WRS STRATEGIC PLAN 2015-2020

Department of Water Resources, ITC

UNIVERSITY OF TWENTE

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Contents

Summary

Water is a necessity for life and is essential for ensuring food and energy security, for facilitating poverty reduction and improving human health, and for the maintenance of ecosystems and biodiversity. There is a growing concern that the water available in many regions of the world will not be sufficient to meet emerging demands arising from population growth, industrial expansion, and climate change. Quantitative earth observation, numerical modelling and data assimilation provide powerful tools for quantifying hydroclimatic variables to effectively address these water management issues.

This strategic plan 2015-2020 provides strategic objectives and directions for our activities in the field of Research, Education and Project activities all linked together to achieve our strategic objectives.

To achieve our vision **"Safe water resources for all",** our mission will be centred on "**Creating and transferring new knowledge in satellite hydrology for solving society's problems in water resources and environment**".

We will continue our successful activities on advancing Earth Observation so as to improve our process understanding of the water cycle and climate to serve informed water resource and environmental management.

- **Science**: advance understanding of the water cycle in the climate system with a focus on land surface processes and land-atmosphere interactions
- **Technology**: advance quantitative earth observation, numerical modeling and data assimilation
- **Application**: monitor worldwide water availability, extremes and food security in terms of floods, droughts, water use and water pollution

A concerted effort will be developing a (virtual) satellite mission for observation of the water cycle at all relevant spatiotemporal scales of interest for water resources and environmental management. To achieve such an aim, the quality of satellite products needs to be made consistent in time and space and consistent amongst various products by observation modelling independent of particular satellite sensors.

Our research results will be published in high quality disciplinary journals, embedded into computer codes and made into climate data records for quantification of water cycle dynamics to contribute to climate services.

In our education we will further strengthen the EO - ICT base of our education portfolio, enhance the flexibility in delivery mode, broaden the enrolment base of our MSc course, and

maintain the internationally recognized lead position in capacity building in the field of earth observation for water resources and environmental management.

Over the years we have developed a well-balanced and ambitious project portfolio. Scientific questions and external demands will continue to lead our project activities, with more focus on research projects. Capacity development projects will be streamlined as much as possible with our in-house educational activities by implementing training courses, adapting delivery modes and preparing training materials.

1. The water imperative

Ensuring safe water, secure food, sustainable energy, and a clean environment are key challenges to our rapidly changing society. Therefore the United Nations Sustainable Development Goals (SDG)[1] explicitly defines 'Goal 6, Ensure availability and sustainable management of water and sanitation for all' and links water to other goals (3, 11, 12 and 15 among its 17 goals). Its 'Goal 13, Take urgent action to combat climate change and its impacts*' and 'Goal 17, Strengthen the means of implementation and revitalize the global partnership for sustainable development' further articulate the needs for actions related to climate change and global partnership.

Subject to climate change, the **security of fresh water resources** has become a key societal challenge. Floods, droughts, water scarcity, water usage, water quality, water and ecosystem interactions, water and climate interactions are all issues of direct importance to our human society.

From a physical process point of view, better water management requires fundamental understanding of the water cycle, water and climate, water and ecosystem interactions, as well as the ability to quantify the impact of human activity on water resources and the Earth's climate system. Because quantitative earth observation, numerical modelling and data assimilation provide powerful tools for quantifying hydroclimatic variables to effectively address water management issues, we focus our efforts on advancing process understanding in earth observation of land surface processes and land-atmosphere interactions. This way we can generate the capability and capacity to monitor worldwide water availability, extremes and food security in terms of floods, droughts, water use and water pollution. This is particularly important in developing countries, where field monitoring is often lacking and where we can best contribute to supporting the UN SDGs and the Dutch policy[2] on development cooperation.

Several current international initiatives such as the EU/ESA Copernicus [3] programme, and the Global Earth Observation System of Systems (GEOSS[4]) of the Group on Earth Observation (GEO), in particular its Integrated Global Water Cycle Observations (IGWCO[5]) theme, have all identified **earth observation of the water cycle** as the key in helping to solve the world's water problems.

Climate change adaptation may determine most likely the future of the mankind, as reported by the High-Level Taskforce for the World Meteorological Organization (WMO) Global Framework for Climate Services (GFCS)[6] which has articulated the needs for four priority sectors of health,

[1] https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals
[2] Beleidsnota 'Wat de wereld verdient: Een nieuwe agenda voor hulp, handel en investeringen', 5 april 2013 (Ploumen Nota).

[3] http://copernicus.eu/

[4] http://www.Earthobservations.org/geoss_imp.shtml
[5] https://www.earthobservations.org/wa_igwco.shtml
[6] WMO Position paper on Global Framework of Climate Services, Climate Knowledge For Action: A Global Framework For Climate Services–Empowering The Most Vulnerable Climate. The Report Of The High-Level Taskforce For The Global Framework For Climate Services, WMO-No. 1065, 2011.

water, **food security and agriculture**, and disaster risk reduction to access climate services. Particularly, climate services are weakest in the places that need them most – climate-vulnerable developing countries.

Better water resources management in turn requires better understanding of the water cycle, water climate interactions and water ecosystem interactions in the Earth's climate system and impacts of human activities on the water cycle, which becomes more prominent due to the increased population and rapid urbanisation. To achieve such understanding it is essential to be able to measure hydroclimatic variables at different spatial and temporal scales. A GEO Africa Water Cycle workshop[7] and the GEOSS Water Strategy[8] have continuously emphasized the importance of earth observation to improve the delivery of multi-disciplinary data and data products to researchers studying climate impacts, adaptation and vulnerability.

From a policy point of view, the Netherlands policy in development cooperation and trade (Ploumen Nota) has clearly defined four spear heads: **food security, water**, Women's rights and SRGR (Seksuele en Reproductieve Gezondheid en Rechten), and security and rule of law.

The University of Twente UT 2020 vision: Navigating with Precision further defines **our core values** as

- Societal impact: making a real difference,
- Synergy: excellence in combinations,
- Entrepreneurship and innovation: the best in Europe,
- Internationalization: tomorrow's global citizens,

that we will adhere to and operate within the "ITC 2020: more space for global development" priorities in the coming years.

Given the above imperatives, the Department of Water Resources (WRS) has the vision

"Safe water resources for all'

with the corresponding mission

"**Creating and transferring new knowledge in satellite hydrology for solving society's problems in water resources and environment**".

An overview of our activities is given in the following Table 1.

[7] 3rd GEOSS African Water Cycle Coordination Initiative Workshop, 4-5 February 2013 in El Jadida, Morocco
[8] The GEOSS Water Strategy: From Observations to Decisions, 2014.

Table 1 The organizing principle of WRS activities

Water Cycle and Climate		
Science	**Physical aspects of water cycle**	**Geo-biochemical aspects of water cycle**
Technology	- **Observation (in- situ and satellite observations)** - **Numerical modelling** - **Data assimilation**	
Applications	**Water resources and food security (floods, droughts, water use, impacts of climate and land use changes)**	**Environment security (water pollution, impacts of climate and land use changes)**
Education and capacity building	- **MSC Water resources and environmental management (WREM, water resources track & environment security track)** - **JEPs in line with WREM** - **Tailor-made short courses**	

In support of the Netherlands policy in development cooperation and trade, WRS will continue its activities in research and education in earth observation technologies to monitor water availability and food security in terms of water quantity and quality, and water disasters in terms of floods, droughts and water pollutions, particularly in developing countries where an in-situ monitoring network is often missing. The focus of our activities will be related to the priority areas of **water and food security**, with attention to the target countries. Our activities encompass a wide range of tasks such as supervising PhD researches, conducting education at MSc level and professional postgraduate courses and short courses, and undertaking research and capacity building projects in developing countries with country focuses as defined in the Ploumen Nota.

Graduates of the WRS courses apply their knowledge in their own countries on issues like management of water scarcity (water use and drought), groundwater monitoring, modelling and management, integrated water management, water and food safety, management of irrigation systems, monitoring and predicting floods, monitoring water quality, environmental impact reporting, and assessment of climate change and land use change impacts and vulnerability and preparing societies for adapting to climate change and population growth and urbanisation.

External funds acquired from the EU, ESA and NWO and other funding agencies all support us in achieving our mission objectives by carrying out fundamental and problem-driven research projects. These research activities strive to create new knowledge in water and food security applications and are organized in four clusters related to improving the quality of earth observation products for food and water, assessing security of groundwater and ecosystems,

monitoring water quality and environmental safety, and predicting water cycle and climate change.

WRS works in close collaboration with the water-related organisations in particular in ODA (Official Development Assistance) countries to strengthen the knowledge and skills of our partners in monitoring and management of water resources. This can vary from getting local water managers acquainted with new techniques in a short course organized with a local university to developing scenarios and accounting systems for an optimal distribution of scarce water, to conduction of integrated research projects.

Collaboration with other organisations (e.g. water authorities and SMEs) will be further strengthened through joint projects. The activities of the department are largely demand-driven and implemented strategically by an 'innovation impulse' of the rapid advances in satellite observations and ICT (information and communication technology) into specific application areas, particularly in Africa in the field of water and food security (e.g. in the ESA TIGER Programme for water management in Africa using satellite data).

2. WRS Research

Our research activities will be organized under the theme **water cycle and climate, focusing on the physical aspects and the geo-biochemical aspects of water cycle.** Each of these aspects will address the issues in science, technology and applications (see Table 1). The focus is **creating new knowledge in satellite hydrology for solving society's problems in water resources and environment.**

To realize our objectives, the research activities will be organized in projects, each of which should be strategically driven by research curiosity, urgency, and whether they are researchable, challenging and realizable. These projects will be either externally funded or centered on particular PhD research topics.

Successful elements in the past years will be strengthened and the projects will be clustered around the four thematic clusters. 1) The **Retrieval of Surface Parameters** cluster is concerned with the question of which physical quantities we can actually observe with remote sensing instruments, in particular with sensors operating in the optical domain, covering the electromagnetic spectrum from the visible, through the near and shortwave infrared, up to and including the thermal infrared. Radiative transfer models are applied which describe the relation between a set of object (land, vegetation and water) properties and the reflected or emitted radiation spectrum. 2) the **Hydrogeology and Ecohydrology** cluster investigates the relationships amongst climate, vegetation functioning and vegetation structure as related to the mechanism of net recharge and groundwater availability. A combination of earth observation, field measurements and modelling is used to assess impacts of land use and climate change on dynamics of surface-groundwater interactions and on groundwater resources in relation to the water cycle, with particular focus on water-limited environments. 3) the **Water Quality and Environmental Security** cluster focuses on analysing and evaluating climate and human-

induced environmental impacts on water resources systems (like catchment flows and water quality, lakes and wetlands and coastal waters), with respect to climatic boundary conditions (e.g. changing precipitation, temperature, extremes, etc.) and human impacts (water resource use and land use). An emphasis is laid on assessment, monitoring and assimilation of water quality and aquatic biogeochemical variables and ecosystems using EO products and model predictions. 4) the **Water Cycle and Climate Change** cluster aims at advancing our understanding of the water and energy cycle and their interactions with climate, ecosystem and human activities. We focus on understanding the coupling between the terrestrial and atmospheric branches of the water and energy cycle, and how this coupling may influence climate variability and predictability through observation and modelling of the land - atmosphere exchanges of water and energy and applications in water resources management under climate change.

In terms of supervision and graduation of PhD students, WRS will continue its successful strategy in promoting high quality research by publishing high quality papers in disciplinary journals. Each qualified staff is expected to supervise 3~5 PhD candidates in his/her research domain, so that a maximum of 40 PhD candidates can be accommodated. Research topics and projects will be clustered around the four thematic areas and with emphasis on areas where we have good research and educational infrastructure, in particular the ITC GEO Earth Observation Research and Education sites.

A concerted effort will be developing a (virtual) satellite mission for observation of the water cycle at all relevant spatiotemporal scales of interest for water resources and environmental management. From a methodological point of view, research strategy will address the following issues:

- improving the quality of RS products by improving consistency in time series and amongst various products by modelling, and by sensor independence,
- Improve process understanding by: i) developing approaches integrating earth observation with groundbased measurements; ii) integrated hydrological modeling, and iii) data assimilation
- Use research outcomes in education and in various application studies (also to attract projects)
- Communicate internally and collaborate internationally.

3. WRS Education

The attention for Water in the 'development arena' has continuously increased in recent years. DGIS has stated in their policy a strong emphasis on water and food security with a selected number of countries where "water" will be the focus. Also other donors focus more and more on

water and food as target areas. The Water Partnership Program of the World Bank[9] is embarking on a new global initiative that promotes the mainstreaming of remote sensing technologies in water resources management and have stated "*The World Bank places Water Resources Management at the center of its efforts to help countries adapt to and mitigate the effects of climate change*".

The UT has expressed that for the coming years an additional effort will be put on "internationalization" and the development of 'blended learning'.

Our educational activities will focus on **transferring new knowledge in satellite hydrology for solving society's problems in water resources and environment,** using the knowledge generated in our research activities.

The department will develop further initiatives to broaden the base for student enrolment in the MSc course. Besides paying attention to NFP scholarships, other funding sources including World Bank, JEPs (e.g. the Capital Normal University, and Chang'an University in China), Erasmus Mundus and the UTS for excellent students will be further explored. We will strive for an annual intake of 30~40 MSc students.

Since the large majority of students indicated that the EO and GIS domain has attracted them to come to ITC, we will continue to introduce students to the benefits of EO and GIS for Water Resources assessment and monitoring.

Given the fluctuating number of students for the three specializations, an investigation will be conducted to seek to have a different structure of specialisations in Hydrology and Water Resources, and Environmental Hydrology.

In the Water Resources and Environmental Management (WREM) MSC course the spato-temporal dynamics of the major water cycle components have a central role. The quantification and monitoring of the water cycle components are presented. Since the principles of measurement and monitoring of water cycle components are universal, the taught modules do not have a specific geographical focus. Case-studies and data-sets from 'real-life' are presented throughout the course. The link to agriculture is mainly present via the analyses of precipitation, evapotranspiration, soil moisture and drought occurrences and should be made more explicit for water use and food security.

Efforts will be made to improve the link between Research and Education activities by regularly updating the MSc syllabus and aligning MSc research topics to research and PhD projects.

The education strategy and the related activities led by WRS are aimed in line with the priorities as expressed here above. The education strategy will aim at:

- strengthening the EO - ICT base of the WRS education portfolio,
- enhancing the flexibility in delivery mode of the education portfolio,

[9] http://water.worldbank.org/node/84263

- broadening of the enrolment base of the MSc course,
- maintaining the internationally recognized lead position in capacity building in the field of EO for WRM.

In order to achieve the above the following activities will be undertaken in the coming years:

1. Satellite data coming from ESA's Sentinel fleet provide a wealth of freely available images for a.o. water managers (and researchers). Case studies based on Sentinels will be developed and introduced in the MSc teaching modules and MSc research activities. These teaching materials could be a good selling-point towards ESA and other organizations.
2. An additional effort will be made to develop distance learning and e-learning packages etc. for various topics taught in the regular MSc program. A start has already been made to 'translate' WREM teaching elements into stand-alone DE-packages. A mechanism needs to be developed at the faculty level to provide exemption for those who have successfully participated in these DE-modules. The separate elements can be easily packaged in capacity building projects.
3. Stronger linkages between PhD researches and the MSc course will be made. This will result in a stronger research base of the MSc research part and brings MSc research closer to recent advances in the scientific field.
4. The WREM will be continuously updated with more emphasis on ICT and we will contribute more to ITC-wide educational efforts such as the UT-minor and the new initial MSc.
5. The enrolment base of the WREM course can be broadened by linking the MSc course to other related programmes at universities abroad. The requirement is that the partner has a strong BSc programme in water resources and attracts potential students for joint education. Partners in different countries, India[10] and China[11] and other regions could be approached after consultation with ITC management. Another approach will be to enter into multi-year agreements (with attractive fees) with Ministries of Water for participation of their employees in MSc courses/short courses.

4. WRS Project Strategy

Externally funded projects can be divided into three categories:

- research projects – 2nd/3rd funding stream
- innovation and knowledge valorization projects
- capacity development projects

[10] Sam Higginbottom Institute of Agriculture Technology and Sciences (SHIATS) in India, China Three Gorges University and universities in Kazkastan, Panama, etc.

We will further strive for a well-balanced and ambitious WRS project portfolio. Fortunately, the agenda's for WRS externally funded projects are multiple, which offers a broad array of funding opportunities. To mention just a few

- MinBuza: Ploumen/PvW/NSO-G4AW/Nuffic
- NWO
- Topsector water
- STW
- ESA
- H2020
- WB/ADB/AfDB

MinBuza

Under minister Ploumen new funding modalities have been launched that are interesting for ITC/WRS, especially in the area of water and food security: G4AW, FDW, WaterOS, among others. Also a new programme will be introduced as follow-up from Partner for Water (III). These opportunities are particularly interesting for innovation and knowledge valorization projects.

NWO

Within the NWO theme Water and Climate, research is being done into areas such as the fundamental principles underlying extreme weather, flood security, fresh water supply, changing ecosystems and climate predictability.

Topsector water

Here the focus is mainly on innovation with involvement of private sector including SMEs. There is a strong connection between the Topsector water agenda and NWO funding opportunities, example is the NWO call: Urbanizing Delta's of the world.

STW

Technology Foundation STW focuses on knowledge transfer between the technical sciences and users of research results. The foundation funds top scientific and technical research through a range of grants. Researchers and users collaborate in each project.

ESA

Continuing innovation in exploratory satellite missions is the essential starting point of the delivery and value chains. Scientific and societal issues demand, in addition, an earth system science approach, which necessitates an integrated EO capability in an optimally designed end-to-end system.

H2020

Priorities are digital security, smart cities, energy efficiency, low-carbon energy, blue growth and food security. Several funding instruments are relevant.

WB/ADB/AfDB

Priorities are training/capacity building projects.

General trends in funding programmes

Water and climate

The United Nations Climate Change Conference, COP21 or CMP11 will be held in Paris, France in 2015. This will be the 21st yearly session of the Conference of the Parties (COP 21) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the 11th session of the Meeting of the Parties (CMP 11) to the 1997 Kyoto Protocol. The conference objective is to achieve a legally binding and universal agreement on climate, from all the nations of the world. It is expected that a new Protocol will release funds for climate adaptation and mitigation in the order of 100 billion USD per year.

Currently the Climate Investment Funds (CIF) managed by the World Bank and the regional banks, include four key programs that help 63 developing countries pilot low-emissions and climate resilient development (seed money 7.5 billion USD).

So increased spending on climate change is an important trend for WRS. Main contribution will be support for developing climate services.

Research and innovation

For a couple of years, bringing research and innovation closer together has become a slogan for funding research. This means that research is defined and carried out with (representatives of) sector organizations and (end) users of innovation products. For WRS staff this means that we

have to work more with a vision on the whole EO value chain in developing research (proposals).

We will closely follow and support the ITC policy in innovation and entrepreneurial activities in dealing with products, services and apps.

Water as a transversal theme

There is an increasing interest in the funding – researchers community to shift from traditional water resources management to integrated themes like water and food security, the water-food-energy nexus, water and climate change, water security and ecosystem services. This trend requires that it becomes increasingly more important that research proposals will be prepared starting from more integrated questions (with societal relevance).

5. Human Resources Management

Human capital is the foundation of our department. A motivated and well-balanced staff formation is most critical to the success of our mission and vision. Due to the retirement of staff in the coming years (e.g. the professor of advanced earth observation for water resources applications), successors will be recruited in accordance with the research domains of the department. Tenure track and other staff vacancies will be defined in accordance with our long term vision.

We will continue the successful management strategy as practiced in the previous WRS strategic planning period, i.e. a personal planning will be established and the realisation will be monitored periodically with the help of the UT evaluation mechanism (UFO & FJUT). For each scientific staff, a clear expectation and accountability will be established, such that the career development of each staff can be guided in a quantifiable manner. An equal opportunity will be continuously pursued for each staff and in turn each staff is expected to take a corresponding share of the total responsibility. WRS is and will be a place for each staff member to utilise his/her own talent. The job/function description of the UFO system is the main strategic guideline and criterion for evaluation and promotion of each staff member.

The actual staff composition of our scientific staff is of a high standard in terms of academic training and expertise, which must be guaranteed in the coming planning period. It is expected that 40% of our staff capacity will be allocated to knowledge creation by means of research projects and PhD supervision, 40% on knowledge transfer (educational activities) and the rest for demand driven projects and supports.

We will cope with the dynamic nature of our activities in research, education and project activities by means of temporary appointments (including visiting staff from collaborative institutes) driven by demands.

Further, consistent with the stated objecives, PhD researchers, postdocs and visiting scientists will be accommodated when the activities fit into the research activities of our department. For

each case, a clearly defined plan in terms of anticipated activities and scientific outputs must be established and periodically monitored and evaluated.

Each staff is expected to assume own responsibility in research, education, projects and representation of the department in networking. WRS management will monitor and coordinate these activities. A merit based competitive system practiced in the past years will be maintained in staff promotion and staff recruitments. Non-performing staff will be helped to seek a better and more fitting opportunity (including change of UFO profile).

6. Research and educational infrastructure

In order to realise our strategic vision and to be able to participate in an ever competitive national and international network of research, it is vital to establish and maintain research and educational field research sites, as has been proven in previous strategic planning period (2005-2014). Costs for additional instrumentations and maintanance will be covered by externally funded projects as far as possible, but need to be guaranteered as basic strategic investment.

We will continue our efforts in setting up ITC GEO Earth Observation Research and Education sites. 1) The set-up of the Twente site will focus in the city of Enschede for urban water cycle and climate observation in order to be able to address the impacts and vulnerability of cities under increased population and climate change (e.g. increased UHI, urban energy balance, changes in urban hydroclimate, extremes in water disasters and water management, etc.); 2) the Speulderbos forest site will be continuously operated and as much as possible exploited for acquisition of external research projects; 3) the Tibetan plateau sites will be continuously operated for Asian monsoon and water resources research in collaboration with the Chinese Academy of Sciences, where we have put in operation three regional soil moisture and soil temperature monitoring networks in east, west and north Tibetan plateau for calibration and validation of satellite soil moisture and soil temperature products (e.g. as SMOS, SMAP core cal/val sites); 4) the existing Sardon monitoring site near Salamanca in Spain will be supported for ongoing PhD research and MSc field works; 5) the Rift Valley Naivasha site in Kenya will be consolidated and extended for African monsoon and water resources monitoring studies. Completion, upgrading and establishment of additional instrumentation and database will be continued.

WRS maintains the ITC MSG GEONETcast facility and continues efforts in developing applications and training packages. This facility has proven beneficial in several PhD, MSc researches and capacity building projects. Further development needs to be continued.

High Performing Computation (HPC) needs further attention. The upgraded “Supercomputer” Linux station X50 has been used intensively for running several high end radiative transfer codes and modeling systems in several research and PhD projects. This system needs to be further enhanced and upgraded to stay in step with the newest development. The access to the supercomputing facility of the Netherlands National Computing Facilities Foundation (NWO-NCF) SARA HPC and networking services and the new European HPC PRACE needs to be secured for modeling and data assimilation and the generation of global products for water resources.

These efforts will be strengthened by the use of the ECMWF (European Centre for Medium-range Weather Forecast) HPC facility and possibly cloud computing.

7. Collaboration and Networking

WRS is a formal member of the Netherlands Water Partnership, National Ground Water Association, the International Association of Hydrogeologists, Boussinesq Centre for Hydrology and Twente Water Centre for Water Engineering and Governance.

Many staffs are active members of various national and international scientific and professional societies (EGU, AGU, IEEE, IAHS, etc.) in personal capacity, participating in various international symposia, meetings and workshops. Several WRS staffs have continued to serve as editors and reviewers for scientific journals and funding agencies. We will continue to co-organize sessions and meetings, and contribute to topical conferences and symposia.

These networking activities are becoming more and more important in project acquisition and student recruitments and will be promoted and supported continuously.

We will further strengthen our contributions and networks with GEO/GEOSS, collaboration with ESA and EUMETSAT as well as other capacity building organizations, such as CapNET, WaterNet and COSPAR.

New MoU's will be developed with other partners to share our curriculum in the forms of JEP and other intake modalities, e.g. with SHIATS in India, and universities in Panama, and others.

In realizing our objectives we will further strengthen our European dimension by increased collaboration with European institutes and stakeholders. Additionally focused activities will be exploited with the World Bank for training and projects in Africa. Collaborations will be sorted with engineering bureaus (SMEs) and water authorities for application oriented projects. Dedicated efforts will be made to establish closer national collaborations with KNMI and other institutes.