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Estimation of Actual Evapotranspiration by Mountain SEBAL Algorithm Based on Pea Plants (Case Study: Semi-Northern Half of Ardabil Province)

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Abstract

1- Introduction

Evapotranspiration monitoring has important implications for climate modeling and water resource management at the global and regional levels. Considering that the semi-northern half of Ardabil province is one of the important agricultural poles of the country, evapotranspiration was, therefore, estimated in this research using the Landsat 8 images (dated 2018/7/1) and the SEBAL and mountain SEBAL methods were applied and compared with the Penman-Monteith method. Then, different levels of land use were extracted in the region using the object-oriented image classification with a kappa coefficient of 0.945 and a general accuracy of 0.956. Based on the obtained results, the water levels (9.61 and 9.5 mm/day) had the highest evapotranspiration and urban and bare lands with mean values of 2.845 and 2.08 mm/day in the SEBAL and Mountain SEBAL methods, respectively, had the lowest 24-hour evapotranspiration. Moreover, amounts of 7.14 and 6.70 mm/day were estimated for water requirement of pea crop for SEBAL and mountain SEBAL methods, respectively. These values were compared with that of Penman-Monteith method (6.32 mm/day) with a mean absolute difference (MAD) of 0.60. Subsequently, the extracted area of

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each land revealed the lowest amount (an area of 1202.62 hectares) of cultivated pea land, which was about 4.6 percent different from the area (1147.25 hectares) previously declared by the Agricultural Jihad in Ardabil province; though, it seems to be acceptable.

In addition to precipitation and runoff, evapotranspiration is one of the main components of the hydrological cycle, which is affected by two biophysical and environmental processes among the soil, plant, and atmosphere. Monitoring evapotranspiration has important implications for both global and regional climate modeling; it is also helpful in the understanding of the hydrological cycle and assessment of the environmental stresses affecting the forests and agricultural ecosystems. This is because evapotranspiration is one of the processes influenced by the climatic elements such as precipitation, cloudiness, humidity, distribution of wind, and concentration of atmospheric gases. Constant precipitation and reduced rainfall in some cases, and, in contrast, increased evapotranspiration have faced most of human, agricultural, and natural needs with available water shortages. As a result, hydrologic equilibrium methods, such as evapotranspiration modeling, are widely used to assess the impacts of climate change on the water requirements of crops and plants. For this purpose, many studies have been carried out around the world and Iran to estimate the amounts of evapotranspiration.

2- Methodology

Areas under study in this research were the semi-northern half of Ardabil province, including Ardabil, Bilesvar, Germi, Meshkinshahr, Namin, and Parsabad, with an area of 12571.33 square kilometers located in the northwest of Iran. The province is geographically located between 37° 45′ to 39° 42′ N, and 47° and 30′ to 48° and 55′ E latitudes. Maximum and minimum altitudes in this area are 4732 and 36 m above sea level. Ardabil is the most important city in this area.

In this study, Landsat 8 image of 2018/7/1 and meteorological data of the same day were used to compare the evapotranspiration of different

land uses by SEBAL and mountain SEBAL with Penman-Monteith methods. ENVI 4.8, ERDAS and RefET were used to process images and implement the algorithms of SEBAL, Mountain SEBAL, and Penman-Monteith. The eCognition software was also employed for object-based land use classification. The SEBAL algorithm (Surface Energy Balance Algorithm for Land) and the mountain SEBAL algorithm are both determined based on the energy balance at the surface. In other words, the energy used for evapotranspiration is calculated as the remaining equation of the flux of the surface flow energy.

3- Result and Discussion

To estimate the actual evapotranspiration of different land uses and the pea crop, the required images were prepared and processed, followed by calculations related to the SEBAL and mountain SEBAL algorithms. Then, the land use map was classified into nine classes (agriculture, bare lands, grade 1 range, grade 2 range, grade 3 range, forest, pea, residential areas, and water levels) using the object-based image classification method with a Kappa coefficient of 0.945 and an overall accuracy of 0.956 for the studied area. Then the area of each application was calculated in hectare, indicating the bare and pea-cultivated lands as the largest (847985.10 ha) and the smallest (1202.62 ha) ones among the studied locations. Also, the area of pea-cultivated land was compared with that (1147.25 ha) declared by the Agricultural Jihad in Ardabil Province, which were 4.6% different that seems to be acceptable.

4- Conclusion

The SEBAL model has high accuracy in estimating the evapotranspiration of flat agricultural areas. However, due to the influence of some factors such as slope, elevation, and direction of gradient on evapotranspiration, a new model, called mountain SEBAL, was presented in order to correct these factors while interfering with the factors mentioned in the calculation process. In this research, therefore, the SEBAL and mountain SEBAL methods were used to estimate the evapotranspiration of different lands. Also, amounts of 7.14 and 6.70 were estimated for water requirement of the cultivated pea crop using the SEBAL and mountain

SEBAL, respectively. These values were compared with the Penman-Monteith FAO method (6.32 mm/day) due to non-availability of a lysimeter and the wide range of the study area. Accordingly, the Penman-Monteith method used to estimate the water demand of chickpea had an absolute difference (AD) of 0.82 and 0.38, and a mean absolute difference (MAD) of 0.66, respectively.

Keywords: Mountainous SEBAL, Penman-Monteith, Object-based classification, Pea plant, Ardebil.