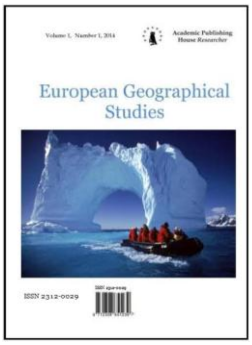
Published in the Russian Federation
European Geographical Studies
Has been issued since 2014.
ISSN: 2312-0029
Vol. 6, Is. 2, pp. 68-74, 2015

DOI: 10.13187/egs.2015.6.68
www.ejournal9.com



UDC 631. 587. 556

Ways of Mitigating the Results of Expected Disastrous Drought

Tsisana Basilashvili

Institute of Hydrometeorology at the Georgian Technical University, Georgia
150a, Agmashenebeli ave., 0112, Tbilisi / 6 Poti str., 0119
Dr. (Geography), Professor
E-mail: jarjinio@mail.ru

Abstract

The reaction of arid regions on global warming and anticipated process of desertification in Eastern Georgia is investigated. The statistical qualities of the Alazani river are presented for the vegetation period (April - September) along with runoff norms for hydrological section serving main irrigation systems. By using their dynamics through years the trands and tendencies of the changes have been identified. The figures are of scientific value and can by used indesigning and economic organizations for calculating water resources.

By applying multifactorial model forecasting equations have been worked out for the Alazani water flow for the whole vegetation period as well as for individual quarters. The long-term prognosis allow rational and through planning of water resources utilization. Due to the warming trend, water evaporation will increase and the river flow will decrease, which will ultimately lead to the lack of water supply in irrigation period in summer. For the aim of mitigation of negative consequences of drought, a set of measures is recommended.

Keywords: desertification, irrigation channels, water deficit, multifactorial model of forecasting.

Introduction

The Earth as a whole or its individual regions climate change is a problem of modernity – one of the most important problem and deserves proper attention. Global warming in light of the fact certain regions of the Earth is experiencing a warming climate, but freezing.

In the last decades frequent and prolonged droughts against the background of hight temperature and negative anthropogenic processes resulted in a series of aggravated ecological, social and economic problems. On the background of this warming the intensity and frequency of drought will raise in the regions of Eastern Georgia.

In recent years, natural disasters have become especially drastic in east Georgia with wide valleys and fertile soils for agricultural crop production. In the vegetation period (IV–IX), number of droughty months is 2-5 months. Kakheti region is specific in this regard and most vulnerable in terms of drought. Due to lack of atmospheric precipitations, high summer temperatures and high speed winds, droughts frequently occur here. This contributes to land erosion and desertification process; and that water-demand phases of plants don't coincide with the precipitation intervals, also creates a problem. As a result, 200 thousand hectares of the territory is severely damaged already. In these conditions, if relevant measures are not timely provided, slowing down of the desertification process in future will be more complicated and expensive.

Materials and Methods

Kakheti vast fertile valleys are irrigated from river Alazani water with the biggest irrigation system constructed on it (in Georgia) and composed of two – upper and lower Alazani magistral channels. The upper magistral canal takes start from the upper part of the river, near hydrological post in village Birkiani, where natural river runoff used to be measured earlier. 76 thousand hectares of land are attached to it for irrigation. The lower magistral canal begins at presently operating post near village Shaqriani and it irrigates 262 thousand hectares of arable [1]. There bas been ascertained the vegetation period of river according to individual months, quarters, maximum and minimal water discharge, extremes, alteration and other statistical qualities – Table 1.

In order to evaluate the impact of climate warming and man-made factors, dynamics of multi-year fluctuation of maximal and minimal runoff, also different intervals of annual and vegetation period of river Alazani water have been studied. Relevant trends have been developed and equations made reflecting their rectilinear approximation, parameters of which are provided in table 2.

Table 1: Features of under discharges (Qm^3/s) of the Alazani river

Estimated Period	Months								
	IV-IX	IV	V	VI	VII	VIII	IX	IV-VI	VII-IX
r. Alazani _ Birkiani F = 282 km^2, H = 2200 m, Q_o = 13.9 m^3/s									
Average	20.4	16.7	26.8	27.7	22.3	15.4	12.7	23.7	16.8
Part, % Q_o	73.0	10.1	16.4	16.4	13.6	9.0	7.58	43.1	30.2
Greatest	32.0	27.6	42.7	57.2	51.1	31.0	26.2	39.4	27.1
Least	13.4	8.16	17.8	13.5	12.4	7.98	5.98	15.7	9.48
Amplitude	18.6	19.4	24.9	43.7	38.7	23.0	20.2	23.7	17.6
Average bend	4.50	4.1	6.37	8.51	9.08	5.45	4.82	5.35	4.97
Variation Cv	0.22	0.24	0.23	0.31	0.40	0.36	0.38	0.22	0.30
Asimmetry Cs	0.94	0.42	0.50	1.24	1.34	1.05	0.71	0.86	0.57
r. Alazani _ Shaqriani F = 2190 km^2, H = 1260 m, Q_o = 45.7 m^3/s									
Average	62.0	70.3	94.0	80.2	52.4	37.0	37.6	81.5	42.3
Part, % Q_o	69.4	12.9	17.3	15.1	9.9	6.9	7.0	45.4	24.0
Greatest	128	120	246	223	112	109	117	176	91.3
Least	36.5	25.0	32.4	31.3	15.8	5.72	9.25	40.4	14.4
Amplitude	91.5	95.0	214	192	96.2	103	108	136	76.9
Average bend	18.5	23.1	37.9	31.1	24.1	20.2	21.3	26.3	16.3
Variation Cv	0.30	0.33	0.41	0.38	0.46	0.54	0.57	0.32	0.38
Asimmetry Cs	1.54	0.29	1.74	1.86	0.77	1.25	1.44	1.46	0.60

Their analysis show that tendencies of the change in river Alazani water runoff vary at different periods. This can be explained by diversity of watery tributaries (flowing into the river before these cross-sections) and their regimes, conditioned by natural conditions in these basins.

Table 2: Parameters (a and b) of trends' equations (T_Q = aN + b)
of river Alazani water discharge periods

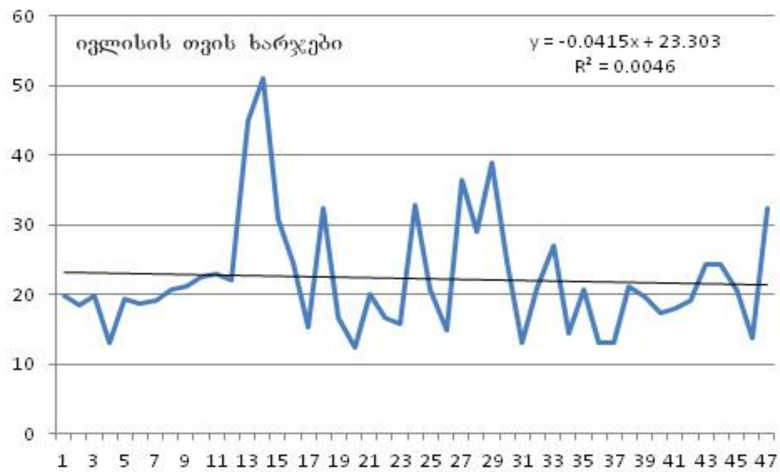
Periods of the water discharges	Months	vil. Birkiani 1950 – 1996		vil. Shaqriani 1933 – 2010	
		a	b	a	b
Annual	I-XII	– 0.002	13.98	0.050	43.79
Maximum	max	– 1.079	98.42	– 1.184	347.8
Minimum	min	0.019	3.731	– 0.126	20.44
Vegetation	IV-IX	– 0.008	20.642	0.031	60.80
April	IV	0.004	16.64	0.337	57.29
May	V	– 0.058	28.23	0.060	90.44
June	VI	– 0.009	27.90	– 0.015	80.79
July	VII	– 0.041	23.30	– 0.014	53.00
August	VIII	0.094	13.13	– 0.005	37.20
September	IX	0.005	12.60	– 0.036	39.01

Trend equation of descending (drop) tendency of natural runoff (Q m³/wm) of river Alazani vegetation period is presented as follows:

$$T_Q = - 0{,}0084\ N + 20{,}642, \qquad (1)$$

Maximal and summer months' water discharges (table 3) drop here with higher intensity (a > 1). Multi-year dynamics of water discharges in July (Q_{VII} , m³/s) of river Alazani with relevant trends is given on figure 1.

Q_{VII} , m³/s A



Q_{VII} , m³/s B

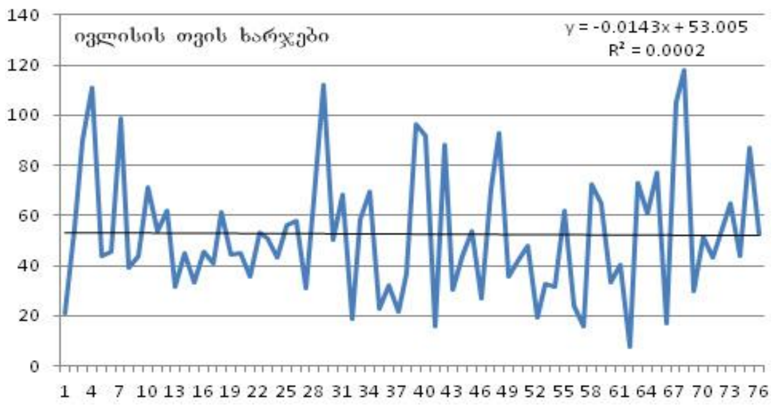


Figure 1. Dynamics of water discharges (Q_{VII}, m³/s) in July on r. Alazani
(A – Birkiani, B – Shaqriani)

Discussion

Irrigation is considered the most effective measure taken against drought in Georgia from the beginning of the II millenium A.D. About 50 thousand ha. of fruitful lands were irrigate with canals in the Eastern Georgia. This area badly needs irrigation nowadays to.

Existing irrigation systems on river Alazani are operating on drift, surface irrigation, accompanied by huge losses. Over the past years, they have been actually non-operating and out of order. Though, presently, these systems are being restored and in general, revival Kakheti agriculture is planned in the near future. This will require regular irrigation of agricultural arable and precise definition of river Alazani water-supply regime.

In order to assess river Alazani water supply for irrigation, as a criteria, Table 2 gives comparison of the water volume required for the target area irrigation and the river runoff in the vegetation period for different supply gradations. It turns out that water deficit is 116 mln/m^3 during the irrigation water and 50 % supply of precipitations. Big part – 80 mln m^3 is observed in August; in the conditions of 75 % water supply, 87 % of 396 mln m^3 water deficit - 346 mln m^3 fall at active irrigation period of plants – in June, July and August; in case of 95 % water supply, water deficit is the biggest – 729 mln m^3, 91% of which - 662 mln m^3 is observed from May till August [2].

Table 3: River Alazani irrigation potential (mln m^3 water) for 50, 75 and 95 % supply with irrigation water and precipitations

Water supply %	Annual runoff	Total water demand	Actual water consumption	Water deficit	Remained 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

Along with such water deficit in the vegetation period, river Alazani runoff in fall-winter and spring flooding periods is left unused, as water consumption is minimal in this period. This remained water volume (table 3, last column) is big enough and its accumulation in specific water reservoirs makes it possible to avoid deficit of irrigation water in the vegetation period.

In order to economically and rationally manage utilization of the existing water resources of river Alazani in the vegetation period, their forecast is required for different time intervals.

River runoff is a complex dynamic process conditioned by multiple factors. But, for forecasting purpose can be used only those that are subject to standard observations and provide operative information. Accuracy of hydrological forecasts depends on the number of existing observation points on hydrometeorological elements, their location, observation rows and quality. In this regard, information on the runoff forming factors is quite limited in Georgia. That's why, it is impossible to reveal those conformities that enable development of modern mathematical forecasting models. Majority of the elements cannot be measured in our conditions.

In our case, existing information on atmospheric precipitations (R mm), air temperature (θ, ^{o}C) and water-consistency of snow (W mm) have been used for forecasting of river water runoff (Q m^3/sec) in river Alazani basin and an enlarged forecast model has been developed, in which separate previous period factors are broken down into different period indicators, thus, impact of their dynamics is envisaged for future runoff. For example, precipitations at fall, winter and spring have diverse impact on the vegetation period runoff. So, it is not expedient to imagine their total sum in this forecast model [3, 4].

Based on the available data and correlation analysis, we revealed the most effectively operating previous period factors and developed a multi-factor forecast model by using them. But, many variables in the forecast model reduce sustainability of the equation, that's why, by specific mathematical criteria and multi-pitched screening method, we corrected the model based on the principle: maximal accuracy with minimal factors [5]. Thus, we developed optimal forecast models by taking into account up to 3-4 factors.

In the process of determination of numerical quality of forecast dependencies, two equation systems are discussed by gradual adding of separate factors, when direct and reversed break down of multi-factor equation is done [6]. This way, possibility of reduction of factors, boosting accuracy and prolonging the forecast period (timeliness) is sinchronously explored. As a result, we receive various forecast equations with different information, accuracy and timeliness. While development of operative forecasts, this enables us to select a forecast model based on the existing information, needed timeliness and accuracy. Besides that, interval of possible fluctuation of water runoff is determined, while inter-control of the received results - done [2, 3].

In order to plan the rational use of existing water resources for the irrigated agriculture, water discharge forecasts of the whole vegetation period (IV–IX) as well as of its separate quarters (IV–VI and VII–IX) is required (table 4).

Table 4: Forecast equations of river Alazani water average discharge (Q, m^3/sec) of the vegetation period (April-September) and its separate quarter; their assessment criteria

Forecast Equations	Assessment criteria			
	s / σ	P %	r	Э %
r. Alazani _ Birkiani F = 282 km^2, H = 2200 m, Q_o = 20.4 m^3/s				
$Q_{IV\text{-}IX} = 0.04\ R_1 + 0.60\ Q_{III} - 0.75\ \theta_{IV} + 10{,}52$	0.72	61	0.72	61
$Q_{IV\text{-}VI} = 0.03\ R_1 + 1.1\ Q_{III} + 0.10\ R_{II} + 11{,}1$	0.65	73	76	68
$Q_{VII\text{-}IX} = 0.21\ Q_{VI} - 1.05\ \theta_{VI} + 25.3$	0.79	60	0.63	65
r. Alazani _ Shaqriani F = 2190 km^2, H = 1260 m, Q_o = 62.0 m^3/s				
$Q_{IV\text{-}IX} = 0.48\ Q_{1I} + 0.27\ R_{II} - 0.53\ Q_{III} + 0{,}09\ R_{IV} + 44.5$	0.84	68	0.63	67
$Q_{IV\text{-}VI} = 0.34\ R_{III} - 3.36\ \theta_{III} + 0.12\ W_{III} - 58{,}4$	0.73	71	0.74	63
$Q_{VII\text{-}IX} = 0.13\ Q_V + 0.12\ \theta_{VI} - 0.34\ Q_{VI} + 0.19\ R_{VII} + 22.4$	0.73	75	0.71	69

Comment: s / σ – correlation between the forecasts' error and average square deviation of the runoff; P % – forecast prediction reliability; r – correlation between the actual and forecast meanings; Э % – economic effectiveness of forecasts. Forecasts are permissible, when: $(s / \sigma) < 0.80$; $P > 60$; $r > 0.60$.

Forecasts of II quarter (IV - VI) are exceptional by their accuracy, which is very important as this is the quarter when biggest spring floods occur in this river and often create danger to the environment and the population. That's why, these forecasts have two-fold designation. The economic effect received using the developed forecasts exceeds by 10-35% the effect received using the forecast discharge norm. Now, we may say that their application in practice with the purpose to serve irrigation systems and channels, gives possibility to rationally use and appropriately plan the existing water resources of river Alazani – this will increase productiveness of agricultural crop.

Conclusion

Based on the forecast calculations, by the end of the 21st century, due to significant temperature growth (up to 5 °C) as well as increased evaporation from the surface of river Alazani basin, river runoff will decrease by 8,5% compared to the second half of the 20th century [7]. Similar conditions are favorable to frequent drought processes in Kakheti region and the desertification process. For mitigation of negative results of the expected droughts, it is required to use river Alazani runoff in an optimal regime without losses. This requires specific measures:

• Rehabilitation and expansion of water systems, cleaning, restoration and reconstruction of irrigation channels;

• Putting the pumping stations in operation for additional supply of channels with water;

• Development and introduction of optimal water distribution/utilization time-tables for water consumers [8];

• Accumulation of unused water (of fall-winter and spring floods) in small reservoirs for further utilization during the irrigation water deficit in summer;

• Creation of a drip irrigation network; this will increase yield and use less water compared to surface irrigation [9];

• Introduction of a pivot irrigation with those equipment that can be used in huge inclinations and complex relief [10];

• Restoration of windbreak lines in agricultural fields and introduction of drought-resistant varieties;

• Planting of trees on slopes of river ravines;

• Introduction of an active impact on clouds, during which, atmospheric precipitations increase and plants get protected from hail [11];

• Raising awareness of population and farmers to moderately and economically use water resources;

• Annual longterm forecast of river Alazani water discharge for separate intervals of vegetation period (quarters, months and decades). As a result of the planned water consumption regime (and taking into account the water prognosis), the right time for river water irrigation will be determined, as well as timeline for putting the pumping stations in operation, using pivot irrigation systems or increasing precipitations by impact on the clouds.

Implementation of the mentioned measures will slow down and suspend desertification process, fight against drought, increase crop productivity and improve economic condition of the population.

References:

1. Ukleba N. (1977) The use of the Georgian Water Resources in National Economics. Publishing of University, Tbilisi, 394 p.

2. Svanidze G., Chikvaidze G. (2001) On the deficit of irrigation water in river basins of Eastern Georgia. Transactions of the Institute of Hydrometeorology, V.106, Tbilisi, pp.31-39.

3. Basilashvili Ts. (2013) Multifactorial statistical methodology for forecasting floods-high water flows. Georgian Technical University, Tbilisi, p.180.

4. Basilashvili Ts. (2014) Forecast of mountain river flow with a rare observation network. Meteorology and Hydrology, Moscow, Planeta, № 6, pp. 61-66.

5. Basilashvili, Ts. (1977) Statistical Analysis of variables and selection of predictors for Forecasting dependencies. Annotation Index of Algorithms and Programs. Hydrometeorological Institute World Data Centre. Obninks, pp. 43-44.

6. Basilashvili Ts., Plotkina, I. (1985) Determination of multifactor dependencies in equations, estimates of their features and determination of probability Forecasts. Annotation list of new arrivals in OFAP of GosComHydromet. Hydrometeorological Institute World Data Centre. 4th edition, Obninsk, pp. 21-22.

7. Georgia's second national communication to the UNFCCC. (2009) Ministry of Environmental Protection and Researcher UNPP, Tbilisi, p. 237.

8. Sichinava T., Tughushi P., Sichinava K. (2002) Ways to decrease the impact of catastrophic droughts expected in Kakheti region through cooperation with nongovernmental and government structures and local farmers. Proceedings of Hydrometeorology Institute, V.107, pp. 212-217.

9. Chikvaidze G., Shvelidze O., Geladze I., Devdariani N., Arkielidze N. (2002) Introduction of drip irrigation system in arid areas as a tool for rational use of water resources and combating droughts. Proceedings of Hydrometeorology Institute, V.107, pp. 218-221.

10. Nanitashvili O. (2002) New generation equipment for the drought-afflicted areas. Proceedings of Hydrometeorology Institute, V.107, pp. 223-229.

11. Begalishvili N., Kapanadze N., Robitashvili N., Rukhadze I. (2002) Statistical analysis of cloud resources in East Georgia Territory. Proceedings of Hydrometeorology Institute, V.107, pp. 241-253.

УДК 631. 587. 556

Пути смягчения результатов ожидаемых катастрофических засух

Цисана Захарьевна Басилашвили

Институт Гидрометеорологии Грузинского Технического Университета, Грузия
Главный научный сотрудник, Доктор Географических Наук, Профессор
Пр. Д. Агмашенебели 150а, 0112, Тбилиси / ул. Поти 6, 0119, Тбилиси
E-mail: jarjinio@mail.ru

Аннотация. Исследована реакция климата засушливых районов Восточной Грузии на глобальное потепление. Даны статистические характеристики стока воды реки Алазани за период вегетации (апрель-сентябрь). На основе многолетней динамики установлены тенденции их изменения и определены соответствующие тренды. Эти данные имеют практическое назначение для водохозяйственных расчётов.

С использованием многофакторной статистической модели получены уравнения для прогнозирования стока р. Алазани за период вегетации и отдельных кварталов. Такими долгосрочными прогнозами возможно основательное планирование рационального использования водных ресурсов реки.

В результате текущего потепления климата увеличится испарение, уменьшится сток воды, и река уже не сможет обеспечить водопотребность оросительных систем в период активного орошения растений. В целях смягчения негативных результатов от ожидаемых засух рекомендованы комплекс разных мероприятий.

Ключевые слова: опустынивание, оросительные каналы, дефицит воды, многофакторная модель прогнозирования.