Final Report

Stocktaking Report on Water, Technology and Engineering, Scientific Research and Innovations : South-South cooperation and partnership for enhancing Science between Asia and Africa

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Consultant Mission Report
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List of Abbreviations

AP Region	:	Asia Pacific Region
CEWRE of UET–Lahore	:	Center of Excellence on Water Resources and Engineering – University of Engineering and Technology of Lahore
ECOWAS	:	Economic Community of West African States
FEIAP	:	Federation of Engineering Institutions of Asia and the Pacific
FRIEND-WATER	:	Flow Regimes from International Experimental and Network Data - WATER
GEMI	:	Global Environmental Monitoring Initiative (Integrated monitoring of water and sanitation related SDG's target)
HELP	:	Hydrology for the Environment, Life and Policy
G-WADI	:	Global Network on Water and Development Information in Arid Lands
GRAPHIC	:	Groundwater Resources Assessment under the Pressures of Humanity and Climate Change
GWP	:	Global Water Partnership
IAHS	:	International Association of Hydrological Sciences
IFIT	:	Indonesian Funds-in-Trust
IHD	:	International Hydrological Decade of UNESCO
IHP	:	International Hydrological Programme of UNESCO
ILBM	:	Integrated Lake Basin management
ILEC	:	International Lake Environment Committee
IWMI	:	International Water Management Institute
IWRM	:	Integrated Water Resources Management
JFIT	:	Japanese Funds-in-Trust
MFIT	:	Malaysia Funds-in-Trust
RCSE	:	Research Center for Sustainability and Environment, Shiga University
SADC	:	Southern African Development Community
SDG-6	:	Sustainable Development Goals 6 dedicated on Water and Sanitation in the UN 2030 Agenda
STI	:	Science, Technology and Innovation
UMT–Lahore	:	University of Management and Technology of Lahore
UN	:	United Nations
UNDP	:	United Nations Development Programme
UNEP	:	UN – Environnent (*former* United Nations Environnent Programme)
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
UN-Water	:	United Nations inter-agency coordination mechanism on freshwater-related matters, including sanitation
WHO	:	World Health Organization
WMO	:	World Meteorological Organization
WWAP	:	World Water Assessment Programme

Executive Summary

This report consists of taking stock of existing documentation, reports and achievements on major water resources management programmes undertaken in the region by the UNESCO Office in Jakarta. Extensive water-related documentation has been consulted, as well as other related IHP and IHD strategies and reports, AP-FRIEND, AP-HELP and AP-Ecohydrology, including reports on training and capacity building in the Asia Pacific region. Documentation related to MFIT, JFIT and IFIT has been reviewed regarding particular aspects related to water, technology and engineering, scientific research and innovation within the framework of South-South cooperation, with a focus on partnerships for enhancement of science within the AP region, and between Asia and Africa (UNESCO, 2015 & UNESCO IHP-VIII Reports).

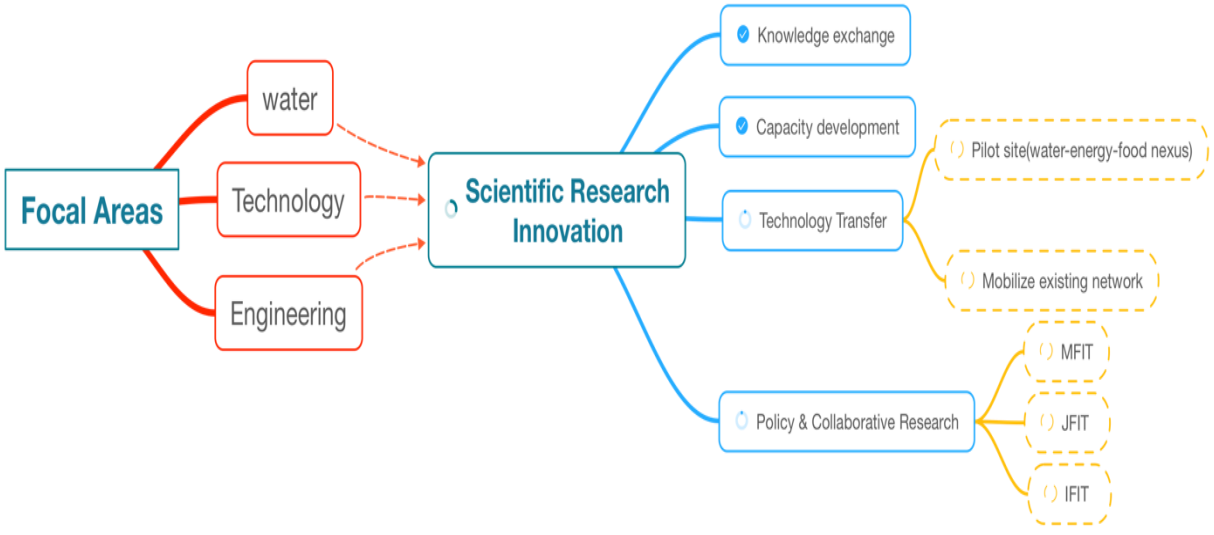
Field office visits, as well as participation in various seminars and workshops in Lahore and in Jakarta provided the consultant the opportunity to participate in discussions and debates on SDG-6; namely, "water and sanitation within the UN 2030 Agenda," particularly the lessons learnt on SDG-6 implementation by voluntary countries, and the results obtained from the monitoring exercise undertaken by the countries themselves on SDG-6 with the assistance of UN-Water and GEMI (UN-Water, 2015 & 2016).

Recommendations are also provided in this final report, as well as guidance on the way forward. A brief project concept is proposed as a possible example to catalyze potential efforts of cooperation between Asia and Africa within the overall framework of UNESCO office in Jakarta. One example is the proposed cooperation activities between CEWRE and some African water research institutions and universities, with a proof of concept proposal *on: "Water, Energy, Food and Climate Nexus".*

Photo 1 : A field water project in Indonesia

1. The First Part

The First Part of the report consists of stocktaking on "Water, Technology and Engineering, Scientific Research and Innovation: a review of South-South cooperation with a focus on partnership for enhancing Science between Asia and Africa." Documentation related to UNESCO IHP and IHD strategies has been consulted, as well as several reports related to training and capacity building within the Asia-Pacific (AP) region. MFIT, JFIT and IFIT documents have been reviewed regarding particular aspects related to engineering, technology, scientific research and innovation. It is clear the AP region is well covered in terms of activities by UNESCO natural science related category 2 centers and UNESCO chairs. Those networks and centers that have been developed, with most of them presently well consolidated, are largely contributing to implementation and expansion of UNESCO's Medium Term Strategy and UN 2030 Agenda. The UNESCO Regional Science Bureau for Asia and the Pacific in Jakarta is providing substantial results through its extensive network in the AP region. On the issue of water in particular, high level programmes focused on IHP VIII have been developed using AP UNESCO water chairs and centers. Capacity building has being constantly organized through training courses, seminars and workshops, mainly using South –South cooperation mechanisms, as well as internal continuous support from Member States in the AP region, with the existing Funds-in-Trust programmes (IFIT, JFIT and MFIT). Regional coordinating bodies are functioning rather well, strengthening UNESCO's water presence in the AP region (See References, including JFIT & MFIT reports, 2015).



Key IHP challenges in the AP region are to address the issues of integrated and sustainable

management of water resources in the region, mainly through IWRM (GWP 2000) and ILBM (RCSE-Shiga University, 2011) programmes, trans-disciplinary water management programmes, science, engineering, technology and innovation programmes, and knowledge for local communities on water resources, regional cooperation and extreme events, risks and hazards related to hydrological regimes and water management (UNESCO Report 2015 – Celebrating 50 years of water leadership in AP region; see above diagram). With the full involvement of all AP region Member States, the UNESCO Regional Science Bureau for Asia and the Pacific in Jakarta is producing considerable achievements in tackling the complex issues regarding the sustainable management and governance of the water resources in the region. A series of comprehensive water publications have been successfully undertaken and realized, constituting the results of a series of projects and programmes linked for most of them to UNESCO chairs, UNESCO centers and UNESCO IHP VIII Strategic Programme. These include ecohydrology, water hazards and risks management, erosion and sedimentation, and IWRM and ILBM, including groundwater management, urban water management, transboundary water governance.

The UNESCO Regional Science Bureau for Asia and the Pacific in Jakarta has made a particularly significant difference in regard to the wise use of FIT's, MFIT in particular by tackling the issue of critical technology transfer through wider generation and dissemination of knowledge, capacity development on STI and engineering, building competence and cooperation through South-South cooperation. With the skills development, the strengthening and improvement of the quality of education through better alignment of curricula, enhancement of science, technology and engineering, UNESCO's office in Jakarta is significantly improving the quality of education in the AP region, while also upscaling skills development of young people (UNESCO Office in Jakarta report 2015 & 2016 – Report of The Regional Bureau's Science Support Strategy 2014-2021 and FEIAP Report, 2016 – Benchmarking Engineering Accreditation System).

One of the lessons learnt from the project on "South-South Cooperation for Enhancing Science, Engineering and Technology Standards in Asia and the Pacific" should be to extend the findings and results in the form of best practices, not only in Nigeria, but also to most African regions (West and East; e.g., ECOWAS and SADC, through direct bi-lateral country agreements and participation.

2. The Second Part

The Second Part of this final report is based on this consultant visit to the Lahore/Center of Excellency on Water Resources and Engineering/CEWRE. The main theme of the international seminar organized at Lahore, University of Engineering and Technology was "*Managing Indus Basin for Sustainable Development, Food Security and Poverty Alleviation.*" The seminar focused on three main topics, including (1) transboundary water issues (and inland waters navigation), with extensive presentations and discussions on shared Indus river water resources between India and Pakistan; (2) water security, including water quality, water allocation and environmental flows; and (3) climate change and its effects and impacts, with the occurrence of extreme events (climate shifts, with floods and droughts events within some shared basins between India and Pakistan).

During his visit in Lahore, the consultant delivered two key note speeches on "water and sanitation within the UN 2030 Agenda" at UET and UMT, and particularly the lessons learnt on SDG's-6 implementation by voluntary countries, and on methodologies and preliminary conclusions from the SDG-6 monitoring exercise undertaken by the countries themselves. Such SDG-6 monitoring programmes have been implemented since April 2016, with the assistance of UN-Water and GEMI. Indeed, UN-Water, in assisting SDG-6 implementation, has always reiterated the need for a clear definition of approaches and methodologies for integrated monitoring of targets and indicators of the SDG-6 dedicated to water and sanitation, bearing in mind that "it is not possible to manage what is not measured." Thus, the importance for countries to obtain reliable data in order to properly inform water and sanitation ministries, as well as other related directorates and managers, is clear. **The following elements were considered and discussed during the consultant's presentation:**

1. Brief description of SDG-6 and the core global indicators that have been considered;
2. What are the countries involved in this exercise, based on voluntary considerations and on their own interests?
3. UN Agencies involved in the follow-up process;
4. Example of indicator 6.3.2 on Water Quality;
5. Example of indicator 6.6.1 on Water & Ecosystems;
6. Lessons learnt and what do we get from such monitoring exercise by countries themselves of SDG-6?

Indeed, the main theme of SDG-6 "water and sanitation" is at the core of sustainable development. "Water Security" is embedded into the SDG-6 principal components, including:

- Drinking water, sanitation and hygiene - pillars of human health and well-being;
- Water for food, energy and industrial production - potentially conflicting uses – and integrated management;
- Wastewater - water pollution - recycling and reuse;
- Water for healthy ecosystems - improved resilience;
- Climate change - shifts in water availability - water scarcity, flooding;
- Risks related to famine, epidemics, migration, inequalities, and political instability.

A SDG-6 goal is to: **"Ensure availability and sustainable management of water and sanitation for all,"** by considering the water cycle in its entirety, including environmental, social and economic aspects, promoting an integrated approach to the management of water resources, and seeking to overcome sectoral and regional fragmentation.

After the presentation of the global indicators, the consultant concluded his communication by highlighting the importance of the monitoring process, while also insisting on the following key elements:

- Data constitutes the "lifeblood of decision-making and the raw material for accountability";
- We cannot manage what we do not measure…;
- Credible water sector data will maximize human, financial and natural resource use efficiency:
- Underpin advocacy and stimulate political commitments, while informing decision-making on all levels;
- Trigger well-placed public and private investments;
- Foster learning about best practices, including new technologies to improve our capacity to collect, store, analyze, report and share data;
- Cutting costs and improving data disaggregation;
- Integrating and expanding existing monitoring efforts, to ensure harmonised monitoring of the entire water cycle;
- Provide Member States with a monitoring guide for SDG targets [6.3-6.6];
- Engaging Member States and enhancing their capacity in water sector monitoring;

- Flexible methodologies for Member States to undertake monitoring efforts consistent with national capacity and resource availability;
- Starting simple and advancing progressively as capacity and resources increase;
- Opportunities for combining various methods and data sources;
- Direct measurements, surveys, remote sensing, estimates and literature reviews;
- Over the short-term: estimating and modelling to fill data gaps;
    - Over the long-term: national monitoring to feed directly into global needs;
    - Building on existing initiatives and efforts…;
    - Ensuring comparable results, across countries and over time, thereby enhancing harmonization;
    - Aiming at internationally-agreed definitions, standards and transparency.

Detailed discussions followed the CEWRE presentation, with the consultant requested to provide his overall views and conclusions on transboundary issues related to the shared Indus river water resources between India and Pakistan, as well as his suggestions for continuing research on the hydrological cycle in a changing environment. He also was requested to provide his perspective on the need for regular data acquisition and scientific observations and monitoring, as well as the importance of overcoming sectoral and regional fragmentation, including the need for a continuing dialogue between managers, policy makers, scientists and high level government representatives.

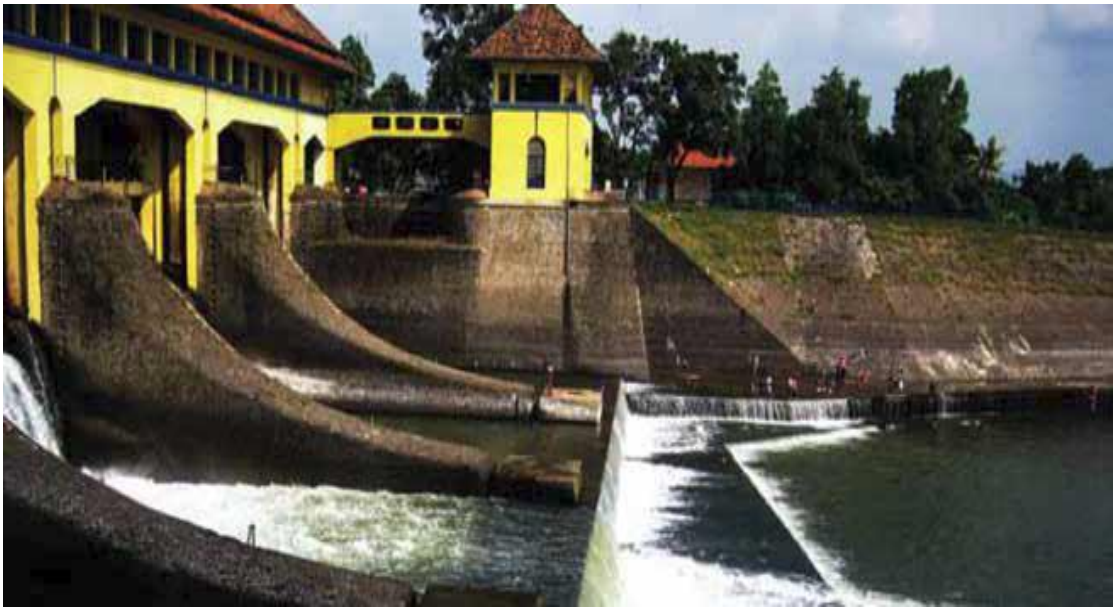


Photo 2 : Dams and irrigation project in Indonesia

3. The Third Part

The Third Part of this report consists of the consultant's participation in the UNESCO workshop in Jakarta from 27 to 29 April 2017 on "Final Dissemination on Promoting Ecological and Eco hydrological Solutions for Sustainable Water Management in Indonesia and Asia Pacific Region." The consultant presented a communication during the workshop on SDG6, "Water and sanitation within the UN 2030 Agenda," whereby, in addition to the SDG water quality indicator (6.3.2) and to the SDG water and ecosystems indicator (6.6.1). The consultant also provided the example of the SDG indicator 6.5.1, related to the degree of IWRM implementation, which is so relevant to the ASIAN region. In regard to the latter, the consultant insisted – among other elements - on the following:

- The multiple dimensional aspects of IWRM and ILBM (at all levels; across all sectors; supporting other targets, including implementation progress (steps versus coverage);
- Enabling Environment: Policy, laws, plans;
- Institutions: Cross-sector coordination, stakeholder participation, capacity, gender and effectiveness;
- Management Instruments: Programs, monitoring, knowledge sharing, capacity development;
- Sustainable Financing: For water resources development and management, with the following key questions:
  - Do policies, laws and plans that support Integrated Water Resources Management (IWRM) exist at the national level? What is the status of the national water policies, national water law(s), and the national IWRM Plan or equivalent?
  - Do policies, laws and/or plans exist that support IWRM at other levels, including sub-national/provincial/State water resource policies and/or basin management plans? What are the existing agreements for transboundary water management?

Because of the importance of IWRM for the AP region, specific recommendations will be provided in this final report in regard to shared transboundary water resources (**see Recommendations 1 at the end of the report**).

Among the main conclusions of the Jakarta workshop on the "Final Dissemination on Promoting Ecological and Eco hydrological Solutions for Sustainable Water Management in Indonesia and Asia Pacific Region," six main elements can be highlighted as possible key

clusters of recommendations, as follows:

- The importance of community participatory approach for achieving sustainable water management – as presented during sessions chaired by the consultant;
- The need for a basin approach that considers surface water, as well as groundwater, resources for developing a better IWRM approach;
- The need for scientific information and data, including monitoring sites, for further modelling and online dissemination of data and results for management purposes;
- The importance of upscaling best practices and success stories within the AP region, as well as in other regions;
- The need to develop curricula in relation to IWRM, ILBM and ecohydrological processes as tools for integrated water management approaches;
- The importance of encouraging countries in their efforts for SDG implementation, particularly the SDG goals related to water and sanitation, while benefiting from voluntary countries experiences gained within the UN-Water initiative.

Recommendations are provided on this aspect as well in regard to implementation of SDG-6 to "Ensure availability and sustainable management of water and sanitation for all" is concerned (**see Recommendation 3 at the end of the report**).

4. The Fourth Part

The Fourth Part of this report includes a brief description of the discussions of the consultant during 14 April 2017, the last day of his visit to CEWRE. A potential cooperative project was discussed between Prof. Habib-ur-Rahman, Director of the Lahore Water Center of Excellence at UET, and his team and the consultant, in order to identify areas of possible cooperation between CEWRE and some African water research institutions and universities. A proof of concept on *"Water, Energy, Food and Climate Nexus"* has been proposed for discussion, to be developed as a pilot project, using the South-South cooperation framework between Asia and Africa, targeting 2 or 3 key regions. The consultant, tasked with developing the concept into a 2-3 page document, has already forwarded the concept for review and discussions to CEWRE (**See annex to Part 4, as attached**).

Annex to Part 4

Concept proposal on: "Water, Energy, Food and Climate Nexus"

Because of Asia and Africa's large potential for developing energy from water and other forms of renewable resources such as wind, geothermal, solar and bioenergies, including biogases, optimization of benefits arising from water, food and energy nexus will imply an ecosystem services approach for food and energy production in order to avoid degradation and irreversible damage to our ecosystems, while also ensuring food and energy security and managing water resources and protecting our ecosystems. Indeed, food and energy production and water resources are generally closely linked. Food production requires water, water extraction and distribution requires energy, and energy production requires water. Food prices are also sensitive to the cost of energy inputs needed for production of fertilizers and for irrigation, transport and processing.

The idea behind the nexus is to find ways and means to manage the growing food, energy and water supply and demand with a holistic approach that also considers the need to build environmentally-sustainable economies and to find synergies between these sectors (see graphic below). The demand for food is one of the most obvious and important drivers of water use in Africa and in Asia. With a growing population, Asia and Africa will need more food, and must secure the water and energy needed to ensure its production, while good quality water resources are also becoming scarcer. Thus, some of the following options for future sustainable management of the water/food/nexus require innovative approaches, strategies and technologies, as well as changed knowledge and behaviors such as appropriate agricultural practices and organic fertilization. Alternative sustainable farming practices include agroforestry and intercropping cereals with legumes to improve nitrogen-deficient soils and reduce reliance on synthetic fertilizers and pesticides, use of natural pesticides and possible (re)introduction of native species and different crops, sustainable hydropower and other renewable energies linked to low-flow enhancement and irrigation, including proper allocation and equitable and efficient use of energy, water and food within existing ecological constraints. In a nutshell, this means investment in best irrigation technologies in order to obtain the best advantages for increasing irrigation, and more efficient water use for food production. These must be among the best selected technologies and practices, managed carefully in order to avoid environmental damage, while also increasing productivity and ecosystem resilience.

It is important at the same time to emphasize that climate change, environmental pressures, and growing economics and populations will increasingly exacerbate the importance of the nexus approach in the future.

The program's overall objectives are to:

- Contribute to strengthening the resilience of rural communities to deal with water resources management and the effects of climate change;
- Contribute to reduction of poverty and the vulnerability of populations of rural communities; and
- Contribute to improving food security and nutrition in rural communities.

The program's development objective is to: “Support communities and local administrations in the development and implementation of adaptation plans to climate change to ensure energy sufficiency and drinking water, food security and nutrition, preservation of natural resources and the environment and improving the livelihoods of rural populations,”

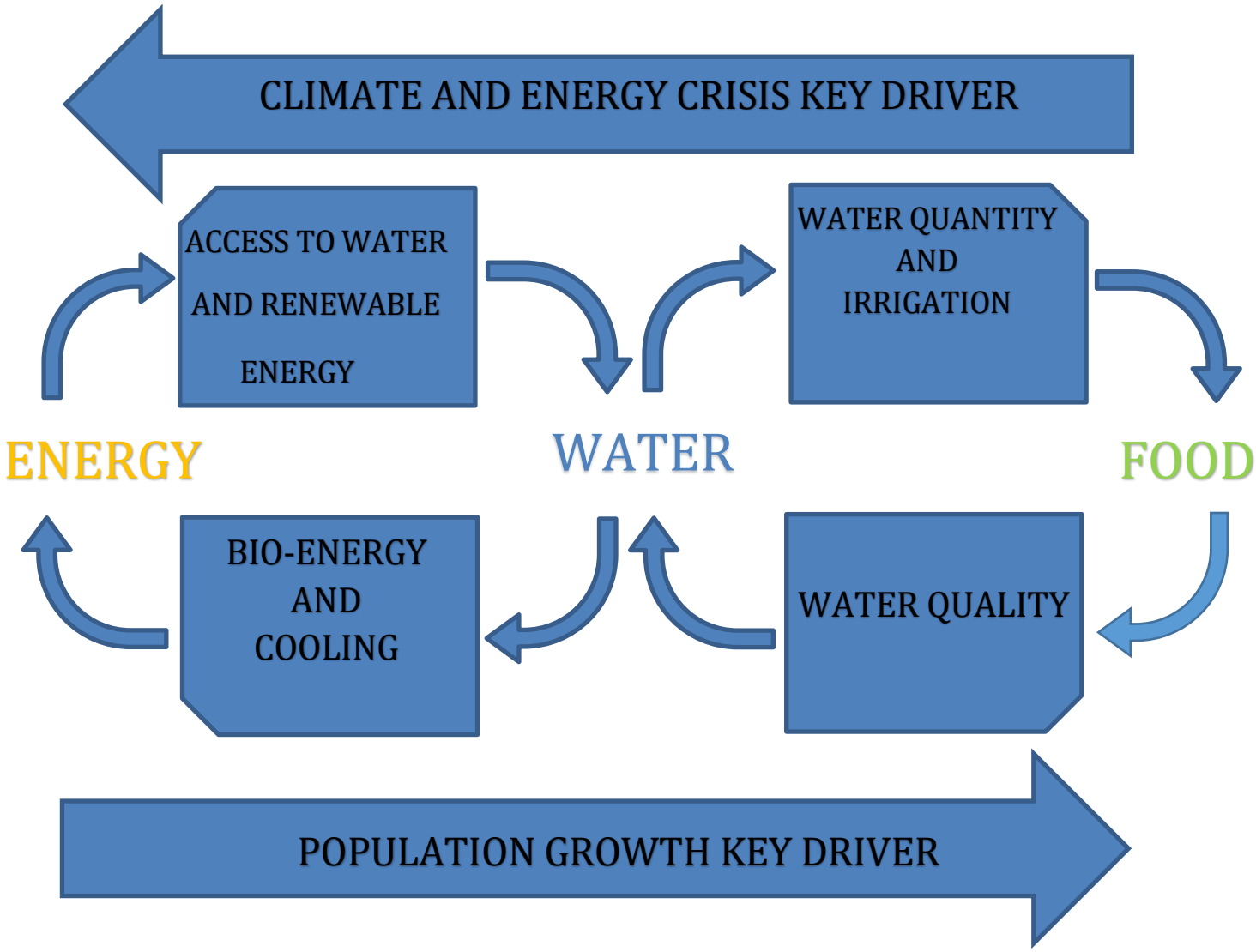
The program will strengthen the capacities of individual, collective and institutional resilience of communities and local authorities to deal with water resources management, and the negative effects of climate change. Through better coordination of actors and their interventions, the program will facilitate the development of tools for planning, leadership training and advocacy with national and local authorities, taking into account measures that contribute to promotion of a country's resistance to the effects of climate change in the development of national policies.

Within the framework of decentralization policies, environmental responsibilities have been transferred to Rural Communities, including development plans and local development incorporating the dimension of climate change in the planning process. Thus, the program will contribute, on the basis of a territorial approach to climate, to improving the integration of climate change adaptation into local development processes.

By disseminating appropriate technologies, and creating genuine strategic plans in key sectors such as renewable energy, water, sustainable agriculture and waste management in accordance with the principles of a green economy, low emissions and low carbon, this program constitutes one original solution for facilitating the resilience of village communities through a combination of environmental, social and economic factors. By adopting a collective approach of activation, qualification and promotion of resources and products of the territories, and using various networks, the program will provide real

development opportunities, based on comparative advantages of rural territories. The originality of this collective process of mobilization and promotion of village resources, based on an integrated approach Energy-Water-Sustainable Agriculture, and on re-greening the local economy, can constitute a good case for best practices in rural areas.

Further, given the fact that competences transferred to local communities as part of the decentralization policy is not accompanied by substantial financial resources, this program will be a great opportunity for rural communities. Through a significant combination of investments and infrastructure with various innovative financing mechanisms, as well as transformation of local economies, and a transfer of appropriate technologies, the program could offer multiple opportunities for gains for villagers and communities, for local governments, and for society in general, that will profit from global environmental benefits.



Pilot areas that should be selected should be able to indicate such factors as the effects of

adverse impacts of climate change, amplified by multiple pressures on natural resources, and particularly on water resources. The state of references should be made in various regions and at the national level, with an indication of different vulnerabilities that confront rural communities, including: *(i)* dependence on wood fuels (wood energy), while their potential is decreasing drastically; *(ii)* degradation of wood resources related to drought and deforestation (wood energy and service); *(iii)* lack of rural access to adequate, reliable energy services (electricity, wind, biogas, solar, etc.); *(iv)* insufficient access to, and water control for, domestic and agricultural production; *(v)* sharp declines in agricultural production attributable to climatic variations, soil degradation and low use of "inputs" ; *(vi)* a high dependence of agriculture on rainfall characterized by large temporal and spatial variability, and drastic declines in volume and quality; *(vii)* food and nutritional insecurity linked to repetitive food deficits; *(viii)* weak capacities of local producers (men, women and youth); *(ix)* unemployment and under-employment of youth in the program intervention areas; and *(x)* exodus of rural youth to urban centers.

Photo 3: Example of water shortage impacts on small dike

Within this perspective, this proposal could constitute one opportunity to mobilize the potential of "green economy" in addressing the challenges of climate change by facilitating better resilience of ecosystems and local communities.

Through its innovative approach and responses in improving living conditions in rural areas, this program will implement a real strategy for adaptation, resilience and mitigation based on the "Energy-Water-Sustainable Agriculture Nexus." It will focus essentially on the

articulated sustainable development around the triptych “Energy-Water-Agriculture” as a genuine solution for facilitating rural communities’ resilience to the adverse effects of climate change and loss of biodiversity. The program, whose ultimate goal is to popularize and multiply technological packages, will essentially be based on the re-greening option of the rural economy (green economy and low carbon), with a supply of energy/renewable energy to local populations, water management, promotion of smart agriculture (agro-biology), management and recovery of waste for agricultural purposes (compost and bio-digester) and energy (biogas). The promotion of renewable energies (solar, biogas and wind) will allow for a good supply and control of existing water resources (boreholes with solar pumping systems, rainwater recovery, watershed management, etc.). In turn, these various complementary elements will enable the development of agricultural entrepreneurship and agribusiness through creation of Small and Medium Enterprises (SMEs), following the approach of agricultural value chains, in order to ensure food and nutrition security to, and poverty reduction of, local communities.

Concluding Remarks of the Final Report

Effective integrated development and management of water resources clearly requires a multi-faceted and multi-disciplined approach, including hydrology, irrigation and drainage engineering, water resources management and engineering, geology, economy, social science, agronomy, soil science and environmental science. How can Water Security and related socio-economic and human well-being development, for example, be achieved and sustained through targeted policy actions in relation to the water, food and energy nexus? It is a fact that water is a crucial resource with great implications for all countries, including Asia's and Africa's development. Climate change impacts, coupled with increasing population growth, have led to increased water demands. Water demands exceed the available water resources in most Asian and African countries (Ahmed et al. 2016). As water availability constantly declines, appropriate partitioning of water for domestic consumption, agriculture and other forms of water use is becoming a subject of serious concern. Sound management of the limited water resources in Asia and Africa is becoming increasingly important to address the needs of a rapidly-growing population and increasing food and energy demands, while also ensuring the health of water ecosystems.

Water is directly or indirectly used in almost every economic sector in Asia and Africa, including agriculture, manufacturing, trade, mining, tourism and transportation. Water is both an ecosystem 'good,' providing drinking water, irrigation and hydropower, as well as an ecosystem 'service,' supplying people, whether they are aware of it or not, with functions such as nutrients cycling and supporting habitats for fish and other aquatic organisms, as well as 'cultural services' such as scenic vistas and recreational opportunities (Network of African Science Academies/NASAC 2015). Rural, urban, and peri-urban environments have unique differences in regard to the availability, use and management of water resources. These differences must be appreciated and considered in the formulation of policies related to water development and management.

The notion of "both continents where there is a need for equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation, and the environment" transpire in the Africa Water Vision 2025, Asian Vision 2020, and the Africa Union 2063 Agenda. Rapid population increase, inappropriate water governance and institutional arrangements, depletion of water resources through pollution, environmental degradation, deforestation, and low and unsustainable financing of investments in water supply and sanitation are some of the main threats posing challenges

to managing the continental water resources. It is widely recognized that such challenges cannot be successfully addressed by adhering to 'business as usual' in water resources management at the national and regional levels. Addressing the threats in both regions requires adoption of good governance, societal consensus, and innovative technologies and well-developed frameworks for cooperative action, guided by the shared Africa Water Vision 2025, Asian Vision 2020, and the Africa Union 2063 Agenda and Sustainable Development Goals. Thus, there are key roles for regions, governments, institutions, academia and other stakeholders to play in all water security development issues.

In regard to implementation of SDG 6, it seems it will be necessary to explore different implementation approaches, such as financing, trade, technology, capacity building, policy and institutional coherence, data and monitoring, and multi-stakeholder partnerships. Although a solid base of experience in monitoring and implementation already exists in many countries, they need to be scaled up, with support required from the international community. This reality is essential to fully realize the human right to safe drinking water and sanitation. Further, there is considerable evidence that achieving SDG 6 will bring economic benefits that will significantly exceed the needed investments. For water and sanitation alone, existing research indicates the benefits exceed the cost of an intervention by 3 to 6 times. The World Health Organization (WHO) and the World Bank have reported that the global economic return on sanitation spending is US $5.50 per each US dollar invested (UN Water, 2015 and 2016. Report on Means of Implementation: A focus on Sustainable Development Goals 6 and 17).

Extensive Recommendations of the Final Report, and the Way Forward in five (5) main areas:

1. **Transboundary shared water resources:** UNESCO, along with other UN agencies, should encourage countries sharing water resources on the need for "credible research on the hydrological cycle in a changing environment, but also on the need for regular data acquisition and scientific observations and monitoring, as well as the importance to overcome sectoral and regional fragmentation, including the need for a continuing dialogue between managers, policy makers, scientists and high level government representatives." Indeed, international water cooperation presents an opportunity to deal with the challenges and constraints through negotiated sharing of basins for both water withdrawals and in-stream water uses. The sustainability of water availability

within a river basin that crosses two or more countries may be assured, and even increased, via such transboundary agreements. These agreements also facilitate equity in the provision of water for all, as well as helping to maintain peace and security. There are several examples of transboundary water agreements and other sharing mechanisms that have been successful in helping riparian African nations to negotiate equitable water sharing, and which illustrate the potential for such agreements to be a catalyst for wider political cooperation.

At the same time, lessons could be learnt from successful transboundary cooperation efforts and agreements among African states, noting that successful transboundary water distribution is inherently dependent on political cooperation between the involved riparian states. In the absence of strong rules and laws, treaties are the best form of formal river basin management and sharing of transboundary water resources.

2. **Engineering, training and capacity development in relation to water science and management:** The UNESCO Regional Science Bureau for Asia and the Pacific in Jakarta should extend the project on "South-South Cooperation for Enhancing Science, Engineering and Technology Standards in Asia and the Pacific," and particularly the project findings and results in the form of best practices, not only to Nigeria, but also to most African regions (West and East; e.g., ECOWAS and SADC), through direct bilateral country agreements and participation. Such initiative could assist national governments to develop their main agricultural research, and to promote local and appropriate technologies within their own agricultural policies. At the same time, countries will have opportunities for job development related to water resources management, including the following examples:
    - Engineering aspects to emphasize alternative sustainable farming practices that include agroforestry and intercropping cereals to improve nitrogen-deficient soils and reduce reliance on synthetic fertilizers and pesticides. Increasing productivity on existing cropland is fundamental if Africa is to avoid destroying vital ecosystems, such as its biodiversity-rich wetlands and rainforests;
    - Increasing irrigation in order to increase food security: The estimated rate of agricultural output increase needed to achieve food security in Africa is 3.3 per cent per year. The potential for meeting this increased output exists, since two-thirds of African countries have developed less than 20 per cent of their

agricultural production, with less than 5 per cent of the cultivated area being irrigated;

- Avoid the pitfalls of over-irrigation: Irrigation development was an important component of the "Asian Green Revolution" used to double yields by supplementing unreliable rainfall, while investing in simple and inexpensive irrigation technologies. Although these offer the best advantages for increasing irrigation for food production, they must be managed carefully to avoid already-extensive environmental damage and the spread of waterborne diseases;
- Parts of sub-Saharan Africa have large untapped groundwater reserves, as well as great potential for harvesting water runoff, and farming lowlands and valley bottoms that catch it naturally. This potential could be unleashed with appropriate investments. Other water conservation techniques include switching from surface to 'smarter' irrigation techniques such as micro-irrigation, mulching, and using cover crops to minimize the loss of available green water;
- An increased level of irrigation can be achieved with both surface and groundwater, drawing lessons from within and outside the region on viable small- to medium-scale irrigation techniques that require limited infrastructural development and which can reach many farmers;
- Methods such as pumping from rivers on an individual and small group basis, and locally manufactured drip systems are still to be fully exploited. Surface irrigation is easy to operate and maintain, and can be developed at the farm level with minimum capital investment, with an indicative field application efficiency of around 60 per cent. Most energy requirements for surface irrigation systems come from gravity, with these systems being less affected by climatic and water quality characteristics. Sprinkler irrigation has a high irrigation field application efficiency of around 75 per cent, and is relatively easy to design, and simple to install and operate. It can be adapted for all types of soils, many kinds of field crops and small irregular plots, and is less expensive than many other modern irrigation systems. Drip irrigation is the most advanced irrigation method with the highest field application efficiency of around 90 per cent. Water is applied to each plant separately in small, frequent, precise quantities through dripper emitters. Switching from sprinkler irrigation to drip systems has resulted in a reduction in water use of 30 to 60 per cent;

- Link irrigation development to issues of social equity and environmental sustainability: The large-scale irrigation schemes of the past have lost favor because of their social, environmental and financial costs;
- Secure sustainable investment for green approaches: Technologies such as the development of under-utilized irrigation potential, and development of high-yielding and more drought-tolerant varieties, can work for Africa, assuming good investments are made. African farmers can reduce reliance on food imports, and also protect against the import of low-price grains. African Governments are taking ownership of their own agricultural policies through initiatives such as the Comprehensive Africa Agriculture Development Programme (CAADP), which provides the framework for supporting the design and implementation of national agriculture and food security strategies. This initiative presents an opportunity for development partners and the private sector to support national governments, and to reduce donor fragmentation, so that financing can be channeled to effectively support the implementation of national-scale agriculture strategies within the framework;
- Invest in targeted breeding of drought-tolerant varieties: The African Development Bank and the African Rice Initiative coordinated project contributed to a six per cent increase in the continent's rice output during 2007. Such targeted breeding can produce crop varieties that are higher yielding, more drought-tolerant, utilizing fertilizers more efficiently, and being more resistant to pests. It is important to note that genetically-modified organisms (including crops) are still considered as an emerging issue in Africa since they present the following concerns and uncertainties in light of increasing cooperation and trade:
    - issues of bio-safety;
    - impacts of GMOs on the environment;
    - trade with non-GMO partners;
    - ethics issues;
    - intellectual property rights;
    - access to seeds by small-scale farmers.
- Develop hydropower because it will boost the economy and human well-being; invest in hydroelectricity rather than fossil fuels, which makes sense in an era of climate change; learn from the many Asian and African countries that have

developed hydropower successfully; also learn from and copy successful regional power pools; and develop small-scale hydropower projects to avoid the environmental and human costs associated with large dams;

- At the same time, regional power pools are able to reduce costs and improve conditions on the supply side. Operational costs are lower, due to investments in least-cost power generation plants on a regional basis. Benefits on the supply side, all of which contribute to increased reliability, include reduced coincident peak loads on the regional power pool, compared with the sum of the individual peak loads for each national power grid; shared power generation reserves for the interconnected power grids; and increased robustness to deal with local droughts or other unexpected events.

All the elements discussed above are linked to agricultural research, and promote local and appropriate technologies, while at the same time providing opportunities for job development related to water resources management, agriculture and energy.

In the area of water-related jobs, as well as technical aspects that could be developed in Asia and Africa, several other opportunities also exist, including:

- Opportunities in rural communities to adopt free-standing small-scale systems capable of treating water; recovering wastewater for re-use and capturing resulting gases as a source of energy for power, lighting and cooking; support to community-level projects on water resource management, water supply and sanitation, etc.;
- Encouraging entrepreneurship for rainwater harvesting and simple water purification techniques, solutions that can use local ingenuity;
- Implementing simple tools and mechanisms that have been shown to improve access to safe drinking water; and
- Encouraging and supporting simple solutions from entrepreneurs, who are increasingly implementing low technology and affordable toilets.

3. **<u>Implementation of SDG-6</u>, "Ensure availability and sustainable management of water and sanitation for all":** It will be necessary to encourage countries to consider the water cycle in its entirety, including environmental, social and economic aspects, and promoting an integrated approach to water resources management. It also will be

important to encourage all voluntary countries to pursue the exercise of monitoring SDG-6 indicators, which should be undertaken by the countries themselves, including development of agreed methodologies and their regular follow-up.

4. **"Water, Energy, Food and Climate Nexus**": A proof of project concept on this issue has been sent to the CEWRE Director for further discussions and possible development as a pilot project initially between 2 or 3 countries (e.g., 1 in Asia; 2 in Africa). This will need to be followed up as a possible example for sustainable management of water resources, with selected examples in Asia and in Africa.
5. **Essential actions for sustainable management of water resources**:
    - Maintain vital ecosystem functions: An example is the allocation of water of a specific quantity and quality to maintain the basic ecological functions of aquatic ecosystems. This quantity of water is typically referred to as environmental flows or ecological reserves. The aim of the reserve is to protect the legitimate right of rivers and other ecosystems to needed water supplies when water allocation decisions are made. Although stakeholders sometimes interpret such protection or allocation as being in direct competition with human needs, such reserves represent an opportunity to maintain the health of rivers and other ecosystems that provide water-related ecosystem services (e.g., maintaining water flows) for the overall benefit of society. Sustaining various ecological functions through the reserve in turn guarantees and prolongs the sustainability of ecosystems;
    - Address the issue of sustainable water strategies, including land degradation and pollution. Another more reason for establishing centers of excellence staffed with scientists networking with other water research and management experts is to build capacity to monitor water quality, collect data and identify good water management approaches;
    - Reinforce traditional adaptation mechanisms and provide early warning systems responsive to assisting local communities vis-à-vis frequent climatic hazards and adverse environmental changes;
    - Better forecasting and early warning systems are a prerequisite for adaptation, particularly for predicting and preventing the effects of floods, droughts and tropical cyclones, as well as for indicating planting dates to coincide with the beginning of the rainy season, and predicting whether or not disease outbreaks may occur in areas prone to epidemics. Improved early warning systems and their application will

reduce vulnerability to future risks associated with climate variability and change;

- Introduce adaptation measures informed by a more reliable system of seasonal predictions, including better management of agriculture and water resources, diversifying livelihoods, and improving production efficiencies in arid lands and marginal areas by intensifying livestock densities, using natural fertilizers and practicing soil and water conservation. Improvement in the present rain fed-agriculture can enhance resilience for future periods of drought stress through technological steps such as water-harvesting systems, dam building, water conservation and agricultural practices, drip irrigation, and development of drought-resistant and early-maturing crop varieties and alternative crop and hybrid varieties. Biotechnology research could also yield tremendous benefits if it leads to drought- and pest-resistant rice, drought-tolerant maize and insect-resistant millet, sorghum and cassava, among other crops, supports public-private partnerships that develop innovative adaptation measures, and improved physical infrastructure that may improve adaptive capacity. Building improved communication and road networks for better exchange of knowledge and information, for example, provides an opportunity for people to migrate more easily in case of extreme events attributable to climate change. General infrastructure deterioration, however, threatens the supply of water during droughts and floods.

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