WATER RESOURCES MANAGEMENT

EXPERTS
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1. INTRODUCTION

1.1. THEMATIC CONTEXT

Africa which has an average annual rainfall of 673 mm/year is 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]. Africa faces significant challenges to ensure effective use and efficient management of its water resources:

- The multiplicity of transboundary river basins with different physical characteristics in Africa poses a challenge for ensuring equitable sharing and development of water resources among riparian states[2]. There are about 60 transboundary river basins covering about 65% of the continent, and 40 transboundary aquifers. Groundwater is estimated to be the source of drinking water for 75% of the population in Africa[3]. There is very little information about the spatio-temporal variability of both surface and groundwater resources due to poorly developed hydro-meteorological observation networks;
- There is low level of development and water utilization. For instance, only about 4% of the available water is used in the whole continent. In the case of irrigated areas, the actual use amounts to less than 10% of the potential, and only 7% of the hydropower potential has been developed, with an electrification gap that keeps growing[4]. High inefficiencies including considerable unaccounted for water in the various uses of water result in a small proportion of the developed water resources being used productively;
- Africa has a very low level of development of the water (harvesting) infrastructure with less than 50 m^3/person storage capacity having been developed compared to over 3000 m^3/person in Europe and 5000 m^3/person in the USA;
- Most African countries will not achieve the Millennium Development Goals (MDGs) related to the provision of safe drinking water and basic sanitation by 2015[5]. Based on the 1990 estimates of the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP), in order for Africa to achieve these MDGs, the population with access to improved water supply and sanitation will have to increase to 78% and 68% respectively[6]. However, the JMP estimated that 66% and 40% of the African

[1] UNEP (2010): Africa Water Atlas. Division of Early Warning and Assessment (DEWA), United Nations Environment Programme (UNEP), Nairobi, Kenya.
[2] World Economic Forum (2013): Global Risk Report. The report states that "Impact and likelihood of water supply crisis has been ranked within the 'top-5' of global risks".
[3] UN-Water/Africa (2006) African Water Development Report 2006. Economic Commission for Africa, Addis Ababa, Ethiopia.
[4] African Water Facility (2012): Strategic Plan 2012-2016. Towards water for all by 2025.
[5] http://www.un.org/millenniumgoals/pdf/2012_Progress_E.pdf
[6] AMCOW (2012) A Snapshot of Drinking Water and Sanitation in Africa – 2012 Update. A regional perspective based on new data from the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation.
http://www.wssinfo.org/fileadmin/user_upload/resources/Africa-AMCOW-Snapshot-2012-English-Final.pdf

population had access to improved water supply and sanitation in 2010, suggesting that attaining the relevant targets seems impossible;

- There is a rapid increase in the demand for water due to growing populations with an average annual population growth during the 1990-2010 period being 2.4%[7], rapid economic growth in some countries arising from expanding mining, industrial and agricultural activities, and improvement of lifestyles. It is estimated that by 2025 about 600 million people will be exposed to water scarcity situation (<1000 m^3/capita/year) (African Water Facility, 2012). This is further aggravated by pollution of surface waters and shallow aquifers caused by poor solid waste and wastewater management in urban areas, and contamination from agricultural activities in rural areas;
- The semi-arid and arid parts which cover 66% of Africa receive precipitation with high inter-annual variability causing the availability of water to be very unreliable. The high inter-annual variability also results in frequent water-related disasters such as floods and droughts and adverse effects on health;
- Climate change has the potential to exacerbate existing adverse effects of climate variability resulting in reductions of water resources in some parts of Africa;
- Conservation of natural resources needs to protect the ecosystems and prevent degradation of these resources including water. Land degradation which affects many parts of Africa particularly the semi-arid and arid regions adversely affects both the quantity and quality of water resources;
- Most African countries have inadequate institutional, financial and human capacities for managing water resources;
- Lack of policy and strategies in some African countries for utilizing data derived from earth observation as compliment to scare field observed data is a constraint for developing human and technical capacities for using these data for monitoring and managing water resources.

In this complex and challenging context, adequate information for sustainable management of water resources is fundamental for improving water governance and successful implementation of Integrated Water Resource Management (IWRM) strategies. For most African countries, policies and management decisions are often based on sparse and unreliable information[8], which is a major limitation for achieving the water-related MDGs and putting into practice IWRM plans. Despite these challenges, there are positive developments in Africa that provide opportunities for improving water resources management. Some of these positive developments include the following:

- The commitment at the highest level as expressed through the 2004 '*Sirte Declaration*' to implementation of integrated water resources management strategies and improving access to safe drinking water and sanitation. Formulation and implementation of integrated water resources management policies by regional economic communities, e.g. ECOWAS, SADC;
- Improvement of water sector policies, legislation and institutions in most African countries provides a framework for sustainable water resources management;
- Establishment of functional transboundary river basin organizations provides a framework for collaboration in the implementation of sustainable water resources management plans including collection and sharing of data among riparian states;
- The on-going expansion of the higher education sector provides a basis for developing the human capacity for improved water resources management including the use of EO data;
- Rapid improvement in communication brought about by mobile phones provides a mechanism for dissemination of early warning information for managing water resources including water-related disasters. The penetration of mobile phones in sub-Saharan Africa was estimated to be 57% in 2012 and will grow to 75% by 2016[9];
- The establishment of space agencies in some countries (e.g. Algeria, Egypt, Nigeria, South Africa), and several regional and national remote sensing training and research centres in Africa is a strong indication of the realization that data derived from earth observation has a vital role in managing resources including water.

[7] http://unstats.un.org/unsd/demographic/products/dyb/dyb2011.htm

[8] Jerven, M. (2013): Poor Numbers. How we are misled by African development statistics and what to do about it. Cornell University Press. ISBN 978-0-8014-5163-8.

[9] Rao, M. 2012 Mobile Africa Report 2012. Sustainable innovation ecosystems. Mobile Monday http://www.mobilemonday.net/reports/MobileAfrica_2012.pdf

1.2. PRESSURES OR CONSTRAINTS

African leaders have committed to the implementation of an Integrated Water Resources Management (IWRM) approach in order to achieve sustainable management and development of Africa's water resources. Although progress has been made, a great deal of work still needs to be carried out in order to strengthen and create an enabling environment[10] for water resources management. For most countries, appropriate policies, laws and plans for IWRM implementation are in the early stages of being put into practice except for some North African countries[11]. Virtual water use and assessment of water footprint of various water using activities are other issues that need to be included in planning and implementation of IWRM.

The provision of data required for IWRM implementation is a major challenge due to poorly developed and/or deteriorating systems for collecting relevant data for assessing the spatial and temporal variability of both surface water and groundwater. Consequently policies and management decisions are based on unreliable information resulting in ineffective and unsustainable management of water resources. Without adequate data for planning and managing water resources, competition and conflicts over these resources are not effectively and efficiently resolved. Furthermore effects of human activities including water resources development on surface and groundwater water are often poorly understood. Groundwater use is largely uncontrolled leading in some cases to unsustainable utilization of this resource. Overcoming these challenges arising from inadequate and unreliable data is hampered by inadequate funding for monitoring at the national level and the reluctance of international funding agencies to provide long-term support for maintaining (*in-situ*) observation networks[12]. Without urgent action to increase the availability of water resources information on a sustainable basis, implementation of IWRM and achieving the Africa Water Vision - 2025 will remain unattainable for a large number of African countries. Efficient management of competition and conflicts over water requires data for quantifying the various components of the water cycle including water quality, and the rates of water use.

GMES and Africa provides an opportunity for the participation of African countries in the rapidly evolving global 'Earth Observing System', (e.g., Global Earth Observation System of Systems, Sentinel series of the European Space Agency and the European Commission, national contributing missions, etc.). This participation will enable collection, analysis and dissemination of water-related information, in a cost effective and sustainable way.

2. POLICY DRIVERS AND NEED ANALYSIS

2.1. POLICY DRIVERS

The *Africa Water Vision for 2025*[13] endorsed by the African Ministerial Conference on Water (AMCOW) and by the Heads of States of the African Union during the February 2004 Extraordinary Summit on Water and Agriculture in Sirte, Libya, serves as a basis for formulating long-term national, sub-regional and regional policies and programmes for equitable and sustainable use of water for socio-economic development on the continent. The framework for achieving this shared water vision[14] calls for strengthening governance of water resources, and developing the capacity for collecting and disseminating information about water resources. Since water is intricately intertwined with agricultural production and energy generation in Africa, effective and efficient management of water resources is critical to these activities which are the main drivers of socio-economic development.

The African Union Science and Technology plan[15] which consolidates the science and technology plans of the African Union Commission and NEPAD, places the development, supply and management of water high on the

[10] This involves developing and implementing the policy, planning and legal framework needed for guiding and coordinating water resources management, development and use. Transboundary agreements are an important part of the enabling environment for water management, especially in Africa where most countries share water in transboundary basins.

[11] AMCOW (2012): Status Report on the Application of Integrated Approaches to Water Resources Management in Africa. ISBN: 978-87-90634-01-8.

[12] World Water Council (2003). Camdessus, M. (ed). Report of the World Panel on Financing Water Infrastructure: Financing Water for All.

[13] http://www.uneca.org

[14] The shared Water Vision for Africa is defined as: 'An Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio economic development, regional cooperation, and the environment (Africa Water Vision 2025).

[15] NEPAD Office of Science and Technology (2006): Africa' Science and Technology Consolidated plan of Action. Johannesburg, South Africa.

agenda owing to the fact that water scarcity and related insecurity contribute to the continent's underdevelopment. This plan explicitly identifies scientific assessment of Africa's water resources and systems, research and technologies to assess and monitor water-related disasters, and technologies for improving water quality and quantity as the key water projects to be implemented. The African Water Facility (2012-2016)[16] also includes the development of water resources projects, enhancing water governance, and promotion of water knowledge in the current (realigned) strategic plan.

Table 1 below provides additional recent policy drivers relevant to the *GMES and Africa* Water thematic area besides the Sirte Declaration on Agriculture and Water in Africa, the African Water Vision 2025, and MDGs on Water Supply and Sanitation mentioned before.

Table 1: Policy drivers in Africa relevant for the Water theme

- AU Sharm El- Sheikh Declaration on Water and Sanitation - eThekwini Ministerial Declaration on Sanitation - Declaration on Climate Change in Africa - Tunis Ministerial Declaration on Water Security - Africa – EU Statement on Sanitation - AU guideline on establishing cooperative framework in transboundary basins - AU Abuja action plan - ClimDevAfrica	- AU comprehensive African Agricultural Development Plan (CAADP) - NEPAD Infrastructure Action plan - NEPAD Environmental Action plan - African programme on action on implementation of the African regional strategy on disaster risk reduction - Great Green Wall for the Sahara and the Sahel Initiative - AMCOMET – Global Framework for Climate Services

The *eThekwini* Declaration in February 2008 is a commitment by African Water Ministers to accelerate the attainment of sanitation MDGs. The *Tunis* Declaration in March 2008 adopted during the first African Water week focuses on improving water security for Africa's socio-economic development. The commitments and actions identified under the various declarations have formed the foundation of activities at continental, regional, transboundary and national levels. These activities fall into the following 7 main themes; (i) water infrastructure for economic growth, (ii) managing water resources, (iii) transboundary water resources, (iv) meeting sanitation, hygiene and water MDG gaps, (v) global change and risk management related to climate variability and change, (vi) financing, and (vii) education, knowledge and capacity development. The African Ministerial COnference of METeorology (AMCOMET) is contributing to the achievement of the MDGs in Africa by encouraging the use of meteorological and climatological information and services, linking weather and climate knowledge to disaster risk reduction, developing usable weather and climate products for users at various levels.

From a global perspective as stated in the UN Water's "*4th World Water Development Report*"[17], it is recognized that the absence of systematic data collection in most countries impedes regular reporting on water resources and water-use trends. On the other hand, there is a growing interest in and demand for accurate and consistent water data and accounting. This requires structured data acquisition and subsequent derivation of information about water. This report concludes that little progress has been made in terms of improving observation networks and systems for water resources monitoring. The UN Convention on Non-navigational Uses of International Watercourses calls on countries sharing transboundary river basins to collect and share hydro-meteorological and ecological data to facilitate sustainable utilization of water resources among the riparian states. Other international policy drivers include the United Nations Convention to Combat Desertification and the recent "*Zero Net Land Degradation*" initiative proposed during the Rio+20 Conference. Information about water resources in Africa is also required to complement the international "*Essential Climate Variables*" (ECV's) research agenda.

2.2. THE NEED ANALYSIS

Africa's water 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 global climate change, and enhancing the capacity to address these water 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 arising from the impacts of El Niño and La Niña resulting in floods and droughts.

[16] African Water Facility (2012): Strategic Plan 2012-2016. Monitoring Resources for Water in Africa.

[17] United Nations (2012): World Water Development Report. Chapter 6. Muller, M. (ed): Managing Water under uncertainty and risk, Volume 1.

One of the major constraints for improving water resources management in Africa 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 not being effectively utilized in Africa.

Both the EU and African Union acknowledged the constraints imposed by inadequate data in the formulation and implementation of effective management decisions related to several sectors including water. Consequently, the '*Lisbon Declaration on GMES and Africa*' was adopted in December 2007 under the aegis of the Portuguese Presidency of the Council of the European Union. This Declaration calls for the preparation of an action plan to be submitted to EU and African constituencies. The objectives of *GMES and Africa* water resources management thematic area were therefore agreed as being the following:

1. To enhance African technical, human and institutional capacities to meet the need for timely, quality long term information at national, regional, transboundary and continental scales as a basis for sound decision making, improved Integrated Water Resource Management, and formulation of effective climate change adaptation and mitigation plans;

2. To build upon existing initiatives and programmes, and establish long-term sustainable end-to-end information systems and services for the major national and transboundary river basins in Africa, and thus enable relevant water authorities and water sector stakeholders to fully exploit the global Earth Observing System in collecting, analysing and disseminating water related information in a cost effective and sustainable manner.

Although IWRM encompasses a wide range of issues such as implementation of policies, laws and plans which differ over the African continent, this Chapter covers the generic elements needed for making appropriate information available for sound decision-making related to water resources management.

3. IDENTIFICATION OF STAKEHOLDERS

To achieve the *GMES and Africa* objectives, it is fundamentally important to mobilize resources, expertise and contributions from different sectors at national and international levels in order to improve the collection of relevant information for implementing integrated water management plans. In this context, *GMES and Africa* should foster partnerships between the various national stakeholders, space agencies - other data providers, expert centres in applications using Earth Observation derived data for water management such as universities and international research organizations, the private sector (e.g. value adding companies), relevant NGOs, user government departments and development agencies.

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 bodies in specific transboundary river basin authorities, are those 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 IWRM implementation. All these organizations collectively represent the ***GMES and Africa*** **Water Theme Stakeholder Group**. Appendix 1 categorizes the typical main stakeholder groups. This table is not exhaustive as there are other agencies and organizations (e.g. at national level) with the potential for utilizing *GMES and Africa* services, and also contributing data and products.

4. MAPPING EXERCISE

There are several completed, on-going or planned long term programmes and initiatives in Africa using EO technology for water resource management. 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 model 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 to have drought policies and drought preparedness implemented in all drought prone regions/countries by 2020[18] for which EO data is instrumental, e.g. as a monitoring instrument. The 'International Charter Space and Major Disasters' is another example. Note that all these programmes are benefitting from sensor observations from new satellite missions, such as the Sentinel satellites intending to provide open and free operational observations over the next 20 years. Appendix 2, (not exhaustive) provides an overview of potential information services especially those based on earth observation that have been developed or will be developed in the near future. Further details of these programmes are readily available from the relevant websites.

The national networks for *in-situ* observation of components of the water cycle remain the backbone for the provision of water information, and are necessary for validation of products derived from EO sensors. Several initiatives have been implemented to improve these networks, e.g. HYCOS. Space agencies of African countries (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.

5. IDENTIFICATION OF GAPS AND SUITABLE PROGRAMMES

5.1. GAPS

General. 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. Apart from financial barriers related for instance to high resolution (airborne) image and laser scanning data acquisition, attention has to be given to the following blockages:

- **Institutional blockages**: Many African countries lack appropriate policies and strategies for utilizing earth observation derived information for national planning and management**.** Africa in general has a low investment in research and development, including EO, which constraints the development of relevant products from EO data**.** There is also lack of awareness of (new) EO capabilities and limits; low level of penetration of Information Technology in several African institutions, lack of solid links between users (water authorities) and potential service providers in Africa; lack of effective institutionally established procedures to integrate geo-information into management practices and planning; lack of a solid consolidated group of potential service providers in Africa including technical centres, universities and private sector. Governments still have to register to become members of relevant international bodies, like GEO or the International Charter Space and Major Disasters;

- **Human blockages**: These include lack of skilled scientists and technicians and EO operators because of inadequate training programmes for professional operators, and the high turnover of skilled personnel within some countries and to other countries, lack of skilled personnel in water authorities with a good knowledge of GIS and EO technologies, lack of appropriate training programmes in African higher education institutions providing a critical mass of African professionals in the area of EO applications, and collaboration between centres of expertise in general;

- **Technical blockages:** These include the limit of current EO systems that will be significantly expanded by the advent of new satellites; inadequate *in situ* (telemetric) data infrastructures; lack of full long-term continuity and user-friendly EO data provision and access; inadequate software and hardware infrastructures in African institutions; slow progress in the provision of fast internet connectivity, lack of ground receiving infrastructure over various regions for direct-real time EO data reception and higher order image generation and dissemination; lack of low cost large bandwidth DVB (-S2) based ground receiving stations for near real-time reception of large volume of EO data and products through communication satellites, like those from the various meteorological series of satellites.

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,

[18] UNCCD (2012): Zero Land Degradation, A sustainable development goal for Rio+20.

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, which is currently limited by the available infrastructure, e.g. low internet bandwidth. Overall, the water related service gaps to be addressed are:

- Ensuring that all of the African water challenges are fully covered:
  - at national, transboundary, regional and continental scales;
  - acquisition and use of *in-situ*, EO data and their utilization.
- Translating science into practise:
  - depends on having the capacity to develop products relevant to water resource problems at various scales;
  - requires dissemination of 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.

More specific gaps related to the space based observation needs are presented in the table below.

Table 2: Typical Space-based observation needs

Scale	Identification of Gaps	Dimensions that GMES Africa service would provide
Continental	Lack of (continuous – reliable provision of) a core set of continental scale products covering different components of the water cycle: e.g. Precipitation; Evapotranspiration; Soil moisture; Water quality; Surface and ground water levels; (short / long range) forecasting products.	GMES should ensure the provision and accessibility of these products at continental scale; Capacity building on integration of EO data and *in situ* observations, and developing early warning tools.
Regional (transboundary river basins) and National	National operational observational capability for information services addressing the needs of riparian states and stakeholders on major transboundary river basins e.g.: • Base mapping for supporting infrastructure development (water supply and sanitation); • Irrigation areas, crop mapping; • Ephemeral water bodies; flooding; • Mapping groundwater aquifers; • EIA for hydro power, water diversions and impoundment or other water related engineering – diversion plans.	GMES should support the empowerment of key African institutions at transboundary level that will be able to operate and run information services allowing the observation and monitoring of water resources over major transboundary river basins and lakes in Africa, while offering a coherent service to their riparian countries (e.g. national water authorities) to better exploit and integrate potential GMES African water services into the national planning and decision making activities.
National	Lack of information to assist farmers in decision-making throughout the crop production cycle. IWRM administration and planning; Urban Sanitation	GMES should provide training and support the development, production and dissemination of relevant Earth Observed derived water-related information for assisting farmers in decision-making throughout the crop production cycle, IWRM and sanitation planning.

***In-situ* based observation needs.** Reference has already been made to severely dilapidated or out-dated *in-situ* networks for collection of water-related data in Africa; hence information derived from them is unreliable to (locally) calibrate/validate EO data. Some existing programmes such as WHYCOS facilitate the installation and free exchange of data obtained from several *in-situ* networks to compliment EO based observation and modelling. Additional efforts should be directed to use of other observation infrastructures or techniques, e.g. use of microwave links from telecommunication networks and the potential to derive relevant hydrological parameters, like rainfall or equip existing telecom towers with other sensors to derive wind speed-direction, etc. or use of sensors (eddy correlation, scintillometer) on multiple towers to record fluxes, e.g. to derive evapotranspiration.

For *GMES and Africa* service, a strong effort should 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.

Table 3: Typical In Situ based observation needs

Scale	Identification of Gaps	Dimensions that GMES Africa service would provide
Continental to national	Inappropriate *in-situ* networks for water management and monitoring; *In situ* data is mandatory for calibration / validation of EO based services in Africa; Other observation methods, e.g. use of telecommunication microwave links or GRACE for ground water! Selection of representative cal/val locations, to prepare for new satellite missions: e.g. SWOT - to derive discharge, here other *in situ* data is required like cross section information; - prepare / test new products / algorithms, e.g. for inland water quality estimation linking EO and *in situ* data.	Problem solving: Focus on basin–wide water budget (rainfall and evapo-transpiration), transboundary river discharges, water extraction (information on well depths, piezometric measurements, well density and pumping rate) for aquifer management, water consumption, water-related infrastructure and investments. Scientific collaboration: Involvement in existing and new satellite missions for validation and if needed the development of locally validated algorithms for (new) products.

Gaps related to climate variability - change. 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 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 under MESA, proposed for implementation by ACMAD. Together with the NMHS's, these authorities should take the lead to assemble long term climatological data sets and the derived climatologies, preferably on the water theme related Essential Climate Variables, in line with the Global Framework for Climate Services. Re-analysis might be a point for consideration.

5.2. EXISTING OR PLANNED THEMATIC FUNDING PROGRAMMES

A number of relevant funding programmes, although not exhaustive, are indicated below:

- **European Water Facility:** In 2004, the EU Council decided to consider allocating a total amount of € 500 million for an ACP-EU Water Facility. €200 Million from the 10th European Development Fund (EDF) has been allocated to the Water Facility. Three calls for proposals and the Pooling Mechanism were launched between February 2010 and December 2011. The specific objectives of the 10th Water Facility are:
  - To assist in achieving the water and sanitation Millennium Development Goals (MDGs), which are to halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation, which is a key prerequisite for reducing child and maternal mortality and combating diseases;
  - To contribute to improving governance and management of water resources and the sustainable development and maintenance of water infrastructure.

- **European Development Fund:** The European Development Fund (EDF), funded by the EU Member States, is the main instrument for providing Community Aid for development cooperation with the ACP States and the OCT. The tenth EDF covers the period from 2008 to 2013 and provides funds for national and regional indicative programmes of the ACP countries, including intra-regional cooperation, and to Investment Facilities. An innovation in the tenth EDF is the creation of "incentive amounts" for each country.

- **7th Framework Programme and Horizon 2020:** Research and development programme of the European Union also supports activities related to GMES and service development, GEO and other research on issues like climate change and water (and waste) management, and technology development.

- **African Water Facility:** The African Water Facility (AWF) is an initiative led by the African Ministers' Council on Water (AMCOW) to mobilize resources to finance water resources development activities in Africa through the establishment of the African Water Facility Special Fund. The African Development Bank (AfDB) hosts the Facility at the request of AMCOW. AWF has fast-approval and flexible procedures and can provide support to communities as well as to national and multinational institutions. It is furthermore committed to enhancing water governance and promotion of water knowledge in the current (realigned) strategic plan (2012-2016).

- **Bilateral and multi-lateral funding programmes**, some examples are:
    - UN multi-lateral funds such as through UNICEF related to water and sanitation (in e.g. Ethiopia, Kenya, etc.);
    - Bilateral water sector donor programmes;
    - Programmes by other international (e.g. World Bank) and national development agencies and follow-up funds related to international initiatives, like Rio+20;
    - Collaboration programmes for capacity development such as the funding programmes for WaterNet and Cap-Net (through UNDP).

- **Dedicated programmes** from NGO's, for example WWF is currently funding IWRM programmes in the Southern African region.

- **Regional and national programmes**: Some of the regional economic communities in Africa have developed policies and strategies for IWRM implementation. These strategies include measures to improve human capacity, improvement of the collection, analysis and dissemination of hydrological information. Funds are being mobilized for implementation of these strategies, e.g. SADC Regional Strategic Action Plan on Integrated Water Resources and Development (2011-2015). In additional regional earth observation centres have programmes which can complement *GMES and Africa* Water Theme. Countries with existing space programmes in Africa (e.g. Algeria, Egypt, Nigeria, South Africa), and national remote sensing centres have some funding for increasing use of EO for various applications including water resources management. All the African countries have in place, although not adequate in all cases, funding for maintaining the networks for *in-situ* observation.

6. BUILDING GMES - AFRICA SERVICE

6.1. SERVICE DEFINITION AND PROVISION

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.

Appendix 3 provides a summary of potential operational services that could be the basis for the *GMES and Africa* water component. Some of the services listed have already been demonstrated and validated in several programmes. 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 (e.g. to ensure incorporation of the achievements within AMESD and those foreseen in MESA), (v) maintained and operated by Africans (through further strengthening of African capacity in various African centres of excellence), (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 furthermore important to aim in the first instance for attainable results, with a clear and sound work plan for generation of usable products that are appropriately documented, including calibration/validation information.

Advanced information services which are in the research domain should be considered part of a long-term development process aimed at exploiting in a synergistic manner the assimilation of new EO data (e.g. from Sentinels, CBERS, PROBA-V, Landsat DCM, etc.), in conjunction with *in situ* data and suitable models (e.g. for runoff modelling, flood mapping, soil moisture, water budget calculations, lineament analysis, etc.), but also related to the use of e.g. GRACE for groundwater applications, inland water quality monitoring using higher resolution sensors and applying algorithms initially developed for ocean water to derive inland water quality parameters, river

and lake level determination and calculation of river discharge, etc.

6.2. CAPACITY BUILDING

6.2a. NECESSARY ELEMENTS

Considerable differences in EO data application capacity for the proposed water service exist in Africa with some countries already utilising EO-based systems, while others have rudimentary capacities. A major component of *GMES and Africa* shall therefore be to ensure the development of the required human, technical and institutional capacities to empower African nations to participate effectively in implementing and running the *GMES and Africa* water service in a sustainable manner. This will require a significant effort dedicated to:

- Long-term development of African operators, technicians and scientists with the capabilities to exploit EO technology for IWRM;
- Increasing the technical capacity of potential African service providers (institutions with technical competences, regional centres, remote sensing centres) with the capacity to provide GMES services to water authorities;
- Improving the spatial coverage and reliability of the *in situ* networks that contribute to GMES services;
- Developing an African private sector that provides value added GMES services to African users. This will require a significant effort in terms of subsidising the initial steps in the development process;
- Developing institutional linkages between service providers and water stakeholders that may be the basis for long-term Service Level Agreements;
- Strengthening the capacity of water authorities and water-related service providers to understand, integrate and use GMES services in their management and operational practices, and thus ensuring clear short-term impacts in the field;
- Improving the provision of water-related information at various political levels for sound decision making.

6.2b. STRATEGY

These efforts need to build on the experiences of existing initiatives and capacity building efforts carried out by different institutions (developing agencies) and programmes (e.g. TIGER Capacity Building Facility, AMESD-MESA, WHYCOS, etc.) and take into account key African players already involved in capacity building activities in the water sector (e.g. regional technical centres such as RCMRD or AGRHYMET, WaterNET, Cap-Net, on-going collaborations between universities, both south-south and south-north, etc.).

In this context, it is also worth mentioning that the Centres of Excellence in Water Science and Technology promoted by NEPAD have a significant potential to contribute in the implementation of *GMES and Africa*. *GMES and Africa* should therefore support the development of these key centres as a basis for service development, service provision and best practice sharing in Africa. The *GMES and Africa* strategy for capacity building should mobilize significant dedicated resources in order to address the needs identified above with the major focus on the following:

In the short term:

- Development or improving existing training centres to enable them to deliver training programmes necessary for the development of knowledge and skills for utilizing EO data in the water sector;
- Development and implementation of training programmes that will produce critical mass of African scientists and technicians with skills for utilizing EO data to generate and disseminate products applicable for water resources management. These training programmes should be run by national and regional training institutions in Africa;
- Establishing value adding companies in Africa with the capacity to develop, run and operate information services addressing the information needs of the African water sector. Reliable access to large volume – near real time satellite observations is a prerequisite for operating relevant EO services;
- Users (water stakeholders) need to be supported with the capacity to exploit GMES services and EO-based geo-information to improve water governance and decision making.

In the long-term:

- High-level Pan African educational programmes need to be developed and supported in order to ensure the continuous availability of appropriately qualified scientists, technicians and managers with a solid knowledge of EO technology and their applications in the water sector (among others).

6.3. PRIORITIZATION OF REQUIREMENTS AND ACTIONS

Implementing operational information services involving EO technology, *in situ* observations, and models is a complex process. The European EO programme 'Copernicus'[19] 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. In this context, the *GMES and Africa* Programme Implementation may follow a similar approach as the one used in Copernicus.

The following key points for implementation are critical for the success of the *GMES and Africa* water thematic area:

- AMCOW being the institution of 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 programme;

- Suitable mechanisms should be established in order to maintain a long-term dialogue with different actors in the *GMES and Africa* Water Theme Stakeholder Group**.** This should utilize existing mechanisms and forums such as the African Water Week, the World Water Week or the World Water Forum and relevant programmes such as MESA. Such *GMES and Africa* forums (having annual occurrence) should be coordinated at a high level by the EU and the AUC with the support of the *GMES and Africa* services coordination group;

- A key element of the consultation process should be dedicated to improve communication between African water stakeholders and service providers. For this specific water theme, AMCOW should play a key role, being the African interlocutor supported by AMCOMET, AMCOST, and regional economic communities, and transboundary river basin organizations;

- *GMES and Africa* shall be 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 of the process 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. This data sharing policy should be harmonized with those adopted by GEO. African Space agencies should be persuaded to subscribe to these GEO data-sharing principles and allow free access of data from their missions and thus ensuring full and open exchange of data, metadata and products. 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 these dissemination techniques for provision of products generated through the *GMES and Africa* services. Copernicus/GMES should put in place a mechanism to ensure the availability of appropriate large bandwidth satellite telecommunication;

- Observational infrastructure and network integration will be a key feature to achieving the operational sustainability of *GMES and Africa* water service initiative. This will harmonize the structures for collecting and sharing *in-situ* data since some countries have more advanced structures than others and therefore coordination and harmonization exercise of networks at the African and European level is necessary;

- 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

[19] http://copernicus.eu/

organizations and agencies have to be effectively involved in determining the types of services required, 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.

6.4. ORGANIZATIONAL SCHEME

The African ownership of the service definition and development of decision-support tools for (African) stakeholders is the key element that should be taken into account for *GMES and Africa* service model. In this context, the organizational scheme for *GMES and Africa* should ensure an African driven process involving the following points:

- AMCOW being the institution in Africa with the mandate to provide political leadership over water resources management issues should be the main political driver for the initiative that has to endorse the implementation plan;

- *GMES and Africa* should consider the basin authorities from sub-national to transboundary scales and national water stakeholders as the main users of the services and end-beneficiaries of the process who have to be effectively involved;

- Services should be operated by a number of national and regional technical centres in Africa. It is worth noting that both the national and transboundary water authorities will need to have technical units with the capacity to operate and provide relevant information services. Transboundary river basin commissions will play a key role as regional service providers for the different national authorities.

6.5. TIMETABLE

The following three phase implementation strategy is recommended:

- **Phase 1 (3 years). Consolidation period:** aimed at fully developing, validating and consolidating an initial set of services on the basis of existing initiatives, projects and programmes in Africa and Europe. 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.
    - Identification of needs will involve close consultation process with water stakeholders at national and transboundary levels under the leadership of AMCOW;
    - Ownership of the service definition and implementation at all levels should be African (defined by African stakeholders and implemented by African Institutions) and builds on already achieved relevant efforts, like from MESA;
    - The identification of needs and service definition should ensure that different characteristics, conditions and requirements of different institutions and regions are taken into consideration. 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.

- **Phase 2 (3 years). Scaling up period:** On the basis of the results achieved in Phase 1 selected 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 involve additional capacity building and institutional development efforts in order to build a solid basis to establish operational and sustainable services.
- **Phase 3 (4 years). Implementation Period:** In this phase, services will be implemented and run in an operational manner.

It is critically important that the timing of the *GMES and Africa* programme is in line with other initiatives, like MESA, to ensure that capacity already developed can be seamlessly transferred. This requires starting *GMES and Africa* by the end of 2017 or in 2018 latest.

6.6. INDICATIVE DEVELOPMENT PLAN AND BUDGET ESTIMATE

Taking into account the required effort against the existing pre-conditions in Africa and with the example of the GMES process in Europe, a proposed budget for independently implementing the water component will amount to about 60 million Euros distributed among the proposed stages as following:

- Phase 1: 10 million Euros
- Phase 2: 20 million Euros
- Phase 3: 30 million Euros

Appropriate funding programmes (European Development Fund) should therefore be mobilised in order to cover the needs to develop and implement *GMES and Africa* Water Thematic Area. Synergy with other *GMES and Africa* services could lead to costs sharing approaches.

7. RECOMMENDATIONS

A number of general priority actions were already highlighted, like:

- Development of information services addressing water resources monitoring and early warning systems, including vulnerability assessment and formulation of adaptation strategies in IWRM especially within the global climate change domain;
- A free and open EO data policy with full support to data access for the African community is a prerequisite for sustainable information services for IWRM;
- Broadcasting of EO data using inexpensive DVB (-S2) based telecommunication broadcast system amongst other means.

The following additional recommendations are proposed for the *GMES and Africa* water thematic area:

Ownership: It is recommended that African ownership of the service definition and development of decision-support tools for water resource stakeholders be the key element that will be taken into account for *GMES and Africa* service model.

Operational scale: It is recommended that the basin authorities from sub-national to transboundary scales and national water stakeholders will be the main users of the services and hence the main end-beneficiaries of the process.

Capacity building: It is recommended that a dedicated Capacity Building Programme at continental scale, building on existing capacity available at African Universities, is further developed to ensure a critical mass of expertise, African technical centres and value adding companies have obtained the necessary capacity to develop and operate EO-based water information services.

Partnerships: It is recommended that a mechanism be created to interface the various African stakeholders with on-going African and international programmes and that there is a clear linkage – network with other components of the *GMES and Africa* services.

8. SUMMARY

Water is intricately intertwined with agricultural productivity and energy generation in Africa which are the main drivers of socio-economic development. Equally important are the MDG's and water related health issues. Implementing Integrated Water Resource Management (IWRM) is a challenging task in Africa where water information systems are poorly developed or deteriorating, resulting in policies and management decisions being based on unreliable information.

GMES and Africa therefore represents a unique opportunity to:

- Enhance African human, technical and institutional capacities to meet the need for timely, quality long-term information at national, regional and transboundary scales as a basis for sound decision making and improved Integrated Water Resource Management and water governance.

- Improve the decision making processes and planning in water resource management in Africa by establishing long-term sustainable information services that overcome the water information gap in Africa by fully exploiting the increasing global EO capacity.

The *GMES and Africa* water resource model can be built on the solid basis of several initiatives that have demonstrated the strong potential of EO-based information to support African progress towards achieving Integrated Water Resources Management at both national and transboundary levels. Key African stakeholders including the African Ministerial Council on Water have supported strongly some of these efforts.

Today, the policy basis is clear; user needs are identified, Basin Commissions and NHMS's are already strongly engaged, methodologies have been validated and demonstrated in several countries. The critical issue for Africa is long-term sustainability. The Lisbon Declaration opens the prospect for a long-term cooperative AU-EU framework which should enable information services to be fully transferred in a sustainable manner to African partners. In order to underpin the high-level Lisbon process, it is necessary to continue building upon existing capacities in Africa, further develop existing cooperation with African partners and the stakeholder community, maintaining existing service capabilities, with special emphasis on capacity-building and building-on-capacity.

The information needs are broad including supporting the establishment of national and regional monitoring and evaluation mechanisms for assessing water quality and quantity, and activities by River Basin Organizations. There are many relevant EO-based precursor services (e.g. base mapping, hydrological network mapping; water availability estimation; catchments characterization; large lake water quality; ground water exploration; water Infrastructure monitoring) already on-going to be re-enforced and build on.

The proposed *GMES and Africa* will accelerate cooperation between African water authorities and other stakeholders, European and African service providers in the context of the AU-EU framework. The African water ministries, river basin authorities, national, regional and transboundary stakeholders are the principal users. African Regional and National Technical Centres are the main service providers, along with universities, research centres and other national institutions.

A 10-year three phase implementation strategy is proposed including a consolidation phase (3 years) followed by a scaling up period of 3 years and a final implementation period of 4 years. The budget proposed for each phase is 10 M, 20 M and 30 Million Euro respectively.

APPENDIX 1*: GMES and Africa Water Theme Stakeholders*

Level	Category	Interests
UN agencies	UN-Water; UNESCO – International Hydrological Programme; UNEP DEWA programme and GEMS/Water; UN-Habitat Water and Sanitation Programme; World Hydrological Cycle Observing System (WHYCOS) of WMO; UN-ECA, UNCCD; WHO-UNICEF Joint Monitoring Programme for Water Supply and Sanitation; UNESCO- Internationally Shared Aquifer Resource Management, etc.	Global trends on the status, quality and quantity of water resources and improving access to water. Provision of in-situ networks and improving free exchange of data to compliment EO based observation and modelling Capacity building. Early warning and assessment.
International	GEO (e.g. Africa Water Cycle Coordination Initiative and GEO Capacity Building task - EOPower); CEOS; World Water Council; Global Water Partnership; International Network of Basin Organizations; International Water Management Institute; Global Energy and Water Experiment (GEWEX); ESA; NOAA-CPC; EUMETSAT and SAF Network (e.g. Hydrology SAF); GEONETCast; FAO-AquaSTAT Programme; etc.	Earth Observation data providers for water management and dissemination. Promotion of better practices on water management in Africa. Strategic framework for Water Resource Management. Provision of in-situ networks to compliment EO based observation and modelling. Capacity Building.
Continental	AU, AMCOW; AMCOMET, Experts Centres for Water Science and Technology promoted by NEPAD; Regional Economic Communities in Africa; African Space Agencies; AMESD-MESA; TIGER; AFREF; AfricaArray; TrigNET; ARSIMEWA; AARSE; African Water Academy; Groundwater Commission of Africa and African Network for Basin Organizations, Pan African University, AfriGEOSS, etc.	Providing political direction regarding water management issues across Africa. Ensuring the provision of African EO data to African stakeholders. Networking among African players involved in IWRM. Capacity building.
Regional	Regional Economic Communities (e.g. ECOWAS, CEMAC, IGAD, IOC, SADC); River Basin Authorities (e.g. NBI, LCBC, VBA and Réseau Africain des Organismes de Bassin, based in Dakar); Regional and transboundary organizations; Remote Sensing Centres in Africa (e.g. AGRHYMET, RCMRD, RECTAS); OSS; African Meteo Centres of Excellence (e.g. IMTR, SAWS), etc.	Networking, developing and implementing regional water management plans in Africa including capacity building. Potential providers of geo-information in support of envisaged water management plans. Provision of in-situ networks to compliment EO based observation and modelling. Capacity building.
National	Ministries of Water Resources, and other ministries dealing with water-related issues; National Meteorological and Hydrological Services, Water Resource Management Authorities, Soil Conservation Agencies, Hydropower Agencies, Water supply – purification, industrial and urban water sectors, other relevant National institutions, National Universities; Research Institutions (e.g. CERSGIS, CRTS; CSIR), Ground reception station operators (like SANSA); Country water partnerships, etc.	Developing and implementing national water management plans in Africa. Real-time EO data collection. Provision of in-situ networks to compliment EO based observation and modelling. Scientific research on water related issues in areas of jurisdiction. Capacity building.
Cooperating	African Development Bank; European Commission; World Bank; Global	Provision of resources aimed at supporting African countries to achieve MDGs water targets.

Partners	Environmental Facility; Relevant Development Agencies	
International and NGOs	WaterNET, CapNet; Water Harvesting and Soil Conservation Networks; Health Agencies; etc.	Capacity building, Water advocacy, Community based mobilization.

APPENDIX 2*: Overview of some programmes relevant for the provision of water-related information*

Programmes	***Information services and scale***		***Data collection, accessibility***		***Products, Monitoring and Assessment***	
	Service	***Scale***	***Data Collection***	***Data Access***	***Products***	***Monitoring and Assessment***
PUMA- AMESD and MESA (on-going)	National Meteorological and Hydrological Services	Sub-Sahara Africa, at country level	Field Data EO Data	Thematic data	Weather and climate information	Continuous reporting and climate outlooks
	Water Management for Cropland and Rangeland Management	Regional (ECOWAS)	Field Data EO Data	Thematic data	Vegetation state; Extent and dynamics of small water bodies;	Yield estimation and drought risks delineation
	Water Resource Management focusing on environmental aspects of watersheds	Regional (CEMAC)	Field Data EO Data	Thematic data	NRT water level for the Ubangi river	Low water alert system
	New MESA services, like the flood service for the SADC region and new Climate RIC	Regional (SADC) and Continental Climate Service (ACMAD)	Field Data EO Data	Thematic Data	To de defined	To de defined
SERVIR Africa	Environmental monitoring and management and (flash) flood modelling and forecasting	East Africa - Continental	Field Data EO Data Modelling	Thematic data	Flooding and droughts	Mitigate against natural disasters
TRMM, CMORPH, UNESCO G-WADI, etc.	Global (near) real-time satellite based precipitation estimates	Continental	Field Data EO Data Modelling	Thematic data, visualize on server	Operational precipitation estimates	Monitoring, forecast and mitigation of hydrologic disasters
Water Cycle and Drought Monitoring over Africa	Real-time monitoring of land surface hydrological conditions	Continental	Field Data EO Data Modelling	Thematic data	Precipitation, evapotranspiration, runoff, snow and soil moisture	Water Cycle and drought monitoring over Africa
TIGER	Various water related application: surface and ground water analysis, water quality, levels, soil moisture, wetland management, mapping of water and catchment characterization, etc. Regional services through nationally operated open source Water Observation Information Systems	Continental, regional and national study areas	Field Data EO Data and Modelling	Thematic data	Various thematic products, like ground water potential and exploration maps, NRT soil moisture maps, river and lake levels, etc.	Derived water consumption and extraction estimates, flood mapping, land use change monitoring, etc.
ClimDevAfrica, Global Framework for Climate Services	Provision of climatological, meteorological products and services in support of economic and social development	Continental	Field Data EO Data and Modelling	Thematic data	Weather and climate information	Various meteorological products, early warnings, etc.
GLDAS-NOAH, ECMWF Era-Interim, WMO-GTS and GSOD, Meteorological Data Dissemi-nation Service	Meteorological information, (real time) *in situ* measurements and weather forecast information, numerical weather prediction model data	Global	Field Data EO Data and Modelling	Thematic data	Various thematic products, like mean sea level pressure, winds at various pressure levels, evapotranspiration, total precipitation, etc.	(real time) Weather data and short range forecast, climatological data archive, NWP model data, etc.

Satellite Application Facilities (e.g. LSA-SAF), Copernicus and Africa Platform	Land surface analysis data and vegetation products	Continental	Field Data EO Data and Modelling	Thematic data	Various thematic products, like Albedo, Down Welling Surface Fluxes, ET, LST, Fire and various other vegetation parameters	Continuous thematic product provision
FEWS-Net and NOAA- Climate Prediction Centre	Time series rainfall and vegetation index products	Continental	EO Data and Modelling	Thematic data	Various thematic products, like rainfall, PET, NDVI, etc.	Continuous thematic product provision

APPENDIX 3*: Potential GMES and Africa Services*

Scale	Service Description	Users
Continental	A core set of continental scale products covering different components of the water cycle at low spatial (approx. 1 Km) but higher temporal resolution (once per day) e.g.: • Soil moisture; • Rivers and lake water levels; • Precipitation; • Potential and actual Evapotranspiration; • Basic meteorological products and short range outlooks, etc. • Water quality monitoring in large lakes (temperature, suspended sediments, chlorophyll, etc.); • Water related disease indicators (rainfall, humidity, etc.); • Integration of some components to derive water balance, etc.;	National authorities, basin authorities, hydrological services, local communities, farming communities, fisheries industry and other stakeholders. Many of the proposed services also address transversal needs. In particular many of them may cover the needs of: • Agricultural agencies; • Environmental agencies; • Developing agencies (for monitoring and assessment purposes); • Forestry departments; • Weather services; • Civil protection services; Research community
Regional (trans-boundary river basins) and national	Base mapping, linked with socio-economic information, for enhancing infrastructure development with focus on water supply and sanitation at high resolution (approx. 10m or higher if required); Catchments characterization including a core set of products at basin scale at high resolution (10-100 meters): e.g., • Quantifying components of the water cycle (e.g. precipitation, evapotranspiration, soil moisture, water levels fluctuations, etc); • Land cover and land use; • Crop and vegetation mapping; • Irrigation areas; • Water quality of coastal and inland water bodies; • DEM's at relevant (vertical) resolution; • Hydrological Network; Ephemeral water bodies identification and monitoring in arid and semi-arid regions at high resolution (10-20 meters); Support groundwater management including (from 10 to 250 meters): • Estimation of water extraction; • Groundwater exploration (e.g., identification of infiltration areas) • Lineament mapping and bare rock unit classification; Rapid mapping of flood affected areas at high resolution (10-20 m); Early warning and outlook for droughts; Wetland and protected area monitoring and mapping at high resolution (10-20m): • Water extension dynamics monitoring; • Inundated vegetation dynamics; • Change analysis;	

ABBREVIATIONS

AARSE	African Association of Remote Sensing of the Environment
ACP:	Africa Caribbean Pacific
AGRHYMET:	Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle, Niamey, Niger
AMCOW:	African Ministers' Council on Water
AMESD:	African Management of the Environment for Sustainable Development
AQUAKNOW:	Dynamic Virtual Space for Information sharing for water sector stakeholders
ARMC:	African Resource management Satellite Constellation
ARSIMEWA:	Applications of Remote Sensing for Integrated Management of Water Resources in Africa
AU:	African Union
AUC:	African Union Commission
CB:	Capacity Building
CEMAC:	Communaute Economique et Monetaire de l'Afrique Centrale
CEOS:	Committee of Earth Observation Satellites
CERSGIS:	Centre for Remote Sensing and Geographic Information Services
ClimDevAfrica:	Climate for Development in Africa Program
COI:	Commission de l'Ocean Indien
CPC:	Climate Prediction Centre
CRTS:	Royal Centre for Remote Sensing, Morocco
CSIR:	Council for Scientific and Industrial Research, South Africa
DTM:	Digital Terrain Model
EC:	European Commission
ECMWF:	European Centre for Medium Range Weather Forecast
ECOWAS:	Economic Community Of West African States
EDF:	European Development Fund
EO:	Earth Observation
ESA:	European Space Agency
EUMETCast:	EUMETSAT Broadcast system for Environmental Data
EUMETSAT:	European Organisation for the Exploitation of Meteorological Satellites
GEO:	Group on Earth Observations
GEONETCast:	Global Network of Satellite-based Data Dissemination Systems
GEOSS:	Global Earth Observation System of Systems
GEWEX:	Global Energy and Water Cycle Experiment
GIS:	Geographical Information System
GMES:	Global Monitoring for Environment and Security
GWh:	Gigawatt Hour
IGAD:	Intergovernmental Authority on Development
IT:	Information Technology
ITC-UT:	International Institute for Geo-Information Science and Earth Observation – University Twente
IWRM:	Integrated Water Resource Management
JRC:	Joint Research Commission of the EC
LC:	Land Cover
LCBC:	Lake Chad Basin Commission
MESA:	Monitoring of Environment and Security in Africa
MDG	Millennium Development Goals
NBI :	Nile Basin Initiative
NEPAD:	New Partnership for Africa's Development
NGO	Non-Governmental Organization
NHS:	National Hydrological Services
OSS:	Sahara and Sahel Observatory
PUMA:	Preparation for the use of Meteosat Second Generation in Africa
RCMRD:	Regional Centre for Mapping of Resources for Development
REC:	Regional Economic Countries
RS:	Remote Sensing
SADC:	Southern African Development Community
TIGER:	A European Space Agency led initiative dealing with Integrated Water Resource Management for Africa using Space Technology
UN-ECA:	United Nations Economic Commission for Africa
UNEP–DEWA:	United Nations Environmental Programme Division of Early Warning and Assessment
UNESCO-IHP:	United Nations Education, Scientific and Cultural Organization International Hydrological Programmes
WHYCOS:	World Hydrological Cycle Observing System
WMO:	World Meteorological Organization of the United Nations