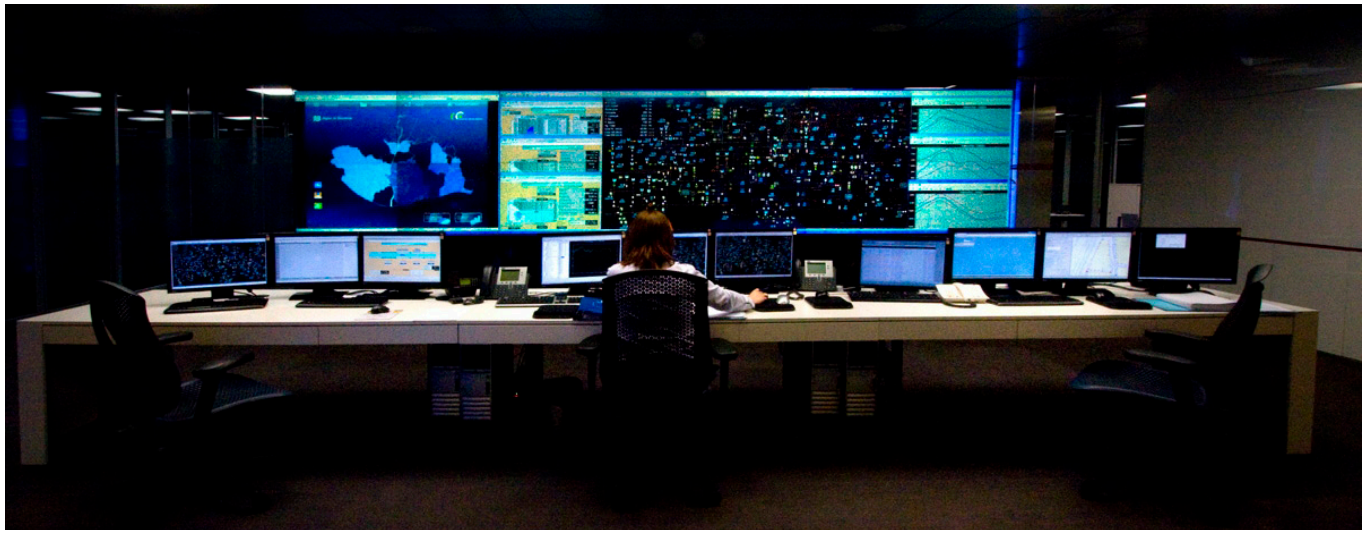


Fig. 1. Collblanc command control.

PUBLIC AND PRIVATE RESPONSIBILITY

A long time has passed since 1980 when United Nations introduced the expression sustainable development into the international debate in the document *"World Conservation Strategy",* with the subheading *"Living Resource Conservation for Sustainable Development".* Just a few years later, in 1987, the former Norwegian Prime Minister Gro Harlem Brundtland raised the alarm in the report *"Our Common Future",* which conceived and institutionalized the concept of sustainable development, subsequently incorporated into all UN programmes, becoming the focal point of major international meetings such as the Earth Summit, held in Rio de Janeiro in 1992.

As defined in that document, sustainable development is that which *meets the needs of the present without compromising the ability of future generations to meet their own needs.* Sustainable development focuses on the idea of needs, in particular the basic needs of the poorest people in the world, which must be given priority, and on the idea of establishing certain criteria and *limitations* so that economic growth does not further erode our environment, the defence of which has ceased to be a national or local task becoming a global issue.

The central idea of the definition of *sustainable development* made by the Brundtland Commission is intergenerational solidarity or justice: the commitment to future generations. The depth and breadth of the definition have enabled it to enlist the support of numerous organizations, contributing new perspectives to the sustainability of a constantly changing planet, with a growing population increasingly concentrated in cities, the urban environment, with the consequent progressive abandonment of rural areas.

The former Prime Minister of Norway, a member of the United Nations High Level Global Sustainability Panel, explained, in a conference organized by the Agbar Foundation on the occasion of World Water Day 2015, that *the traditional separation between the public and the private sector is becoming increasingly irrelevant,* and therefore joint actions will be crucial to confront the dangers of climate change and encourage a green and circular economy, which allows resources to be preserved and reused.

Not only the public sector and society as a whole need to be globally responsible, but also the business community. Companies are also obliged to set an example, because society demands behaviour which fully incorporates a new virtuous circle based on the green economy and the reuse of waste. The citizens shareholders for the common good, in particular regarding water.

We must therefore be able to reflect all the environmental and human costs of economic decisions and establish flags, alerts and criteria which clarify the consequences and the costs, both of action and inaction. This means that contamination, including carbon emissions, must not be free, that subsidies (in the form of free contamination) for fossil fuels must be progressively eliminated and that we must find new formulae to measure or assess development beyond GDP.

One of the biggest challenges faced by the international community is to establish common principles so that developing countries may apply growth policies which are low in carbon emissions, while the more developed countries reduce their emissions. The former are going to experience a higher population increase, more energy needs and a more pronounced population and urban development growth. Good global results may conceal growing inequalities, not only on the global level, but also at the heart of these developing countries.

Fig. 2. Navarre irrigation channel.

At the end of last September, UN approved the *17 Sustainable Development Goals* (SDG) in New York. Their aim is to set the post-2015 agenda. That is to say that they are a new action plan to continue and complete the work of the former MDG (Millennium Development Goals) up to the year 2030. The major new development that they present is their special emphasis on the involvement of companies of all sizes and from all sectors to achieve a sustainable and inclusive economy. Responsible production and consumption patterns and sustained industrial growth must prevail in this economy. We should not lose sight of the fact that the world population is growing by leaps and bounds. A circular economic model must therefore be built which benefits everyone and, in this respect, the business sector will play a decisive role.

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WATER, MAIN CONCERN FOR THE NEXT 10 YEARS

The World Economic Forum held in Davos this year, in addition to expressing its fear of worldwide political instability, situated water as the main cause for concern over the next 10 years, followed by our failure of the fight against climate change. Business leaders are beginning to become aware that the current model of growth is not viable in the medium and long term. Moreover, since the US president, Barack Obama, recognized the existence of the planet's global warming, this issue has gained mommentum on the international political agenda. Even Pope Francis, in his encyclical *Laudato si,* gave a firm warning stressing the need to *care for our common home,* our planet and its natural resources, with a special mention for water.

Water, as I was saying, is at the centre of sustainable development. Water is vital when it comes to reducing the worldwide burden of diseases and improving the health, welfare and development of countries, of their citizens, and is essential for the production and preservation of a series of benefits and services that people enjoy. Water is also at the heart of the adaptation to climate change, being a crucial link between the climate system, human society and the environment. Indeed, water is the lifeblood of the Earth. For the first time, thanks to remote sensors, science has a way to monitor water during each phase of its natural cycle: when it falls as rain or snow, when it flows toward the rivers, when it is extracted from aquifers, when it returns

to the atmosphere through evaporation or when it is reused for different purposes. Researchers rely on what has been learnt to predict droughts, announce floodings, protect drinking water and improve crops.

The recent water crisis in California has converted this state into a sort of laboratory for remote-sensing projects. Over the last three years, a team from NASA has been devoted to fly over Yosemite National Park with an aircraft equipped with specific instruments to measure the accumulations of snow which feed Hetch Hetchy Reservoir, the main supplier of water to San Francisco. The smaller quantity of water reaching the rivers and reservoirs of California has led the authorities to restrict the volume supplied to the state's farmers. The reaction of the farm owners has been to extract more water from the wells to irrigate their fields and, consequently, the groundwater levels have gone down. This is precisely one of the fundamental problems that we are facing: depletion of part of the planet's aquifers, which supply at least a third of the water that Humankind consumes. Some data available indicate that half of the world's aquifers are being emptied faster than they are recharged, above all in the Arabian peninsula, India, Pakistan and the north of Africa.

The dynamic interactions between climate change and freshwater resources on earth are closely linked to the availability of good quality water for human consumption. At present, at least half of the world's population depends on groundwater for safe consumption. With the current urban growth forecast, it is expected that by 2050 demand will have increased by 55%, meaning that water management will become a strategic issue. In most areas of the world, the problem is not the lack of fresh drinking water, but rather the bad management and distribution of the water resources available. This is where knowledge transfer becomes the most effective way of cooperation.

THE MAIN VERTEX OF A VITAL TRIANGLE

The liquid element plays a decisive role in the Water-Energy-Food triangle, as it is an essential requirement for the other two. You just need to look at what happens when searching for life on other planets in our solar system. NASA scientists recently expressed their great satisfaction on having found signs suggesting the existence of liquid water, most probably salty water, on the planet Mars. We have also learnt that there is a large body of water beneath the surface of Enceladus, one of Saturn's moons. The interest in locating water lies in it being the key to the possible existence of life, in whatever form, outside Earth.

Agriculture is by far the world's largest consumer of water, representing 70% of extractions worldwide, although this figure varies considerably between countries. Rain-fed agriculture is the world's predominant agricultural production system, and its current productivity is on average a little more than half the potential that could be obtained from optimal agricultural management. By 2050, apart from the waste or bad use which may be made of the food existing, agriculture will have to produce 60% more food worldwide and 100% more in developing countries. With irrigated agriculture, the majority of the systems operate inefficiently, thus losing around 60% of the water that they use. Inefficient irrigation methods entail their own health risks: waterlogging of some areas of South Asia, as a result of excessive use, is the main factor in the transmission of malaria, a situation repeated in many other parts of the world.

For its part, global warming can affect the current distribution of crops. Thus, for example, climate change will leave new areas available for the cultivation of corn, but will reduce production in the current areas. It is therefore expected that it will be grown by more farmers in more places. On the contrary, all climate scenarios point toward a reduction in wheat yields. Furthermore, a warmer climate may activate more harmful plagues. It should not be forgotten that, in order to meet the demand resulting from the population increase in 2050, worldwide agricultural production will have to increase by between 60% and 70%. In relation to livestock, the proportion of producers who will change to breeding heat-resistant species will increase. This will represent more sheep, pigs and goats to the detriment of beef and poultry farming.

In these circumstances, water and energy are a highly interrelated combination. They are two fundamental pillars for balanced economic

Fig. 3. La Farfana Water treatment plant.

development and access to each of them represents a key for the eradication of poverty in widespread areas of the world. Water requires energy in all stages of extraction, treatment and distribution; energy requires water to be produced in almost all its forms. They can moreover be united to produce hydropower. According to a report by Spanish energy grid operator, Red Eléctrica, in Spain hydropower represented 14.6% of the energy generated and consumed in 2012, exceeding solar photovoltaic, renewable thermal and solar thermal.

It therefore seems clear that both water and energy supplies are limited and that demand is ever increasing. Estimates indicate that demand will continue to grow significantly in the coming decades. A United Nations report estimates that by 2030 demand for water will increase by 40%, energy demand will double current consumption levels and food demand will increase by around a third. Often, a population which does not have access to water and to sanitation facilities also lacks energy.

The neediest sector of the world's population urgently needs access to both water and electricity services. Estimates indicate that worldwide there are 1.3 bn people without access to electricity, 768 m who lack improved drinking water sources and up to 2.5 bn who are deprived of sanitation services. It is a priority to reduce these inequalities in order to eradicate poverty from the planet. Cooperation and knowledge transfer are the best paths to make progress in this field.

NEW CONFLICTS

The latest United Nations report on the Development of Water Resources, entitled *Water for a sustainable world,* highlights the relationship between water and critical areas such as human health, food and energy security. However, this observation is not reflected in the global focuses and action plans. There is a lack of global perspective dealing with the needs foreseen for present and future generations. In 2013, the rich countries allocated a total of €35.2 bn to environment-related development cooperation projects. On too many occasions, greater emphasis is placed on infrastructures than on their management. For instance, the sectors which received the largest injections of capital were energy (with €4.4 bn) and transport (with €4.4 bn). On a lower level we find water, agriculture and environmental protection in general. The biggest donor was Japan with €6.4 bn (far ahead of the second donor, which is the World Bank), and the biggest recipient was India, with €2.65 bn.

Global warming modifies rainfall patterns and increases the melting of glaciers, altering water reserves and intensifying flooding and droughts. It changes the climatology and leads to one major catastrophe after another. This is a new scenario which, in addition to increasing the humanitarian drama and major migratory movements, opens the door to the possibility of new conflicts in the world, in which the dispute for water may reopen historical enmities. The reduction in the surface area of agricultural land, food insecurity or the difficulty to access raw materials, often understood as financial assets, and the forced displacement of significant population masses are some of the foreseeable effects about which the main specialists in geostrategic risks have already warned.

A journey around the latest conflicts that have shaken the world shows us the connection existing with climate change and its effect on water availability. In Darfur, the recurrent droughts confronted the nomadic population with the tribes of farmers, who closed their land to defend themselves from the avalanche of people in search of new pastures for

their cattle. The tensions between the two groups turned into a war which has caused over 300,000 victims and 2.5 million displaced persons, according to the United Nations.

Many people also think that the drought that plagued Syria between 2007 and 2011, the most important ever recorded, was an important factor contributing to the destabilization of the country. In 2009, more than 800,000 Syrians had lost their livelihood and, in 2015, over nine million were in a situation of food insecurity, 6.8 million of which on a serious level. This episode led almost two million people dependent on agriculture and livestock to flee toward the more developed areas of the country, which had already taken in a huge contingent of Iraqi and Palestinian refugees. Many other factors played a role in the Syrian hornet's nest, but we should not underestimate factors related to the effects of the aforementioned population movements.

Likewise, the drought in Somalia (it has hardly rained for a year) threatens 300,000 people, a further tension added to the imbalances suffered by the country, including the environmental problems of its coasts, related to the development of maritime piracy in the country. The same applies to the Sahel area, where climate change is a factor accelerating civil conflict and interethnic violence.

The Mekong River is one of the longest rivers in the world and one of those which is most exploited, as it feeds Thailand, Cambodia, Laos, Myanmar and China. If modifications occur to the Himalayan glaciers which feed it or changes to the monsoon pattern, the flow may be reduced and destabilize the region, particularly when China, which is also suffering from a considerable drought, is accused by its neighbours of having contributed to the reduction in the water flow on building hydroelectric dams in its territory. This is another example of a new danger for geostrategic stability.

THE CITIES' CHALLENGE

Over half the world population lives in urban areas. In 2050, it is likely that cities will house two thirds of the planet's population. Given that urban areas are already responsible for approximately 76% of CO_2 emissions and that many of them are vulnerable to flooding and high temperatures, it is logical that local administrators are beginning to take climate change and the new sustainable development paradigm seriously. It is an opportunity to reduce contamination, improve infrastructure management and maintenance and introduce a circular economy model for the permanent reuse of waste.

Sustainable water management is a pending issue in many cities. This is not just the case in emerging or developing countries, but also in our affluent western world. It is therefore necessary to make an effort so that innovation, talent and knowledge make it easier to develop and use new technologies to take full advantage of each drop of water in the supply and distribution channels, and to reuse it in the best way possible. The urban planning of cities plays a very important role and sustainability also entails incorporating so-called green buildings, which save energy using the most advanced air conditioning systems so-called smart streets and all the infrastructures and connections necessary for the development of electric vehicles. This is a smart concept, involving a succession of small revolutions which must result in a new concept of city, designed to be at the service of sustainable development.

A city's average annual air temperature may be between two and six degrees higher than in the surrounding rural areas during the day, and between two and five during the night. New solutions, such as heat-insulating roofs, can mitigate this heat island effect. The 2014 report on *World Urbanization Prospects* prepared by the UN Population Division indicates that the highest urban growth will take place in India, China and Nigeria. The management of urban areas has become one of the 21st century's most important development challenges. Thousands of kilometres of pipes make up the water infrastructure of each city. Many antiquated systems waste more freshwater than what they offer. In many fast-growing cities (small and medium-sized with a population lower than 500,000 inhabitants), the wastewater infrastructure is non-existent, insufficient or obsolete. A great deal of work remains to be done and we are all invited and obliged to take part.

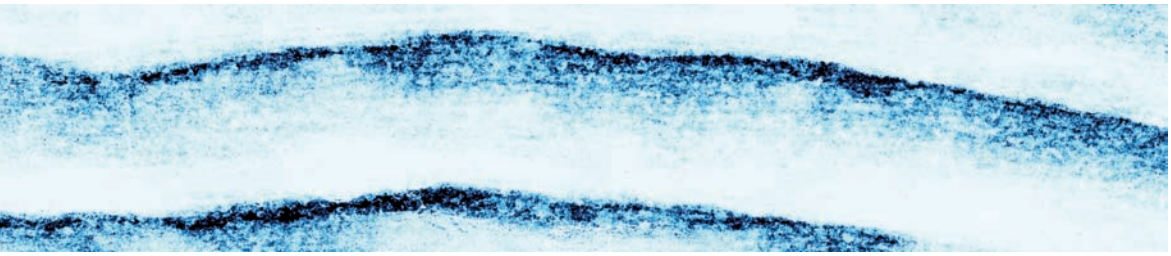
Good companies are groups of people, tens, hundreds, sometimes thousands, who cooperate to generate not only products but also knowledge which is useful and beneficial for other people. The income statement and the assets of these companies increasingly incorporate the knowledge produced and the social returns of their actions. In companies such as ours which participate in water management, this individual and group responsibility, this commitment, is not a choice but rather the starting point which legitimizes our front-line position on shaping the future of humanity. This is our commitment, in order to bring about a sustainable future.

Ángel Simón Grimaldos
Ingeniero de Caminos, Canales y Puertos
Chairman of the Aquae Foundation

AN APPROACH TO SUSTAINABLE WATER MANAGEMENT THROUGH REGIONAL COLLABORATION AND COOPERATION:

THE CONFERENCE OF IBERO-AMERICAN WATER DIRECTORS (CODIA)

Liana Ardiles



KEYWORDS:
SUSTAINABLE MANAGEMENT; REGIONAL COOPERATION; CODIA; IBERO-AMERICAN FORUM OF ENVIRONMENT MINISTERS; MILLENNIUM DEVELOPMENT GOALS; SUSTAINABLE DEVELOPMENT GOALS; PUBLIC PARTICIPATION; WATER SUPPLY AND SANITATION; FINANCING OF WATER SERVICES; HYDROLOGICAL BASIN PLANNING; INTEGRATED RESOURCE MANAGEMENT; HUMAN RIGHT TO WATER AND SANITATION; SOCIAL EQUITY; DEMOCRATIC AND PARTICIPATORY GOVERNANCE; EUROPEAN UNION; UNESCO; SEGIB

INTRODUCTION

The First Ibero-American Forum of Environment Ministers, held in 2001 in Spain, agreed, inter alia, that "the environmental challenges of the Ibero American Community can be largely overcome *by boosting and strengthening the current collaborative means, expanding their scope to share the pool of skills, knowledge and experiences* that the Iberoamerican Community holds on environmental matters." The Ministerial Declaration fruit of this forum included several topics related to water resources which showed the views and concerns of the Latin American community of countries regarding water management and its administration.

Such views and concerns that then focused on the need to accomplish the challenges of water management as presented in 2000 by the Millennium Development Goals.

From its outset, the Forum presented some guidelines that should draft the political and administrative action for the accomplishment of good water governance in the region, guidelines which today remain in full force and have become the roadmap to a new agenda on sustainable development. Such key issues address the shift of focus from the Millennium Development Goals to a new more inclusive approach that will result in the post 2015 UN agenda and the new Sustainable Development Goals (SDG).

Presently looking into the future to respond effectively to the challenge of water security in the region, it is time to highlight what had already been mentioned during the First Ibero-American Forum of Environment Ministers in 2001 regarding the planning and management of the water resource, a strategic resource to ensure the region's development, inequality reduction and improve the protection and conservation of the environment.

As early as 2001, references to watershed management were made: "The most adequate territorial framework for integrated water resources are watersheds. The most appropriate way to address water management is through river basin authorities".

The importance of public participation was also mentioned: "Public water management policies require a high degree of social consensus, requiring substantial

Fig. 1. CODIA Conference01-10-2013. Water Directors at the 14th meeting of the CODIA. Madrid, Merida and Elvas.

public participation. Means should be facilitated to establish the widest stakeholder participation and enable the coverage of the more water related issues in the discussion."

The importance of planning was stressed: "Water planning should be developed through river basin management plans, which are a basic tool in water management. Such plans should be flexible and allow periodic review and evaluation, hosting mechanisms to enable inter-agency and inter-sectoral coordination and facilitate the involvement of water users, civil society and environmental organizations in such planning."

The need to ensure supply and sanitation to populations through water services financing was underscored: "One of the most important problems facing our societies today is to ensure urban and rural populations drinking water in the amount and required quality together with adequate systems for the sewage and treatment of wastewater, with sound impacts on health, welfare and the environment. The scope and complexity of the problem and its investment needs –which should include the fund allocation for the maintenance of such facilities– are so great that should mobilize all possible funding sources, including the private sector and international financing organizations."

And finally, included among the actions to be undertaken, *"The creation of a Conference of Directors*

(CODIA) responsible for water management as a technical support group to the Ibero-American Forum of Environment Ministers to explore and implement new cooperation policies."

The elapsed time has only strengthened the validity of each one of the former conclusions of the Forum.

What was found at the time is that Ibero American countries share common challenges regarding water resources: how to achieve universal access to water and sanitation; how to achieve the good condition of its rivers, how to reconcile food security, energy security… But above all a shared common vision on the management on water resources was stated. A vision which focuses on river basin approach and a participatory governance scheme, respectful to the environment, based on water planning.

And this has become CODIA's raison d'etre. A forum where different countries with a common vision on water challenges, could present and share their experiences. A forum that may enlighten decision-makers on water related issues in each country on how to address such challenges. Thus gave birth to CODIA.

CODIA

The Conference of Ibero-American Water Directors was created in 2001 in response to the mandate of the First Ibero-American Forum of Environment Ministers held in Spain which agreed to set up a body which would had to be participated by each country's water management decision makers in the IberoAmerican region.

That same year CODIA's first meeting was held in Cartagena de Indias (Colombia) to establish its ob-

jectives, which broadly speaking are: to facilitate cooperation in the field of water, to serve as a platform to facilitate the presence of the common regional positions in international forums, to promote the development and exchange of experiences and technology among its member countries and coordinate cooperation activities within Ibero America.

Through CODIA's establishment, the Iberoamerican Commonwealth grafted water issues the importance that by that time were not shared on the same terms as today on that many countries worldwide. The Ibero-American Forum of Environment Ministers could foresee that water management was and is essential to developing countries. Essential, above all, for their sustainable development.

Since then, 15 conferences have been held, in which developments have brokered to consolidate the CODIA's new strategic framework. The last conference was convened late last year in Panama. In such conference, CODIA's mission buttressed its role as a regional platform for cooperation and collaboration between Ibero American countries in the area of governance and management of water resources to promote sustainable development and human welfare.

SPAIN'S COMMITMENT TO THE IBERO AMERICAN WATER AGENDA

Such objectives are shared and promoted by Spain. Our country has played a key role not only as a driver of this forum but also as a facilitator stimulating cooperation in the field of water in the region and cooperation between the water administrations of Ibero American countries.

Spain's geography and climate have forced us since antiquity to develop sound management models to handle a resource as precious and scarce as water. A system based on good water governance; a governance based on the hydrological basin planning, public participation, integrated resource management, legal security, traditional infrastructure, technological know – how and innovation in its business sector community.

A model of governance that has become the development of a water vision, a water culture which states its responsible use, which allows us today to have a wide experience in managing the risks associated with its exploit, especially those concerned with its shortage. It has also led Spain to assume an ethical and social commitment on water access. A commitment which has resulted in the recognition of the human right to water and sanitation and its practical implementation as one of the backbones of Spain's political commitment with the international community. Spain is now working to share its knowledge and experience in governance and water management with countries that, though geographically apart are facing similar challenges, challenges which are well knowledgeable to the Ibero American Commonwealth.

Spain's commitment with the international community and the recognition of the human right to water and sanitation is practically universal and covers all regions of the world. However, for cultural, economic, social, linguistic and historical, Ibero America has been and remains today the region over which Spain has turned most of its efforts on collaboration and technical and economic cooperation.

The very fruitful collaboration that Spain has developed through its Development Cooperation Agency (AECID) is an expression of such commitment, whose main instrument of action has been the Latin America and the Caribbean Cooperation Fund for Water and Sanitation, now eight years old, whose partnership with the IDB has allowed to multiply investment and results.

Despite progress in recent years, millions of people in Ibero America and around the world still lack access to safe water and sanitation. In the Latin America and the Caribbean, progress in these areas have a very positive impact, but are not enough, despite the great efforts made to increase levels of drinking water coverage in many countries.

Spain continues working and collaborating with its partners in the Ibero American Commonwealth to increase the quality and improvement of services that contribute to the current coverage. This is not only done through economic cooperation. Water governance, planning and management systems are key to ensuring the sustainability of these services.

Furthermore, it has also recently renewed this commitment to cooperation with the Ibero American Commonwealth, to which the Spanish Government has given top priority in its Strategy for Foreign Action, adopted in December 2014.

Therefore, today, and in Ibero America, and from the point of view of governance, the commitment to the sharing of experience in water management is managed through the Conference of Iberoamerican Water Directors, in which its Permanent Technical Secretariat (PTS CODIA), unit responsible for preparing the works and meetings of this collaborative forum program, is based in Spain.

Fig. 3. Course on integrated water resources management in the training center of AECID, Montevideo, 2011.

CODIA EMPOWERMENT

In order to development this commitment, Spain, both as a member of the CODIA, and in its capacity as the hosting country to its CODIA's PTS lately, has been promoting a process of revamping this collaboration platform.

The work of revitalizing the CODIA has relied on two pillars: institutional strengthening on the one hand, and the development of a new outreach capacity. Such revamp is closely related to the negotiation process on the Sustainable Development Goals (SDG) and the need to promote sustainable water management policies in Ibero America, through better governance and management of water resources.

To build these pillars two coordinated different lines of work have been developed. On the one hand, the CODIA'S presence has been strengthened in water related Ibero American policies, especially in its role as an advisory technical organ of the Ibero American Conference of Ministers of Environment and its responsibility for raising their proposals for action for the Forum's political ratification. On these grounds, CODIA has adopted a new strategic plan and new internal rules of operation.

On the other hand, and this is a particularly novel aspect, an objective has been established of making CODIA an influential forum for international discussions on water.

Water management is essential for developing countries. Spain is in favour of continuing to promote the

work that CODIA has been doing, not only to strengthen our governance capabilities and empowering the authorities responsible for water management in the region, but also to achieve that IberoAmerica's vision on water management issues may become a reference to be taken into account in discussions on the international water agenda.

Reflecting this new international dimension, CODIA has presented its position to the UN in favour of the recognition of the human right to water and sanitation and its support to the creation of specific SDGs on water and sanitation and monitoring indicators based on good governance of water and its horizontal dimension. A position which has also become visible in the recently held 7th World Water Forum in South Korea.

In the same line, CODIA defends the creation, under the umbrella of the UN Framework Convention on Climate Change – UNFCCC–, of an Intergovernmental Panel on Water to provide scientific advice to policy makers.

SPECIFICS OF IBERO AMERICAN COUNTRIES

Spain is working within the Ibero American Commonwealth for CODIA to become an instrument not only to know the specifics of the Ibero American countries, but for these specifics to be taken into account when defining a common strategy on water.

CODIA wants to project a vision for water management based, inter alia, on the principles of social equity, democratic and participatory governance, and the promotion of hydrological planning, as well as consolidating the river basin as the basic and integrated unit of planning for the management of water resources.

A vision concurrent with the Sustainable Development Goals and the Millennium Development Goals agendas, in the recognition of the human right to water and sanitation, as well as upholding the concept of water security and cross-border cooperation as a means for the peaceful settlement of conflicts associated to shared water management.

CODIA members are committed to continue working for this platform, making it present in as many debates held outside its scope so that common problems to Ibero American countries are taken into account when designing water policies.

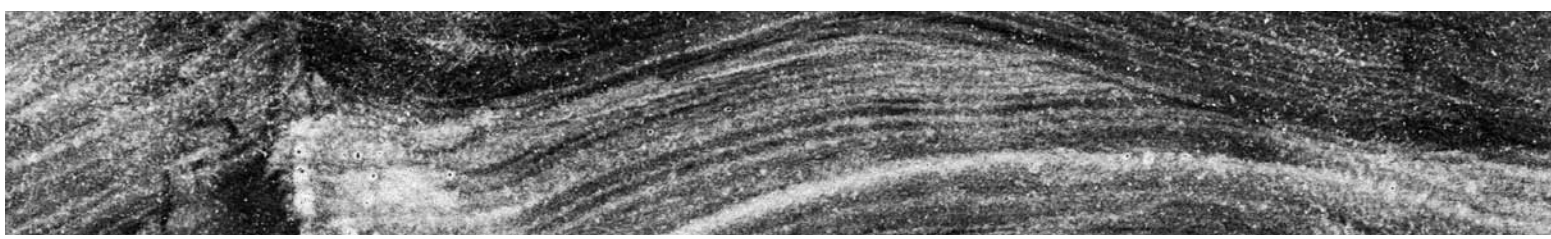
A vision that feeds on the experiences of water management on both sides of the Atlantic, in America and in Southern Europe, two areas geographically distant but sharing the uniqueness of facing both low rainfall, droughts, and its excess, flooding.

Indeed, the last meeting held in Panama served to forge new alliances with international stakeholders such as UNESCO, the World Bank, the IDB, the OECD and the European Commission through RALCEA, alliances which have allowed to adopt a series of partnership agreements deals to exploit their potential and capacity to interact in international forums and institutions.

CODIA'S REVAMP

On the other hand, CODIA has undergone in recent years a major overhaul to fulfill the current needs of training and knowledge transfer with which to tackle challenges concerning water security and the protection of present and future water resources, which the countries of the region are facing. All this from a clear commitment to sustainable resource management.

The keys of this renewal have been based on a review of the training topics to be provided, making them consistent to current challenges. It has been necessary to maximize the capabilities of virtual training, particularly on the side on the training of new knowledge or technical skills, without forgetting classroom learning, especially oriented to promote the exchange of technical



personnel as the most effective way to provide solutions to real problems of management and resource planning based on experience.

A review which has been accompanied by the entry of new players by establishing partnerships with institutions which have a predominant role in training. In particular, work is being done in order to establish a Network of Centres of Excellence to support managers (alliance with RALCEA programme) and to promote cooperation with UNESCO.

At the last meeting of the CODIA held in Panama,the basis for this trend change began with the adoption of a series of agreements as to entitle the Permanent Technical Secretariat to prepare an annual operation plan for the year 2015 that will define CODIA's short and medium term objectives, the budget needed to implement them, as well as enabling the co-financing of CODIA by entities such as UNESCO, SEGIB and the UN Office for the Water Decade, or foster the development of exchanges of experience and technology transfer among Member States in the framework of the management of water resources.

In order to expand CODIA's outreach it was agreed to support the integration of CODIA in the Americas regional preparatory process to the 7th WWF in Korea first and Brazil's 8th WWF in 2018, the Mexican proposal to establish an Intergovernmental Water Panel under the UN Framework Convention to Combat Climate Change was endorsed as well as the enhancement of the collaboration with the Spanish Agency for International Cooperation for Development (AECID). All these commitments have been fulfilled thanks to the active collaboration of the Ibero American countries at the World Water Forum in Korea.

FUTURE CHALLENGES

Once we have achieved CODIA to adapt to the new challenges that water management is facing, the next meeting in Bolivia aims to consolidate the strategic lines of change started in Panama in order to gain more institutional presence in the Ibero American Forum of Environment Ministers; to promote alliances with new partners, seeking synergies between institutions that promote the CODIA and its training pro-

grams; and continue to win greater international presence; and finally, by fixing the position for 2016's international water agenda.

It is possible to make this forum a platform with effective capacity to, through cooperation and collaboration, provide effective solutions to the challenges of water management in IberoAmerica and to accomplish such objective, it is key the sum of efforts not only of all the CODIA directors but also of other institutions like the World Bank, the IMTA, the AECI, CEDEX, or RALCEA.

Undoubtedly, CODIA has become the ideal forum to publicize the shared specifics of Ibero American countries and to demand these specifics to be taken into account in all forums in which water and its sustainable management is discussed. A platform which, since its birth 14 years ago, has adapted to the times and has reached enormous importance outside its scope.

The countries of the Iberoamerican Community have endorsed the goal of putting water management within a sustainable path, to walk together such path through the MDG agenda to the SDG agenda. We all have much to contribute and is an ethical imperative that all countries make the effort to channel their potential and make come true the human right of access to water and sanitation in all IberoAmerica.

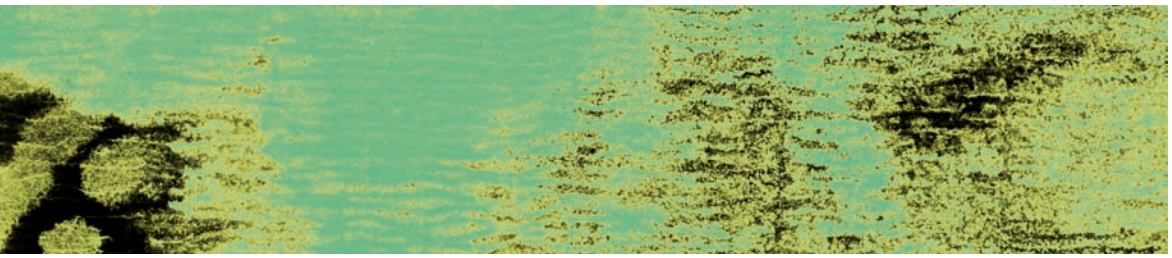
This year is a crucial year for development and in particular for water in the world. In New York, in September, UN Sustainable Development Goals will be adopted, shaping the development agenda for the coming years. The King of Spain declared in June in Madrid "both in New York in September and in Paris in December we will set the path beyond 2015, specifying ambitious instruments and goals and persisting in the fight against poverty and climate change. I am sure we will continue working together as partners and fellow countries".

Liana Ardiles
Civil Engineer

Director General on Water
Ministry of Agriculture,
Food and Environment, Spain

WATER IN AFRICA CHALLENGES FOR SUSTAINABLE DEVELOPMENT

Adama Nombre



KEYWORDS:
WATER
SUSTAINABILITY
COOPERATION
KNOWLEDGE
RENEWABLE ENERGY
CAPACITY BUILDING
GOVERNANCE

INTRODUCTION

Africa has a population of around 940 million inhabitants and will reach 2 billion by 2030 characterized by an increasing rate of urbanization, one of the highest in the world, with the resulting consequences in term of pressure on undeveloped natural resources.

Africa has a population of around 940 million inhabitants and will reach 2 billion by 2030 characterized by an increasing rate of urbanization, one of the highest in the world, with the resulting consequences in term of pressure on undeveloped natural resources.

The aim of this paper is to share some views and proposals for contributing to the discussions and search for Sustainable development in Africa and will focus on the water aspect of the problem of sustainable development.

WATER RESOURCES IN AFRICA: A GENERAL OVERVIEW

The main source of freshwater in Africa is coming from rainfall and water stored in some large aquifers. There is no important snowmelt contribution to the water resources in Africa.

Rainfall

The total amount of mean rainfall for Africa is around 20 000 Km^3 per year (UNECA, 2006). The variability of rainfall is very high in many parts of the continent in term of spatial seasonal and inter-annual distribution. The yearly rainfall is very high in the forest zones in Central and West Africa, whereas there is hardly any rainfall in the Sahara and a low one in the Sahelian region which is located between the Sahara and the forest area of West and Central Africa. Due to the impacts of global climate change, there are more and more extreme event like severe droughts or floods and an increase in flows' variability.

Surface water

Africa is covered by 13 large international rivers with some of the largest rivers in the world like the Congo and the Nile. Within these rivers systems there are around 160 lakes, among them some of the world's largest. The main features of these resources are their uneven distribution and also their important variability leading to severe recurrent droughts and floods. Chart 1 shows the main characteristics and the importance of the run off for some large rivers systems in Africa.

Chart 1

Large rivers systems in Africa

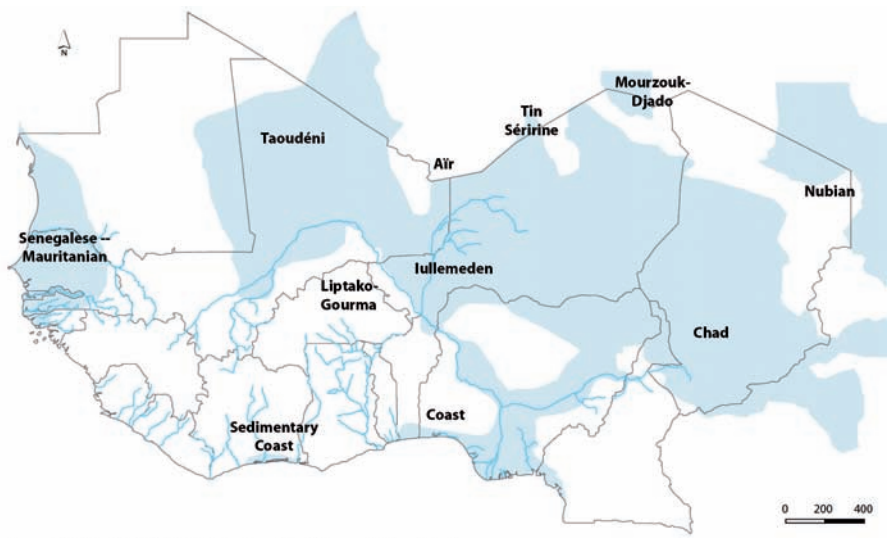
River	Drainage area, 10^3 Km^2	Length, Km	Average discharge at mouth, m^3/s	Runoff volume, Km^3/year	Runoff layer, mm
Congo	3680	4370	41250	1300	353
Nile	2870	6670	1696	53.5	18.6
Niger	2090	4160	4217	133	63.4
Zambezi	1330	2660	3519	111	83.4
Orange	1020	1860	486	15.3	15.0
Chari	880	1400	1252	39.5	44.9
Juba	750	1600	546	17.2	22.9
Senegal	441	1430	545	17.2	39.0
Limpopo	440	1600	824	26.0	59.1
Volta	394	1600	1288	40.6	103
Ogowe	203	850	4729	149	734
Rufiji	178	1400	119	35.3	198
Cuanza	149	630	946	29.8	200

Source: IA Shiklomanov 2002.

Large aquifer systems in Africa

Ground Water is crucial and vital for many countries in Africa mainly in the northern part of the continent. The case of Libya is illustrative of this situation as 95% of the needs are fulfilled by ground water. Many rural communities rely on groundwater during the long dry season. In North Africa over extraction of groundwater is a real problem. An important part of the groundwater is constituted by fossil water. The following map presents the situation in West Africa (Figure 1).

Fig. 1. Main Transboundary groundwater systems in West Africa.



Source : ESRI, Global GIS, WHY MAP. Produced by: M. Niasse, C. Mbow (2006)

Water availability

The situation of Water availability in Africa is much contrasted: whereas there are huge water resources in the Congo River basin, the northern and soudano-sahelian area are characterized by water scarcity. Chart 2 shows the situation for the different regions in Africa.

Chart 2

Water resources availability in Africa

Sub Region	Available Water Resources			Water Use Km^3/year			Water Use in Relation to Water Resources %		Per Capita Water availability 10^3 m^3/year	
	local	inflow	total	1950	1995	2025	1995	2025	1995	2025
Northern	41	140	181	43.0 34.6 *	110 78.0	144 94	61 43	80 52	0.62	0.32
Western	1088	30	1120	2.3 1.7	26.0 20.1	52 32	2.3 1.8	4.6 2.8	4.9	2.1
Central	1770	80	1850	0.5 0.18	2.5 1.4	14 9.0	0.14 0.08	0.76 0.49	27.2	12.0
Eastern	749	29	778	3.7 2.8	50.4 41.0	83 59	6.5 5.3	10.7 7.6	3.6	1.5
Southern	399	86	485	6.5 5.0	26.4 19.1	43 28	5.4 3.9	8.9 5.8	5.3	2.8
Continent	4050	-	-	56.0 45.0	215 160	331 216	5.3 4.0	8.2 5.3	5.2	2.4

Source: IA Shiklomanov 2002.
* The first line indicates Water withdrawal and the second water consumption.

THE MAIN WATER ISSUES AND CHALLENGES IN AFRICA

Water availability

The main issues and challenges in Africa in term of water availability is the uneven distribution and high interseasonal and interannual variability within the seasons of available water resources and also the lack of adequate water resources' mobilization and management. Many areas in Africa are facing already water stress or scarcity today and large parts of Africa will face water scarcity by 2025 considering the high rate of growth of the population and urbanization and also due to the quality of water available.

The need to have an important storage capacity for improving water availability and managing both its variability and the recurrent droughts and floods is very critical. Africa is the continent where dams and reservoirs for water storage are not yet fully developed. Figure 2 indicates the available water storage capacity per capita for some African countries compared to others well-equipped countries and regions of the world.

The real water available is the water stored in natural and manmade reservoirs and also renewable groundwater resources. When considering the data on the above figure, one can see that the majority of Africa's regions are really facing water stress when considering the water really available for use. Such confirms the statement declared in a recent television documentary "one cannot eat the potential" and water needs to be controlled and managed wisely for life and development.

Pollution of freshwater is an increasing concern in Africa due to the deficit in sanitation systems, the huge and fast development of mining activities, artisanal and industrial systems and the use of pollutant from the agricultural sector. Considering the emergency situation of the people, misuse of the reservoirs areas and dams' upstream land are leading

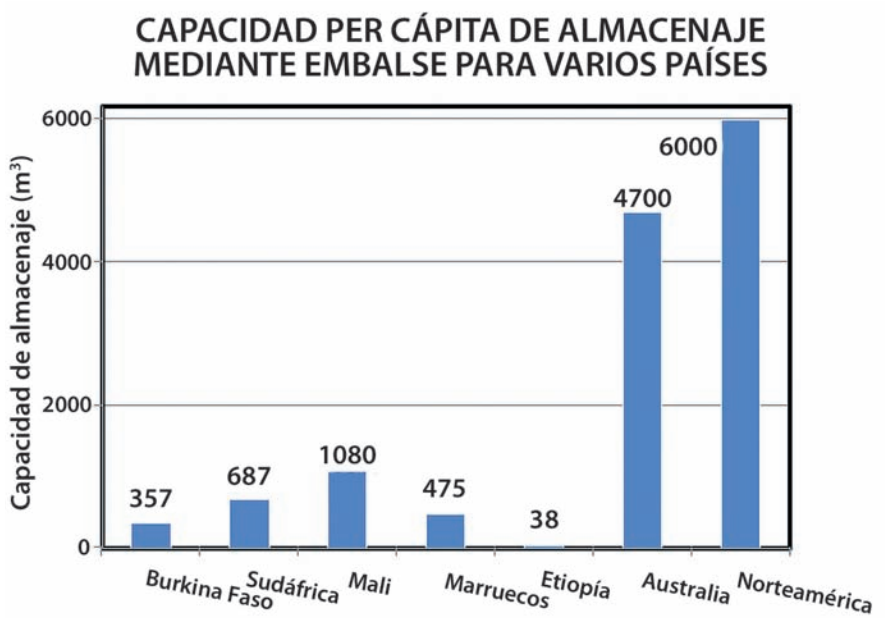


Fig. 2. Per Capita water storage for some countries.

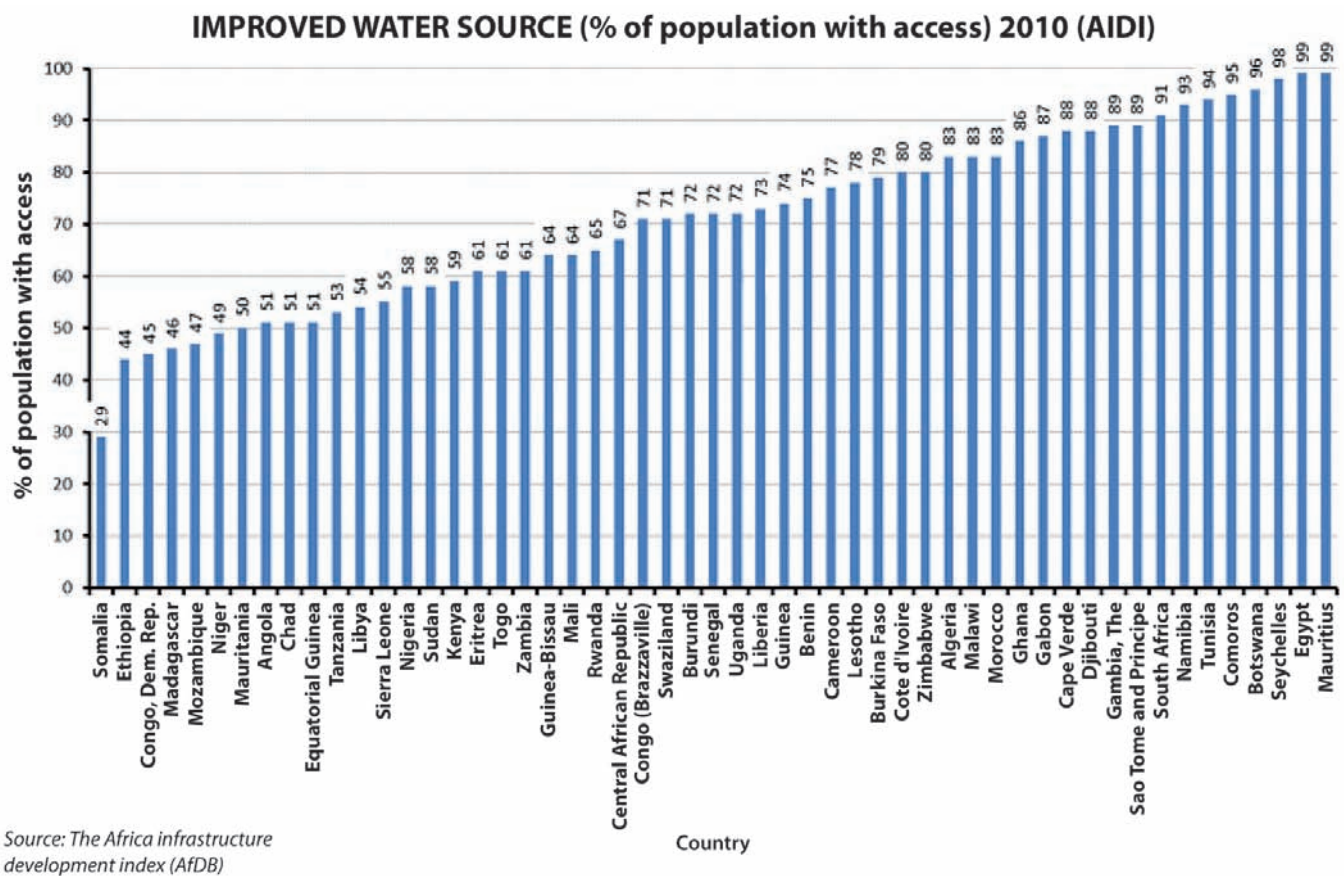
to fast sedimentation and also pollution. In many areas of Africa, the pollution from uncontrolled mining activities has become a real threat for the water resources.

The knowledge and assessment of the resources and their variability and their is still weak due to lack of sound data collection, processing and management systems in many countries and regions. One of the main challenges in term of water resources management will be in the future, the increasing pressure on water resources due to the growing demand of an increasingly urbanized population and the impacts of climate change which will be translated in more variability and the multiplication of extreme events like floods and droughts.

An important part of small cities and villages are dependent on groundwater for access to drinking and domestic water. The fast depletion of such resources is acknowledged in many regions in Africa, mainly in the Sahel.

Access to clean water and modern sanitation

An important share of the population of Africa lacks basic access to clean water and sanitation. With the effort committed at the national, regional and international levels in the framework of the MDGs ending this year 2015, millions of people have access to clean water today. Access to modern sanitation is still very low with dramatic consequences in term of morbidity and mortality rate in many countries and region of Africa. Figures 3 and 4 present the situation by countries in term of access to water and sanitation services.



Source: The Africa infrastructure development index (AfDB)

Fig. 3. Access to improved water sources.

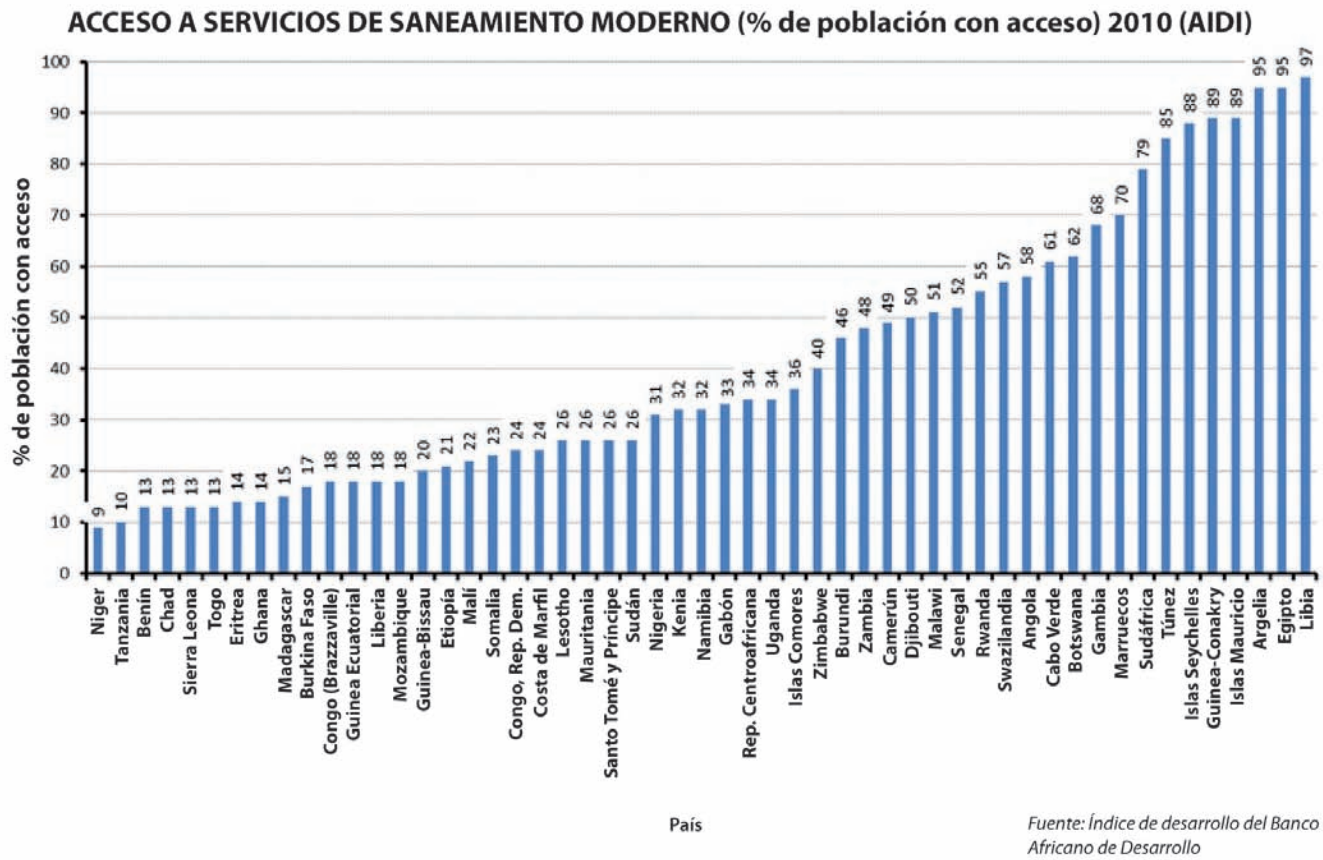


Fig. 4. Access to modern sanitation services.

Access to food security

Africa is one of the continent where unused arable lands are still available in large quantities and also where there is no food security. Famines are current in many areas of Africa and an important share of the population, mainly women and children, is suffering from malnutrition and starvation due to lack of sufficient food production. We know the role of irrigation in securing food for billions of people around the World, mainly in Asia. 40% of the world food production is produced under irrigated agriculture and provide food to feed 2.4 billions of people around the world.

Only a small proportion of the cropped lands (around 7 to 10%) are under irrigation in Africa as showed in Figure 5.

One of the main cause of the food crisis, which reached a critical state on 2008 with foods riots in many countries in Africa, are the insufficient production of food due to insufficient development and use of arable land, the high dependency of agricultural activities on rainfall and other highly variable climatic conditions and the commitment of the available resources to crop for exportation like cotton and other agricultural commodities. The crisis of 2008 shows also the fallacy of the concept that any country and region can find food commodities at the international level and does

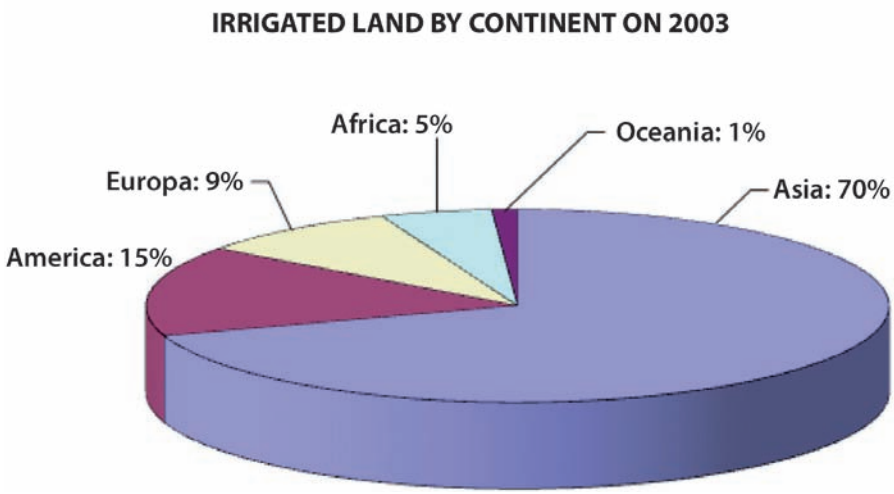


Fig. 5. Irrigated land by continent.

not need to have a minimum food sovereignty (between March 2007 and March 2008, the price of wheat more than doubled).

Access to modern energy

Despite Africa is one of the most important world oil and gas producers and is endowed with large potential of Hydropower, rate of access to modern energy is the lowest of the world. Millions of households are still in the dark. The main energy consumed in Africa is biomass and wood fuel counting for more than 75% of the total final energy consumption, with a huge impact on the environment in terms of deforestation and huge degradation of land cover leading to soils' degradation and river and reservoirs sedimentation. The consequence on women and children's health is also worsened with an important rate of mortality due to fume pollution. The limited access to modern, affordable and clean energy is a huge constraint for economic development and welfare in the continent.

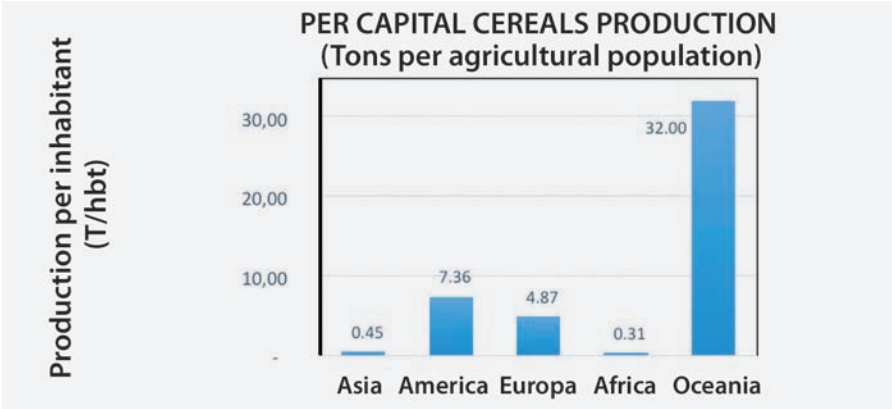


Fig. 6. Per Capita cereals production by continent.

Africa has an important hydropower potential which can be developed to supply a clean, affordable and renewable energy. Only 7% of the economically feasible potential has been so far developed. Countries like Democratic Republic of Congo with the Inga site, Ethiopia, Cameroon, Angola, Madagascar, Gabon, Mozambique, Nigeria etc. have a huge potential which needs to be developed.

Figure 7 presents the situation in term of electricity generation for different countries in Africa.

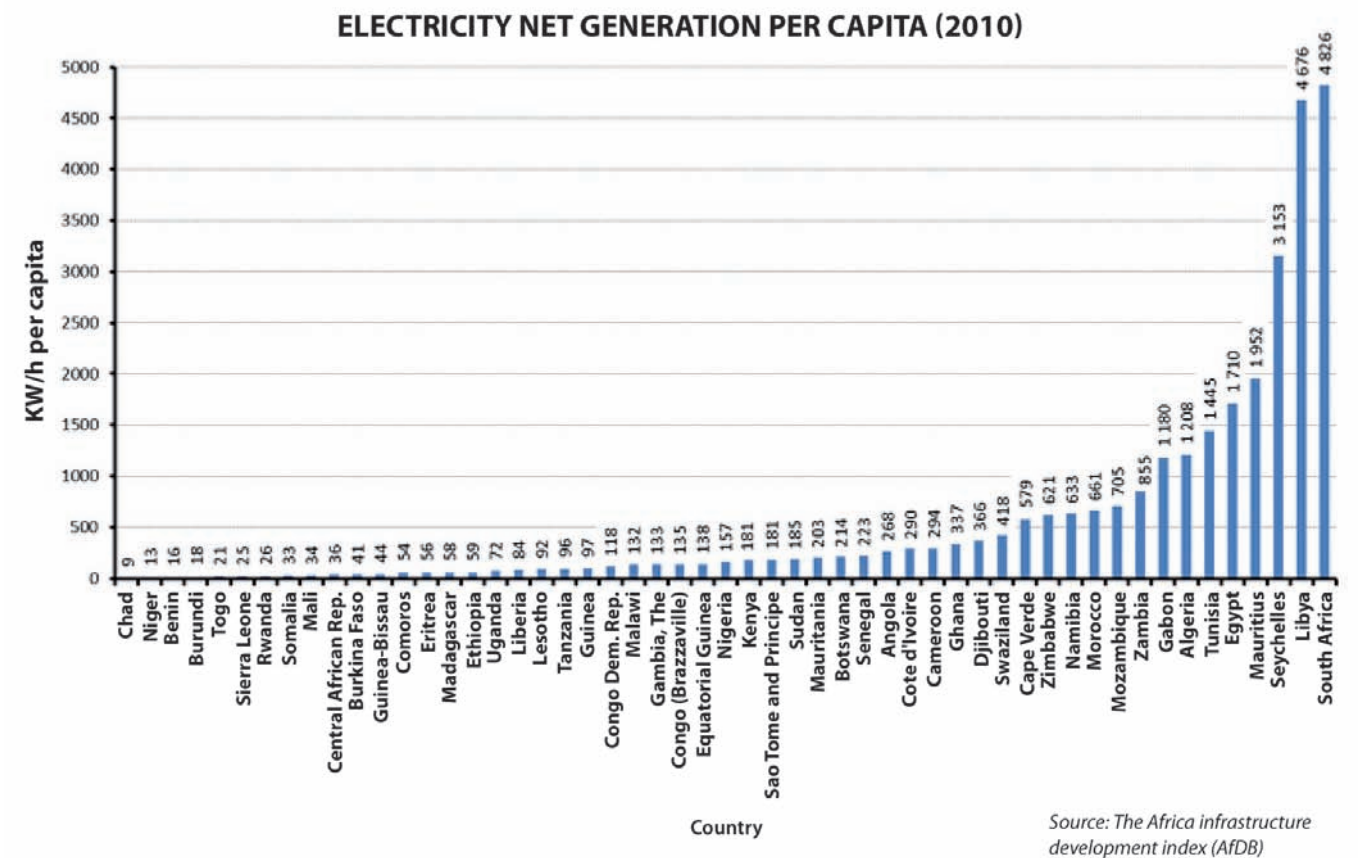


Fig. 7. Electricity Generation per capita in Africa.

Protection against natural hazards linked to water

Africa, like many areas and regions of the world is suffering from natural hazards linked to water, mainly floods and droughts. One can recall the historical droughts in the Sahel region in the 1970's and 1980's and also in the African horn with the resulting famines. Floods are also the most frequent and worst natural hazard hitting regularly many regions and areas with important fatalities and loss of natural and economic asset. One can remember the severe floods of Mozambique and the recurrent one in the Niger River basin.

The overall consequences of the situation regarding Water issues is the weak human and economic security in Africa as an impact of insufficient development and management of water resources.

The main constraints for sustainable development can be summarized as presented in Figure 8.

TOWARDS A NEW WATER APPROACH FOR SUSTAINABLE DEVELOPMENT ON AFRICA

Water has provided room for life development and is vital for any living species on the earth. Water harnessing and wise management is also a fundamental issue for social and economic prosperity and no sustainable development will be achieved without a sustainable management of the Water resources.

For preparing and achieving sustainable development in Africa is necessary to work on the improvement of human security, keeping in mind that a healthy population is an active and productive one. Water security will help to improve the long term economic development in Africa which will provide the means to ensure sustainability. Based on the Sustainable Development Goals under preparation and considering the important progress with the decision of the UN to make access to water and sanitation as a basic human right, the important areas for actions could be the following:

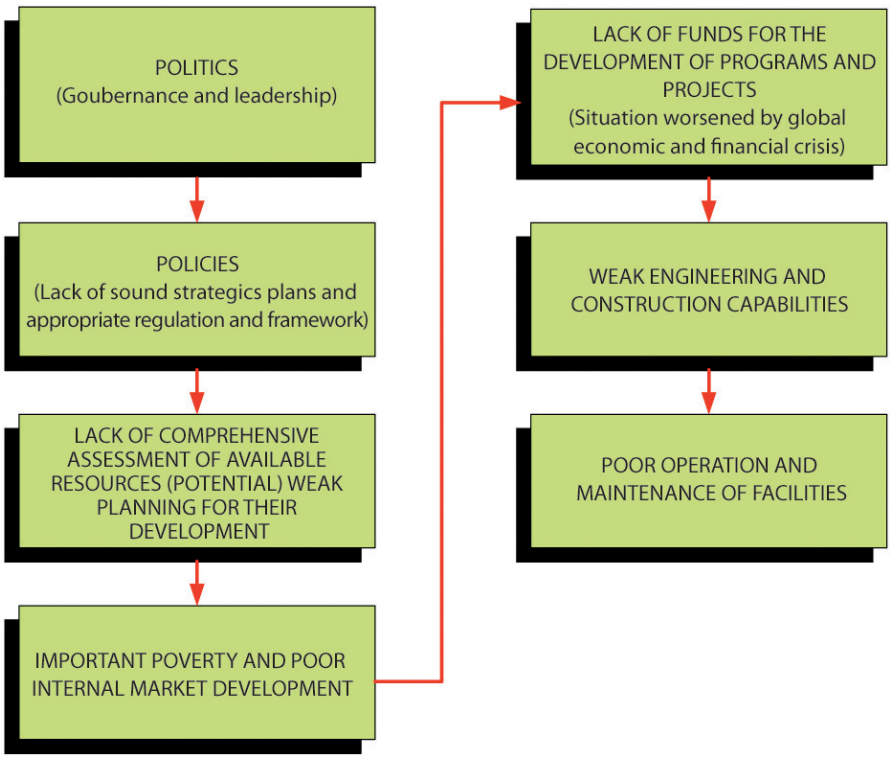


Fig. 8. Constraints for the sustainable management of water resources.

— Invest in multipurpose Water storage dams and infrastructures combining large, medium and small reservoirs and also in the protection and improving of natural reservoirs and water storage areas like wetlands. Invest in water conveyance and distribution network in an integrated manner. Protect the quality of available fresh water against pollution.

— Develop universal access to clean water and modern sanitation and education services. Africa Water resources' need to be developed and managed wisely for such purpose. The majority of African population does not reach the internationally accepted minimum of 40 - 50 liters per day per capita which ensures real access to clean water.

— Improve food security through land reclamation and irrigation development. Africa is the continent with the largest resources in term of arable land which once developed can feed the African population and contribute also to the food security worldwide.

— Develop a universal access to modern, affordable, clean and renewable energy. For such purpose, Africa has sufficient natural resources in term of fossil fuels, hydropower potential, solar and wind sources to be developed. It is internationally agreed also

that a minimum of 500 Kwh per Capita is needed to ensure a decent quality of life. Multipurpose storage reservoir needs to be developed and Africa's Hydropower reservoirs will provide also room for the storage of renewable intermittent energy sources like solar and wind power and will provide water for irrigation and water supply.

— Improve the protection against floods and droughts' damages and improve the resilience against the adverse impacts of global climate change by increasing the water storage capacity to mitigate floods and also reduce the severity of droughts. Considering natural variability of Water resources in Africa, Water storage is a prerequisite for any development process.

— Develop inland navigation facilities and protect the rivers system against degradation and silting.

— Improve the Environmental and social impacts management and protect ecosystems endangered in many areas.

As stated in the World Water Council report on Africa, there are three fundamentals pillars for the progress: *knowledge, governance and finance* Actions for sustainable development in Africa should take into consideration the development and improvement of these pillars.

Urgent need for knowledge development and capacity building in the Water Sector

The state of knowledge development is still weak in many countries and regions in Africa with high level of illiteracy and low availability of Water resources' scientists, professionals and engineers. The situation in term of general education and availability of Engineers is presented in Figures 9 and 10.

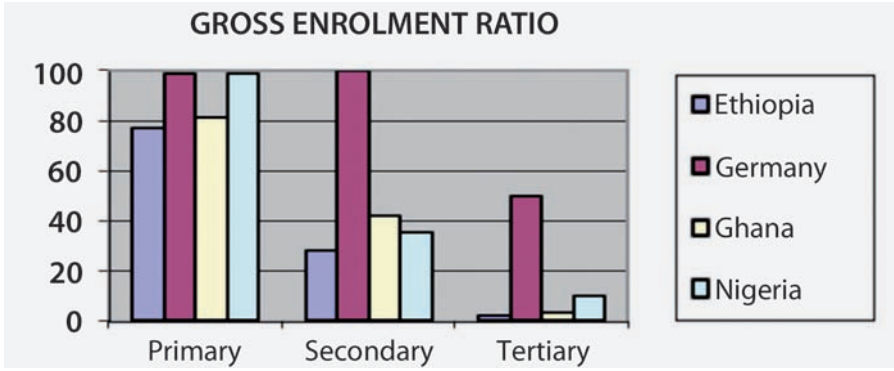


Fig. 9. Gross enrolment ratio in Africa.

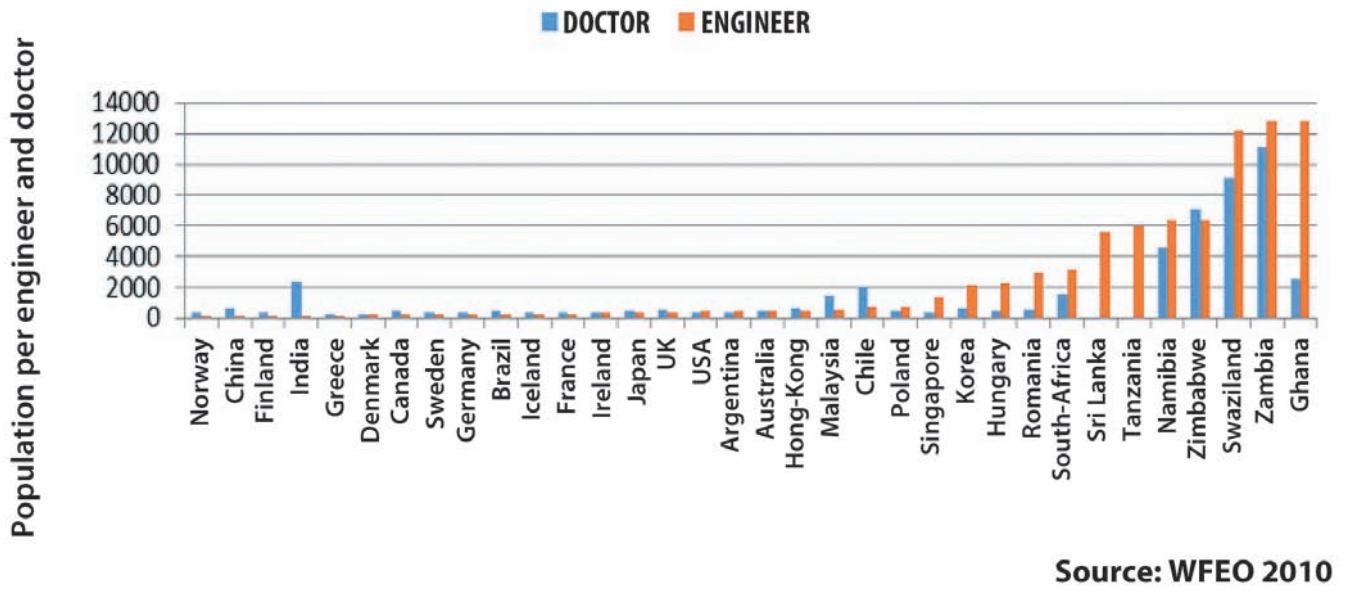


Fig. 10. Population per Engineer and doctors.

It seems important to reverse the trend consisting on a high rate of privatization of engineering education in Africa. It is strategically important to develop public universities and engineering faculties to ease access to brilliant young people of any conditions. The rate of production of trained and qualified scientists and professionals should be developed by public education complemented by the private one and not the reverse. Continuing education and on the job training should be used during projects and plans' preparation and implementation to provide practical experience and knowledge transfer from International and local firms to professionals.

The R&D sector in Africa is not receiving the necessary care for development and improvement of knowledge and technology in the sector of Water resources. Figure 11 shows the situation of fund allocation to the R&D for some regions of the World.

Knowledge development is an important key for a better planning of water resources and for well-prepared, implemented and operated water infrastructures projects. This is a condition to mobilize funds and also for long term development.

Need to improve the Governance of water and its Water sector

A better knowledge, assessment and monitoring of Water resources

Water resources development and management is facing some important constraints like the lack of sound data on water resources (surface and ground water even for medium and small rivers systems). Many projects and initiative have been and are developed and implemented by the World Meteorological Organization (WMO) in term of rivers gauges and data transmission and management improvement but there is need for government and Rivers Basins organization to improve deeply such systems.

Implementation of integrated Water resources and river basins management

Lot of progresses have been achieved in many countries and regions of Africa by the implementation of the Integrated Water Resources Management (IWRM) and Integrated Rivers basins management-IRBM) during this decade. There has been important developments in term of Water policies, institutional frameworks at Regional, National, major Rivers basins and local levels, albeit the development of River basins plan for the major International and local rivers basins need further development. The holistic approach for water resources development and management should be really implemented to fulfil all the present and future needs when developing water resources plans and projects. IWRM planning and implementation is time and fund consuming and sometimes the stakeholders may not find the expected results in term of real progress for their life. There is a need to adapt this process to the reality of each country and river basins considering the priorities of people.

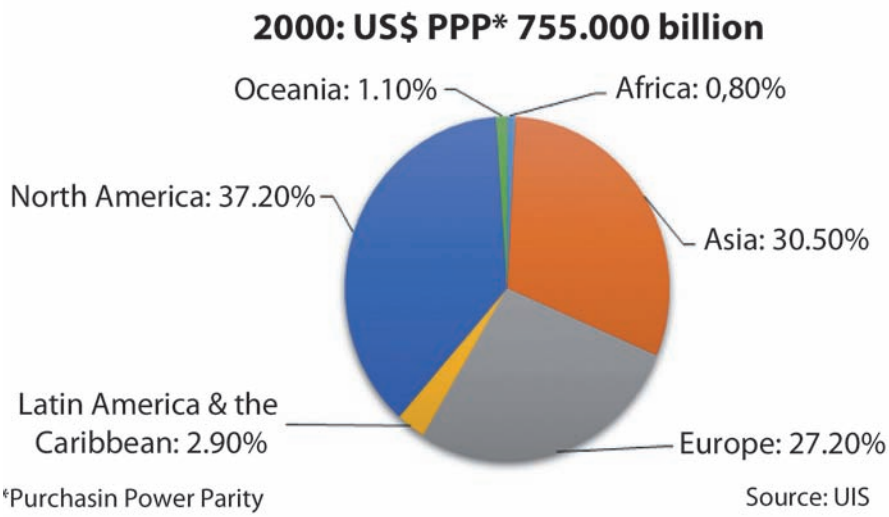


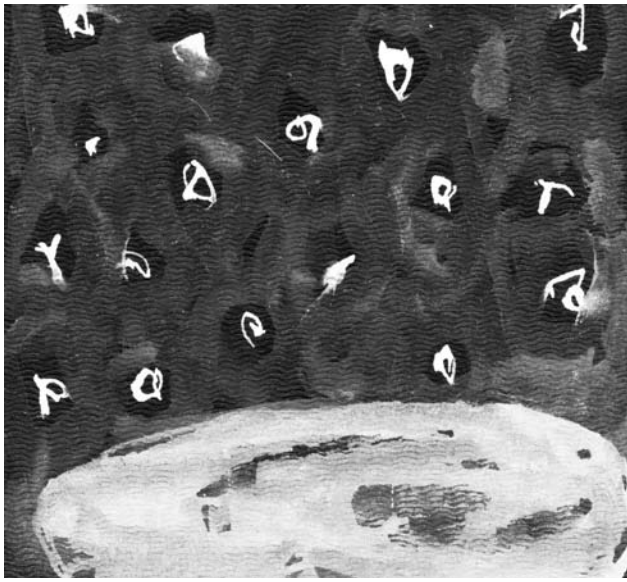
Fig. 11. Fund allocation of R&D by Continent.

Cooperation at the international river basins and regional levels

The context in Africa is characterized by the fact that all major rivers systems are shared by at least five countries and such requires improved cooperation between countries at the large river basins' level. The major rivers basins are now organized through River Basin Authorities (Volta, Niger…) or Initiatives like the case of the Nile River. A common vision and integrated development plans are under development to its implementation in many of these agencies. Improving the common vision and building a common future will be an important tool for the sustainable development of Africa.

Regional cooperation through the regional organization such as ECOWAS, SADCC is also important for the development and management of the water resources for human security and economic prosperity. Such initiatives are under development or implementation (ECOWAS Guidelines for large dam projects).

In terms of planning, there have been some progresses with the NEPAD Program, the PIDA and many others regionals programs and plans for the water resources sectors and a growing political will is developing in Africa with the AMCOW plans and initiatives, providing room for future progress.



Ensure participatory approach, equity in the development of Water resources projects

At the local, river basins and national level it will be important to ensure full participation of all stakeholders including affected people in the process of projects' preparation and implementation to achieve equity and long term development.

Need to improve funding of the Water sector in Africa

Funds for Water resources development and management are coming from the international agencies, bilateral and interstate cooperation and from national regional and local resources both public and private. The internal effort to mobilize funds for water sector is still weak in many countries and regions. In the framework of the MDGs, lot of funds have been mobilized and some successes in term of access to water have been achieved but there is a need to improve the funds' mobilization at national and local levels to ensure accelerated development in the sector. The economic growth experienced in many African countries provide important possibilities for such actions and when combined with international support, will provide sound basis for sustainable progresses.

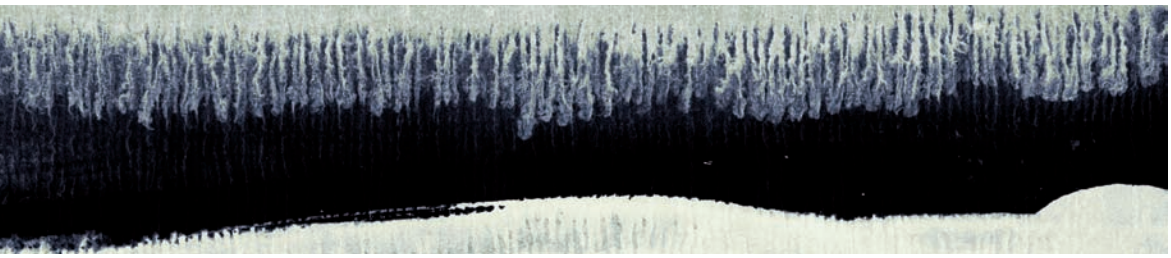
Africa is receiving more and more direct investment and is experiencing in some regions an important economic growth. In general, Hydropower and energy sector are providing an important return on investment with an important growing market through the regional power pools and are more adapted to Public Private Partnership investment approach as it is occurring now in many parts and sectors of the African economy. An important part of the Public and multilateral funding should be allocated to Water supply, sanitation and foods production through irrigated agriculture. The funding approach needs to be adapted to the fact that water is a vital resource for life and economic security.

As the new sustainable Development Goals will be adopted soon, it is important to ensure that the goals will be backed by real actions in term of fund allocation, better implementation conditions and also monitoring.

Adama Nombre
Ingeniero Civil
President Burkina Faso Committee on Dams
Honorary President of ICOLD

WATER AND SUSTAINABLE HOUSING

Emiliano Rodríguez Briceño



KEYWORDS:
WATER AND SUSTAINABLE HOUSING
WATER FOR LIFE
DRY TOILET
RAIN WATER CISTERN
BIO FILTER
SOLAR HEATER
FUEL EFFICIENT STOVES
SOLAR COOKER
ORCHARD AND HOTBED

It is a bit over two years when Ramiro Aurín, friend, engineer and director of this publication asked me for referrals to develop a workshop on women and water in Mexico. I, recalling such conversation and without the relationship seeming obvious, got in touch with the project *Water and Sustainable Housing,* whose NGO's sponsor is now known as Latin American Foundation for *Water and Sustainable Housing* and was developing in the Mexican state of Querétaro.

Today I write this article pushed by him, but also in the assurance of the importance for millions of people that may have the replication and dissemination of an initiative like this.Let me begins with a quote from Ramiro Aurín, to which I concur: "With age, nothing excites me more than the candid sincere desire for cooperation, and nothing upsets me more that the sophisticated manuals for mean intentions."

Water and Sustainable Housing is a project that has allowed me to witness how the life of entire families has changed in terms of health, education and economy in an indigenous community in Mexico.

The *Water and Sustainable Housing* project was proposed at the initiative of Ramiro and through him by the World Council of Civil Engineers and Interagbar to UN-*Water for Life* Best Practices Award, and to describe it I will mainly use the information prepared by the project directors and Ramiro himself, to which I modestly contributed.

Water and Sustainable Housing is a program developed by the Latin American Foundation for *Water and Sustainable Housing,* an NGO created by three people 15 years ago and is dedicated to this social initiative in nine municipalities in the Mexican state of Querétaro. Municipalities as Amealco, Jalpan, Arroyo Seco, Landa de Matamoros, Peñamiller, Cadereyta, San Joaquín, Ezequiel Montes, which have very different geographical and environmental conditions ranging from semi-desert and barren climate from the Mexican plateau, to the hot, suffocating desert, through summits with pinales and dense and humid permanent fogs.

In the development of the project, several individuals, as well public and private stakeholders have participated

and supported it such as the Secretariat for Environment and Natural Resources, Lerma-Chapala Rescue Program, the Secretariat of Social Development and the Commission for Indigenous People as well as several Querétaro state government agencies, the Autonomous University of Querétaro and with them many people who have lent their effort, but its main driver has been the NGO, led by Lic. Manuel Pérez Cascajares and Ing. Abraham Ramos Alvarado.

The description of the project in terms of infrastructure is simple: with an approximate budget of 9,000 dollars per housing, it includes the construction, installation, monitoring and improving:

- Dry toilet
- Rain water cistern
- Bio filter installation for grey waters
- Solar heater
- Fuel efficient stoves
- Solar cooker
- Orchard and hotbed

The project included a process of awareness and capacity building for family parents. Labour force was provided by the family themselves which represented up to 3,500 dollars, to be applied in the selfconstruction and installation of the items above mentioned.

The primary objectives of the project were to raise the health standards by improving sanitation and feeding, as well as water quality and its efficient use.

The project and the awareness efforts provided knowledge about the proper use of water and sanitation in daily life, through better comprehension.

Having water culture as guiding principle, these concepts are transferred to practice at home, with repercussions on family education and are implemented both in the land and housing units. The aim is to promote a qualitative leap in family homes' living conditions and sustainability of scattered rural nuclei, populated with indigenous / or mixed origin people, with none or very poor access to water, sanitation and energy, in which families should become the main actors, and simultaneously, to make the awareness program become effective to disseminate the project, creating a generation of women to lead change.

Fig. 1. The circle of life.
© Emiliano Rodríguez.

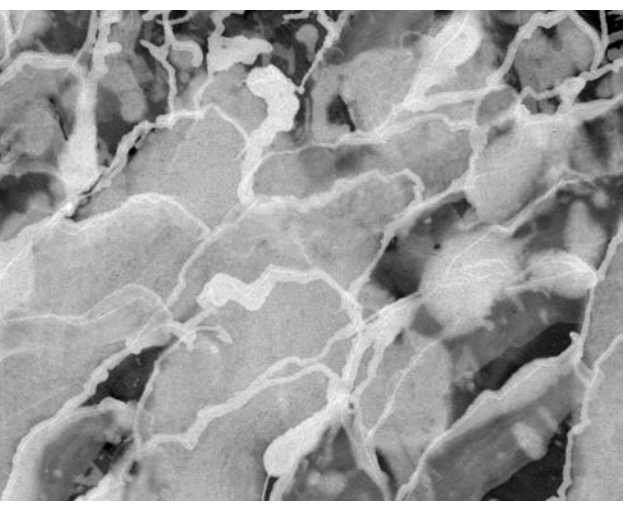
The means implemented for such purpose are:

1. Installation of dry toilets, where before there was open defecation, or downloaded near the home area. The product of these dry toilets is a very good quality compost.
2. Catchment and rainwater storage that provides drinking water for the family.
3. Gray water treatment through green filtering, and subsequent use for orchard and garden irrigation.
4. Creating orchards from compost, not only from dry toilets, but also produced from plant waste and water, which provides an important improvement in food production, which may sometimes produce food surplus for sale or barter.
5. Solar water heater, which allows them to have hot water, sometimes unavailable, or in the best case, required timber to as fuel for its heating.
6. Replacement of open furnaces with ceramic closed furnaces, saving almost 70% of fuel consumption.
7. Use of solar cookers, which save both time and care by mothers. They are portable, and allow to cook in the field during labour.
8. Sometimes also the installation of solar interior lighting systems.
9. Creation of a solar dehydrator to better preserve the garden surplus.

Fig. 2. Barren yellow grassland.
© Emiliano Rodríguez.

With this set of actions family incomes have increased up to 50% more.

The quantitative and qualitative results are felt in everyday life; Chitejé del Garabato's community in Amealco Querétaro, Mexico, which is project's core community, reports the largest suicide and inter-family rapings index in the state, while the families involved in the project reports no cases. Since the housing selfconstruction, mothers have become the drivers of the model, making a difference in the perception and considerations of the mother figure and feminine in general, to the children. Fathers interact respectfully as mother has become a basic resources supplier. Sustainability education in the family core provides an identity that keeps them away from addictions and criminal behavior, aware that their home labour involves them as household providers, becoming essential to maintaining and improving the infrastructure of sustainable housing. Diseases associated with poor supply or lack of sanitation and hygiene disappear, as indicated by the drastic reduction of visits to the doctor in the families involved in the project.



MILESTONES

1. Awareness campaign to convince families to join the initiative.
2. Construction / Selfconstruction. Labour force comes from the family itself, a fundamental element in the identification with the initiative.
3. Capacity building for the operation of the new infrastructure and its integration into daily life.
4. Commissioning of the infrastructure.
5. Moment in which, through self-sufficiency, the family is able to make the project evolve, generating new revenues.

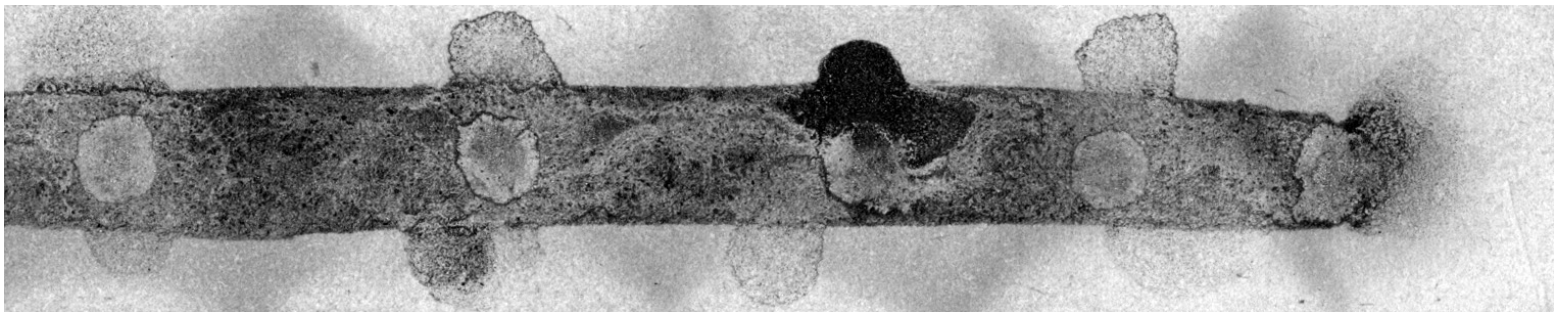
Until here comes the description of the project, presented by those who proposed it for *UN-Water's Water for Life Best Practices Award.* While I was reading it myself, as a person accustomed to read books and enjoy the images that my imagination evokes from such texts, I realized that reading itself did not bring to my imagination the vision we readers recall, and which allows us to enjoy a book or an article; much less even grasp the reality of what I had lived in the field, witnessing the results of the project, which made me talk about it, not only with Ramiro, but with many other people with whom I have shared the vision of life and cultural change of the families involved.

Such was what led me to write, probably aware of my lacking the necessary skill, but with the desire to reflect in part the truth of my personal experience and incorporate the words of several of the protagonists to talk about the project, words I have attempted to preserve as heard, with particular emphasis and structure that imprints Spanish the indigenous Otomí mother tongue. Moreover, I wish to bring to the potential readers, not only the words of the participants, but try to find in them the emotion of a living process that has altered forever the environment of families who live in physical and cultural conditions in which health, development and dignity are seriously threatened, becoming owners of their own future and their awakening to a different culture, more complete and satisfactory.

THE SETTING

Amealco, municipality in which the project is located, within the Mexican plateau 2,500 meters above sea level; and up to 3,500 above the sea, hills held forests that due to deforestation have become yellow grassland.

Chitejé de Garabato, an indigenous settlement, whose urban center consists of a few streets and extends itself among different pathways in scattered housing, around 500 m or more away from one another, hardly earning to be called "town", albeit its population figures. Such place is described by the Dean of its High School as follows:



"My name is Jesús Camargo Hernández, I work in the High School located in the community of Chitejé de Garabato, is an indigenous community of about 2,700 inhabitants. Being such a small community, we have a lot of problems of social character among which we can mention Alcoholism, Drug Addiction, violence and one that causes certain shame to being spoken openly, not by me, but by the people of the community, which is the sexual abuse. Sexual abuse has become a problem that ultimately leads youngsters to embrace other tendencies may them be suicide, drug addiction, alcoholism, violence. We, as a school, we grab any program that comes our way which give our young the opportunity to leave such situation."

We walk through the town centre and head up to Sofia's house. We drive through the hills and we stop by where the rocky path allows us to reach by car, then we walk through paths formed by other people's footsteps and storm water runoffs from the rain season, until suddenly we run into a grove of trees whose green contrasts with the yellow grass and appears as a small oasis. A small gate opens our way and we enter a lush compared with its surroundings. A typical house comes before us and among different vegetables several facilities can be noticed.

To our meeting comes a little dark-skinned woman, with intelligent eyes and a pleasant smile which welcomes us. She is Sofía, owns the house is the leader of the process triggered by the project *Water and sustainable housing*.

Seated at the refreshing shade of a thick group of trees and flowering shrubs, Sofía shows us some facilities, and from now onwards, I give the floor to the descriptions and comments of Sofía and her family:

"Well, there is the roofing where we collect rainwater, its ferrocement, the same as the cistern where we store it and the bath where we wash ourselves. The bio filter is at first, the second and the third are gardening pots, there behind is the pool where we store the water and at the back, we have the landscape garden. To take care of our water we have a dry toilet, a toilet which does not use water, only earth, as our toilet has gates in the back, because here we only use earth, which helps us a lot, because we do not use water but the toilet gives us compost. Such compost serves us to improve the quality of the soil of our orchard. Here we have planted lettuce, carrots, beets, usually all types of vegetable, may them be leaves or bulbs. It has been a great benefit as our children eat all of them.

To save water is very important to know how to work with it. On these grounds, we have planted our medicinal plants to improve our health, and for biological pest control and over there we have green compost, that is homemade with green and dry leaves and earth beneath, and a bit further we have the organic fertilizer. We also have learned how to sow and plant."

She shows little cardboard boxes, waste soda cases which she uses land filling them and using them as seeders.

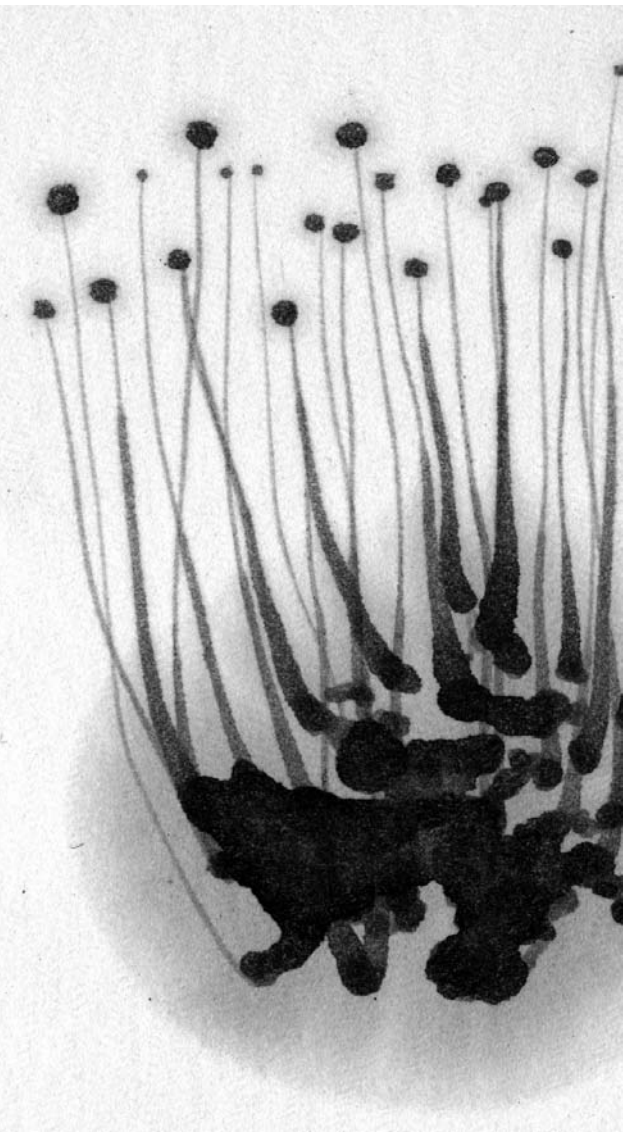
"Sowing is not directly made, we may use too much water, because the seed is too tiny; what we do is fabricate tiny pot for early plant and then we transplant them. That is when they are very tiny. Then it is moved to bigger pots."

Inside one of the rooms she shows us:

"Well, is where we have our fuel efficient stove. It has been very good to us, healthy and economic, healthy as we no longer breath smoke and economic, because we use very little timber, from the brambles we collect, what we pick up near the trees. Previously we had to buy the timber, but later we knew that cutting down impacted the environment, so now

Fig. 3. Dark skinned, intelligent eyes. © Emiliano Rodríguez.

Fig. 4. Her teenage daughter.
© Emiliano Rodríguez.



what we do is to plant our own trees and take their timber, we no longer buy and apart from this, leaves us the ashes, which we also use add to the compost, and that improves the quality of our environment."

Through the door, she proudly points us another construction:

"The solar heater is another great benefit because we no longer buy gas because the gas right now is very expensive. Now we benefit from the sun, which helps us a lot as we have hot and cold water at any hour. I can bath whenever, whereas before we had to heat water and took very little time to cool down, but now we have water and we can bath whenever we want.

For us, water is sacred and saving water, as I commented, we have managed to have 500 trees when before we had only one. Trees give us a better life, a better air and this also takes care of our environment. Because it is what I said a moment ago, which is a circle of life of everything we saw earlier. If we had not the water we saw in the catchment, I would never have had such beautiful garden, a place to enjoy by my family. I never dreamt that I would own such a place.We begun working hard and we made it, now we are happy, and when my family comes and they tell us how much they enjoy our garden, for me it is marvellous, as it closes the circle of life I told you before. Truth, as I am happy, my family is happy, and those who visit are also happy. I think more families should live this, to have a homely place for a better family integration."

Her teenage daughter talk to us:

"My name is Perla Iveth and I am 16 years old. Personally, this project has helped me because I have learned to esteem my family and especially my mom and thanks to this project we have always been together in the good times and the bad times and we have learned to have better health and eating more and better food, balancing our meals, and such has motivated me to continue helping my family.

My Mom and my dad quarreled a lot before, I don't know, because of money, perhaps because we had nothing to eat, but now we have the orchard, we do not need any more food, as from the orchard, any fruits or vegetables we collect from it can be sold and with that we can buy any other things we need.

We all have obligations here no matter if you are a boy or a girl, we all cook, we will labour the field, and in general, we all have a responsibility."

Sofía smiles at the words of his daughter and she adds:

"As family heads and mothers, is our duty to engage our children, motivate and show them what this project is about, which is what we have, about life in general. I started to see that everything I was doing was considered positively by the people and I kept on working, nothing could stop me now and I felt the need to learn more and more..I started looking for books that would give me more information, and I was invited to a workshop, to give talks. I am not that meek person who was always at home, and I started to involve my children.

Earlier before, our family barely talked, now in the orchard we are happy and it has become the place where we meet and talk and we discuss about our concerns.

We now understand family as a team, I think mutual support is the family essence."

—And how was all before this Sofía? How was your life?— I asked now seated in a modest room.

"I was not very sociable, my only life was to take care of my kids. I had my daughter, my son had only

8 months, I took him to primary school, it was almost 40 minutes to get to school, and she was so small I had to carry her in my arms. I could not stop to talk to anyone as I had no time because I had to go to fetch water 1 km away, as we had no drinking water available. In addition to this, I also had to go and fetch the timber. Such was my daily life, which also included going to cooking to the primary school my daughter attended.

A day, I remember very well that we were called for a very important meeting, but I had no interest in attending, because I never feel lucky, but a friend finally convinced me. They were talking and discussing about water cisterns. I left, because as I said before, I don't feel lucky. About a month later, we went to Amealco municipality and we found the city delegate stressed, as 10 people had been awarded, but they had not submitted the required paperwork. Thankfully, one awardee resigned and we were awarded the cistern, the stove, the toilet and the bio filter.

By that time, I was with child with my daughter and I was very big depressed, I was very much half-hearted. But by January or February we started to collect water, I saw that my job of fetching water reduced, I saw the usefulness of the toilet and it was then when we gradually begin to accept the project.

It did not cost me much, because I have always liked having my place, there is now green where before it was just barren. My husband encouraged me to have flowerpots and seeing the flowers grow made me feel good, and I began to overcome my depression. My husband and me began to share our tasks and that was a great motivation."

Curious about the change she was narrating, I asked:

—How much did it take you to build the toilet and begin to use it properly?—

"It took us about half a year after we finished it, but during the first year we had no problems, it had no smells, anything, everything was fine. After the first six months, the first chamber was full, but we still had the second chamber empty. The difficult part came at the end of the year when we asked ourselves who was going to take out everything in there.

It was the most complicated part, but us, as housewives are always the first to take the initiative in our home, and I grabbed a shovel and a wheelbarrow and I begun. My family thought there would find a monster in there, but with my first shovel, they saw it was only compost, we were already doing compost at that time, and later the earth we added with some moisture moist, that was the only difference. We kept on working and we found nothing, not even smells, just moist air.

Later we covered the compost with leaves for another six months. Then, we removed the coverage, and later we covered it with fodder and we added it to the trees. I am very happy because I have managed to plant about 500, and stop erosion in this barren piece of land. I have my pines which I was yesterday pruning when I said to myself, how incredible it is to me that I am now removing some branches, when I first planted some cuttings. I am very happy because we have not just saved ourselves from carrying water, but also on the environmental part, as our soil is much richer now and we have planted trees as a windbreak barrier.You see, here is a a very rough place with huge temperatures changes, even reaching below zero centigrade.Or when the strong winds come, which are very aggressive. But right now, we do not have that problem any more.

And besides, we have found many different birds nests, we had none before. Beehives hang from the trees, and we are not polluting. We are not using water access, although we

Fig. 5. The cistern.
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Fig. 6. Bio filter.
© Emiliano Rodríguez.

Fig. 7. Here we plant lettuce.
© Emiliano Rodríguez.

Fig. 8. A small oasis.
© Emiliano Rodríguez.

Fig. 9. We noticed there was no odor.
© Emiliano Rodríguez.

Fig. 10. Our saving stove.
© Emiliano Rodríguez.

now have it, as we have our cistern. In fact, when there are problems in the water supply network, that does not affects me as I have my cistern. If I need to water some plant during droughts I use recycled water, so for me its marvelous.

It is the only project that I have been granted by the government and I have accepted it as it is, with the benefits it brings. When I saw all the profits it was giving me, back in late 2007, such motivated me much more to continue, and I began to socialize with my partners as I asked myself: Why other people may not profit the same as me?

Now, if anyone of us, has a problem, we face it like family. We are 70 persons now, and if anyone of us has a bigger problem, it is given priority."

The project has been adopted by a total of more than 70 families. Some, with difficulties similar to that of Sofía, and others probably with minor difficulties. But among them Sofía has arisen as a true leader of her community and has turned her community as a sample group, which receives visits from institutions, schools and other NGOs interested in the project. Each organized tour offers a meal that is paid to the family that fixes it and this leaves a profit per visit of approximately 100 dollars, which are shared equally among all community members. The order is altered if a family is in need and receive preference. There are also sanctions to any families which do not work properly, losing their turn.

Sofía continues relating:

"This season we have planted roman lettuce, zucchini, coriander cilantro, all seasonal vegetables. We plan on season basis, roman lettuce right now is not very viable because we do not have a greenhouse. A consultant advised us on the orchard, he taught us how to make organic fertilizer and such motivated us. He told us it would be madness to stop such a beautiful project.

My daughter had asthma, and the advisor taught me how to prepare energy juices to avoid illness and my overcome her asthma problem. At that time we learned the importance of having a balanced diet and we began changing our eating habits. We paid our advisor to give us a workshop and we dig up a well.

Some weeks ago, *Mexico tierra de amaranto,* offered us to plant amaranth and they left with the idea that we know how to work as they tested our amaranth and reviewed all our process as organic, and now we are earning some money by selling amaranth leaf, and I was able to pay my daughter's high school tuition fees, with the savings that came from the amaranth selling. We planted lots of vegetables and sometimes we have had some surplus, but now with the amaranth, I only devote a share to vegetables and the rest to amaranth. Now, our next goal is to save money for building a greenhouse, in fact, some colleagues already have one and we are saving week by week."

—How is the difference between your current and former living?—

"Complete. I am now a different person. I had the impetus to do something but now I know my community. At that moment, I did not knew my community, neither its needs. I am quite encouraging with my friends when they tell me their husbands will not help them."

—Why others are not supported by their husbands?—

"I was fearful that I was breeding conflicts in marriages, but that did not happen in the end. They stood tall, and were able to shoe the profits to their husbands.

I think that sometimes the women of our community are very compliant to our husband's opinions

and we get to do nothing, but in the end, we come to the conclusion that usually we as women are the ones who suffer more; for our children, for is there anything to eat, money to buy food for our children, if not, who are we going to ask for help? Mum has to fetch timber, mum is to carry water. We no longer suffer these problems anymore.

I always tell my friends that before expecting to be given, yo need to give.

Now, after I have analyzed, why they have to pay me for making my own profit?, but it had to be that way and I am very happy so far for all that, and the hardest part was to convince the partners."

And I am curious about another topic and I ask her:

—And what about the sons Sofía?—

"When we started, we had two grown children, one was 15 and the other 13. These really had a hard time changing their habits, eating vegetables or making compost. One day my 13 year old boy asked me why did I follow those "madmen". I answered him that he will have to do it whether he liked it or not. And that was one of the thing I learnt. And that has been one of the things I have learned, to say the things with authority.

Bit by bit we have grown and we are now a united family. With the other daughters all was easier, as they began to engage more, in fact the daughter that I was with child back then has assumed and learned his responsibility from the beginning. I recall a day when she came back from her first day at school, and asked me startled: Why the teacher does not separates the garbage and his schoolmates threw their bottles of juice anywhere?

They have had a good experience but sometimes, back then, I was afraid to get involved in the project too much because I may become absorbed completely by the project and I would forget about my daughters, but that did not happen, we grew together. In fact, Michel is my son right now and he is now 20, he works in a ranch where he does the same as us. One day a person passed by and told us that he was about to open a ranch in Colorado and asked me if I knew someone that could help him. At that time, my son was only 16 then, but he wanted to go to work to Colorado. Looking at his impetus, and what I have taught them, I thought. Isn't it true that folly is contagious?

My children have become aware much to care for the environment. I think we've brought up a good family and hopefully these generations get older that. Now we have no problems of malnutrition as I had with my first two children"

Sofía has discovered her inner leader, she is now another person and enjoys his awakening. His words move and drive her environment. They make you aware that water is not only life or development, health and welfare, but water is also dignity.

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Fig. 11. Seeders.
© Emiliano Rodríguez.

Fig. 12. Why the teacher does not separate trash? © Emiliano Rodríguez.

Fig. 13. Isn't it true that folly is contagious? © Emiliano Rodríguez.

RIBAGUA

ISSN 2386-3781

Volumen 2 Número 1 - 2015

REVISTA IBEROAMERICANA DEL AGUA

AQUAE FUNDACIÓN

IAHR AIRH

Supported by Spain Water and IWHR, China

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