

Build capacity on water harvesting in general on Haffirs construction and rehabilitation specifically	Ensure proper construction of Haffirs, Ensure effective use of resources and to avoid negative environmental impacts	MoWRE, HCENR, PWC, SWCs, FMoF	ST	Advocate and provide funding for researches related to the technology, Provide internal and external trainings, Conduct EIA, Use local capacities like PWC training center	55,000	MOWRE, UNEP, UNOPS, FmoF, SmoF, NGOs, UNICEF	No. of researches related to water harvesting conducted No. of people trained internally and externally No. OF EIA conducted	Limitation in financial resources
Grand Total 266,500 USD								

Note: ST: short term 0 -5 years , MT: medium term 5 – 10 years, LT: long term 10 -20 years

2.3 Action Plan for Seasonal Forecasting and Early Warning (Automatic Water Level Recorders)

2.3.1 About the Technology

The development objective of seasonal forecasting and early warning system is to reduce human suffering and damages and capture the benefits of flooding. Monitoring water level fluctuations for early warning system is achieved by one of several technological methods. One is Remote Sensing technology for the receipt and processing of satellite images used to estimate daily rainfall quantities over the catchments of the Blue Nile and Atbara rivers in Ethiopia and Sudan; whereby a communication system transmits water levels in the Blue Nile, Atbara River and main Nile in Sudan to the Flood Warning Centre in Khartoum. A computerized Flood Forecast System, consisting of a set of mathematical models with an appropriate user interface allows smooth and rapid data processing and forecasting. Seasonal forecasting and early warning systems related to Nile floodings and its risk in Sudan are not well developed, mainly because of inefficient and old technologies. Hence, the application of the automatic water level measurement technology is essential to accurately monitor the water levels in the River Nile and its tributaries at the key stations and report early warning information in appropriate time to protect about six millions people residing in the Sudan's flood plain. It is note worthy that this technology fits well for both present and expected climate conditions. To facilitate the success of the technology it is essential for government agencies to provide the floodplain dwellers with flood relevant information

(water level fluctuations) in a clear and useful form to be easily understood by the intended users.

The automatic surface water level measurement technology uses a surface water data logger and submersible pressure transducer combination to measure Nile level fluctuations designed for remote monitoring and recording of surface water level or pressure data. A water level logger can record over 81,000 readings. It has four unique recording options and a 25 ft. vented cable on all water level loggers. Installation of the automatic loggers and their management require experienced staff and institutional organizations.

Many economic, social and environmental benefits can be gained from the implementation of the automatic water level such as preventing loss of communities' resources and their lives resulting from floods; and facilitate forecasting of extreme weather events. The climate change mitigation benefits are strengthening local communities' resilience. One of the main drawbacks of the automatic water loggers is their high costs compared with normal gauges. In addition, they are sensitive and thus can break easy. Therefore, special care should be taken to the area of allocating water level measurement technologies.

2.3.2 Target for technology transfer and diffusion:

The Seasonal Forecasting and Early Warning System have been developed to predict storms and floods in order to provide the flood plain dwellers with flood relevant information (water level) and to develop plans in time to minimize negative impacts. This information has to be delivered effectively in a clear and useful form readily understood by the intended users. This technology has an important role in countries like Sudan which are prone to flood while having quite poor infrastructure. Seasonal forecasting and Early warning systems in Sudan are not well developed; this is because the used technologies are old ones and not efficient. Hence, the application of the Automatic water level technology is essential to accurately monitor the water levels in the River Nile and its tributaries because about 6 million people are residing in Sudan's floodplain. It is worth mentioning that this technology fits well for both present and expected climate conditions. Seasonal forecasting and early warning technology (automatic water level recorders) has a wide international market and it should be ordered and implemented by the government of Sudan (Ministry of Water Resources and

Electricity). No market mapping has been used in the barrier analysis as it is a public good. Many benefits could be gained from the implementation of the automatic water level measurements. Here are some results from the 14 Key stations:

- * Improvement of the network of hydrological data collection
- * Collection of hydrological data on a more regular basis and at a lower cost
- * Provision of improved monitoring systems, which is the main input to the existing forecasting models

2.3.3. Barriers to the technology's diffusion

It has been noted that the main economic barriers for the application and distribution of the technology are lack of funding. According to Sagyroon, the costs of the automatic surface water level recorders (Pressure Type - SEBA) are about USD 56,000. The high capital costs of the gauge station including the costs of automatic surface water level recorders, installation and maintenance costs, as well as required training of personals form the main financial barriers. Another important aspect may be that the automatic water level recorders have a wide international market. It is necessary to reiterate that they should be ordered and implemented by the Government of Sudan, in particular the Ministry of Water Resources and Electricity.

The non-financial barriers include overlapping roles and responsibilities of different institutions related to water resources, as well as conflicting policies and regulations. For example, the water resource sector suffers from limited institutional cooperation, coordination and data sharing. Hence several legal and administrative conditions do not facilitate data sharing across different governmental agencies. This creates a non-collaborative atmosphere among the different institutions of the same interest and destroys communication and data integrity across the sector. Further barriers are lack of technical know-how and experience to implement automatic water level technologies confidently and effectively; cultural and social unsustainable tranquillity poses a barrier. Sensitive and easily breakable equipment is an important consideration to bear in mind. Lack of proper wireless network which is needed for real time data transfer and gaps in information, research and development are other barriers to be overcome. Furthermore, siltation can technically affect the proper work for some logger types, therefore pressure types have to be used.

Generally, barriers related to automatic recording systems can be summarized as:

Financial barriers:

- * High capital costs of the gauge station including the costs of automatic surface water level recorders, installation and maintenance costs, as well as required training of personnel
- * Automatic water level recorders have a wide international market; yet they should be ordered and implemented by the government of Sudan, in particular the Ministry of Water Resources and Electricity

Non-financial barriers:

- * Overlapping roles and responsibilities of different institutions related to water resources
- * Conflicting policies and regulations related to water management, creating a non-collaborative atmosphere among the different institutions of the same interest and undermining communication and data integrity across the sector
- * Lack of technical know-how and experience to implement automatic water level technologies confidently and effectively
- * Cultural and social unsustainable tranquillity
- * Sensitive and easily breakable equipment
- * Lack of proper wireless network needed for real time data transfer
- * Gaps in information, research and development

2.3.4 Identified measures for overcoming barriers for the transfer and diffusion of automatic water level measurements

Best water resource management can be achieved by using modern techniques like automatic water level measurements for adequate and effective monitoring and observation of both water quantities and qualities. Adoption of these technologies will assist in reduction or avoidance of the negative impacts of climate change on floods and droughts phenomena. The identified measures to address the aforementioned barriers can be categorized as follows:

- * Funding and awareness raising to finance the pilot station projects comprised of automatic recording systems in 14 river gauge stations along the River Nile. Hence, the benefit revenue from these pilot stations could be allocated to the annual cost of operation and maintenance.
- * Advocacy for the program at high level to convince decision makers

of the essence and the outcome of the project and thus facilitate funding. Grants and loans also can be advocated to convince decision makers to implement the project, especially those who have an interest in such type of projects.

- * Set awareness sessions for target groups at national and state levels to highlight the importance of the project and its impacts along with mobilization of local resources

- * Create enabling and conducive policy and legal frameworks in planning and management across all water departments in Sudan

- * Institutional strengthening and capacity building to enhance adaptation capacities and human resource development via series of training sessions

- * Collaborative cooperation with international agencies of same interest and with international experts and professionals in these technologies to assist in identifying the best measures and practices and strengthen technical know-how

- * Securing and preventing expected damage or loss of sensors by providing the automatic loggers with steel cages or protective coverage, especially in report areas.

2.3.5 Proposed action plan for seasonal forecasting and early warning (automatic water level recorders)

The action for diffusion and transfer of automatic water level recorders are threefold: namely (1) funding and awareness raising (2) enforcing policies and legal frameworks and (3) institutional strengthening and capacity building.

- * Funding and awareness raising: In order to overcome financial barriers related to capital and operational costs of automatic water level recorders in 14 river gauge stations in Sudan, allocated funds to finance the pilot station projects should be used. Hence, the benefit revenues from these pilot stations could be allocated to the annual costs of operation and maintenance. After providing first successful reports of the technology, policy makers and other donors can be attracted to secure funding to upscale the technology by implementing it in other areas throughout Sudan. This requires determining a long-term budget plan covering implementation and maintenance costs that can be included in the national development programs.

- * Policy and legal framework: Developing and adopting climate change

policies and strategies is essential for the government of Sudan as it will systematically enhance forecasting and early flood warning and help in disaster management and response. As discussed in the previous sections, lack of inadequate policies and legal frameworks constitute a major barrier to the successful implementation of automatic water level recorders. Thus, to overcome this barrier and promote sustainable development, it is recommended to adopt integrated water resources management and catchment management systems across all water departments in Sudan. This can be achieved by developing and finalizing water resource policies. In particular, the TAP proposes establishing collaborative cooperation with international experts and professionals in these technologies to assist in identifying the best measures and practices.

* Institutional strengthening and capacity building: Capacity building of the MoWRE should be improved to manage automatic water level recorders and to enhance sustainability. Capacity building for these institutions can be realized in terms of providing training and raising awareness in the installation and operation and management (O & M) of these loggers. Training can be accomplished through the service providers and can include onsite training in installation along with training in O & M. Moreover, training of staff and raising their levels of awareness on possible consequences of climatic changes is essential to keep focusing on managing the impacts of climate changes through available adaptation technologies. In addition to that, the provision of related equipment and materials like power sources, computers and network inputs will support a smooth and effective implementation of the project. It will also be beneficial to use most reliable wireless network for real time data transfer. Past experience indicated that some of the surface water loggers were vandalized by some local people for unknown reasons. It is worth mentioning that protection of equipment is essential to enhance the effective use of resources which can be achieved by procuring loggers with steel cage or concrete housing. Visit exchanges with countries using the same equipment will be very useful and improve the implementation capacity.

Table 10: Summary of Technology Action Pan for seasonal forecasting and early warning (Monitoring System: automatic water level recorders):

No	Action	Why is needed	Who take action	When	How	Cost in USD	Funding source	Indicator	Risk
Funding and Awareness									
1	Integrate the technology into planning and development program at the national level and river basins projects	Providing funds for technology promotion, national projects and NBI has secured funds	MOW-RE	ST	Coordinate with national funding agencies and FMoF, Applying for financial support from both domestic and foreign funding agencies, ensure the technology in the national and foreign funded projects	10,000	FMoF		lack of financial resources for funding national project.
2	Build public awareness on the essence of the technology at local, state and national levels	Facilitate understanding and funding, Enhance the role of public communities, Safeguard resources from damage by public	MOW-RE	ST	Develop programs and materials for awareness raising using mass media, Organize training courses to raise awareness, Conduct house to house visits at village close to the sites, Conduct focus group discussion to raise awareness, Brainstorming on the requirements, application, and communication of prediction and warning data	50,000	FMoF, MOW-RE,	No. of campaign conducted No. of training conducted No. of HHV conducted No. of FGD conducted	Limited resources
3	Determining long-term budget plans to assure that it covers maintenance	Ensure sustainability of service	MOW-RE PWC	MT	Develop long term operational plan, Include plans in national development program , Advocate for funding	10,000	FMoF, MOW-RE,	Long term budget document provided	Limited funding for development project
Policy and legal framework									
4	Support development of water resources policy	Encourage technology diffusion, Strengthening roles of IWRM focal point	MOW-RE GWWD	ST	Review the current draft policy, raise awareness on essence of the policy, advocate for IWRM	70,000	MMOW-RE, UNEP, FAO, FMoF, UNDP	water resources policy document provided	Continous change in Government structure and senoir officials
5	Develop rules and regulations for coordination between organizations and formulation of water resources forum	Sharing of information, Avoid duplication, Effective use of resources	MOW-RE GWWD	ST	Review functions of relevant organizations	7,000	FMoF, MOW-RE, , UNEP	Water resources forum formulated	Competition among government institutions on resources and power

6	Develop clear understanding among the relevant agencies in the collection and co-ownership of data and data sharing, and support development of water resources database	Effective planning, Max. use of resources	MOW-RE	ST	Raise awareness on data collection and sharing, Share available data with partners	6,000	FMoF, MOW-RE,	Water resource database established A forum for coordination and information sharing established	Competition among government institutions on data collection and lack of interest in sharing information
Institutional Strengthening and capacity building									
7	Raise awareness on the application of prediction and warning systems using this technology for different groups of users	Support technology promotion, Improving knowledge on CC, Enhance local capacities in forecasting, Improving knowledge	MOW-RE	ST MT	Arranging local trainings on the prediction climate disaster and warning systems Arrange awareness workshops on the technology importance. Exchanging research scholarships, seminars and trainings on seasonal climate prediction, Collaborating with research institutes from overseas to provide training on forecasting and early warning	60,000	FMoF, MOW-RE, UNDP, FAO	No. of trainings conducted No. of awareness workshops conducted No. of related research conducted	Lack of funding from all partners
8	Building a national and international research networks for technology transfer from overseas and to exchange knowledge	Improving knowledge, Updating on new technologies, Provide technical backup for the process	MOW-RE	MT	Facilitate networks for local and international experts, Organize training on technology applications			Research networks established	Institutions will not share adequate information
Grant total						213,000			

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