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Pilot Water Use Project

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Advancing Integrated Water Resource Management (IWRM) across the Kura river basin through implementation of the transboundary agreed actions and national plans

Using Hydrological Modelling to Estimate the Impacts of Rational Water Use Pilot Projects

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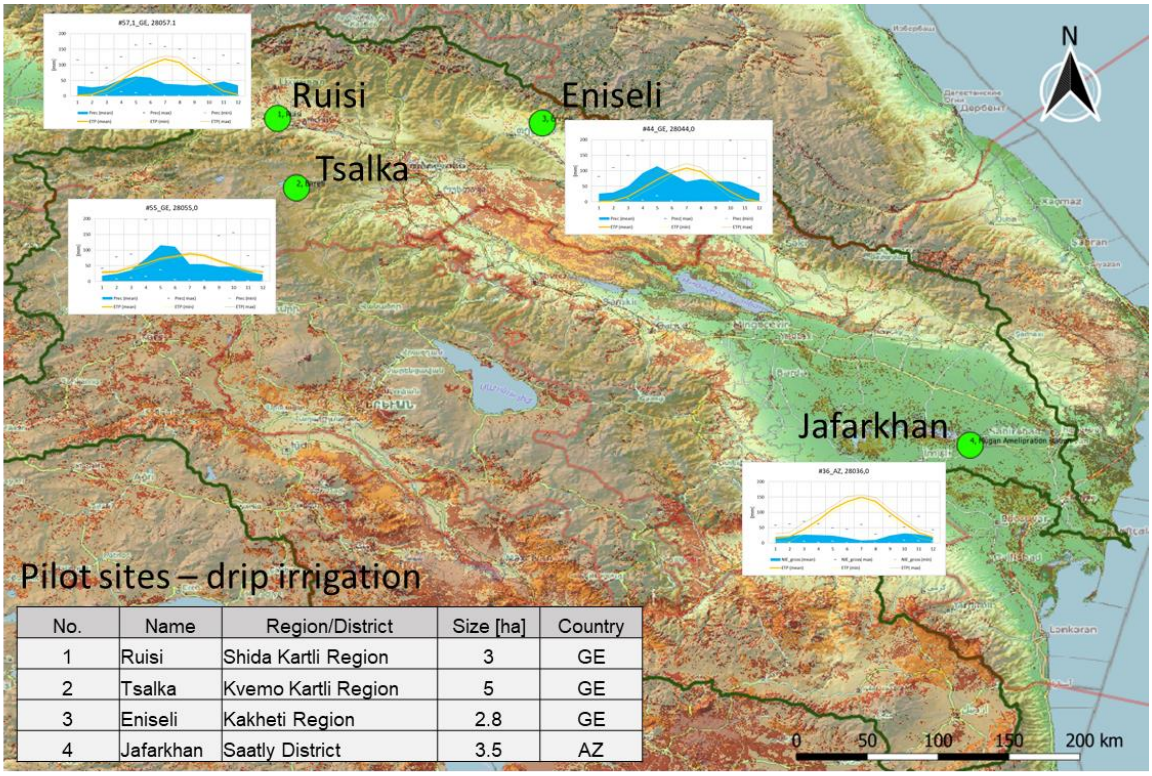
1 THE RATIONAL WATER USE PILOT PROJECTS

The project Kura II - Advancing Integrated Water Resource Management (IWRM) has implemented pilot projects showcasing water saving potentials such as:

- Mobile application for municipal water network leak detection and awareness raising
- E-learning modules for rational water use for school students in the two national languages
- E-learning module for rational water use for local communities similar to the one above but it will target the households and the commercial enterprises
- Installation of drip irrigation at pilot sites in Georgia and Azerbaijan

The drip irrigation pilots were implemented starting in 2019, one in Azerbaijan and three in Georgia. While the Georgian sites had already irrigation infrastructure, the Jafarkhan site in Azerbaijan was previously not used for agriculture activities. The Georgian sites were already irrigated to cultivate onions and potatoes. This means that a comparison with/without drip irrigation was not possible at all locations. Therefore, water savings are elaborated by data from the pilot sites and additionally amended with secondary data, published experiences from FAO and modelling results (Lohr, 2021). The locations of the drip irrigation projects including their water balance are shown in Figure 1. The pilot projects on network leak detention and E-learning modules are independent from locations and not shown in the map.



No.	Name	Region/District	Size [ha]	Country
1	Ruisi	Shida Kartli Region	3	GE
2	Tsalka	Kvemo Kartli Region	5	GE
3	Eniseli	Kakheti Region	2.8	GE
4	Jafarkhan	Saatly District	3.5	AZ

Figure 1: Pilot site for drip irrigation

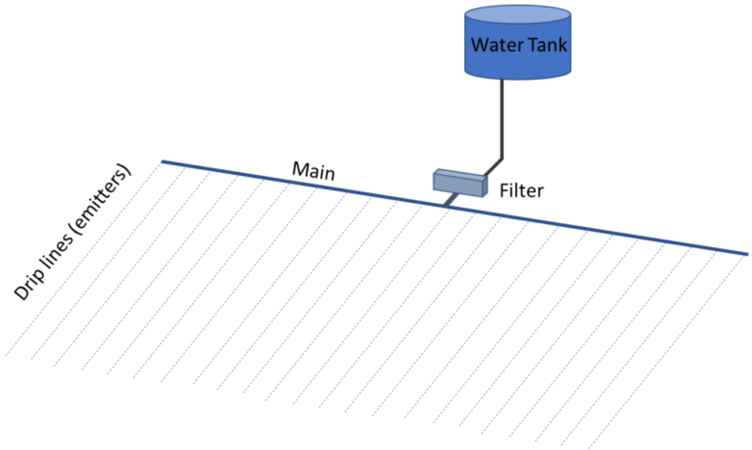
Drip irrigation or trickle irrigation provides water at very low rates through small diameter plastic pipes to the fields where it drips slowly onto the soil. The plastic pipe or emitter or dripper is designed to deliver flow rates between 2 to 20 litre per hour. The advantage of drip irrigation is that only the rooted part of the soil is wetted. Water savings occur due to reduced evaporation losses, no surface runoff and reduced percolation losses.

(Brouwer, Prins, Kay, & Heibloem, 1985) state that drip irrigation is particularly suitable for row crops like vegetable, trees, vine. It requires comparatively high initial investment costs for installing the system. However, investment costs must always be contemplated within the context of water availability and loss of opportunities due to inefficient water use. Therefore, a cost-benefit analysis should allow for both direct gains from the crops that are supplied and indirect benefits through additional economic opportunities that become possible through the water savings. There are a number of prerequisites for drip irrigation that must be taken into consideration (Brouwer, Prins, Kay, & Heibloem, 1985):

- Crops and thus emitters should follow contour lines to minimize changes in discharge as a result of elevation
- Flow rates must be adjusted to the infiltration capacity and permeability of the soil, which means low rates in clayey soils and higher rates in sandy soils.
- The water should be free of sediment since pipe diameters and openings are small ranging from 0.2-2.0 mm.
- Water containing fertilizers, algae or dissolved chemicals should be avoided because they can cause blockage due to fall out and precipitate calcium and iron.

Generally, a drip irrigation system consists of

- Supply (tank, pump)
- Gate valve regulating the inflow into the system
- Filter for removing sediment
- Mainline
- Sub-main
- Emitters

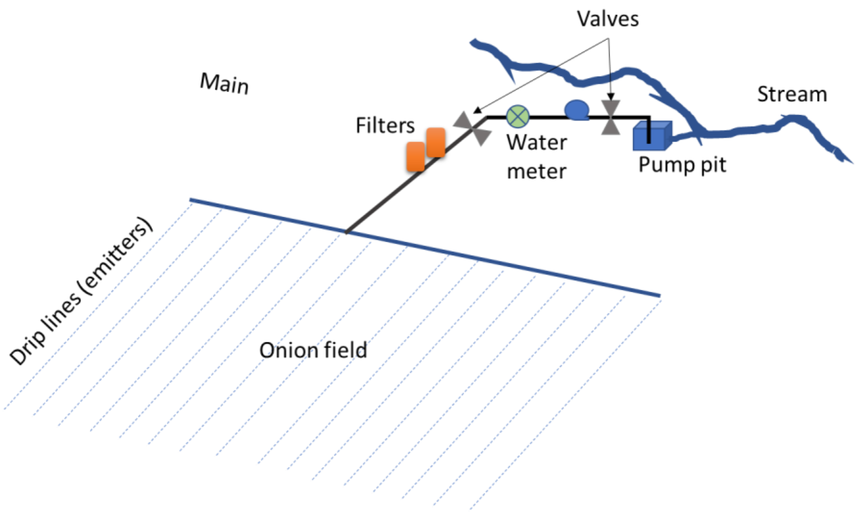


Since drip irrigation provides a small but more permanent doses of water advantages like good aeration of the top soil and optimal soil moisture between field capacity and wilting point can be accomplished. Thus, plants can develop a good root system and water intake is improved.

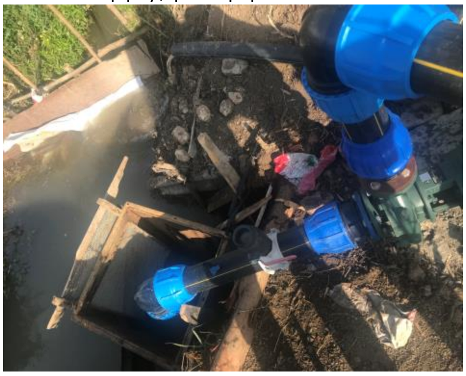
1.1 The Ruisi pilot site (Georgia)

The Ruisi pilot site is located west of Gori close to the village Ruisi in the Kareli Municipality, Shida Kartli Region. The pilot site embraces 3.0 ha. The crop grown at this site is onion. The site is illustrated in Figure 2.

Ruisi pilot drip irrigation scheme:



Water supply, pump pit:



Pump:

Filter:

Mainline:

Onion field:

Emitter with onion

Harvest:

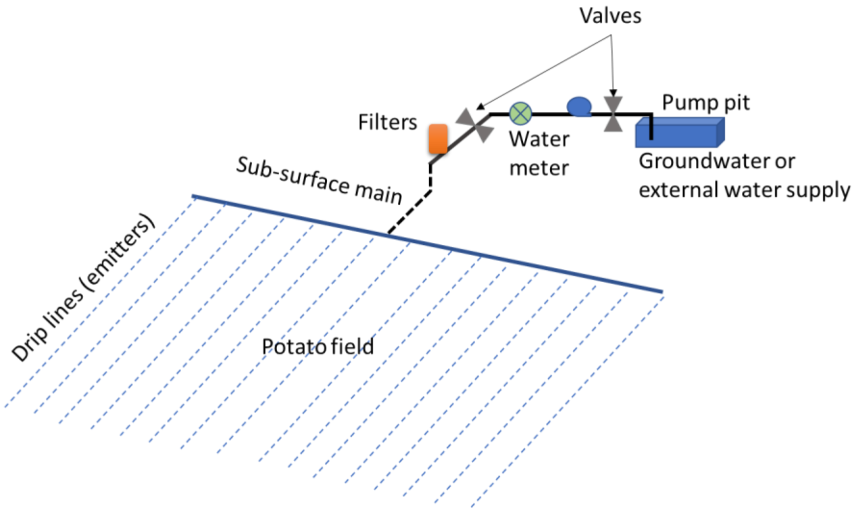
Figure 2: Ruisi pilot site for drip irrigation

The onion field was irrigated once with approximately 6000 m³ or 2000 m³/ha during the typical growing season between first of May until end of June. According to (Gachechiladze, 2020), 60 000 m³ had been irrigated with classic furrow irrigation, which results in a reduction of 54 000 m³ per year or 18 000 m³ water savings per ha and year. Water efficiency could be increased by 90%!

1.2 The Tsalka (Bareti) pilot site (Georgia)

The Tsalka pilot site is located west of Tbilisi Gori close to the Tsalka Reservoir in the Tsalka Municipality, Kvemo Kartli Region. The pilot site has 5.0 ha and the crop grown is potato. The site is illustrated in Figure 3.

Tsalka pilot drip irrigation scheme:



Water supply, pump pit:

Filters and valves:

Emitters:

Emitters:

Potato field:

Harvest in September:

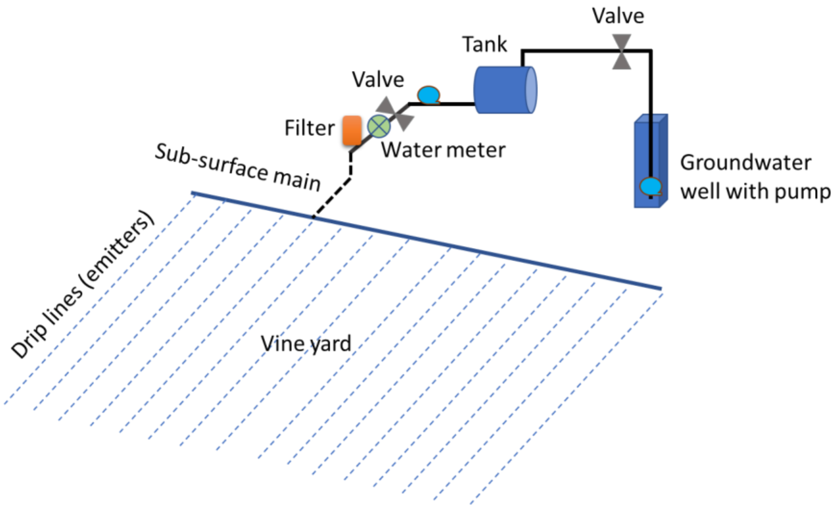
Figure 3: Tsalka (Bareti) pilot site for drip irrigation

The potato field was irrigated once with approximately 2500 m^3 or 500 m^3/ha in the growing season between end of June until end of September. Water savings amounted to approximately 7500 m^3 according to (Gachechiladze, 2020) compared with traditional furrow irrigation. 75% improvement in terms of water efficiency is the accomplishment associated with the use of drip irrigation.

1.3 The Eniseli (Khaketi) pilot site (Georgia)

The Eniseli pilot site is located in the Alazani river basin, east of the Stori river basin in the Kvareli Municipality, Kakheti Region. The pilot site has 2.8 ha of vine yards, which is typical for the Alazani area. The vine from this region is well known and exported in various countries. The site is illustrated in Figure 4.

Eniseli pilot drip irrigation scheme:



Groundwater supply with tank:

Filter and valves:

Emitters:

Emitters:

Opening ceremony:

The vine yard:

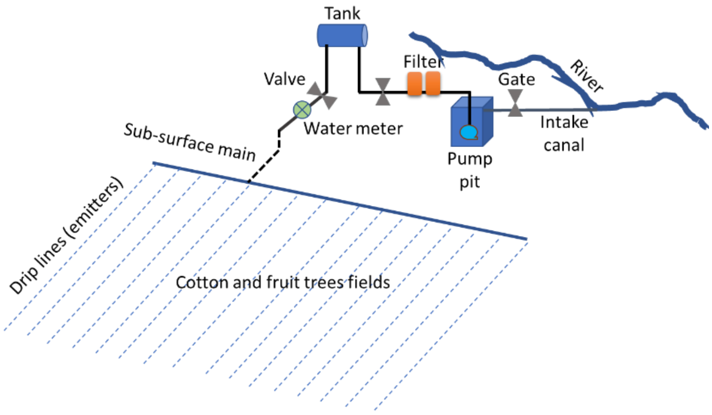
Figure 4: Eniseli pilot site for drip irrigation

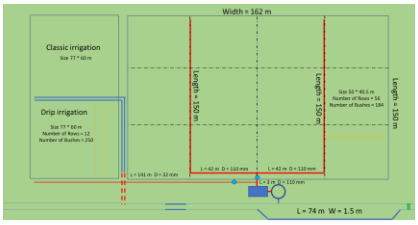
1.4 The Jarfarkhan (Saatli) pilot site (Azerbaijan)

Jafarkhan Amelioration and Scientific Practical Station is situated 8.0 km south-east from Sabirabad, 14 km east of Saatli region. Azerbaijan Amelioration and Water Management JSC have prepared 3.5 hectare of agricultural land for this demonstration project. One part (3.0 ha) of the plot is used to test cotton and fruit trees with drip irrigation while a second part (0.5 ha) is prepared to grow fruit trees (apples, pears, pomegranate apples) with furrow irrigation. The site is illustrated in Figure 5.

The Sabir canal, in approx. 3 km distance from the fields, is tapped as the water source. The pumped water feeds an earth canal. The already existing cotton field and fruit garden had been irrigated with classical furrow irrigation methods. The vast majority of fruit trees planted in the garden area dried up.

Jarfarkhan (Saatli) pilot drip irrigation scheme:





Intake canal and gate:

Pump pit:

Filters:

Valve and water meter:

Tank:

Mainline and sub-main:

Overview:

Sub-main with emitters:

Emitters:

The field:

Figure 5: Jarfarkhan (Saatli) pilot site for drip irrigation

The cotton field was irrigated 3 times between June and August 2019. In total 3x755 m³ of water were supplied per ha, which follows the recommended norm for cotton in Azerbaijan which is 3360 m³/ha per season based on a 4 times irrigation strategy. In comparison, irrigation demand for cotton provided in (Lohr, 2021) was calculated to 3700 m³/ha and season with conditions similar to the Jafarkhan site. Losses are estimated to sum up to nearly 27% subdivided into evaporation, percolation and return flow, which is 3360 x 0.27 ~ 900 m³/ha.

The gross demand for irrigation is then 3360 + 900 = 4260 m3/ha when irrigated four times.

Water savings can be estimated when all figures are used as per irrigation per ha basis, which is:

Traditional: approx. 1060 m3/ha; Drip irrigation (in 2018): 755 m³/ha

The savings are roughly 30% of water per ha.

Concerning production, drip irrigation resulted in 28.4 quintals of cotton compared to 32.3 quintals in the previous year, which is 11.36 per ha with drip irrigation compared with 12.92 per ha with the classical irrigation method. Although, the total amount is less with drip irrigation, the production rate per m3 of water supplied gives evidence how advantageous advanced irrigation methods are. Drip irrigation provided a production rate of 0.015 quintals per m³. The classical irrigation reaches only 0.012 which is 80% of the rate for drip irrigation. The fact that only a three-time irrigation strategy was applied instead of 4 and still the production rate per ha and per m³ was higher underlines the usefulness of drip irrigation.

1.5 Awareness raising campaigns

Awareness on the value of water in general and sustainable use in particular are pillars for efficient water use. The Kura II project embarked on and supported strategies in terms of awareness raising in two ways:

- Mobile application for municipal water network leak detection and awareness raising
- E-learning modules for rational water use

The leak detection is based on crowd sourcing in which leaks are reported by everybody who detects one. Instead of only a few specialists that try to find leaks in a water supply network, everybody can contribute, which in turn multiplies opportunities to find a leak by many times. An app was developed that can be downloaded. The Hydro-Heroes Water Saving App is an opportunity to empower stakeholders to report water leakages from their mobile phones directly to the municipal water companies and learn about conserving water in the process. It is like “Pokemon Go, but saving the world, one drop at a time”. The app is targeted for youth aged 14-35, but can be used by anyone to report leakages using mobile phones and geolocation, linking in to the on-line system that municipal water companies currently have.

The app goes together with E-learning modules for rational water use for

- school students in the two languages Georgian and Azerbaijani
- local communities targeting local households and the commercial enterprises

E-learning modules are state-of-the-art and have proven invaluable many times when access to the Internet with computer and smartphones is just normal, especially for the young generation.

1.6 Constructing a training centre for Aquaponic system

With the support of the NGO International Dialogue for Environmental Actions (IDEA) in Azerbaijan, the project facilitates the construction of a training centre for the use of Aquaponic systems. Aquaponics is the cultivation of fish and vegetables/ plants together in a constructed, re-circulating ecosystem utilizing natural bacterial cycles to convert fish wastes to plant nutrients. The main advantage of Aquaponics over competing technologies for fish and vegetable growth are:

- Water Reuse: Aquaponic systems are completely contained systems that reuse most of the water from the fish holding tanks.
- Space and Production Efficiency: The productivity is higher than conventional aquaculture, while allowing for optimal year-round growth. Market-sized fish can be produced in 9 months compared to 15-18 months in conventional fish farms. For example, it takes 197.6 acres of open ponds to produce the same amount of shrimp that an aquaponic farm can raise on just 6.1 acres of land
- Biosecurity: Aquaponic fish farms, which are fully closed and controlled and operate without any inputs of chemicals, drugs or antibiotics, are bio-secure, as diseases and parasites cannot get into the system.

Introduction of such technology in an arid country like Azerbaijan will generate more jobs with less water resources needed.

2 SUMMARY - WATER SAVING POTENTIALS

Water savings in the drip irrigation pilot sites in Georgia were huge. 90% at the Ruisi site with onions and 75% with potato at the Tsalka site. Water savings at the Jarfarkhan site in Azerbaijan were in the range of 30% and revealed 20% higher production rate per m³ of water supplied. The figures may not be fully representative since the comparison is based on only two years so that hydrological conditions during these given years may have impacted on the water needs and thus on water savings and production.

However, drip irrigation is regarded as the most efficient irrigation method and FAO estimates water savings potentials of approximately 50% (Perry, 2017). Changing from traditional to hi-tech (drip) irrigation has a number of implications.

- Water saved is released to other users
- More production is achieved per unit of water
- Maintenance is regularly required to prepare the fields with the emitters
- Water accounting is recommended to enable the evaluation of water savings
- Training in the use of a drip irrigation system
- Interrow cropping is difficult or even impossible without destroying emitters

The water released to other users offers opportunities that are not possible otherwise. The opportunities enable downstream riparians to use the water for their own purposes, which must be included in a benefit-cost analysis. One central advantage to stakeholders is the possibility to tailor the amount of water required so that the optimal soil moisture is kept and losses are minimized. Water accounting in order to evaluate water savings is required to inform future investments. Water accounting should regard the losses that are generated through traditional surface irrigation like percolation through the soil into the aquifer, surface runoff and thus return flows and losses from evaporation. Only the loss as evaporation, which is not caused by the plant, is real loss while percolation and return flow has still positive aspects. However, percolation and return flow still impedes on proper water allocation planning.

The evaluation of crop water requirements in (Lohr, 2021) revealed estimates of irrigation demand required for different water use efficiencies.

Table 1: Water requirements per year for a set of crops with conditions of the Lower Kartli region, Georgia

		Additional water required with different water efficiencies and crop types (MCM/a)		
Crop type	Area* (ha)	Low (0.3)	Medium (0.6)	High (0.9)
Vegetable	12600	121	61	40
Potato	16400	149	74	50
Tomato	3900	35	18	12
Maize	74700	662	331	221
Vineyard	?	-	-	-
Wheat	43600	227	113	76
Barley	26500	118	59	39
Beans	4900	17	9	6
Total	**195 000**	**1513**	**757**	**504**

*area under cultivation, source: national experts, 2020

Table 2: Water requirements per year for a set of crops with conditions of the Aran region. Azerbaijan

(location #40)		Additional water required with different water efficiencies (MCM/a)		
Crop type	Area* (ha)	Low (0.3)	Medium (0.6)	High (0.9)
Rice	4000	74	37	25
Sugarbeet	7400	103	51	34
Cotton	100100	1320	660	440
Garden vegetable	21400	286	143	95
Vegetable	69400	833	416	278
Potato	56900	696	348	232
Maize	32800	372	186	124
Sunflower	16600	160	80	53
Wheat	670000	5601	2801	1867
Barley	342200	2354	1177	785
Oats	5500	37	19	12
Total	**1 326 300**	**11 836**	**5 918**	**3 945**

*area under cultivation, source: national experts, 2020

The Implications on crop yield and water use efficiency in Azerbaijan using the crop water requirements calculations in combination with the effect of drip irrigation can be concluded as the following:

- The Aran regions is considered most important for agricultural development in Azerbaijan. The Jafarkhan (Saatli district) pilot site is located within this region.
- The deficit season, which is characterised by higher potential evaporation rates than precipitation, covers almost the entire year and calls for the necessity of year-round irrigation.
- High water deficits and thus low to zero crop yields are unavoidable without irrigation.
- Water deficits and in turn irrigation demand can be summarized for the Aran region as the following:
  - Assuming a water efficiency of 30%, the Aran region requires
    - 13,200 m³/ha/a for cotton in order to compensate expected annual water deficits.
    - Rice cultivation would require up to 18,600 m³/ha/a.
    - Potato and vegetable up to 12,100 m³/ha/a.
    - Barley and oats result in the lowest values with 6,800 m³/ha/a.
  - With drip irrigation and assuming a water efficiency of 90%, the Aran region requires
    - Cotton 4,400 m³/ha/a in order to compensate expected annual water deficits.
    - Rice up to 6,200 m³/ha/a.
    - Potato and vegetable up to 4,030 m³/ha/a.
    - Barley and oats 2,250 m³/ha/a.

The Implications on crop yield and water use efficiency in Georgia using the crop water requirements calculations in combination with the effect of drip irrigation can be concluded as the following:

- All regions in the countries, which seem suitable for large-scale agriculture, have a deficit season, which is characterised by higher potential evaporation rates than precipitation.

- The risk of annual water deficits and thus low crop yields without irrigation is high but varies largely with the crop type.
- Water deficits and in turn irrigation demand can be summarized for Georgia as the following:
    - Assuming a water efficiency of 30%, the **Alazani region** requires approximately 125% the amount of annual precipitation in order to compensate expected annual water deficits. In other words, 25% must be transferred from outside to an agricultural production area. The additional amount of water required approximates to 2000 m³/ha/a for potato or vegetables or roughly 600 m³/ha/a for maize.
    - Similarly, the **Rustavi/Lower Kartli region** requires up to three times more the annual precipitation resulting in 9300 m³/ha/a for potato or vegetables and 4000 m³/ha/a, 8800 m³/ha/a for maize and 4000 m³/ha/a for barley and beans.
    - Considering drip irrigation, observations at the pilot sites that up to 90% could be saved compared to traditional furrow irrigation. Taking this into consideration, additional water could be decreased to a level between zero and 600 m³/ha/a in the Alazani region and 1300 to 3100 m³/ha/a for Lower Kartli.

The amount of water needed to compensate water deficit is directly proportional to water efficiency. Wit drip irrigation water efficiency can be significantly increased.

Azerbaijan (with a focus on the Aran region):

Approximately 1.326 Million ha of land is under cultivation with an estimated water efficiency of 0.3 as it is common with traditional irrigation techniques. When the calculated water demand is compared with three different water use efficiency, the potential in saving water resources is huge. It changes from 11.836 MCM/a with 0.3 efficiency and could be reduced by 5.918 MCM/a with an efficiency of 0.6. The highest water efficiency of 0.9 achieved with drip irrigation would further reduce the potential water deficit by 1,973 MCM/a and the irrigation demand drops down to 3,945 MCM/a.

Provided that 1 m³ of water has a price of 0.71 USD based on the average supply cost for public water supply in Azerbaijan (Paccagnan, 2020), doubling water efficiency from 0.3 to 0.6 is worth approx. 4 billion USD. An increase from 0.6 to 0.9 is worth about 1.4 Billion USD. In total, more than 5 billion USD could be saved and invested otherwise if water use efficiency reached a level of 0.9.

Georgia (with a focus on the Lower Kartli region):

Georgia has an area of suitable land for agricultural of 195 000 ha. The water demand with an efficiency of 0.3 sums up to 1.513 MCM/a. The efficiency could be increased with the application of advanced irrigation technology. Assuming an efficiency of 0.6 results in a reduction of water demand by 757 MCM/a. Increasing efficiency further to 0.9, which is attributable to drip irrigation, water demand could be decreased further by 252 MCM/a resulting in a remaining irrigation demand of 504 MCM/a.

Provided that 1 m³ of water has a price of 0.62 USD based on the average supply cost for public water supply in Georgia (Paccagnan, 2020), the gain in reducing water demand by increasing water efficiency from 0.3 to 0.6 is worth about 469 Million USD. Increasing water efficiency further to 0.9 is equal to 156 Million USD. A low level of water efficiency is a high incentive to invest in water efficiency. The application of drip irrigation is certainly an attractive possibility to save water resources and gain more economic opportunities due to the water savings.

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