Improving irrigation efficiency in the Bekaa Valley

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Irrigation History

Anthropic pressure will continue to escalade over water resources of Lebanon and the Bekaa Valley in particular as the main agriculture zone. Before 1980s, water resources were easy to be managed because of its abundance. The government used open water channels to divert permanent watercourses to agricultural lands. Water demand was not high in comparison to supply. Gradually after, agriculture was intensified demanding high water volumes for irrigation. In addition, urban encroachment expanded randomly where tube wells followed similar geographic distribution. Thus, surface water recharging aquifers are depleted aggressively through random excavation of deep tube wells. Permanent rivers and surface water sources are transformed into intermittent or are drying off. Concurrent drought events and climate change scenarios are aggravating the pressure over water resources (e.g. AUB, 2014). Plans are highly required to increase water supply and manage restoration measures.

Throughout the centuries, irrigated agriculture has expanded mainly neighboring surface water resources. Farmers constructed open water channels from soil materials. Dirt-made open channels diverted water for surface irrigation systems on field crops. Increased number of farmers surrounding water resources required in establishing rules of sharing water resources. Water should reach longer to the sides where farmers also need to irrigate.

Networks of open channels were among the first surface water management actions. Open channels diverted water to reach distant lands off the stream shores. Scheduling periods were designed by open channels, depending on water availabilities.

Farmers knew the turning plan by open water channel and they irrigated for an allowed number of hours. Irrigated water volume was not a managerial limit factor. Irrigation-water-use efficiency was not part of the execution plans. Water flourished in sufficient volumes and it was available to overcome demand.

Irrigated agriculture on surface water resources was sufficiently enough to secure food demand. Limited irrigated lands did not require large volumes of water supply. Lands far from the surface water resources were mainly rainfed with some exceptions that used shallow groundwater resources. Groundwater irrigation was rarely found in very limited locations. Thus, irrigated agriculture was mainly found on rivers, streams and surface water springs.

Rainfed agriculture is distributed over elevated areas. Fruits of mainly grapevines and figs were scattered on mountains, hills and lands of no irrigation possibilities. Figs were only irrigated at El Qaa village, which is an area of arid climate. Upper lands drains into lower valleys and plains where irrigation agriculture has expanded. Water from permanent springs, streams and rivers have been divided between neighboring lands into sharing phenomenon.

The water-share was stamped over the land ownership official documents. The water spring name, open channel share or river-water share were registered on lands ownership. This management process is independent of time and age. The water-share remains unchanged by land. This kind of water distribution demonstrates the short vision in managing water resources.

Management plans of water resources seem not to draw prospected image of possible future circumstances. It could be called "short vision plans". Population increase has raised the food security requirements which might need larger irrigation lands (e.g. MoE/LEDO/ECODIT, 2001). In addition, water shortages and drought events has affected water availabilities. Furthermore, technological advances had become largely available at farmers' hands. These technological advancements had paved the roads for longer history of agriculture intensification.

Early 1970s, water pumps of diesel and electrical features had made it simple to reach water anywhere and on demand. Farmers may now grow irrigated crops independently of locality and even far from a surface water resource. Exploiting groundwater for irrigation was included into the agriculture production since that date and on growing scale. Domestic and agriculture use of groundwater was escalading rapidly to meet the cultivation intensification (e.g. MoEW and UNDP, 2014). Intensive agriculture had caused farmers to use large water volumes for irrigation purposes without seeking application efficiency.

The Uncontrolled Expansion of Surface Water Use and Groundwater Pumping

In mid 1980s, irrigation agriculture has expanded largely to remote places far from surface water resources. Groundwater utilization for irrigation purposes has expanded rapidly (Jomaa et al, 2015). Farmers cultivated high water demanding crops and used low efficient irrigation systems. Sprinklers were the only irrigation system to expand among Bekaa area growers. Irrigation water applications were largely higher than crop water requirements. These conditions extended over the last three decades exhausting groundwater resources and largely affecting surface water resources.

At farm level, understanding farmers' irrigation practices remains a challenge where farmers variably apply their cultivation routines. Although application similarities exist between farmers in relation to field management, irrigation practices widely variant among them. Understanding variability of farm-level water-applications was possible through targeted field surveys. Field surveys were randomly held for more than 250 famers over the Bekaa Valley. Irrigation scheduling and practices were the targeted subject of the survey. Methods of water application in relation to cultivated crops were inspected and registered. Greenhouse farms and open field crops were both covered through the investigated field survey.

Results showed that each farmer applies fixed irrigation scheduling protocol. Farmers use the same irrigation scheduling between the seasons. However, these scheduling designs varies among them, where each farmer tend to apply his own concept. As a tradition, each farmer inherited the irrigation scheduling and irrigate following fixed rules. Farmers apply fixed rates of irrigation water for each crop phenological stage. They do not examine soil moisture to schedule for irrigation; rather they apply a counting system that depends on the number of days between water applications. Once the period between two irrigation elapses, farmers apply water in specific number of hours in relation to crop growth stages. A perfect rule of thumb for farmers is to apply more water if it is easily available. Regardless of the irrigation system, farmers apply the same concept of watering protocols.

Drip irrigation system was the next method of water application that it was introduced to farmers in late eighties to early nineties of the last century. The efficiency of drip irrigation is not investigated at farm level in the Bekaa Valley nor in Lebanon. Farmers use drip irrigation in the same concept of utilizing sprinkler irrigation. In comparing the two-irrigation systems, the irrigation scheduling difference resides in the number of days and number of application hours of each watering periods.

Mini-sprinkler, on the other hand, has started since 2010 to be widely used at the Bekaa Valley for open field crops. For example, some farmers are irrigating potato crop on large scale using mini-sprinkler techniques. In comparison to sprinkler technique, mini-sprinkler irrigation system saved energy and consumed less power by irrigation. However, this energy saving reaches the same as regular sprinkler irrigation system throughout the whole crop season. Applied water volumes through mini-sprinkler appeared to reach almost the double in comparison to the sprinkler systems.

Irrigation water volumes varied between farmers for the same crop. Water application time in number of hours differs per farmer and per crop. Each farmer apply his rules that suites the availability and cost of water resources. Farmers divide crop growth stages between initial, middle and late. Irrigation timing decision for each crop phenological stage differ per farmer. It became clear that farmers incorrectly use new irrigation systems by applying more water than actual crop water requirements, decreasing the irrigation-water use efficiency (IWUE).

Using sprinkler systems, farmers are forced to use diesel pumps, pressurizing 5-inch aluminum pipes with 4 to 5 bars, distributing water efficiently over the field. Mini-sprinkler requires less pressure and farmers might use electric pumps of less energy requirements. However, frequency of irrigation application increases while using mini-sprinkler systems. Farmers of mini-sprinkler systems tend to do not monitor applied water volumes because of the lower energy cost. Therefore, the IWUE and water productivity decrease while using mini-sprinkler systems. However, farmers differ in their water application within the same crop type.

As an example, In the Bekaa valley, potato is grown in three different seasons: early, middle and late. Early potato season is cultivated between February-March. Middle potato season is cultivated in April-early June, while late season starts late June to July. Early potato season benefit from spring rainfall that saves between 20 to 150 mm, depending on the length of the rainy season per spring (e.g. Darwish et al., 2016). Potato was only irrigated by sprinkler irrigation between 1970s and 2010.

After 2010, mini-sprinkler systems have been used for irrigating potato fields. However, farmers tend to apply water more efficiently while using sprinkler irrigation in comparison to mini-sprinkler systems. Potato crop is frequently irrigated in ranges between 1 and 7 days, depending on farmers' experience and behavior plus field/irrigation system conditions. Initial potato growth stage is irrigated in a range of either 1 or 7 days, in relation to each farmer concept. Using mini-sprinkler and at the initial stages, potato farmers tend to irrigate in similar timing methods to sprinkler farmers. Farmers increase irrigation frequencies while using mini-sprinkler systems at middle and late potato growth stages. Other examples of water application at farm level are cauliflower farmers irrigate between 800 and 1500 mm of water while the crop water requirements is about 750 mm. Lettuce is irrigated at certain farm with double the required water. Eggplants are irrigated three times the crop-water-requirement quantities. Kiwi is new crop introduced in the area where farmers irrigate it daily.

Another type of agriculture intensification is under protected greenhouses. In early 1990s, greenhouse agriculture was mainly at the coastal portion of Lebanon. Since late 1990s, farmers is extensively growing crops under protected environment at the Bekaa Valley. Farmers are cultivating greenhouses between 3 to 5 crops per year round. Lettuce and tomato are among the frequent crops under protected cultivations. Ornamentals are rarely grown under greenhouses. Drip irrigation system is practiced with almost fixed scheduling rules per famer, whatever is the cultivated crop. Differences in irrigation scheduling are rarely applied at the same farmer.

Low Water Use Efficiency and Potential Improvement

Groundwater was rarely used for irrigation until the mid-1980s. Domestic water use was increasingly relying on groundwater once water networks got failed and broken during the war period. Farmers were also forced to rely on groundwater because of the great competition over the limited surface water resources.

Availability of surface water resources kept declining with increasing population and agriculture intensification. Hand-burrowed wells of few to twentieth meters were drying off at midsummer periods. Farmers, at the same time, started to practice agriculture intensification seeking higher productivity. By that time, new wells-excavation technologies were introduced in the country.

Machines for burrowing tube wells started to extensively function at the valley. Tube wells were extensively scattering for domestic and agriculture water use (e.g. MoEW and UNDP, 2014) Tube wells were becoming the main source of water for irrigation purposes. Tube wells distributed over the Bekaa Valley whenever surface water resources are not in the reach. Depending on the location over the Bekaa, tube wells has started in depths up to 50 m. Currently, depths of tube wells range between 20 and 600 m. Depths of tube wells depend on the area within the Valley. However, overall the valley farmers are seeking in deeper horizons for groundwater resources.

Groundwater is under severe depletion conditions, which is being reflected on the availability of surface resources. Once permanent water source, the Litani River main upstream water source called "El Oleik" was completely dried off since the mid-nineties. This river has changed from permanent to temporary stream, especially at its upper portion. Many other water sources had completely dried off during the same period. At the Upper Litani River part, especially within the stream first 20 to 30 km, river-water is becoming only villages' sewage systems. This portion of the river has the least clean surface water sources recharge, where the majority of them dried off.

Remained surface water is at high risk of being dried off. Tube wells are getting excavated in higher numbers and in the recharge areas of surface water sources. Excavating more tube wells is because of the current urban encroachments, agriculture intensification, drought events and climate change. Reasons for seeking deeper groundwater will continue to rise. Extremely dry year was recorded during the rainy season of 2013-2014. In addition, the last five years were either below the average or just approached it. Therefore, the water recharging potentiality of winter season not sufficient and it did not met the increasing demand. Groundwater will be further depleted under the accumulating challenges.

Overcoming these challenges, one attempt by the Lebanese Agriculture Research Institute -LARI- was developing, early 2015, a smart phone application to communicate with farmers (LARI-LEB, 2015 and Jomaa, 2015). This app replaced a short message system –SMS- that LARI was previously using, for seven years, to send Early Warnings to farmers. Farmers receives daily warning on their irrigation water requirements among other agriculture concerns and weather forecasting.

Conclusions and Recommendations

Water demand will continue to escalade under urban encroachments and agriculture intensification in Lebanon in general and at the Bekaa Valley in specific. Frequent drought events and climate change scenarios are also putting the water resources under severe pressure conditions. Seeking groundwater through tube wells are the only hope for farmers and urban to reach fresh water resources. Overexploitation of groundwater through tube wells has appeared to be among the main causes behind surface water waning. Depletion of water resources will complicated possible water management plans.

Water management plans is challenged by high water demand vs water shortages. Urban expansion, agriculture intensification and climate change scenarios complicated designing successful future strategies. Under the current circumstances, depletion of groundwater and disappearing of surface water resources will be either permanent or require long periods of reclamations. Plans will require focusing on increasing the water supply in parallel with reclamation scenarios.

Bibliography / More information

- AUB,2014. *Impact of population growth and climate change on water scarcity, agriculture output and food security*. Issam Fares Institute for Public Policy and International Affairs. *www.aub.edu.lb/ifi*
- Darwish T., Fadel A., Baydoun S., *Jomaa I.*, Awad M., Atallah T. 2016. Improving Water Productivity in the Bekaa Valley,

the case of Potato Crop. LAAS, the 22nd International Scientific Conference, USEK, 14-15 April 2016.

- LARI-LEB, 2015, Smart phone application on both on android and apple system. https://play.google.com/store/apps/details?id=com.moussawi7.lari&hl=en https://itunes.apple.com/lb/app/lari-leb/id982760031?mt=8
- *Jomaa I.* 2015. Early Warning System for Lebanon. In the Best Sustainable Development Practices for Food Security (BSDP) of Expo Milano 2015. Feeding Knowledge Programme. www.feedingknowledge.net
- Jomaa I., Saade Sbeih M., Jaubert R. 2015. *Sharp expansion of extensive groundwater irrigation , semi-arid environment at the northern Bekaa Valley*, Lebanon. Natural Resources.
- MoEW and UNDP 2014. *Assessment of Groundwater Resources of Lebanon.*
- MoE/LEDO/ECODIT 2001. *Lebanon state of the environment report*. Prepared by ECODIT.