Public Investments to Development of Irrigation System and Main Enlightenment Issues of Climate Change Adaptation in Agriculture of Azerbaijan

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Abstract Climate change mitigation and adaptation strategy is one of the seventh goals of the Sustainable Development Goals committed by more than 190 leaders in 2015 year. Adaptation strategy in agriculture involves different options and actions by producers and public agencies seeking to maximize public good aspects of adaptation. Public investment to irrigation system of Azerbaijan is vital for country where only 1/3 of all agricultural lands are irrigated and arable. Besides this the water resources in Azerbaijan are very limited and country annually using the 70% of all renewable natural water recourses. Annual water shortage in Azerbaijan varies between 4.5-5 billion m^3. The public financial capital should be invested to irrigation system of country as a part of national adaptation program. Public investments to climate change adaptation strategies should aim at maintaining, or even increasing, food production in key exporting developed and developing regions, or in regions key to regional food security.

Key words: Climate change, Public investment, Adaptation, Agriculture, Irrigation

1. Introduction

Agriculture is not only a fundamental human activity at risk from climate change, it is a major driver of environmental and climate change itself. It has the largest human impact on land and water resources. About 1.4 billion ha of arable land (10 percent of total ice-free land) are used for crop cultivation and an additional 2.5 billion ha are used for pasture. Roughly four billion ha are forested land, five percent of which is used for plantation forestry. Climate change vulnerability and adaptation options in agriculture involve different agents and scales and include actions by producers, input and food industries and governmental agencies, with individual acting for private benefit, and public agencies seeking to maximize public good aspects of adaptation.

Guided by international experience adaptation options for agricultural sector include the following aspects:

1. Technological development
2. Technological adaptation
3. State programs and insurance

Technological development

Technological development includes the following:

1. Public and private investment in land management, in seasonal forecasting, and early warning system
2. Evaluation of restoration and development of irrigation system
3. Public and private investment in water management technologies

Technological adaptation

Technological adaptation includes the following strategies:

1. Diversification of crop types and varieties including crop substitution
2. Changing location of livestock and crop production associated with climate change

State programs and insurance in agriculture

State programs and insurance should obtain the following issues:

1. Assessment of agricultural insurance stability
2. Analyzing of compensation policy for extreme events and disasters in agriculture

2. Problem Statement

The territory of Azerbaijan Republic is situated on the east part of South Caucasus and the west part of Caspian Sea, between 38024' and 41054' north latitudes, 44046'and50056'longitudes.The area of Azerbaijan Republic's territory consists of 86,6 thousand km^2, the 5,2 km^2 of it belongs to Nakhichivan Autonomous Republic, which is the part of Azerbaijan Republic. Only 54.9% (52.4% Ministry of Agricultural source) of the country's territory is suitable for agricultural production. 2.9 million hectares of these territories are perennial plants (gardens, vineyards, furrows, tea plantations) and grasslands. Arable lands are about 1.8 million hectares. But only 1/3 of all agricultural lands are irrigated (1.4 million. hectares) and 90-95% of all agrarian production derived from these lands.

The water resources of Azerbaijan are very limited. The over ground water reserves constitute 32.2 billion m^3 which decreases till the 22.6 billion m^3 in a dry season. Underground water reserves constitute 5.2 billion m^3. Yearly from all reserves expends 10-14 billion m^3 water for country needs. 60-70% of whole expended water takes agriculture, 20-25% -industry, 10-15% - households and urban consumption. The water resources of Azerbaijan consist from 8359 rivers, 450 lakes and 135 artificial reservoirs. Despite of the large number rivers and lakes the water capacities of them are limited. 8359 rivers flow through the territory of the Republic of Azerbaijan, the length two of them is more than 500 km, 22 rivers has length – 101-500 km, 40 rivers- 51-100 km, 107 rivers- 26-50 km, 8188 rivers has length less than 25 km. The two biggest rivers of Azerbaijan Kura and Araz originate outside the territory of country and the water resources used jointly with neighbor countries. Common area of 450 lakes observed at the territory of Azerbaijan Republic is 395 km^2. An area of ten lakes more than 10 km^2 but others much less. By the origin they divided on seven types: glacier lakes, flood plain lakes, storage dam lakes, lagoon lakes, karsts lakes, landslide lakes and connate lakes.The largest lake of republic is Sarisu lake in Kur-Araz lowland (the area of water surface is 65,7 km^2 , the volume is 59,1 $mln.m^3$). Tufangol (its area is 0,01 km^2, volume 0,11 $mln.m^3$) is on the basin of Demiraparan and on the height of 3277 m. It is highest mountain lake in republic. Water from some likes are used as source of potable water. Annual water shortage in country varies between 4.5-5 billion m^3.

3. Method

Water provides coherence to climate change adaptation and mitigation, integrating energy, water, food production and agriculture, and ecosystems and the environment. Typical investments in this category include water infrastructure for the purposes of water collection, storage, treatment or distribution, or for flood protection or drought resilience. Investment to water infrastructure divides on two categories:

- ✓ Engineered water infrastructure or water-use systems that collect, treat and distribute water, or that protect against floods or drought
- ✓ Nature-based water resources management systems that are managed to collect, store, treat, or distribute water or to buffer floods or drought.

Engineered water infrastructure investment projects include:

- ✓ Installation or upgrade of water irrigation system, such as high-efficiency drip, flood, and pivot irrigation systems
- ✓ Construction or upgrade of flood defense infrastructure
- ✓ Installation or upgrade of water capture and storage infrastructure
- ✓ Installation or upgrade of flood monitoring and warning system

Investment in nature-based water resources management systems include:

- ✓ Creation of safe delta flood zones as natural habitat for the river to expand into
- ✓ Metering / monitoring systems to detect and warn against flow, snowpack, or groundwater systems for water management and drought warning
- ✓ Planting/removing vegetation explicitly to modify water temperatures, evaporation rates, runoff patterns
- ✓ Use of pumps to transfer waters to / from natural aquifers
- ✓ Creation artificial water retention ponds

Investment in engineered water infrastructure and in nature-based water resources management systems in Azerbaijan broadly implemented by governmental structures. The main public structure which governs and serves the water frame of the country is an Azerbaijan Amelioration and Water Management OSJ. This organization close to coloborate with “Azenrji” OSJ, the main electric producer of country. Azenerji has in possession 19 hydroelectric stations (12 large and 7 small) with total capacity 1164.4 Mvt (18.5% all produced electric energy in country). All artificial reservoirs which builds for needs of hydroelectric stations has a dual purpose and used for irrigation and amelioration too.

4. Anaylsis of Engineered water infrastructure of Azerbaijan Republic Artificial Reservoirs

Nowadays for needs energetic, agriculture and population in Azerbaijan uses 135 reservoirs. The volume 8 of them is more than 100 mln.m^3; 12- 10-100 mln.m^3; 42- 1-10 mln.m^3 and 73 reservoirs has volume less than 1 mln.m^3. Reservoirs, built on Kur, Araz, Samur and Terterchay rivers (Shamkir, Mingechevir, Yenikend, Varvara, Bahramtapa, and Ceyranbatan) has complex water management systems and used for energetic, irrigation, source of potable water and other purposes.

The project cost of constructing 1 m^3 of useful volume of artificial reservoirs is shown below:

For reservoirs with volume less than 1 mln. m^3 - 1m^3/ 11.8$- 14.7$

For reservoirs with volume more than 1 mln. m^3 - 1m^3/ 4.7$- 6$

5. Irrigation Canals

During the XX century a large irrigation canal system had been built in Azerbaijan.Total length of all irrigation canals in Azerbaijan is 51 755 km. 2184 km from them is the main line, 8014 km is inter-farms and 41 557 km inside-farms canals. Irrigation system with existing natural water resources and reservoirs embraces whole Kur-Araz lowland (21 631 km^2) which is the main agricultural territories of country. The average annual rainfall at this lowland is 200-450 mm and for agricultural irrigation broadly using water from canals. Overall length of 15 main irrigation canals which had been built in Kur-Araz lowland is 1001 km with total water stream passing ability 718 m^3/sec. This system provides by water 761 thousand hectares of arable lands which is 52% of all irrigated lands.

Most of these canals needs in through reconstruction because water loss from seepage varies from 30% till the 59% depending on how canal had been built (concrete canal or digged canal). Average water loss from running meter of canal is equal to 5-8m^3 per day. Global warming leads to increasing of water consumption by agricultural crops. The main advantages using of canal irrigation is energy saving. Disadvantages are water loss and future soil salinity.

The project cost of constructing 1 line m of concrete canal is shown below:
1 line m of main canal water with stream passing ability 10 m3/sec- varies between $588 - $2941
mark of concrete: B15
armature: d=12
facilities for every 200 m
1 line m of main canal water with stream passing ability 1 m3/sec- varies between $117.6- $588
1 line m of iron pipe for water transferring with diameter 720 mm - $264
The price include all engineering structures which installing during the canal construction

6. Hydro Schemes

Rivers flow management in Azerbaijan carried via hydro schemes. Hydro schemes are subdivided by water receiving capacity indicators as shown below:

1. Water receiving capacity >50 m^3/sec; 4- hydroschemes
2. Water receiving capacity 10-50 m^3sec; 4- hydroschemes
3. Water receiving capacity <10 m^3/sec; 8- hydroschemes

All collected from rivers water through the hydro schemes is passing to the canals and using for irrigation, energetic or for other purposes.

7. Collectors Drainage System

Complex melioration measures had been implemented in 43% of all irrigated lands (609 thousand hectares). 288 000 hectares are provided by surface, 308 000 hectares – by subsurface and 13 000 hectares are ensured by vertical drainage network system. 9569 km of open drainage networks, 9326 km of closed drainage networks, 6157 km of water collectors, 4768 km of main line collectors (total 29640 km) had been built and transferred into operation.Water from drainage systems via the three main line collectors (Main Mil-Mugan, Main Shirvan and Mugan Salyan) flows into the Caspian Sea.
The cost of construction of 1line m of closed drainage with collector varies between 29.4$ - 41.2$
The price includes all engineering facilities

8. Pumps Stations

The pump stations for transferring water from natural aquifers and reservoirs had built up on the main rivers of Azerbaijan Kur and Araz and besides it on the some artificial reservoirs. The main purpose of these stations is to transferring water for irrigation and ensures operation of water supply stations. Also some of these pump stations are using for transferring water from collector drainage systems. The table bellow illustrates common indicators of existing pump stations in Azerbaijan Republic.

№	Indicators of pump stations	Unit	Total	For irrigation		For melioration	
				Electric	Fuel	Electric	Fuel
1	Number of pumps	Pieces	931	705	170	56	-
2	Number of aggregates	Pieces	1889	1469	250	170	-
3	Accumulated power	Mvt	596,9	533,9	39,2	23,8	-
4	Efficiency	m3/sec	1282,2	1029,9	137,5	114,8	-

Table 1. Indicators of existing pump stations in Azerbaijan Republic

9. Based on Data Azerbaijan Amelioration and Water Management OSJ

The cost of the construction project of 1 pump with electric aggregate varies from 65 955 to 466 911 US dollars depending on the technical characteristics. The price includes the construction of special facilities. The cost of building a fuel pump with the unit is cheaper by 17-20%, but the efficiency is lower than an electric pump.

10. Pivot irrigation equipments

For the last five years the big farms in Azerbaijan broadly implemented pivot irrigation equipments. These equipments classified as:

- Center pivots
- Linear pivots

At present the pivot irrigation equipment are using in five districts of Azerbaijan, Agsu, Kurdamir, Khachmaz, Haciqabul and Bilasuvar. The pivot irrigation method has different specifications but in compare with ordinary method of surface irrigation by canals or by artesian pumps, the result and efficiency are quite different. The table below illustrates efficiency of implementation pivot irrigation in wheat production.

N	Indicators	Pivot irrigation	Surface irrigation
1	Automation of irrigation process	100%	less than 100%
2	Irrigation norm per hectare during the vegetation period (3 times)	1600m^3/he	4500m^3/he
3	Intensive crop rotation during the year and additional production	2-3 times	1time
4	Influence of irrigation to soil structure	successful	water erosion in an

		implementation in inclined areas	inclined areas
5	Influence of irrigation to soil salinity by rising of ground water level	no influences	Influences
6	Fertilization and chemical treatment	injected by special dispenser during the irrigation	spreaded by special additional aggregates
7	Yield from hectares	5-6 ton	2-3 ton

Table 2. Efficiency of pivot irrigation in wheat production

There is one main disadvantage for farmers in using pivot irrigation equipments. The equipments and installation process is quite expensive and only sustainable farmers could purchase it. Depending on the system and field conditions, installing a center pivot system costs is $1765 USD per hectare.
The price includes all engineering facilities.

11. Sub-Artesian Wells

On 01.06.2018 date the total number of sub artisan wells in Azerbaijan is more than 14 000 items. The total number of sub artesian wells which is used for irrigation constitutes 8587 items. The irrigation efficiency is 10-30 hectares per day with total water supply 1700-8600 m^3. But disadvantage of this method of irrigation is a high cost of water supply (0.03 USD/m^3) and future salinity problem of soil. At present 300 sub artesian wells are under the construction and soon would be given into the operation.
The cost of construction of one sub artesian wells with pump aggregate could be varies between 29 500$ - 59 900$ (diameter 150mm-375mm; depth 60m-180m). The price includes all engineering facilities.

15. Results, Conclusions and Recommendations

Public investments to development of irrigation system as main **c**limate change adaptation option in Azerbaijan Republic includes different challenges and issues. The main problem of agriculture is a water shortage. Azerbaijan economy consumes during the year 70% of all natural water reserves while the world standards constitute only 40%. The biggest problem of shortage is the water loss during its transfer by the irrigation canals. Up to 59 % of transferred water losses during its motion through canals. From this perspective the major part of public investment must be allocated on restoration of irrigation canals, water-use efficiency related techniques and increasing the number of artificial reservoirs. The measures must be the part of National Climate Change Adaptation Program and includes the following elements:

- ✓ reduce the volume of water losses
- ✓ broadly implementation of contemporary system of watering (pivot, drip and etc.)
- ✓ creation of safe delta flood zones as natural habitat for the river to expand into
- ✓ installation or upgrade of water capture and storage infrastructure
- ✓ continue to construction of artificial water retention ponds
- ✓ construction of water treatment plants

The second main target of adaptation plan regarding to irrigation system should include special measures against the saline and alkali soils. State should invest to such kind of measures and improve the quality of lands suitable for agriculture.

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