GMES and Africa 'Water Resources Management' Implementation Plan[1]

According to the Water Atlas produced by UNDP (2010) Africa has an average annual rainfall of 673 mm/year and can therefore be classified as the world's second-driest continent after Australia, and had in 2010 a human population of about 1,022 million (UNFPA estimate) or 15% of the global population. This continent has 9% of global renewable water resources that are either abundant or scarce depending on the season or the place. Furthermore, water is a crucial element in ensuring livelihoods since more than 40% of Africa's population lives in arid, semi-arid and dry sub-humid areas and about 60% live in rural areas and depend mainly on rain-fed agriculture for their livelihoods.

1. Need s

Africa's Water Resources Management challenges arise from the need to provide safe drinking water and adequate sanitation in order to meet the Millennium Development Goals, cooperating in managing transboundary river basins, improving use of water for food security, developing hydropower, satisfying the growing water demand for the various uses of water (e.g. industrial, mining, agriculture, navigation, recreation, etc.), preventing land degradation and water pollution, managing water under climate variability, and enhancing the capacity to address these Water Resources Management challenges. An additional challenge relates to the need to provide (early warning) information regarding the onset and duration of rainy seasons, intra-seasonal dry spells, and rainfall anomalies due to climate variability.

One of the major constraints for improving Water Resources Management so as to overcome the above challenges is the lack of adequate data that accurately captures the spatial and temporal variability of available water and the demand for water. Lack of data is due to hydro-meteorological networks of *in-situ* observations not adequately covering river basins and aquifers, inadequate funding for the expansion and maintenance of these networks, poorly developed data archiving, processing and dissemination systems. Developments in earth observation provide opportunities for quantifying components of the water cycle and the various uses of water, and thus enable provision of much needed data for Water Resources Management. However, most African countries currently lack technical, institutional and human capacities for acquiring earth observation data and deriving products for water resources management. Thus the opportunities provided by earth observation are currently not being effectively utilized.

2. Existing Initiatives

There are several completed, on-going or planned long term programmes and initiatives in Africa using EO technology for Water Resources Management. Next to the more global programmes like GEWEX, the on-going PUMA-AMESD-MESA programme and TIGER Africa Initiative typify African - European cooperation in water resource management applications using space technology and are continental in scale, operational in nature, and thus relevant to and can be used as a baseline for *GMES and Africa.* Other programmes are starting to take shape like the GEO 'African Water Cycle Coordination Initiative' (AfWCCI) and AfriGEOSS or as follow-up from the Rio+20 process, like the objective expressed to have drought policies and drought preparedness plans implemented in all drought prone regions/countries by 2020. EO data is instrumental here as well, e.g. as a monitoring instrument. The 'International Charter Space and Major Disasters' is another example. All these programmes are benefitting from satellite missions, such as the Sentinel satellites intending to provide open and free operational observations over the next 20 years. African Space Agencies (e.g. Algeria, Egypt, Nigeria, South Africa), regional and national remote sensing centres are already providing data and products derived from earth observation which are relevant for Water Resources Management.

The national networks for *in-situ* observation of components of the water cycle remain the backbone for provision of water information and are necessary for validation of products derived from EO sensors. Several initiatives are on-going to improve these networks, like those under the WHYCOS umbrella, complementing national efforts to provide information on Water Resources Management. Water resources are inextricably linked to climate, and climate variability and climate change have serious implications for water resources availability in Africa. The development of appropriate

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adaptation and mitigation strategies requires hydrological data and information. Earth Observation technology makes a major contribution to eliminating the gaps in the availability of water resources information in Africa. Within *GMES and Africa* Water Thematic Area, beneficial synergies need to be created with the Climate for Development in Africa Programme (ClimDevAfrica) spearheaded by the African Union Commission, and the new Climate Regional Implementation Centre proposed under MESA, to be implementation by ACMAD. Together with the NMHS's, these authorities should take the lead to assemble long term climatological data sets and the derived (re-analysed) climatologies, preferably on the water theme related Essential Climate Variables, in line with the Global Framework for Climate Services.

3. Gaps

Based on the experiences gained and lessons learned related to support service development in Africa, several general blocking factors and gaps have been identified that need to be addressed by the *GMES and Africa* process in order to ensure successful development and implementation of sustainable operational services utilizing Earth Observation derived data. Firstly special attention has to be given to general institutional, technical and human blockages. Furthermore *GMES and Africa* should build upon existing programmes and implementation models with the long-term target for developing an end-to-end African ownership of the full service chain, allowing for the long-term sustainability, institutional and user acceptance of the GMES process. A prerequisite for sustainable uptake of EO data in Africa is full, free and open data access to satellite observations and derived products. This open access is currently limited due to the available infrastructure, e.g. large data volumes and low internet bandwidth. Overall, the water related service gaps to be addressed are:

- Ensuring that all of the African water challenges are ultimately fully covered:
  - at national, transboundary, regional and continental scales;
  - acquisition and use of *in-situ*, EO data and their utilization.
- Translating science into operational services:
  - having the capacity to develop products relevant to water resource problems at various scales;
  - dissemination of (validated) products derived from EO data in a manner that is readily accessible to the users.
- Capacity development programmes addressing continental and regional needs in such a manner that all countries have similar opportunities to develop the capacity which will enable them to participate in utilizing EO data and sharing information at regional and continental scales.

Results achieved using Earth Observation for Water Resources Management in existing initiatives should be included in building the *GMES and Africa* Water Service and based on the gaps indicated above these should be complemented. For the *GMES and Africa Water Service*, a strong effort should also be dedicated to enhancing permanent *in-situ* network infrastructures allowing data to be regularly collected, harmonised, standardized, and structured in accessible and interoperable databases. Attention should be given to the distribution of data from the *in situ* network in near-real time as well. This is critical in order to develop and validate effective operational (near real-time) services that integrate both EO and *in situ* data in a scientifically sound manner.

4. Suggested priority products and services

On the basis of technical considerations the setting up of an operational observation and information programme for water in Africa requires dedication of significant resources to further consolidate, develop and validate a solid portfolio of scientifically sound information services based on the results of existing initiatives, projects and programmes in Africa and Europe. Full data access to and the synergistic use of EO data, *in situ* networks and appropriate model outputs should be given special attention.

National Meteorological and Hydrological Services (NMHS) play a critical role with regards to maintaining and coordinating the network of *in-situ* observations, maintenance of long term data archives based on these observations, developing and disseminating usable products from these data, and provision of early warning information. Other relevant national and regional authorities are

dealing with renewable energy (hydropower), agricultural production, land and soil conservation, water supply, water quality management, water-related diseases (and health), and those which are part of institutional frameworks for Water Resource Management implementation. All these organizations collectively represent the *GMES and Africa* Water Theme Stakeholder Group and will make use of the products and services provided.

The *GMES and Africa* water service should be: (i) Pan-African, (ii) utilizing EO data from space agencies, (iii) comprehensive such that end-to-end services are provided with value-added products, (iv) build on existing (research) programmes, (v) maintained and operated by Africans (through further strengthening of African capacity), (vi) linked with national, regional and continental governance schemes and ensure effective consultation with all stakeholders involved, (vii) equipped with sufficient and continuous funding to achieve sustainable operation of the service.

It is important to aim for attainable results, with a clear and sound work plan for generation of usable products that are appropriately documented, including calibration/validation information and therefore the following set of products is prioritized:

- At Continental scale: a core set of continental scale products covering different components of the water cycle;
- At Regional (trans-boundary river basins) and National scale:
    - Relevant water resources base mapping and basin / catchment characterization
    - Ephemeral water bodies identification and monitoring and support to groundwater management in general;
    - Early warning and outlooks.

The core Continental scale products should first focus on precipitation and (potential) evapotranspiration at a number of spatial and temporal scales. Already basic satellite derived products are available but these require more thorough (near real time) local calibration and validation. First these existing products have to be harmonized in format, temporal resolution, etc. and can then be gradually improved through the integration with more *in situ* observations and made available at more detailed (spatial and temporal) resolutions. Additionally, structured provision of basic hydro-meteorological data and selected short range forecasting products are having a high priority as well. Appropriate data archiving, processing and dissemination systems have to be put in place for provision of these basic hydro-meteorological data sets. The nowcasting or short range forecasting information can be provided through real-time unrestricted access to global and regional climatological model output on a number of selected parameters (including rainfall) and temporal forecasting intervals. This information is currently already operationally provided by a number of forecasting centres but a system should be put in place to ingest this nowcasting and short range forecasting information in an appropriate manner for water resources related decision making by the various stake holders, and not only for - or limited to the weather services.

Information on other components of the water cycle can gradually be integrated as well through incorporation of continental services developed under MESA, like the one related to lake and river levels. Next through collaboration with certain data providers further (local) improvement of their products can be achieved through integration of relevant *in situ* information. The already existing soil moisture and soil water index products are suitable candidates. Last but not least, mature processing routines, applied within another service can be adapted to provide new products for the Water Resources Management service, like adaptation of algorithms developed and operationally used in the Marine Service but now to provide information about the water quality of inland water bodies.

At Regional (trans-boundary river basins) and National scale more detailed base mapping is required, firstly to cover the needs for further infrastructure development to support expansion of water supply and sanitation schemes. Secondly, detailed physical catchment, aquifer and basin characterization is required in support of modelling. This includes extraction of the hydrological networks and (intermittent) water bodies, provision of longer term gauge observations, but also elevation information at required vertical resolutions, stream cross sections and longitudinal profiles, more (time series) information on precipitation and stream discharge, just to mention the most important ones. These data sets, in conjunction with additional land cover information, to be provided through the Natural Resources Management Service, is required by the regional basin authorities and national hydrological services to appropriately parameterize their models at different scales, from regional basin to national (sub-) catchment scales and allowing them to apply different model time steps. In

addition to this, for assessment of the ground water resources, additional information is required on the ground water levels, abstraction rates, monitoring of ephemeral lakes, streams and recharge areas. None of the above mentioned data layers are readily available within the regions / countries. Various organizations do have partial information at their disposal but currently are not providing all the required physical-terrain and time series information needed to facilitate efficient parameterization of relevant models.

Early warning and medium range to seasonal outlooks should provide the water stakeholders with advanced information needed as a basis for planning and informed decision making. Early warning systems with respect to flood or drought occurrences are being developed or operational in a few regions but need to be implemented at a much larger scale. Same holds true with respect to medium range or seasonal outlooks.

All in all it can be concluded that rudimentary information with respect to Water Resources Management for Africa is available but it does not provide the full picture to address the current water challenges. The *GMES and Africa* Water Service should fill these gaps and enable the various stakeholders to acquire water related information in a readily manner. To implement operational information services involving EO technology, *in situ* observations and models is a complex process. The European EO programme 'Copernicus' is an example on how the water service can further be defined, developed and implemented at continental scale involving multiple partners and institutions at different political, technical and institutional levels. The following key points for implementation are critical for the success of the *GMES and Africa* water thematic area:

- AMCOW, being the institution of the AU mandated to provide political leadership over water issues in Africa, the regional economic communities and transboundary river basin organizations need to commit themselves to owning and supporting implementation of the *GMES and Africa* Water Theme Service. Suitable mechanisms should be established in order to enhance the dialogue with different actors in the *GMES and Africa* Water Theme Stakeholder Group;
- *GMES and Africa* is an African driven process aimed at establishing long-term sustainable information services in Africa and addressing African priorities and needs. In this context, governance of *GMES and* Africa should ensure that African institutions retain the programmatic leadership and ownership including ensuring sustainability of collection of data, development of products and their dissemination from both *in-situ* networks and EO;
- GMES data policy should enable free access to data by African institutions providing *GMES and Africa* services. More (GEONETCast) ground receiving stations covering Africa should be established at various African Regional Centres to enable use of EO data from (weather) satellites, to provide real time image coverage and the derived key (meteorological) products, as well as the use of telecommunication based dissemination techniques for provision of products generated by the *GMES and Africa* Service. Observational infrastructure and network integration will be another key feature to achieve operational sustainability of *GMES and Africa* water service.

Although *GMES and Africa* is a continental initiative, the major drivers with regards to collection, processing and development of usable products for water resources management will be the respective regional organizations such as transboundary river basin organizations and national agencies. These organizations and agencies have to be effectively involved in the services, and development of technical and human capacities among them for providing these services. The sustainability of *GMES and Africa* will greatly depend on the effective involvement of these organizations and agencies.

5. Timeline

The following three phase implementation strategy is recommended:

Consolidation period (minimum of 1 year): aimed at fully developing, validating and consolidating an initial set of services on the basis of existing initiatives, projects and programmes in Africa and elsewhere. In this context, to successfully define sustainable and fully accepted GMES services for the African water sector, a number of key issues should be taken into consideration:

- Formulation of plans for developing technical and human capacity for implementing

GMES and Africa Water Theme. Refinement of needs will involve close consultation process with water stakeholders at national and transboundary levels under the leadership of AMCOW;

- The service definition should ensure that different characteristics, conditions and requirements of different institutions and regions are taken into consideration and builds on already achieved relevant efforts. A one-size-fits-all approach will not work: e.g. water scarcity is a problem in certain areas of Africa and not in others;
- Suitable service models should be developed depending on regional and national existing institutional set- up and partnerships and are adjusted to their needs.

Scaling up period (3 years): On the basis of the results achieved during the consolidation period, prioritized services should be further developed and scaled up (extending the user base together with further development of African capacity to operate and run the selected services). This will also involve additional capacity building and institutional development efforts in order to build a solid basis to establish operational and sustainable services.

Implementation Period (4 years): In this phase, services will be implemented and run in an operational manner for the priority services. During this period efforts are also required to put in place additional services which have not received highest priority but are required to complement the needed information for the *GMES and Africa* Water Resources Management Service.

The result should be that after about 8 years a mature – consolidated *GMES and Africa* Water Resources Management Service has been firmly established, providing the required information and products needed by the water stakeholders to address and assist in overcoming the current water related challenges at various scales.