white paper

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An integrated management approach for water security in all sectors

Implementing Integrated Water Resources Management

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Version 1.2

About this white paper
This white paper is developed by the Rethink Water network in Denmark. The work is coordinated by the Danish Water Forum.

The Rethink Water network consists of more than 60 technology and consulting companies, water utilities, water organisations and public authorities. It was established to support our partners internationally in developing the highest quality water solutions.

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Executive summary

Access to clean and sufficient water is crucial for economic growth, food security and our health. For decades the protection of our water resources and environment in Denmark has been based on a broad political commitment. This long term consensus is the platform for development of a balance between growth and environment – and we continue to develop effective and smart solutions.

ESBEN LUNDE LARSEN
Danish Minister for Environment and Food
DENMARK

The conflicting interests of nature and the different sectors involved in sharing limited water resources must be addressed in an integrated fashion at both policy and operational level.

Increasingly difficult to reconcile goals

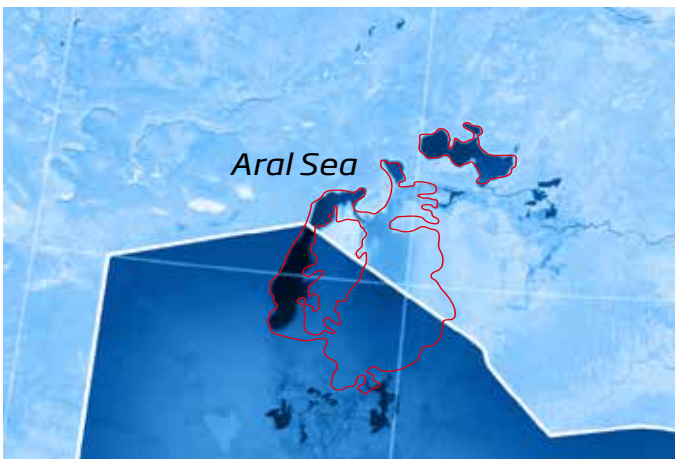
According to the UN Water report on integrated approaches to water resources management (2012), around half of all countries have made significant progress towards implementing the principles of Integrated Water Resources Management (IWRM) while many others are well underway. The principles aim at securing water for all sectors, conserving water in a sustainable way and protecting water resources from pollution. However, it is increasingly difficult to adhere to these objectives as populations grow, demands for food and energy rise, the climate changes and environmental sustainability becomes increasingly important.

Data and decision support is required

An outcome of implementing IWRM is the ability to manage the demand for water. Programmes that increase water efficiency of domestic, industrial and agricultural water uses are developed along with programmes to increase the efficiency of water utilities that today face a level of 25 to 50 percent water loss at global scale. As the need for data, information and knowledge within water resources management becomes increasingly evident, so does the need for a strong decision support system to assist water authorities in the many parts of the IWRM cycle right from planning to monitoring the impacts of interventions. Climate adaptation measures to secure water resources are built on downscaling of regional forecast models, vulnerability, risk assessments and strategic priorities.

Expertise in implementing IWRM

Denmark played a key role in the international foundation and development of IWRM being the first country to pilot and apply IWRM in national and international projects and by hosting the Secretariat of the Technical Advisory Group of the Global Water Partnership. Strict environmental regulations, private-public partnership, public, high quality data and significant involvement of research and knowledge institutions have driven Denmark ahead in integrated water resources management. Today the public authorities and the private sector, made up of consulting companies and technology providers collaborate with customers and colleagues around the world to address complex water challenges. This expertise is what we want to share in this white paper.



Improved management, Central Asia *One of the world's largest transboundary river basins, the Aral Sea in Central Asia, faces alarming aridity and pollution levels. The water of the basin is under severe pressure as the former surface area of 68,000 square kilometres is reduced by 90 percent. Social, environmental and economic impacts on the countries in the basin are harmful. To address the situation, an economic model for the integrated management of the river basin's water resources has been developed by Danish water experts. Stakeholders were involved in setting the requirements to model outputs and in the assessment of scenarios and their impacts. Today the model supports policy makers and allows economic assessment of water use. It also supports the development and comparison of scenarios for more equitable and effective water management and allocation in the transboundary context. (Courtesy: DHI and COWI)*

Restoration of the Skjern River Delta, Denmark *In the 1990s, a major restoration project was carried out in the Skjern River Delta in the western part of Denmark. For a couple of decades, this fertile agricultural land produced rich crops, but as costs of drainage and environmental impacts escalated, restoration of the delta became economically viable. In the 1960s Skjern River was channelised to prevent flooding and improve run-off, and the surrounding marshland with a mixture of swamps, watercourses and shallow lakes was drained. The reduction of wetlands resulted in less retention of nutrients, and the lowering of the groundwater table caused land subsidence and leaching of ochre from the drained organic soils. The decline in water quality had severe impacts on the fish and waterfowl populations in the coastal lagoon. In the late 1990s a major restoration project brought the river back to its original course and wetlands were re-established. Today, it is the largest river restoration project in Northern Europe. The important lesson learned was that changing a complex natural ecosystem requires sustainability analyses in line with IWRM principles. The project also illustrates the financial value of water to the local community which five years after the restoration obtained greater revenues from eco-tourism than previously generated by farming. (Courtesy: Orbicon, COWI and DHI)*

Restoring nature is most successful when conditions for both plants, animals and humans are improved and climate change is taken into account

HENRIK VEST SØRENSEN
Head of Department, Nature and Planning
ORBICON

Positive impacts on the aquatic environment through nutrient reduction, Denmark *Three decades ago, nutrient loads from agriculture and urban areas caused major pollution of surface waters in Denmark, mainly lakes and shallow coastal waters. Around 1980, the situation became so severe that many aquatic environments suffered from lack of oxygen during the summer, leading to massive destruction of ecosystems and severe impacts on fisheries. In response, the Danish government passed the first water action plan comprising regulation of agriculture, strict requirements for sewage treatment from urban areas, a new monitoring programme, and a strategic research programme. The action plan has since been revised regularly based on the results of the monitoring and research programmes and today sewage treatment from urban areas is highly efficient, nitrate load from agricultural areas has been reduced by 50 percent and the ecologic conditions of many aquatic environments have improved. Furthermore, Danish technology suppliers have, in cooperation with utilities and governmental bodies, developed new innovative technologies for urban sewage treatment and a suite of sophisticated modelling tools to assess the movement of nutrients in the landscape. (Courtesy: GEUS Geological Surveys of Denmark and Greenland)*

1. Developing water security with integrated management

A water crisis is ultimately a management crisis that can be solved through the application of IWRM approaches with emphasis on stakeholder dialogues, institutional roles and water sector reforms

DR. TORKIL JØNCH CLAUSEN
Chair of Scientific Programme Committee, STOCKHOLM WORLD WATER WEEK

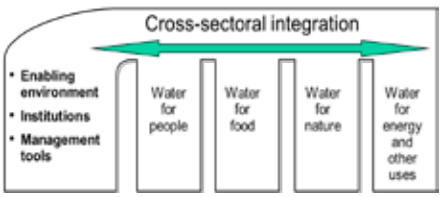
The exploitation of freshwater resources, population growth and the impacts of climate change calls for water management based on sound knowledge and sustainable practices. The conflicting interests of nature and the different sectors involved in sharing a limited natural resource must be addressed in an integrated fashion at both policy and operational level.

An objective of water security

Water resources management authorities all around the world look for approaches and systems that can help them achieve their objectives of water security. The authorities have found help in the principles of Integrated Water Resources Management (IWRM), which is defined broadly by the Global Water Partnership as a process which aims to ensure the co-ordinated development and management of water, land and related resources by maximising economic and social welfare without compromising the sustainability of vital ecosystems. IWRM has now been implemented in a large number of countries. A recent survey published in a 2012 UN Water Report showed that approximately 50 percent of the world's nations have made significant progress towards implementation of IWRM, while many others are well underway.

Challenged by global trends

Integrated Water Resources Management aims at securing water for all sectors, conserving water in a sustainable way and protecting the resource from pollution. However, these management objectives are not the only ones for a nation or a river basin management authority that also must protect people, infrastructure, agricultural lands and production facilities against floods and droughts. It has become increasingly difficult to adhere to these objectives as populations grow, demands for food and energy increase, the climate changes and environmental sustainability becomes increasingly important.

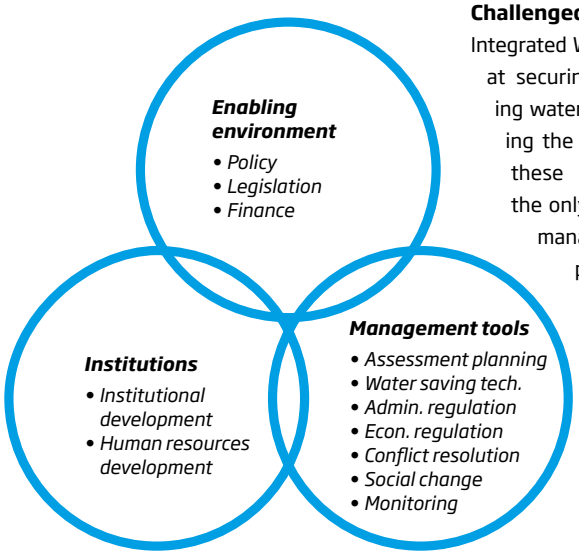


Key principles

The key principles of the IWRM approach takes into account equity in access, economic efficiency in use and environmental sustainability. Furthermore, integration takes place horisontally across water-dependent sectors such as domestic use, agriculture, industry, hydropower and navigation. The concept is also about institutional integration on a vertical scale with implementation taking place at national, regional and local levels involving key stakeholders.

Development facilitated by Danish experts

Denmark pioneered the development of the IWRM concepts, principles and on-the-ground application with Danish water professionals facilitating an international, technical consultative process. The outcome was a set of principles, which later were consolidated in Dublin, Ireland, in 1992 at the International Conference on Water and the Environment. The conference contributed to the Agenda 21 recommendations adopted at the UN Conference on Environment and Development (UNCED) thus ensuring political support. Denmark was also the first country to pilot and apply the principles in international projects, e.g. in Uganda, Vietnam and Burkina Faso and Danish water professionals have since then carried IWRM forward and ensured that it has remained prominent on the global agenda. Denmark has hosted and staffed the Technical Advisory Committee Secretariat of the Global Water Partnership, a worldwide



Change of agricultural policy, Vietnam *In 1993 an action plan for development of water resources in the Upper Srepok Basin in Vietnam was designed to introduce and test IWRM. The project covered the 12,000 square kilometres catchment of a river basin in the Central Highlands of Vietnam and was later followed by pilot projects in 1994-1997 and full scale implementation in 1998-2006. The project demonstrated the economic value of water in competing uses which made Vietnam change its agricultural policy and investment planning to encourage cultivation of coffee and other tree crops in the Central Highlands and other mountainous areas. The analysis showed that the national economic value of irrigation water was ten times higher when used for coffee than for rice. The project resulted in an increase in the area of coffee farms from 40,000 ha in 1993 to 400,000 ha in 2005, a rise in productivity from 800 kg/ha to 2200 ton/ha, coffee becoming the second largest export commodity for Vietnam, improved livelihoods for 2.5 million people. (Courtesy: COWI and DHI)*

Failing to recognize the links between water-dependent sectors and their mutual impacts will lead to gross inefficiencies in the system, trespassing of regional or global resource limits and water crises

HENRIK LARSEN
Senior Water Resources Specialist
DHI Group

network of partners with IWRM at the core of its activities – with a Danish water professional as the Chairman of the Committee. In 2001, Denmark established an extensive cooperation with United Nations Environment Programme (UNEP) with IWRM and environment as the key program areas. The UNEP-DHI Collaborating Centre has since then provided services to many international processes and UN organizations in relation to water resources management.

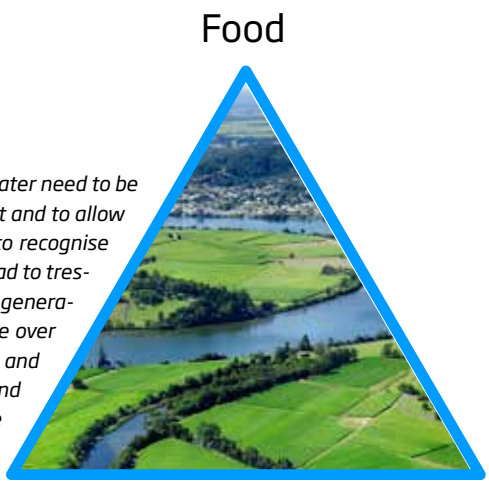
The Danish approach to IWRM

In Denmark, water supply relies on groundwater. The pressure on groundwater from agricultural pollution from nutrients and pesticides is very high as Denmark has one of the world's highest rates of cultivation. In the past four decades, severe conflicts have emerged between water supply (urban, industrial, irrigation), environmental protection and agriculture. Addressing these challenges, Denmark was the first country in the world to establish a Ministry of Environment in 1971. New legislation was implemented, including suitable enforcement mechanisms, which led to institution building of comprehensive water administrations at central government, regional and municipal levels, all staffed with natural scientists, engineers and planners closely linked to research institutions and a large private consulting sector.

The professional water administration with its associated institutions, was deliberately given knowledge and capacity to deal with new challenges. A number of major conflicts of interests between various stakeholders have over the years attracted high public interest and political attention in the Danish Parliament. This has encouraged the Danish Parliament to allocate funds for dedicated strategic research and monitoring programmes, to be implemented in cooperation between research institutions from the conflicting sectors and in this way build mutual trust among professionals.

Experience on the IWRM mechanisms

In Denmark, water resources management is handled in a partnership with the private sector with consulting companies carrying out most of the complex studies. The sector is characterised by a very high degree of innovation facilitated by strict environmental regulations, private-public partnership, public access to high quality data and significant involvement of research institutions. Economic priorities have changed over time and experiments have been made with various modalities for administrative and institutional structures. This has provided the Danish companies with useful experience on the mechanisms which work best under given conditions. Based on this, the public administrative authorities and the private sector of consulting companies and technology providers today collaborate with customers and colleagues around the world on the complexity of water resources management in development projects.



Water, energy and food nexus *Basic goods and services like food, energy and water need to be supplied in a sustainable manner in order to provide opportunities for development and to allow a significant proportion of the global population to emerge from poverty. Failing to recognise the impacts of one sector on another can lead to inefficiencies in the system and lead to trespassing of the global resource limits. For instance, decisions on the type of energy generation can significantly influence water demand and in the case of biofuels, compete over land for food production. Additionally, the way water is sourced, treated, priced and distributed can raise or lower energy requirements, and the choices made on food and diet influence both water and energy needs. Therefore there is a need to build more innovative solutions to achieve sustainable socio-economic development.*

Decreasing domestic water demand by 40 percent, Denmark *Since the 1990s domestic water consumption in Denmark has declined by 17 percent and is today at an average level of 114 litres per capita per day. This reduction has been achieved by strict water demand management, including an increase of the water price, installation of water meters at household level, water saving campaigns and higher awareness of the environment among consumers. These initiatives have all motivated people to save water and use water efficient showers, toilets and washing machines. In Copenhagen, the capital of Denmark, water usage has dropped from 171 to 104 litres per capita per day over the last twenty years, producing an annual saving of 12 billion litres of water. (Courtesy: Greater Copenhagen Utility)*

Photo: Kontraframe/City of Copenhagen

2. Managing demand to ensure water use efficiency

It is very important to set ambitious goals to make progress in the field of demand management. We are proud to tell that Copenhagen over two decades has been able to reduce per capita water consumption by 40 percent from 171 to 104 litres.

BJARNE KORSHØJ
Chief Operational Officer

Implementing demand management is an important part of IWRM. At the global level, agriculture's share of water consumption is 70 percent, industry is responsible for 20 percent and domestic use for only 10 percent. Water demands of these different sectors differ much from country to country. For countries or regions facing water scarcity, and increasing water consumption per capita due to industrial and population growth, the need to manage water demand is evident.

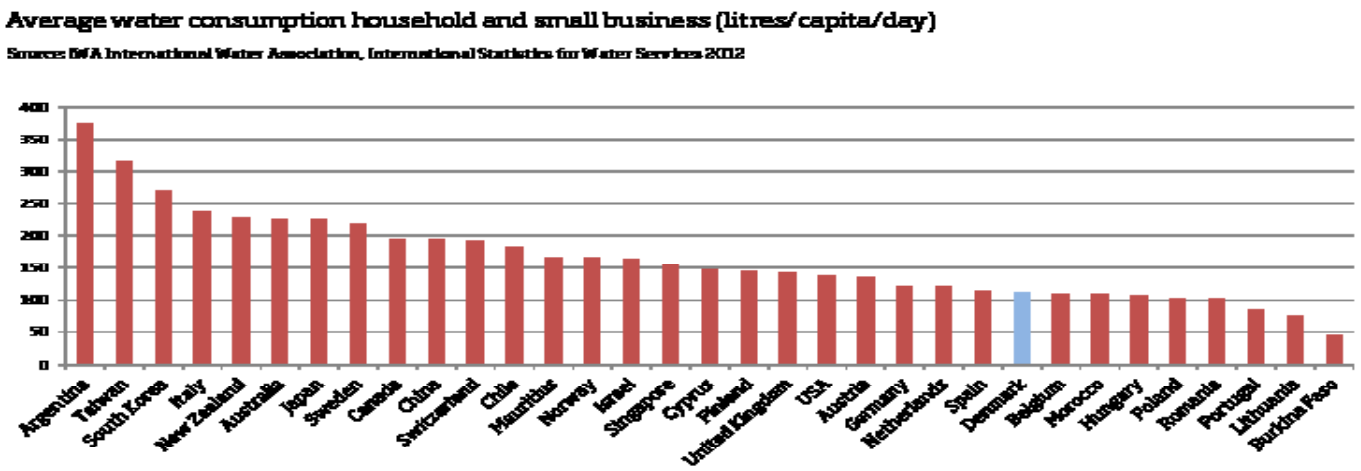
Decreased domestic water consumption

Typically the easiest and most obvious demand to regulate is domestic water consumption. Introduction of water meters, regulation by water and wastewater pricing and environmental taxation are some of the tools that motivate people to decrease their water consumption. The Danish government and water utilities have worked with these management instruments – supplemented by water saving campaigns and other tools – for three decades. Since 1985, an increase in the combined water and wastewater tariff has been the main incentive behind a drop in average domestic water consumption by nearly 40 percent from 180 to 110 litres per capita per day. Today Denmark has the world's highest water rates.

Increasing industrial water efficiency

In the industrial sector, high water efficiency is a priority for most Danish manufacturing industries, which in the last decades have reduced water consumption remarkably in response to water pricing, environmental taxes and integrated permitting of water use, wastewater disposal and air emissions based on best available technologies. The water rates have been an effective demand management tool, because most companies are connected to public water supply and sewer systems and therefore subject to the same high water supply and wastewater disposal rates as domestic users. Within the food processing industry, which is very large and important, water consumption per slaughtered pig has been reduced by 80 percent over the past three decades.

Integrating the European Union Water Framework Directive into Danish legislation has led to prioritisation of drinking water demand before environmental water demand before industrial water demand, which includes agriculture. This common legislation of the European Union puts pressure on large water consuming industries to increase their water use efficiency. Large water consuming industries and agricultural organisations as well as



Domestic water savings, United Kingdom *Globally only 10 percent of water consumption is domestic use from households and small scale business, but the global trends of population growth and urbanisation concentrates an increasing demand for water in urban areas. In the United Kingdom, two major water utilities facing water scarcity have taken new steps to "persuade" their domestic customers to decrease water consumption. Individual water meters are not common, so most consumers are not motivated to conserve water – many customers even remove installed water saving devices on showers and faucets. However, by installing tested and proven Danish toilet flush technology for 150,000 of their customers, average water savings of 47 litres per day per household have been achieved. The simple, yet award-winning, technology changes existing toilets from one flush into two-flush toilets and – as there is only one button (or handle) to use – changes people's behaviour to using the big flush only when it is really needed. In offices and public buildings, this technology has proven to save around 30 percent of the building's water consumption as toilets typically take up the largest share of water consumption. (Courtesy: ecoBETA)*

High industrial water efficiency, Denmark *Industrial processing takes 20 percent of global water consumption and as demand for water increases, water is emerging as a major issue in this sector. Water efficiency is today a priority for industrial companies in Denmark and the sector has reduced water consumption remarkably in recent decades, highly motivated by some of the highest water prices and disposal costs in the world as it has been politically prioritised to handle water sustainably. An example of industrial water efficiency is in car washing, that in Denmark typically takes place at gas stations. An oil company has achieved a reduction of the average amount of water from 150 to 3 litres per car wash achieved by a highly energy efficient evaporation system developed by an innovative Danish cleantech company (Courtesy: Envotherm)*

The backbone of IWRM is a holistic approach to water management, and this is the only way forward towards sustainable use of water in societies

ANDERS REFSGAARD
Project and Market Director
COWI

individual farmers today work intensively with water use efficiency and the reuse of different "types" of water (blue, grey and black) in order to lower their water consumption per produced unit. The water abstraction fee is small and may not influence water use, but around 2000 the fee resulted in a drop in water abstraction permits of 40 percent or more giving government freedom to allocate this released water for new domestic users and industrial development, i.e. socio-economic development.

Water and energy efficiency of utilities

Looking into the water sector itself, the efficiency of many water utilities can be increased remarkably. Globally it should be a priority to close the considerable gap between the volume of water they produce and that which is billed to the customers. This difference is known as Non-Revenue Water (NRW), or urban water loss, and globally it amounts to between 25 and 50 percent of the production causing huge financial losses to water companies and eventually to users or tax payers. The losses are caused by inaccurate or inadequate billing and metering systems, low collection rates, leakage from deteriorating distribution infrastructure, excessive water pressure in distribution systems, reservoir overflow and illegal connections to the water network. Urban distribution losses are down to 7 percent in Denmark owing to efficient leakage detection programs and good maintenance.

Agricultural water efficiency

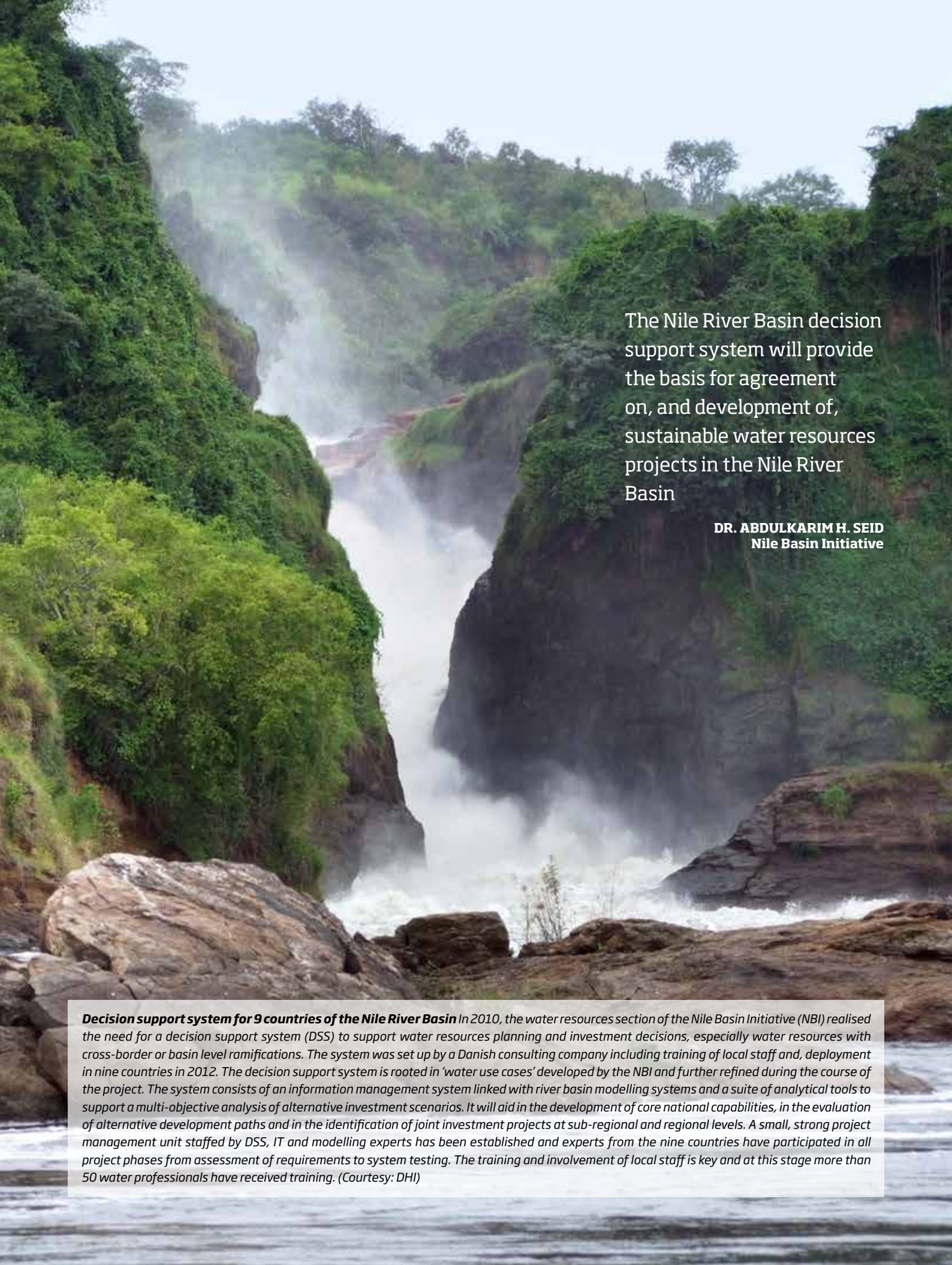
As the largest water consuming sector, it is obvious that relatively small gains in water use efficiency in agriculture will enable a relatively large increase in domestic or industrial water use. At the same time the water demand of this sector will increase steadily due to population growth with an increasing demand for food putting more and more pressure on limited land and water resources. For this sector, demand management strategies may involve technical solutions like more efficient irrigation infrastructure and technologies, better irrigation management, but also development of or shifts to less water demanding crops and better farming methods.

EU Water Framework Directive (2000)

The widest application of IWRM is in the EU Water Framework Directive which applies to all 28 member states of the European Union, and also is adopted by four transboundary river basins in neighbouring countries under the Helsinki Convention. The directive set a milestone for IWRM by definition of a systematic process for upgrading, restoration and protection of water bodies in the European Union with a firm timetable for River Basin Management Planning based on IWRM principles and tools. Globally the directive set a new standard for water management by the objective to achieve good status of all water bodies by 2015 and by inclusion of ecological criteria together with traditional water quantity and water quality criteria in definition of this objective.

Increasing attention to water footprints

Fortunately, there is an increasing attention to the water footprint and virtual water as concepts that are expected to receive attention from consumers, and to become highly visible on political agendas in the coming years. The water footprint is defined as the total volume of fresh water used to make a product, or consumed by a person, community or country. A product's water footprint is an indicator both of direct and indirect water use. It is thus a measure of how a consumer or producer relates to the use of freshwater systems. The water footprint concept can for instance be used to quantify and map the water use behind consumption and guide reduction of water use to a sustainable level. Virtual water is also the amount of water used to generate a product and therefore incorporated in the product, but used to illustrate how much water a region or country imports or exports and in this way regional or global water efficiency can be optimised through trade.



The Nile River Basin decision support system will provide the basis for agreement on, and development of, sustainable water resources projects in the Nile River Basin

DR. ABDULKARIM H. SEID
Nile Basin Initiative

Decision support system for 9 countries of the Nile River Basin *In 2010, the water resources section of the Nile Basin Initiative (NBI) realised the need for a decision support system (DSS) to support water resources planning and investment decisions, especially water resources with cross-border or basin level ramifications. The system was set up by a Danish consulting company including training of local staff and, deployment in nine countries in 2012. The decision support system is rooted in 'water use cases' developed by the NBI and further refined during the course of the project. The system consists of an information management system linked with river basin modelling systems and a suite of analytical tools to support a multi-objective analysis of alternative investment scenarios. It will aid in the development of core national capabilities, in the evaluation of alternative development paths and in the identification of joint investment projects at sub-regional and regional levels. A small, strong project management unit staffed by DSS, IT and modelling experts has been established and experts from the nine countries have participated in all project phases from assessment of requirements to system testing. The training and involvement of local staff is key and at this stage more than 50 water professionals have received training. (Courtesy: DHI)*

3. Converting data into sound management decisions

The importance of national information infrastructure cannot be overestimated. Sound water management requires easy access to national databases with quality assured data, well tested models and credible applications of data and models

JENS CHRISTIAN REFSGAARD
Professor
GEOLOGICAL SURVEY OF DENMARK AND GREENLAND (GEUS)

There is an increasing understanding of the need for and benefit of data, information and knowledge within water resources management – an understanding that is often catalysed by inadequate water security and conflicts between environmental and other water demands. In order to resolve these conflicts and achieve sound water management, water authorities can benefit from decision support systems provided these are based on reliable data and information and adequate institutional capacity to manage and apply.

The complexity and the amount of data involved in water resources management decisions has led to the development of computerised Decision Support Systems (DSS). The MIKE-suite of hydrological and water resources modelling tools developed by the consulting and research organisation DHI are probably the most widely used Decision Support Systems worldwide. These systems link databases with knowledge and information systems, modelling and analysis frameworks, socio-economic analysis frameworks and communication frameworks.

Decision support systems

A fully developed decision support system is of great assistance in the many parts of the IWRM cycle right from the identification of water resources issues to action planning to monitoring the impacts of interventions. It must be anchored in an appropriate water agency with adequate funding and with qualified staff available to realise the full potential of the system. Global experiences from implemented decision support systems are that they have greatly assisted in understanding river regimes, enhanced cooperation on water resources development and made stakeholder involvement more meaningful.

Piloting IWRM at the national level, Uganda
Following the international agreements on the principles of IWRM, Uganda's department of water resources started a journey towards IWRM in 1993 facilitated by the IWRM experts of two Danish consulting companies and today the country participates on equal footing in the co-operation around the equitable and sustainable development of the waters of the Nile River. The first step in the process was the development of a Water Action Plan setting out the required developments ranging from a water policy and associated legislation to institutional capacity building and management tools. Over two decades the water resources department has advanced from a few staff to today's Directorate of Water Resources Management with a full professional staff capable of regulating the water sector and making sound decisions based on data, knowledge and modelling of the water resources. (Courtesy: DHI and COWI).

Developing a surface water modelling centre, Bangladesh *Recognising the huge and destructive extreme water events in Bangladesh, the country's Ministry of Water Resources decided to develop a high level of analytical capabilities by use of state-of-the-art mathematical water modelling and in 1986 a surface water simulation modelling program was launched. The two disastrous floods of 1987 and 1988 pushed the development of a professional institution to carry out all the mathematical water modelling tasks in Bangladesh, including the hosting of all flood action plan models. Technical assistance was given from a Danish consulting company. The assistance included transfer of knowledge, IT technology and advanced mathematical models coupled with professional training. Today the Institute of Water Modeling in Bangladesh functions as a centre of excellence and research in the field of water modelling, computational hydraulics and allied sciences, and provides services in these fields to enhance the quality of planning and implementation at public and private organisations.(Courtesy: DHI)*

Management framework of Denmark
In Denmark, groundwater dominates the hydrological regime and besides conflicting demands by nature and the different sectors, additional conflicts emerge due to agricultural pollution of both surface and groundwater from pesticides and fertilisers. An integrated national information infrastructure has therefore been developed including 1) national databases for geological, geophysical and other water related data, 2) national groundwater mapping, 3) a national water resources model using data from national databases and 4) application of data and models as the basis for preparing river basin action plans and national maps for climate change impacts on groundwater and river regimes.

Supported by a number of strategic national research programs with the main purposes, to provide a firm basis for sound water resources management and development and enable public access to all key data and information, Danish water agencies have developed a range of new innovative tools like databases, data collection systems and modelling software – and integrated these in Decision Support Systems. The outcomes today are:

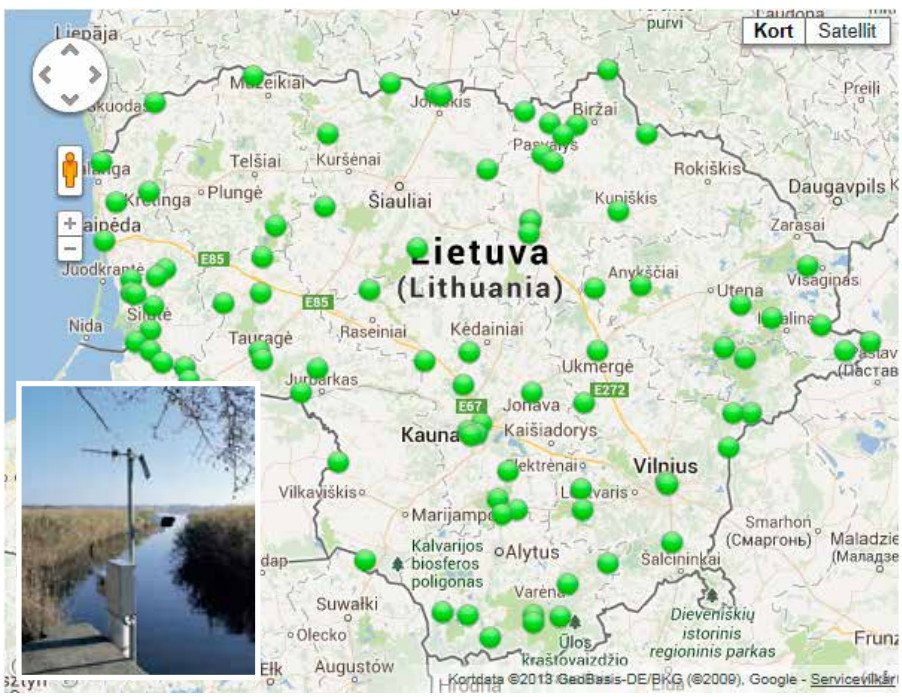
- **National databases** that include data on topography, geology, groundwater, geophysics, soil, land use, agricultural management, climate, river discharge and water quality, and are operated by research institutions and government agencies. National legislation ensures provision of data to these databases and there is public access to all.

- **Comprehensive monitoring programs** Ongoing groundwater mapping and monitoring of surface and groundwater continuously provide new information. These data are quality checked and stored in the national databases.

- **National water resources model** using the national data bases is continuously updated and tested as new data and new knowledge becomes available. The national water resources model serves the dual purpose of gradually gaining better insight into the water quantity and quality at national scale and providing support to specific water management decisions such as preparation of river basin management and action plans.

- **National maps** Application of data and models to update national maps for climate change impacts on groundwater and extreme river discharges. These maps are publicly available and support initial screening by municipalities, when they prepare their climate change adaptation plans.

Hydrometric network, Lithuania *Knowledge of the water flows of rivers is basic to water resources management and can prevent accidents and even disasters. In Denmark regular hydrological monitoring of streams and lakes was established as early as 1917 and data are today used in river basin modelling, groundwater modelling and groundwater resource assessment. This expertise is now applied in Lithuania which shares major river basins with Belarus, Russia and Latvia making data exchange across borders necessary. To increase current knowledge of conditions and to benefit from historical data, Lithuania has upgraded their hydrometric data collection, data processing and information systems. The Lithuanian Hydrological and Meteorological Service under the Ministry of Environment now provides their stakeholders an online map with data from a hydrometric station network and hydrological forecasts of minimum and maximum water levels and water discharge (Courtesy: Orbicon)*



Master Plan for water resources, Mauritius *The water supply on the island of Mauritius relies on heavy storms filling water reservoirs at high altitudes. Each reservoir is connected to a supply zone and before there were no linkages between the various reservoirs or the various supply zones. The water security was challenged by the variability of storms that either were not strong enough to fill the reservoirs or not equally distributed over the island whereby only some of the reservoirs were filled. If a reservoir was not filled during the rainy season it was not possible to provide water for both domestic water consumption and irrigation in the related supply zone. As a solution to this, a robust water resource system connecting the various reservoirs and supply zones has been developed and established by a Danish water consulting company. Using an advanced modelling tool the system is designed to ensure 95 percent reliability of domestic water use and 80 percent reliability for irrigation. The investment comprises new reservoirs, pipes and pumps between reservoirs, conjunctive utilisation of groundwater and investment in new distribution lines to reduce water losses (Courtesy: NIRAS).*

4. Water in climate change mitigation and adaptation

Cost-effective climate change adaption is created through interdisciplinary and holistic water management. The major flooding and droughts challenges we face all over the world must be resolved through IWRM

JENS BRANDT BERING
Business Unit Director, Water & Utilities
NIRAS

Implementing IWRM and adaptation to climate changes are closely linked due to their impact on the availability, quantity and quality of water resources. Climate change causes lower predictability of weather, changes in precipitation patterns, increased frequency of extreme weather events, extended periods of drought, changes in ground water levels, increased variability in river flows, and floods caused by rains and rising sea levels.

Involving other resource areas

Climate change thereby creates new conditions for many sectors and increases disaster risks through changes in precipitation, evapotranspiration and temperature. Implementing IWRM addresses the planning and development of water resources in the broadest possible context, including the economic, social and ecological climate change impact on a specific river basin. In practical terms, this means that climate change adaptation policies, strategies, programmes and projects involving other resource areas are carefully analysed to assess the impact they may have on demands imposed upon a watershed, a coastal zone or a river basin's water resources.

Ecological engineering

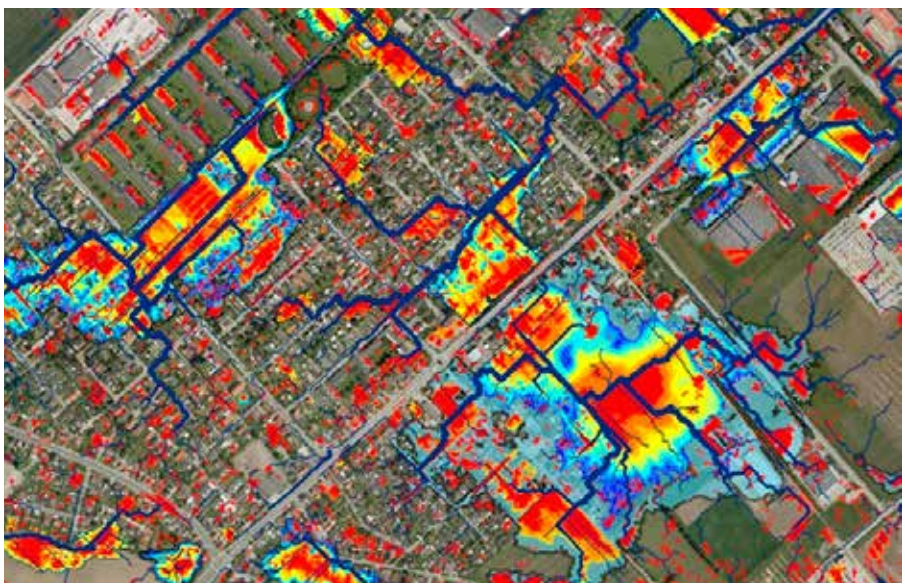
Climate change has led to an increased focus on IWRM, particularly on floods and droughts at the river basin level, and through Integrated Urban Water Management (IUWM), particularly for water security and stormwater management. Prevention of regional floods increasingly relies on harvesting the benefits of floods by ecological engineering – keeping water in the landscape as long as possible rather than conveying it rapidly to the sea by traditional flood protection infrastructure such as river dikes and embankments. Ecological engineering includes maintenance or restoration of a good vegetation cover in upper catchments and terracing which regulate and retard run-off. At the same time it contributes to climate change mitigation through carbon capture. Further downstream catastrophic floods are mitigated by connecting rivers with flood plains and wetlands with the added benefits of capturing sediments and nutrients and increasing groundwater recharge.

Urban development

Mitigation of urban flooding also relies increasingly on harvesting the benefits of flooding by ecological engineering that incorporates water

Avoiding stormwater damages, Denmark

In recent years, Denmark has faced more extreme weather events and developed a method for climate adaptation. By converting detailed laser scanned terrain models into intelligent hydrological maps, the flow paths of rain water are predicted. Flood risk maps are then created by combining these terrain models with hydraulic models of the sewer system and surface waters, supported by sophisticated statistical risk analysis. Then designs of technical solutions are developed, each with a price tag, and it is then possible to prioritise climate change adaptation measures by an evaluation of assets, infrastructure and buildings at risk and required investments. The final climate adaptation plan is then developed by combining these technical parts with a thorough stakeholder inclusion process and a holistic water cycle analysis.



Stormwater investments creating more liveable cities, Denmark *In 2011, the capital of Denmark experienced the worst and most destructive cloudburst in the city's history. Water poured into basements and stock rooms, resulting in damages of approximately 800 million euro. Now Copenhagen invests heavily in safeguarding against future extreme weather, while at the same time exploiting positive aspects of the restructuring. A blue and green city with more urban quality and increased biodiversity will be created. The innovative plans developed by a multidisciplinary team of experts within project management, storm water management, hydraulic modelling, landscape architecture, urban development, traffic, nature, and socio-economic assessments are already attracting international attention. The full page image shows Lake of Saint Jorgen in Copenhagen that will change from water reservoir into a park. The water table will be lowered to be able to buffer rainwater during heavy rainfalls and thus minimize the risk of flooding. (Courtesy: Rambøll and COWI)*

Stormwater initiatives can be integrated with city planning creating more liveable cities

LYKKE LEONARDSEN
Head of strategy and authority
CITY OF COPENHAGEN

In a river basin the impacts of climate change on water security are in most cases subsidiary to the impacts of socio-economic development

Jesper Karup Pedersen
Chief Project Manager
COWI

in the urban landscape in the form of canals, lakes and parks, which serve as buffers for stormwater. This reduces the need for costly investment in upgrading of sewer systems and at the same time creates recreation areas, where vegetation generates oxygen and regulates air temperature by evaporation thus improving the micro-climate in urban areas. Measures to integrate water in the urban environment are often paid for by increased property prices, reflecting the high financial value of water living next to water in urban settings.

Flexible solutions involving stakeholders

Climate change adaptation measures to secure water resources must build on downscaling of global and regional forecast models, vulnerability and risk assessments, strategic priorities and, above all, a holistic view on water management. It is essential that all aspects of the water management cycle, both technical and administrative are considered. Viable solutions for increasing water availability and security must deal with the growing uncertainty and risk posed by climate change. Therefore, an adaptive water management approach is required and water infrastructure design must be adaptable to unknown or unexpected future conditions. Taking an integrated approach implies technical expertise and technologies carefully adapted to the environment they are applied to. Typically, standardised turnkey solutions are often not favourable as the programmes must be developed in close dialogue with all stakeholders and adapted to the social, political and economic environment.

Improving river operation efficiency, Australia *The Murrumbidgee River in Australia is important for irrigation and for maintenance of the surrounding wetlands. The river system's complex nature coupled with critical water demands of the different sectors had resulted in excess water being withdrawn of diverted and subsequently lost to the river system. Therefore, supported by Danish water experts, the river operator has now implemented the Murrumbidgee Computer Aided River Management System comprising a suite of simulation models that accurately reproduce key catchment and river processes. Through a reduction in river operating levels, water savings have been realised as less water is lost through evaporation and evapotranspiration. The project also established the region as a leader in river management and water use efficiency techniques. (Courtesy: DHI)*

Tailored training, Southern Africa *An IWRM training programme has been developed for the eight riparian countries of the Zambezi River basin in Africa by a Danish consulting company together with the Stockholm International Water Institute. The critical situation of the region was that different sectors managing water were competing for the water and not cooperating. With the International Water Management Institute in South Africa as regional partner, the training programme enhanced managerial, technical and facilitation skills within the water sector, improving water governance and institutional development. The training targeted management staff from governmental and non-governmental organisations as well as the private sector involved in the physical planning of water resources. The programme covered a wide range of subjects from rural water supply and sanitation to integrated river basin planning and as part of the training the participants created individual institutional change projects relevant to their own working situation and the priorities and tasks of their organisation. (Courtesy: NIRAS)*

5. Starting and sustaining integrated water resources management

Two important premises for sustainability are management at the lowest appropriate level and stakeholder participation in management, decision-making and implementation. Having worked with these issues all over the world, there is no doubt that stakeholder engagement and skilled professional staff are what makes the difference

HENRIK LARSEN
Senior Water Resources Specialist
DHI Group

A strong political drive is key to start the implementation of IWRM and this drive is often catalysed by water scarcity with conflicts of interest between water dependent sectors – often the conflicts are between agriculture and environmental interests and the concern is both for water quantity and quality. The first important step is to foster the political determination to develop an IWRM action plan creating or consolidating the policy and legal framework, forming of an institutional framework to anchor water management and establish capacity to use IWRM management tools and implement management decisions in full cooperation with stakeholders at all levels. Keeping the focus on IWRM in national and regional water institutions in developing and maintaining human resources are crucial.

Sustainable foundation

Knowledgeable professionals and motivated stakeholders are prerequisite to sustain the implementation of IWRM. The philosophy is that institutional changes must be followed by a long term sustained effort to consolidate and continue the principles, the knowledge and the capacity in the public and private sector. Two of the key principles of IWRM are "management at the lowest appropriate level" and "stakeholder participation in management, decision-making and implementation". The sustainable foundation is thus created by involving stakeholders as close as possible to the management issues at hand, being those who have to live with the consequences of the decisions.

Local decision power and responsibility

In Denmark, this was addressed in 2007 by a structural reform allocating higher local responsibility for the water and environment to 98 municipalities instead of the 14 counties they were previously allocated to. Today, municipalities are responsible for water abstraction permits and permit owners have to report regularly to the municipality on their compliance with the conditions of the permit.

Likewise, permits for discharge of wastewater and drainage water are issued by the municipalities, who also have the supervisory responsibility. Permit owners have to report their abstraction, discharges and pollution levels to the municipalities that carry out spot-checks. Municipal plans for water use and environmental quality are thoroughly discussed with stakeholders at sessions, which are required by law and described in regulations. Transparency in operations and the possibility to complain and appeal at several different levels provide important elements of good water governance.

Assuring a steady flow of funding

Maintaining data monitoring, knowledge, skills development and professional staff has a financial cost. Logically, these costs should be carried by the beneficiaries paying for their use and for the pollution caused. Sustainability requires a steady flow of funds to finance the water resources management operations. In Denmark, important parts of the IWRM principles have been operationalized by funds provided from the municipal taxes, while funding of the operations of the water utilities (water supply and sewerage) takes place through volumetric water charges. Special regulations and charges are in place for industries.

Capacity building in IWRM, Malaysia *Over seven years, a capacity building project for integrated management of river basins (IRBM) and water resources (IWRM) was carried out in Malaysia at federal level and in two states. The project was instrumental in the preparation of IWRM plans for two river basins in Malaysia: the Selangor River which supplies 60 percent of the water to the capital, and the Kedah River which feeds the most important rice cultivation area in the country. Today, the river basin plans include policies for water resources, water quality, flood mitigation, and conservation of firefly habitats and cultural heritage, and they identify specific measures, time frames and the agencies responsible for implementing each measure. The principles of IWRM were the basis for a comprehensive water resources law that was drafted with the assistance of the project and now has been enacted in Kedah. At a practical level the project designed a number of demonstration projects which have been implemented by the government. (Courtesy: COWI)*

Water harvesting, Kenya *If water is scarce due to limited rainfall and surface runoff, harvesting water is an obvious solution to increase climate resilience, food security and livelihoods. In the arid lands of Kenya, the solution is a combination of innovative and adaptive water harvesting structures, improved agronomic practices for food and fodder production and support to the establishment of local user groups. Water harvesting techniques are implemented in combination with appropriate social mechanisms and tailor-made agronomic practices. The innovative approach lies in the combination of modern water harvesting techniques, agronomical practices, and social organization where cross-cutting aspects such as gender and HIV/Aids, are given special attention. (Courtesy: NIRAS)*

Groundwater mapping, Malaysia *In search for water, a region of Malaysia has now mapped the groundwater resources supported by a team of Danish consultants. The main objective of the project was to get a clear picture of the potential for relying on safe and stable groundwater resources rather than solely relying on surface water with a highly varying quantity and quality and being prone to future climate change. An additional outcome from finding new groundwater resources was the ability to postpone major investments in expensive dams, treatment facilities and pipelines. Water security increased in the rural areas and conflicts of interest with heavy industry over the right to river water were avoided. The project involved the integration of environmental impact assessment, hydrogeological modelling, water quality evaluations, hydraulic modelling and cost benefit scenarios. (Courtesy: EnviDan, SkyTEM and I-GIS)*

IWRM in the Mouhoun and Comoe River Basins, Burkina Faso *To promote growth in the rural economy agricultural activity in Burkina Faso has been intensified, modernised and diversified by providing technical and marketing support to producers, developing rural infrastructure, and improving rural accessibility. A Danish consulting company has since 2010 helped in developing IWRM in the Mouhoun and Sourou-Comoé basins, under one of the country's first structure-defining programmes in the agricultural sector that takes IWRM into account. The prevailing issues in the area include low availability of water, poor water resources management, low capacity of the beneficiaries, limited access to information, markets, and inputs and inadequate access to loans. Burkina Faso is today one of few countries in Africa to have the experience of establishing a River Basin Agency, from which it is now possible to draw lessons. (Courtesy: COWI).*

Restoration Programme - Modelling of agricultural area storage reservoirs, Florida, USA *The water resources in South Florida are under heavy stress due to the rapidly increasing population and there is a growing awareness of the need to protect the unique aquatic ecosystems in the Everglades wetlands. To achieve the goals set out for the protection and restoration of the wetlands, the South Florida Water Management District realised early on that an IWRM strategy was needed. The Everglades Agricultural Area covers over 700 square miles of farm land and receives water from Lake Okeechobee, runoff from the watershed and inflow from wetlands surrounding it. The irrigation water demand is high in the area and a dense network of irrigation canals has been constructed to convey water to the farms and to provide flood control. As a foundation for the development of the IWRM strategy, an integrated groundwater and surface water model and a decisions support system were developed. (Courtesy: DHI)*

If your goal is smart and efficient water solutions,Denmark is ready as your partner

Water is an increasingly scarce resource in most parts of the world and we need to rethink how we use it. Denmark holds a long tradition of integrated water management and is committed to take responsibility and contribute to solving the major global water challenges.

A long tradition of sustainable water management

As awareness about sustainable water practices has increased, Denmark has spent the past decades building expertise within water efficiency and water management. Today, our tap water is as pure as the finest spring water, water loss in our pipelines has been reduced to less than 8 percent, wastewater is treated efficiently with a strong focus on energy and resource recovery and the water in our capital's harbour is clean enough to swim in.

The knowledge we have about water resources, security and efficiency is no coincidence. Successive governments have addressed our country's limited natural resources and the Danish water sector holds a long tradition of water utilities, technology providers, consulting companies and universities working jointly together to promote integrated solutions for efficient and sustainable water management.

A shared water vision for the future

The close collaboration between multiple stakeholders has put Denmark at the forefront of research, technology development, know-how and best-practice in integrated water management, urban drainage, water supply, wastewater treatment as well as governance and ensuring public awareness and support for water policies.

Denmark is prepared to take responsibility in solving the world's major water challenges and has ambitious plans for its water sector. A water vision for 2025 has been created through dialogue between the Danish water sector and the Ministry of Environment and Food with the intention of developing Denmark's position as a water hub for intelligent and efficient water solutions. The aim is to create solutions which will increase access to clean water and sanitation, promote efficient use of water resources, improve the competitiveness of water consuming industries, lead to a cleaner global environment and protect cities from floods and storm surges.

As a country, we see great opportunity for mutual benefit in the transfer of knowledge and we aim at turning global water challenges into opportunities for sustainable growth.

Explore water solutions online or experience them live in Denmark

We invite you to explore the newest Danish water solutions, policies and news online at www.stateofgreen.com/water. You can also visit Denmark on a State of Green Water Tour where you can experience innovative water solutions first-hand and take advantage of the lessons learned by leading Danish companies and utilities.

For more information about State of Green Water Tours, please visit:
www.stateofgren.com/tours

"Danish water companies, utilities and organisations have shown that by working together, it is possible to create more innovative solutions which lead to added value for both their customers and society as a whole. This is a great example of how Denmark contributes to finding solutions to the major water challenges the world faces"

ESBEN LUNDE LARSEN, Minister for the Environment and Food, DENMARK

the international water association

Join us in Copenhagen for the IWA World Water Congress & Exhibition in 2020

Denmark is proud to host IWA Congress and Exhibition on 18-23 October 2020. Proposed Congress topics are "Water for smart liveable cities", "Water – Energy – Food Nexus" and "Recruitment and career development in the water sector". The proposed topics address future water challenges all over the world. Before, during and after the conference, a united Danish water sector looks forward to demonstrating smart water technology, system solutions and discussing governance and policy in order to secure resilience in the future in towns, basins and cities around the world.
Read more at www.iwa2020copenhagen.dk

Download this white paper and other related publications at:

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Water utilities

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