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Navigating Climate Challenges: The Drought Index's Key Role in Climate Change Impact Studies

Konul Mammadova

PhD candidate, Department of Field Econmy, Agro Research Center, Azerbaijan

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Abstract: Drought indices play a crucial role in identifying, categorizing, and monitoring drought conditions, facilitating the quantification of intensity, duration, and spatial extent of anomalous climate conditions. This information is invaluable for decision-making systems. In order to study the drought in Azerbaijan and its impact on the agricultural sector, the Nagorno-Shirvan region, where the non-irrigated land is developed, was chosen as a sample area in the research work. The VCI index was applied to the area in different years and the changes in the vegetation depending on the drought were detected.

Keywords: climate change, agriculture, Nagorno-Shirvan, Remote Sensing, VCI, drought

Introduction

In the Republic of Azerbaijan, numerous studies have been conducted in different years to study climate changes. The most fundamental studies were carried out by prominent climatologists. Climate changes occurring in the territory of the Republic of Azerbaijan are studied based on the data of more than 40 hydrometeorological stations located in the territory of the country. For example, starting from 1881, the study of climate changes in Baku, Nakhchivan, Ganja, Zagatala, Lankaran, Shusha and Guba areas was conducted using the data of these stations in the area from 1958 to 2000. Based on the results, it can be said that there are different effects on the formation of climate in different physical and geographical zones of Azerbaijan, and during the study of climate changes during this multi-year period, it is possible to see that it occurs more in winter/autumn months in Azerbaijan. The process taking place in our zone is very complex. This is due to the country's location on the coast of the Caspian Sea, being surrounded by the Caucasus Mountains and the local relief/circulation (Imanov & Mammadov, 2011).

Generally speaking, climate changes specific to the territory of the country - the temperature increases by 0.6-1.5 ^{0}C; the average annual air temperature does not increase in spring compared to other seasons, and in some years it even decreases; The temperature increases more in zones above 1000 meters. Climate change trends in Azerbaijan and its impact on agriculture were investigated using Remote Sensing technology. Remote Sensing is defined as the technology of collecting and analyzing information about the earth's surface and objects located at a certain distance from the earth's surface through platforms in the atmosphere or in space, or methods of obtaining information through distance measurement without physical contact with the objects. In order to determine the impact of climate change on agriculture in the country, the Nagorno-Shirvan region was chosen as a sample area, where the dry-farming land is developed (Khalilov, 2009).

Research Results

Nagorno-Shirvan relief and climate. The mountains and plains located in different parts of the territory vary from 200-300 m to 2200-3500 m. But most of it is mountainous terrain. Smooth landforms are observed in the central part of the region, and landslides are intense on the slopes of the river valleys. Mountainous plateaus such as Chukhuryurd, Sundu, and Meraza widely cover the territory of the region. The Langebiz range is located on the southwestern border of the Kura-Araz lowland. There are tectonic stages such as Gobustan, Tufan, Govdag in the physical-geographic region. Climate. Semi-desert and dry desert climate in the territory of the region - Gobustan region, mild hot climate with dry summer - Gurjuvan-Shamakhi- Meraza plateau, mild warm climate with rains evenly distributed in all seasons - Shamakhi and Ismayilli regions, mild warm climate with dry winter - Greater Caucasus mountains covers its parts with an altitude of up to 1000-1200 meters, mountain tundra climate - around the Babadag peak, which is more than 3000 meter (Wikipedia, n.d.).

Figure 1

General Terrain and Study Area

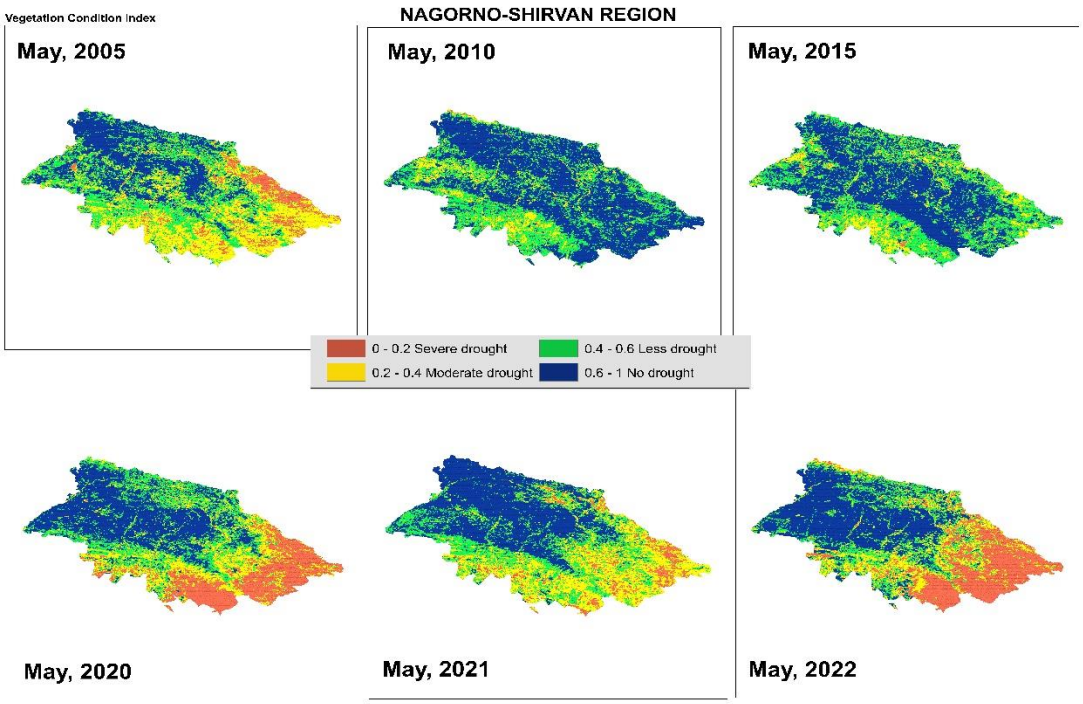
Source: Author own development.

For research different indexes of Remote Sensing will be applied for different years. Many drought monitoring approaches with satellite remotely sensed data are typically based on Normalized Vegetation Index (NDVI), land surface temperature (LST) (alternatively, brightness temperature) or a combination them. (Vegetative drought indices mainly based on NDVI (e.g. NDVI anomaly, integrated or standardized NDVI, Vegetation condition index, etc.) have been widely and successfully used to identify and monitor drought-affected areas at regional and local scales (Tucker & Choudhury, 1987). The proposal suggests calculating the NDVI for each pixel, normalized by the maximum and minimum statistical range over available images, to develop a Vegetation Condition Index (VCI) as an indicator of environmental stress (Peters et al., 2002). Following the VCI definition, the current moisture is determined by the NDVI minimum, and the historical maximum by weather conditions. Thus, NDVI acts as a synoptic indicator between soil and atmospheric conditions when describing vegetation conditions.

The VCI index utilized in the platform is calculated using the formula: VCI = 100 * (NDVI - NDVI min) / (NDVI max - NDVI min) (Kogan, 1995). VCI is expressed as a percentage, and its interpretation is based on extreme values from previous years (minimum and maximum), providing a comparative perspective. Lower and higher VCI values indicate poor and good plant conditions, respectively. VCI ranges from extremely unfavorable conditions (zero) to 100 for optimal conditions (Drought Monitoring System, n.d.).

Figure 2

VCI Index for Nagorno-Shirvan Region



Source: Author own development.

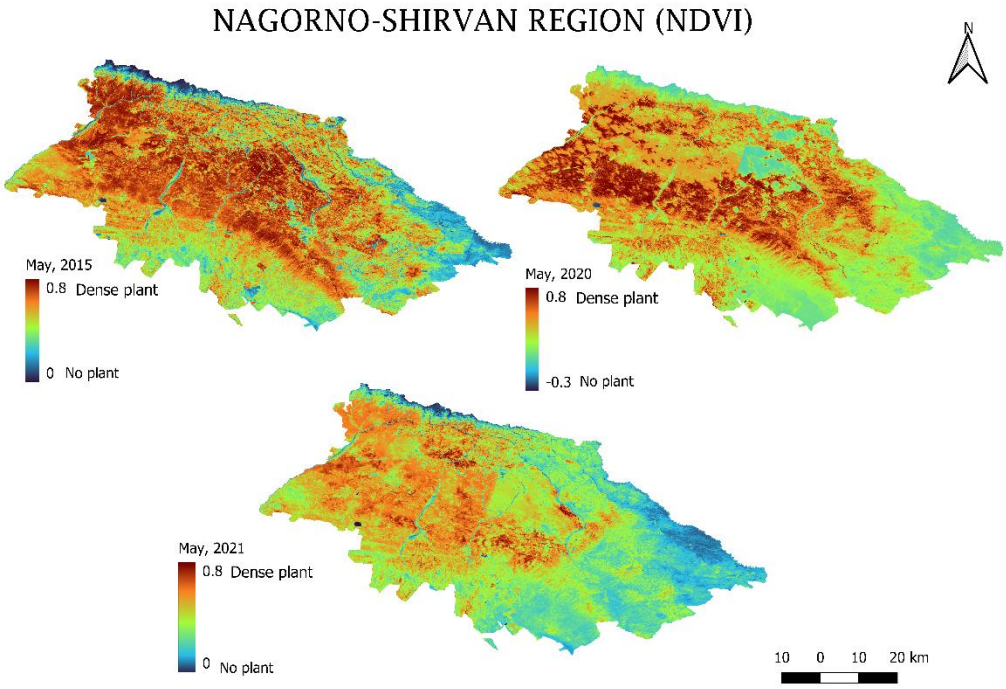
As you can see from the figure, 2000 is the year with more drought. Although the drought decreased in the following years, it is again at a high level in 2020. The peak of the drought is observed in 2022.

Here, NDVI was used for drought detection and monitoring. The validations showed that the drought monitoring tool derived from VCI is quite promising. Let's also look at the only NDVI values to check the result. NDVI has become a key tool for describing vegetation phenology, continental land cover, vegetation classification and dynamics, and agricultural practices.

Also attached below is the NDVI index for 2015 (year of mild), 2021 (moderate) and 2022 (severe drought).

Figure 3

NDVI Index for Nagorno-Shirvan Region



Source: Author own development.

Conclusions

From the indices used, it is known that after 2015 the drought manifests itself sharply. Although in some years drought is less observed (for example, 2021), in general, it can be said that the area covered by drought is increasing over the years. In years with more droughts, crop yield decreases as a result of plant stress. If the process continues in this way, the problem of decreasing productivity and production in the agricultural field will be inevitable.

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