JEB
Journal of Environmental Biology

Journal Home page : www.jeb.co.in
E-mail : editor@jeb.co.in

ISSN: 0254-8704 (Print)
ISSN: 2394-0379 (Online)
CODEN: JEBIDP

Desertification risk in Kakheti Region, East Georgia

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Publication Info

Paper received:
04 July 2013

Revised received:
20 October 2013

Re-revised received:
18 June 2014

Accepted:
22 September 2014

Abstract

Desertification or land degradation in drylands is caused by various factors. The most important of these is climate change, a significant global ecological problem. Desertification, like erosion, as an environmental process of ecosystem degradation, is often caused by human activity. It is a common misconception that droughts cause desertification. Well-managed lands can recover from drought if the rains return. These practices help to control erosion and maintain productivity during periods when moisture is available. Traditionally, the most vulnerable territories considered under the threat of desertification in Georgia is Kakheti region (East Georgia), which has been selected as one of the priority investigation area. In Eastern Georgia, intervals of atmospheric precipitation do not coincide with the phases of water demand of plants. In recent decades as a result of more frequent droughts in Kakheti, the region has already lost hundreds, thousands of hectares of fertile land. Based on the contemporary climate warming projections, the temperature is expected to increase and precipitation to decrease. This will lead to an increase in evaporation and reduction of river flow. Under such conditions the danger of desertification is evident. To mitigate the negative effects of desertification, it is recommended to put forward set of adaptation activities through rehabilitation of water use systems, prevention of loss of water, reconstruction and expansion of irrigation canals, accumulation of unused autumn-winter river water and spring floods in reservoirs, developing an optimal scheme of distributing water resources among water users, device windbreaks and work on breeding of drought resistant varieties, preparation of water volume forecasts of rivers and their role in planning of water use; application of apply drip and sprinkler irrigation, using artificial precipitation following increase as a result of active influence on clouds. All these activities will provide means for suspending desertification process, create ecological safety for the environment and improve the economic wellbeing of population.

Key words

Desertification, Drought, Runoff forecasting, Water demand, Water supply

Introduction

Drought is one of the most important natural phenomena of the environment, which has increased during the last decades due to global warming (Matchavariani and Lagidze, 2012, Kereselidze *et al*., 2013). Desertification can become a threat under regular droughts, which is aggravated by increasing temperature and decreased precipitation as well as lack of water resources.

Number of arid months in East Georgia, where most fertile fields for agricultural crops are situated, is 2-5 months during the vegetation period. The precipitation intervals do not coincide with the periods, when plants require water; as a result the crop yield is decreasing. During the last two decades, 200,000 ha of land has already been damaged due to intense droughts. The 1998 drought alone resulted in 60 million USD worth of damage to the country. Under these conditions, if the proper measures are not taken on time the desertification process will become evident, stopping and reversing that process in future will be more difficult and costly.

Many interesting publications are available on the problems of desertification and droughts, land degradation,

erosion, sustainable land management, etc. of different regions of the Earth (Ozturk *et al*., 1998; Geeson *et al*., 2003; Kepner, 2006; Ozturk *et al*., 2010; Johnson and Lewis, 2007; Kapur *et al*., 2011; Kereselidze *et al*., 2013; Begalishvili *et al*., 2002; Basilashvili, 1990).

The book "Land Degradation and Desertification: Assessment, Mitigation and Remediation" (Zdruli *et al*., 2010) reports results in sustainable land management and land degradation status and mitigation in 36 countries around the world. It includes background papers with continental and international perspectives dealing with land degradation and desertification studies.

Currently, under the world economic crisis and high unemployment rates, the rural communities of Georgia live by the agricultural products they get from their land plots. That's why it's important that their land plots are supplied with irrigation water uninterruptedly. This is especially important in Kakheti, where high-quality vines are cultivated (besides wheat and sunflower), which yield delicious grapes that are used to produce high-quality wines. However, the vegetation period here is characterized with little precipitation, because of which it's impossible to receive high amount of agricultural crops without irrigation. Therefore, irrigation is an essential factor for improving the socio-economic situation of population. Consequently, the biggest irrigation system in Georgia, which consists of two Zemo (upper) and Kvemo (lower) Alazani main channels, was built here on the Alazani River during 30's in 20th century. Kvemo (lower) Alazani channel irrigates 262,000 ha of land and Zemo (upper) Alazani channel irrigates 76,000 ha of land (Ukleba, 1977). These irrigation systems are based on gravity flow and surface irrigation principle, characterized with great water loss. The situation is also aggravated by the fact that due to the damaged irrigation system these irrigation channels have become almost unusable. Currently, the rehabilitation works are underway and agricultural rehabilitation in Kakheti region is also planned for which regular irrigation of agricultural crops is necessary. Correct water use regime for Alazani River needs to be defined. Irrigation systems have to function while there's water deficit during the peak water usage during summer.

Fig. 1 : Location map of the study area

The present research work aimed at studying the desertification hazard assessment against the background of global climate change, and development of appropriate adaptation measures in arid region of eastern Georgia.

Materials and Methods

Study area : Kakheti is a region located in eastern Georgia with a total area of 11379 km^2 (Fig.1). It is bordered by the Russian Federation to the Northeast, Azerbaijan to the Southeast, and Georgian regions to the west.

The region is especially vulnerable towards droughts. Natural disasters have been occurring here repeatedly over the last several years. In July 2012, large amount of hail and rain as well as a strong hurricane took place during overnight; as a result, thousands of houses, roads, agricultural land plots, orchards, cattle, poultry and other sources of income of the local population were destroyed.

For evaluating the Alazani River's irrigation water capacity Table 1 includes an indicator, which shows a correlation between the amount of water serviced with the irrigation system and river runoff during the vegetation period (Svanidze and Chikvaidze, 2001).

Besides deficit irrigation water during vegetation period, river runoff during autumn-winter floods remained unused, as the river water used during this period was minimal. The remaining amount of water (Table 1) was quite substantial and accumulation in a reservoir could resolve the water deficit problem during the vegetation period.

Results and Discussion

According to Georgia's Second National Communication to the UN Framework Convention on Climate Change, change in temperature, precipitation and river runoff levels based on forecast calculations (Table 2), the precipitation level slightly changed while temperature increased. By the end of 21st century, the temperature level would reach 5C, correspondingly, as the vaporization on the basin surface would increase, the river runoff would decrease by 8.5% in comparison to the second half of the 20th century (Georgia's Second National Communication to the UNFCCC, 2009).

Table 1 : Alazani River's irrigation capacity (in million m3 water) for 50 %, 75 % and 95 % supply with irrigation water and precipitation

Supply %	Annual runoff	Total water demand	Actual water use	Water deficit during vegetation period	Remaining runoff
50	1804	731.5	615.8	115.7	1188.2
75	1535	1189.3	793.7	395.6	740.3
95	1209	1434.8	705.3	729.4	503.8

The dynamics of natural runoff (Q m^3 s^{-1}), during vegetation period (April-September) of the Alazani in Birkiani village (covering 40 years), where the Zemo (upper) Alazani main irrigation channel starts was also studied (Fig 2). The following equation was formulated with the linear approximation of the descending trend reflecting the channel:

$$Q = - 0.0084 N + 20.642 \quad (1)$$

where N: is the number of year starting from 1950 (N=1), its coefficient (-0,0084) shows the intensity of annual decrease in river runoff.

Kvemo Alazani irrigation channel starts near Shakriani village where, according to the local hydrological station it was functioning since 1933 to 2010; the ascending trend (Fig. 3) is shown in the following equation:

$$Q = 0.031 N + 60.805 \quad (2)$$

where N starts from 1933 (N=1).

The desertification process in Kakheti region has been increasing due to decrease in river runoff on the Alazani River during the vegetation period. Lack of precipitation, high temperature and fast winds during summer cause frequent droughts, which lead to land erosion and beginning of desertification process. The fact that precipitation intervals do not coincide with the period when plants require water most is another cause of desertification.

The primary and most radical measure to neutralize the negative impact of drought is to artificially compensate the lack of

Table 2 : Forecast values of air temperature, precipitation and runoff

Time period	Mean annual temperature (ºC)	Precipitation (mm)	Total annual runoff (million m^3 yr^{-1})
1951-1980	3.3	2240	459.7
2071-2100	8.4	2205	420.2
Change	5.1	-1.5%	-8.5%

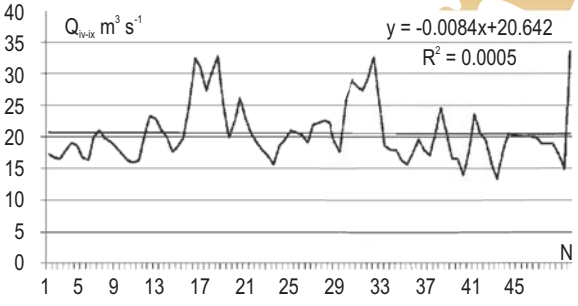

Fig. 2 : Water use dynamics for the Alazani river during vegetation period near Birkiani village

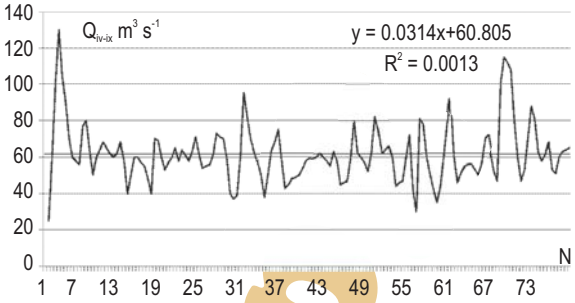

Fig. 3: Water use dynamics for the Alazani river during vegetation period near Shakriani village

precipitation through irrigation, that's why agricultural land plots have been regularly irrigated here, which was done in order to mitigate the climate impact, these measures brought best results in terms of productivity.

There was no preplanned optimal water distribution schedule here that could indicate when, where and what amount of irrigation water should be supplied. In fact, the owners of land plots situated near the beginning of the irrigation channel, are using irrigation water in large quantities without any control that is why water doesn't reach the land plots situated at the end of the irrigation channel and harvest is scarce there. Therefore, local people do not cultivate these land plots as a result initial signs of desertification have started appearing. This situation is further aggravated by the false notion that exists among the peasants according to which "lots of water means lots of harvest", which has a negative effect on land productivity, therefore farmers often use irrigation water in a barbaric manner without any regard to norms and terms.

The lower main irrigation channel on the Alazani river receives up to 24 m^3 sec^{-1} water during peak time in summer, but it experiences lack of water as the river water is also being used by Zemo (upper) Alazani and other irrigation channels. The lower Alazani irrigation channel actually receives only 10 m^3 sec^{-1} water. Previously, the land plots, situated at the end of main channel, were supplied water by pump stations; however, most of those stations no longer operate. Thousands of hectares of land along the last 30 km of the main channel remains unirrigated, where no crops can be harvested without watering. In order to solve this problem, a system of water distribution among the water users needs to be introduced, which would ensure distribution of water in necessary quantities in all sections of the irrigation system, so that people can know when they will receive water and what amount of water they are entitled to.

The watered areas can be increased by 50% by using optimal water distribution system even under the existing amount of water resources. Such efforts can effectively stop the process of desertification (caused by water deficit) evident in the lower

parts of the region and maintain environmental stability in the region (Sichinava *et al.,* 2002).

As the gravity flow-based surface irrigation leads to significant loss of irrigation water, nowadays drip irrigation is being used for watering, during which water loss is minimal and only 33 % of water is being used for surface irrigation, that means 3 times less water is being used that would approximately save 67% water and 10 times increase in plant productivity (Chikvaidze *et al.,* 2002). Therefore, introduction of drip irrigation systems, intended for combating aridity in the river basins that experience water deficit, can be considered as an essential effort.

Selection of irrigation method must be based on local natural-economic conditions. The center pivot irrigation is an irreplaceable tool for humidifying the air, ensuring economic use of water and preventing salinity and erosion of soil. Unlike its predecessors modern center pivot irrigation equipment is characterized with productivity, it covers large areas and ensures automation of irrigation process. However, most of these machines are less adapted to mountainous areas of Georgia. A new center pivot irrigation equipment has been manufactured, which is environmentally safe and can be used in areas with big rocks and hard relief (Nanitashvili, 2002).

Currently, due to poor technical condition of irrigation systems and channels, water loss is quite substantial. In order to maintain and rationally use water resources, water use systems need to be rebuilt, rehabilitated and expanded; pump stations need to be used for ensuring additional supply of water to irrigation channels. Local population should be mobilized in order to clean and restore irrigation channels going through individual villages so that the water loss is minimized as much as possible.

In order to avert water deficit during droughts, river water resources need to be regulated, saved and restored. Given the rocks and relief, network of small reservoirs must be created. Annual water discharge forecasts regarding vegetation period runoff should be taken into account during the planning of water use as far as irrigation systems are concerned. In order to avert desertification processes, new forests must be planted and windbreaks must be restored along the agricultural land plots; degraded soils and pastures must be rehabilitated.

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