Technology Fact Sheet for Adaptation

M. Early Warning System for Water Supply Management (river flow) through Snowpack Monitoring [i]

Technology characteristics	
Introduction	Climate change will affect snowpack and water supply systems. It is expected to dramatically alter the flow regimes of the rivers, particularly those where melt water from snow constitutes a dominant component of stream discharge. In Lebanon, most river basins are mainly dependent on snow melt. Moreover, large variation in snow cover between years has direct impacts on water supply to rivers, especially that changes in flows can have adverse effects on multipurpose water resources supply if no appropriate adaptation measures would be undertaken. Accordingly, early warning system for water supply management through snowpack monitoring increases readiness to these changes.
Technology characteristics/highlights	Providing an early warning system for water supply management involves the development of a model that predicts stream flow based on snow cover in the river basin. Such model relies on snow cover spatial and temporal variations data derived from remote sensing. The system requires: • An automated on-ground snow stations that record real time snow depth in different locations within the river basin. • A gauging station on the river that records stream flow data. • Using Moderate Resolution Imaging Spectro-radiometer (MODIS) satellite images for snow cover monitoring. The snow cover maps obtained from MODIS are corrected using ground information in order to assure a high overall data accuracy. • Model calibration and validation by using actual measured data and historical series of stream flow data, provided by the Litani River Authority (LRA) and eventually Skiing stations.
Institutional and organizational requirements	The LRA is the responsible authority for monitoring Litani River flow. Linkage with other relevant public authorities (Ministry of Energy and Water (MoEW); Kadisha Electricity; the Lebanese Army-Mountain Fight Units, etc.), Chouf Cedar Reserve, skiing stations or other partners from the private sector (i.e. skiing and ecotourism clubs, Mineral water companies, aquaculture exploitations, etc.) is required for ensuring sustainable monitoring and data transfer to the responsible authority of each water basin. As this technology has to be newly introduced to Lebanon, capacity building is required among concerned stakeholders.
Operation and maintenance	Operation and maintenance consist primarily of carefully procuring continuous maintenance of stations that record snow depth and gauging station for stream flow measurements.

Endorsement by experts	In Lebanon, very limited research was conducted in the field of early warning systems and snow monitoring. The findings of such research will help to develop a good tool to be used in water supply management.
Adequacy for current climate	Fits well, both for present and expected climate particularly that this technology highlights well challenges linked to both climate change and climate seasonal and annual variability.
Scale/Size of beneficiaries group	The beneficiaries involved with such technology could be primarily authorities that are responsible for water supply management, such as MOEW, LRA, MOA, Water Establishments and municipalities. Farmers or the end-users from water resource constitute an important beneficiaries group. Mineral water companies could be also an important stakeholder, as well as other private companies dealing with snow and water resources.
Disadvantages	Early warning systems require permanent monitoring; particularly the stations that record snow depth should be continuously maintained. Moreover, some disagreement between MODIS and ground-observed snow depth data could be faced due to cloud cover that could prevail in the study area. Hence the system will has to rely on human resources for ground double checking for satellite data. The cost-effectiveness of Remote sensing versus ground measurement of snow depth backed up with aerial photos s required.
Capital costs	
Cost to implement adaptation technology	The cost is mainly attributed to the snow depth record stations and to stream flow gauging stations to be established along different basins. LRA has flow gauging stations along Litani River. However these stations are not enough for monitoring. Several stations should be installed along Litani basin or other river basins. Stream gauge unit costs 15 to 20000$, according to the type and size. If snow depth monitoring is done through real time ground sensors, the cost varies between 500 and 1000$/sensor according to the prototype.
Additional cost to implement adaptation technology, compared to "business as usual"	The cost of gauge maintenance, satellite images, field check, and data analysis may be more than 15000$/year. If data is transferred through a wireless technology from gauge stations and sensors, an additional cost should be noted. Training and capacity building for the concerned stakeholders should also be taken into consideration.
Development impacts, direct and indirect benefits	
Direct benefits	- Providing an early warning system that is based on river flow prediction through monitoring snow cover. - Reducing the pressure on water resource on the basis of water supply management.
Reduction of vulnerability to climate change, indirect	Providing a better allocation of water between the end-users on the basis of seasonal stream flow predictions. Insuring a better Qaraoun reservoir (or other eventual dams) operation optimization. Enabling municipalities, farmers to be more ready to climate extremes. Flood risk management especially in prone areas around Litani River.

Economic benefits, indirect Employment	Enabling better efficiency and effectiveness for insurance business, winter sport business, mineral water companies and aquaculture investments.
Social benefits, indirect Income	The end-users can increase their income by properly managing the water that is allocated to them according to each growing season.
Environmental benefits, indirect	The early warning systems for water supply management are considered among the most sustainable alternatives to cope with water shortage. It would have a number of advantages that include good management between water supply and demand, better allocation of water resources, and providing sound solution to water scarcity and climate change.
Local context	
Opportunities and Barriers	The development of a database on pilot area, particularly the Litani river basin, is needed. Barriers could be related to a lack of interest from the concerned entities.
Market potential	The number of beneficiaries and their diversity of end-users make of this technology highly marketable in Lebanon.
Status	Not present in the country.
Timeframe	The implementation can start on Litani river basin (short to medium term)
Acceptability to local stakeholders	The technology is easy to be accepted by local communities.

[i] **This fact sheet has been extracted from TNA Report – Technology Needs Assessment Reports For Climate Change Adaptation – Lebanon. You can access the complete report from the TNA project website http://tech-action.org/**