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Analysis of the Kura River flooding in Azerbaijan territory in 2010 based on Hydrometeorological Observation and Remote Sensing

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Abstract

Because of ongoing global climate change on Earth, along with other natural disasters floods widespread and frequent occurrence of this process in the Kura River basin in Azerbaijan creates great threat for the local population, agriculture and economy of the country. The core objective of the study was the analysis of the flooding in 2010 based on hydrometeorological and satellite data. Assessment of the hydrometeorological parameters that could cause flooding and tendency in comparison of the water level with perennial norm in the Kura River were conducted. Landsat 5 Thematic Mapper (TM) multispectral satellite images reflecting this event were used. The map of flooded areas was developed by the usage of different tools and modules of ArcGIS 10.2.1.

Keywords: Floods, the Kura River, Remote Sensing (RS), Geographical Information Systems (GIS), Image Classification.

Introduction

Flood management requires a good understanding of complex interaction of the geographical space and related spatial information such as surface and groundwater sources, land vegetation cover, land use, meteorological parameters, hydrological condition and human activities (John, 2002; Ertek et al., 2003). Combination of the hydraulic series data within a spatial interface, such as a Geographical Information System (GIS) and Remote Sensing (RS), are the key to graphical visualizations on the hydraulic modelling and effective spatial support for flood risk analysis (Gazioğlu et al., 2014). The increasing availability of very high performance GIS software packages such as ArcGIS opens new opportunities for engineers to perform flood inundation analysis in conjunction with hydraulic models with interactive visualization within immerse decision support environments (Sinnakaudan, et al., 2003; Ghani, et al., 1999; ESRI, 1992; ESRI, 1996; ESRI, 2001; Farhan et al., 2018; Büyüksalih & Gazioğlu, 2019; Rashidin et al., 2019; Badolava, et al., 2019). In this point of view, study of the 2010 flooding in May in the Kura within Azerbaijan territory through hydrometeorological, GIS and Remote Sensing data is an important issue in the paper.

Study Area

The water basin of the downstream of the Kura River was selected as the study area (Fig. 1). The territories were object to the impacts of the flood waters in some extent. The last flooding occurred in 2010. The main reasons for the flooding were consistent heavy rains at

the same time in Turkey and Georgia, as well as in the territory of Azerbaijan and agricultural activities of people (Abbasov & Mahmudov, 2009; Махмудов, 2001; Aslanov, 2013). During the flooding increased extreme water level broke protective dikes around the river and caused inundation of some territories mainly in Sabirabad, Saatli, Imishli, Zardab and Shirvan cities (Fig. 2).

Rising of the water level in the riverbed caused not only destruction of dams, but also resulted with the rising of groundwater in the area with little altitude difference to the riverbed, typically from one to several meters (Fig. 3). Due to this low difference the territories are constantly under threat. Fluctuation between 0,5-1 meters is sufficient for rising of groundwater level and inundation of residential settlements located close to the river bed.

Usually, Salyan and Neftchala districts were mostly affected regions by floodwaters, but during 2010 flood, there were less inundations there than in other regions (Imishli, Saatli, Sabirabad). Just with the rising of groundwater, the areas close to the riverbed with little altitude difference were subject to the impact of subsoil waters.

Besides from natural flooding in 2010, some areas were inundated intentionally. Therefore, on the 31st May 2010, a new tributary near to the Bahramtapa hydro junction was opened by The Ministry of Emergency Situations of Azerbaijan Republic to overcome the consequences of the flood, clean flooded areas from floodwaters, and to reduce water level (Fig. 4). The stream of the river in near territory to the existing

Bahramtapa hydrojunction locating on the Aras River and within the administrative boundary of Imishli region

was directed to the Mughan plain and thus resulted with the inundation of the most part of the plain.

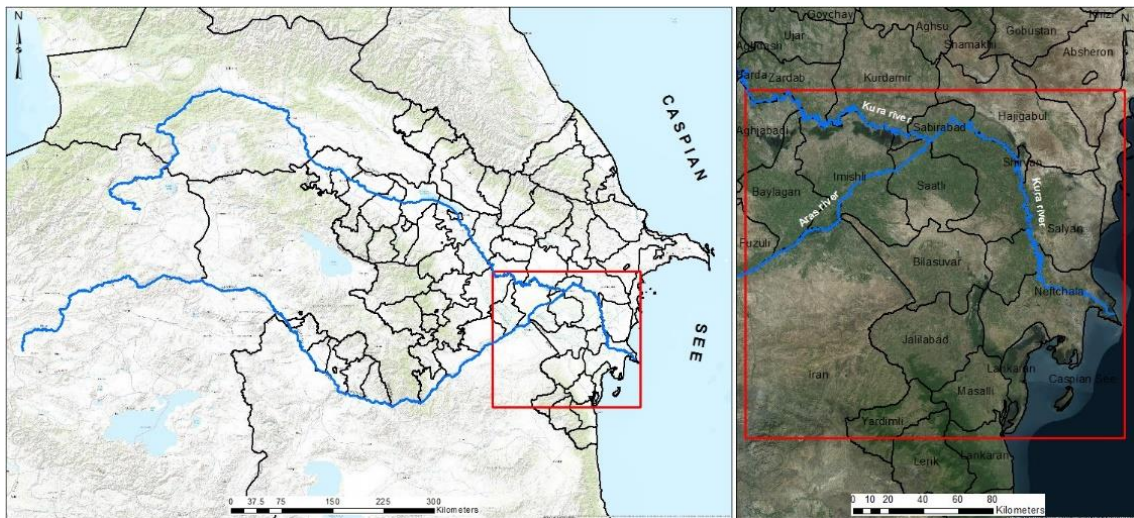


Figure 1. The study area.



Figure 2. Photos of 2010 flooding (URL 2).



Figure 3. Inundated yards by subsoil waters (spring, 2010) (Есо-миграция, 2013).

During the 2010 flood, a map had been developed based on the data collected from the field surveys during the flood and archival materials by the specialists of the former State Committee of Land and Cartography (SCLC) of Azerbaijan Republic. According to the map 70,000 hectares were inundated:

- ❖ Sabirabad region – 43726 ha
- ❖ Imishli region – 14770 ha
- ❖ Hajigabul region – 2470 ha
- ❖ Bilasuvar region – 120 ha
- ❖ Saatli region – 8926 ha

The map that was prepared by SCLC was compiled with the use of topographic maps in 1:100000 scale and according to the data of July 7, 2010. Generally, it was difficult to delineate precisely the extent of flooded areas during flood. At that time it was almost impossible to transfer field survey of flooded areas into map accurately. Because flooding covered a larger area in a short period. The only and most simple solution to this problem are remote sensing techniques. The only and most simple solution to the problem is remote sensing techniques.

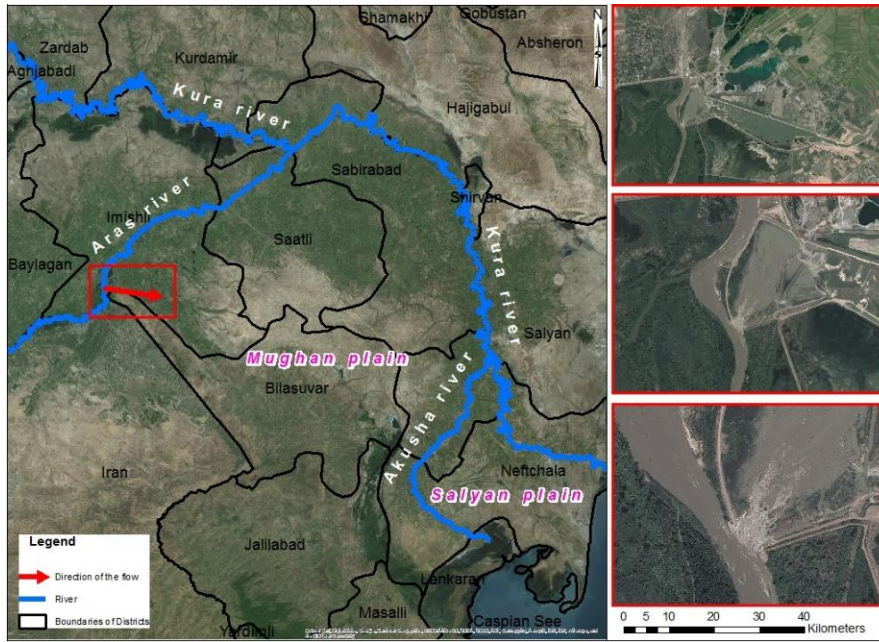


Figure 4. Cartographic presentation of the branch that separated from the Aras river after 2010 flooding event

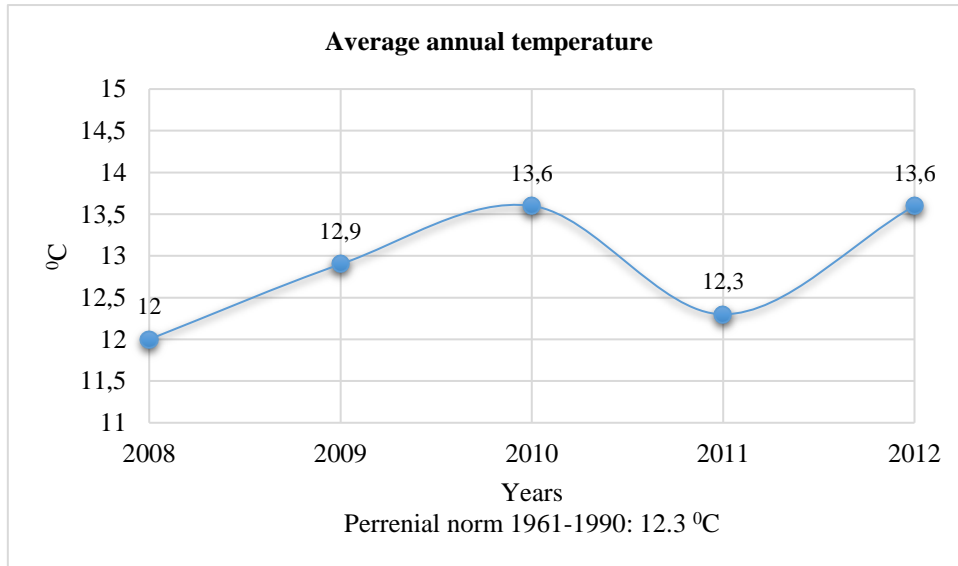


Figure 5. Average annual temperature during 2008-2012 in Azerbaijan.

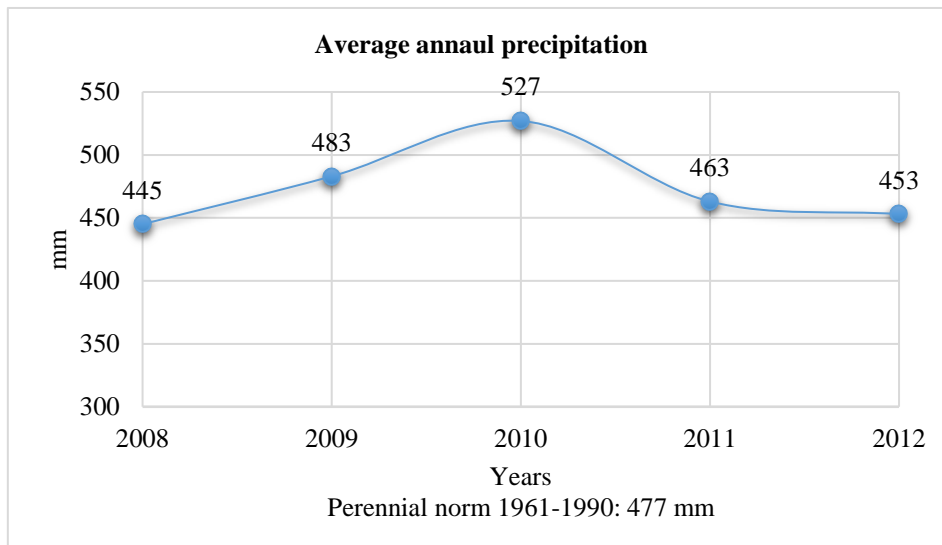


Figure 6. Average annual precipitation during 2008-2012 in Azerbaijan.

Material and Methods

The data obtained from The National Hydrometeorology Department of the Ministry of Ecology and Natural Resources of Azerbaijan Republic obviously showed that along with anthropogenic factors, mainly natural factors played a key role in the occurrence of the flood (Mahmudov, 2014; Махмудов, 2016; Mahmudov, 2015). So according to the data the norm of average annual temperature in the country was 12,30C in 1961-1990, but this figure was 13,60C in 2010 (Fig. 5). Thus high temperature intensified melting of snow and glaciers in mountainous areas, and in a result it created flooding of rivers.

Furthermore, along with an increase in temperature in 2010, precipitation differed considerably from previous years. Although perennial norm of the precipitation was

477 mm in 1961-1990, but this figure was 527 mm in 2010 (Fig. 6).

The 2010 flooding covered mainly May and June. The following graph shows that monthly perennial norm in 1961-1990 was high in April, May and June absolutely (Fig. 7).

Being higher than the norm of the levels of temperature and precipitation led to sharply rise of the river flow. As a result of continuous rainfall in the neighbouring countries of the Kura River peaked the runoff of the river, critical situation was arose by the drastically level of the water. In considered case, following graph illustrates the shifting level of the water in the Kura River in a particular period. So, from 2008 to 2012, the maximum level of the Kura river reached to 592 cm in Zardab gauge station in 2010 (Fig. 8).

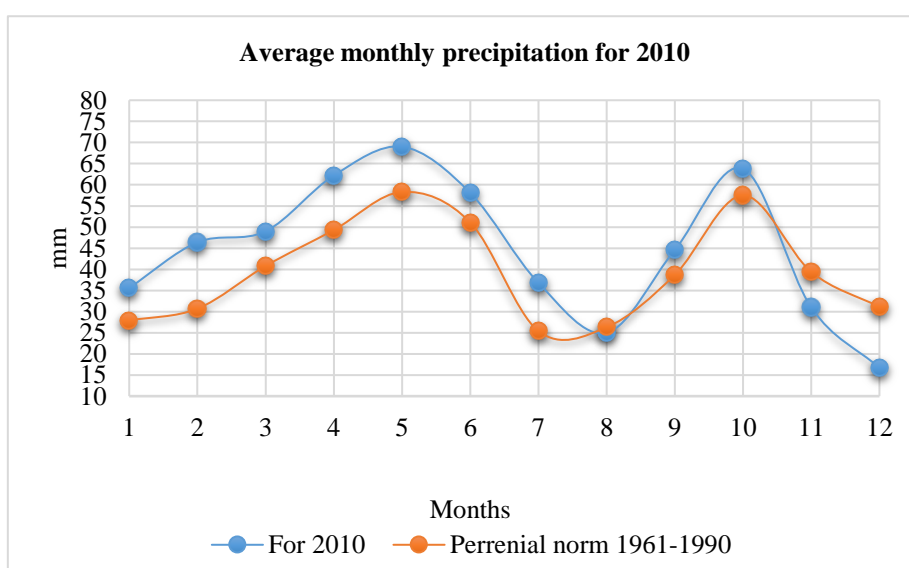


Figure 7. Average annual temperature for 2010 in Azerbaijan.

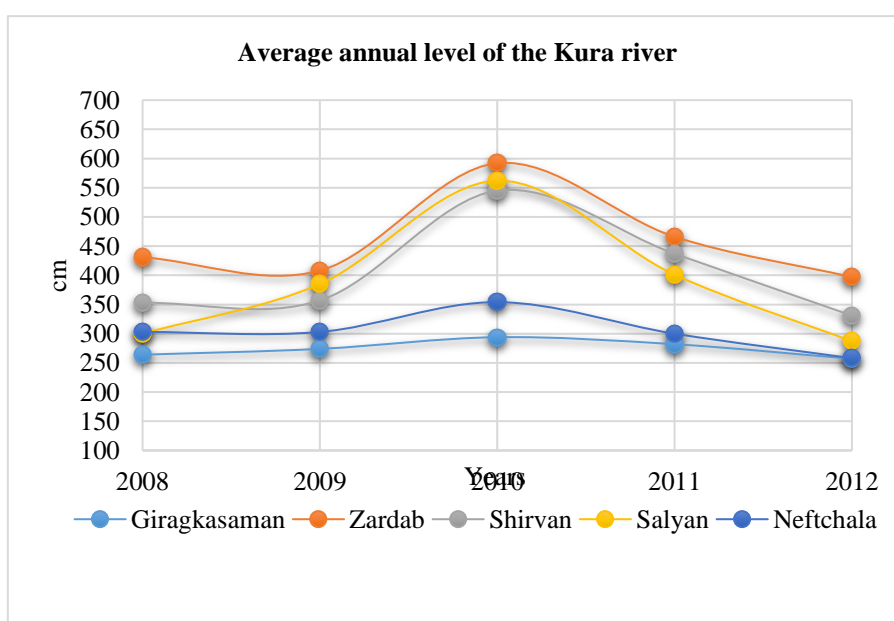


Figure 8. Variation tendency of the average annual level of the Kura River over different station during 2008-2012.

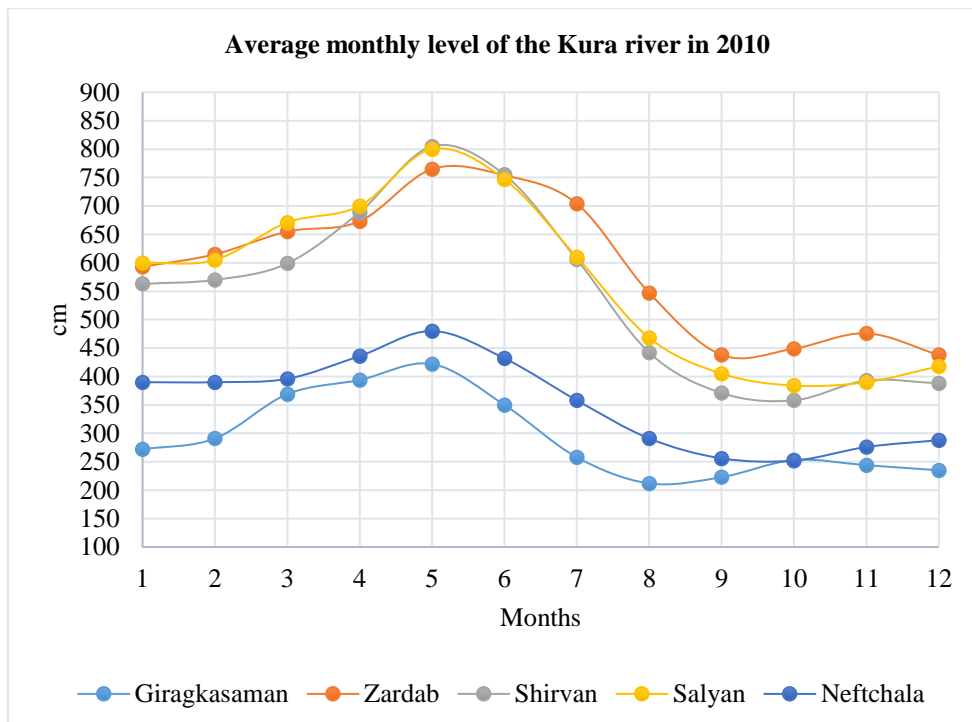


Figure 9. Variation tendency of the average monthly level of the Kura River over different stations in 2010.

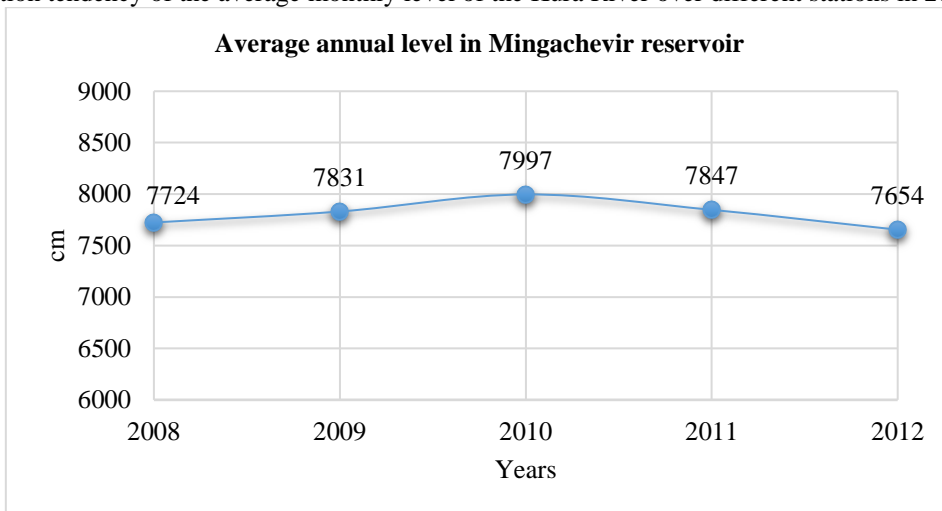


Figure 10. Average annual level in Mingachevir reservoir during 2008-2012.

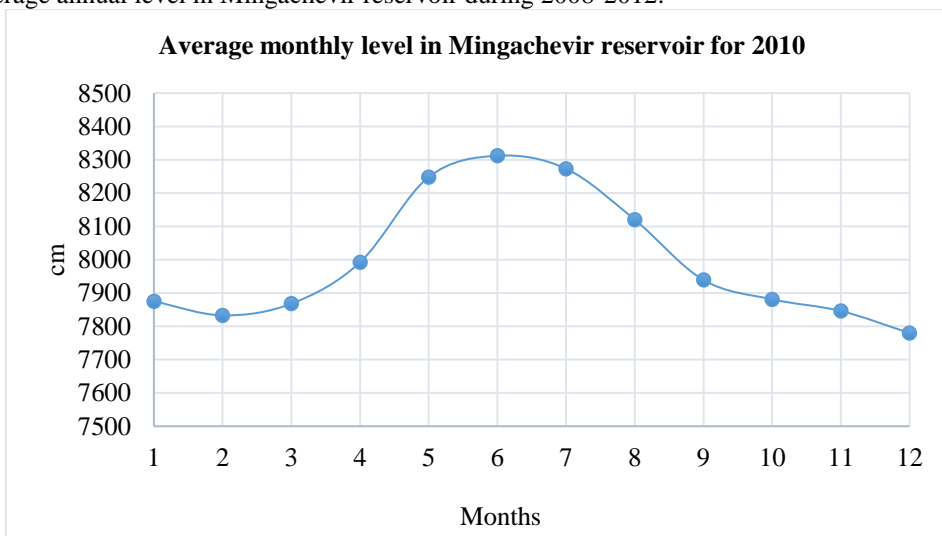


Figure 11. Variation tendency of the average monthly water level in Mingachevir reservoir for 2010.

Along with the high level of precipitation in April, May and June in 2010 in the country, the increase in water level of the Kura River was observed. The analysis of hydrological observation data shows that the average monthly water level of the Kura River in Zardab, Shirvan and Salyan stations was high in both three months (Fig. 9).

The potential of the Mingachevir water reservoir on the Kura River was utilized maximum for the regulation of water runoff of the Kura River and volume of the water almost reached the maximum level. Utterly the reasons for the flooding were maximum level of the water in Mingachevir water reservoir and excess release of the water. Comparing with other years, the water level in

Mingachevir reservoir from 2008 to 2012 was actually high in 2010. So, the level was 7997 cm in Mingachevir reservoir in 2010 (Fig. 10). In a viewed case the water level was high mainly in May and June in 2010 in Mingachevir reservoir, so the flooding coincided with the same months. The next graph illustrates that the maximum extent was 8320 cm in the end of May and in the beginning of June in the reservoir (Fig. 11).

Beside the analysis of meteorological data, the usage of satellite data was necessary for the determining of the flood extent. For that reason internet resources of USGS (URL 1) and Landsat 5 TM multispectral satellite images were used for the objective of the study (Table 1, Fig. 12).

Table 1. Parameters of acquired satellite images

Data Set Attribute	Attribute Value	
	Image 1	Image 2
Spacecraft Identifier	LANDSAT 5 TM	
WRS Path	167	
WRS Row	032	
Date Acquired	26/09/2009	24/05/2010
Quality Band 1-7	9	
Output Format	GEOTIFF	
Grid Cell Size Reflective	30	
Grid Cell Size Thermal	30	

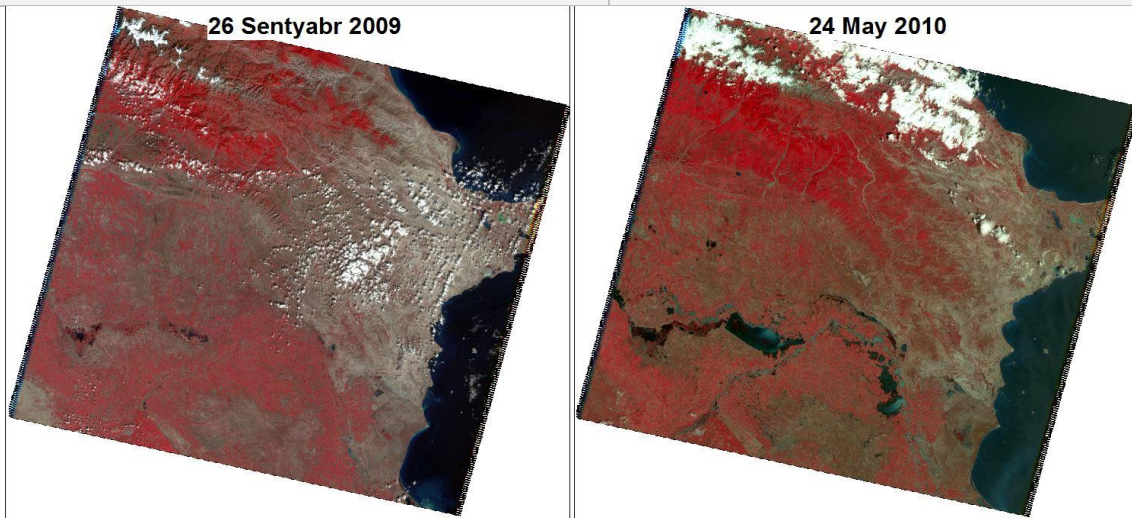


Figure 12. Obtained multispectral images from Landsat 5 TM satellite at different dates.

Conclusion

Based on acquired satellite images, delineation of inundated areas was conducted by the different tools of ArcGIS software and the extent of flooded areas was revealed (Fig. 13).

The assessment of hydro-meteorological parameters that could cause flooding and trend of the water level with the comparison of perennial norm in the Kura River was

conducted, systematic diagram of statistical data was presented, as well as statistical analysis of temperature changes for the period of 2008-2012, precipitation amount and fluctuations of water level in Mingachevir reservoir were conducted.

Final map of the water bodies on the multispectral satellite images for different period was developed through different tools of ArcGIS software.

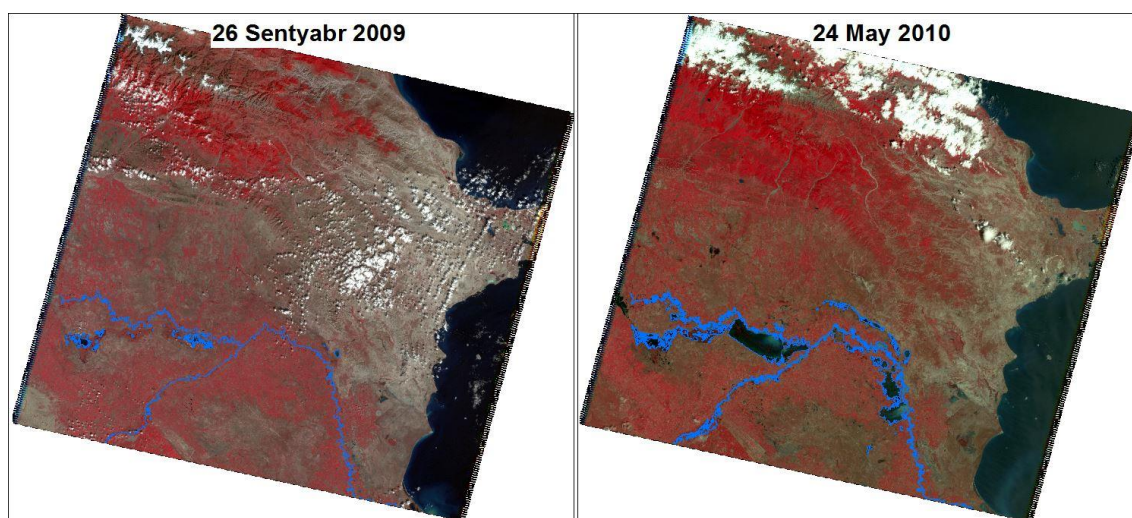


Fig. 13. Results from satellite images.

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