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Assessment of LST and NDMI indices using MODIS and Landsat images in Karun riparian forest

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Abstract: Riparian forest plays a significant role in ecosystems. Also, research on land surface temperature and soil moisture is essential in earth science and forest studies. Because measuring methods are difficult to apply in large areas and especially in dense forests, in this study normalized difference moisture index (NDMI) and land surface temperature (LST) were estimated using the infrared thermal method by data of Landsat 8 and Moderate Resolution Imaging Spectroradiometer (MODIS) in the Karun riparian forest that is of ecological importance in the Khuzestan province of Iran. The results showed that the accuracy for estimated NDMI and LST was appropriate (root mean square error = 3.45). In addition, the used polynomial support vector machine algorithm for classification by four classes (forest, agriculture, river, and others) and the validity of classification in these areas were suitable (overall accuracy = 95%, kappa coefficient = 0.93). Also, the NDMI index was dependent on changes in LST and Pearson coefficients were 0.94 and 0.84 for Landsat 8 and MODIS data, respectively. The average temperature of the area was obtained as 43.22 and 42.77 for Landsat 8 and MODIS, respectively. Finally, more protection of this forest against LST enhancement and reduction in soil moisture is necessary.

Keywords: moisture index; temperature; forestry; river; climate; infrared thermal method

According to the phenomenon of global warming and regional climate change, studies are needed on the investigation of land surface temperature and relation between this temperature and other parameters like soil moisture for forest management. Land surface temperature can be effective in relation to the land use type. Shortwave infrared and near-infrared (NIR) thermal methods are very useful in global warming studies (Feizizadeh et al. 2016). Infrared waves have been widely used in global warming studies because they indicate the land surface temperature and the exacerbation of heat islands (Hosseini et al. 2014). Also, the riparian forest has diverse species, and they play essential roles in water and landscape planning, biomass production and impact in natural cycles (Naiman, Décamps 1997; Kozlowski 2002). So the study on the capability of satellite data images in these areas is important. Emami et al. (2016) validated the data of Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat to estimate the land surface temperature and the results showed these sensors have the high accuracy for this evaluation. Khanmohammadi et al. (2015) estimated a normalized difference moisture index (NDMI) using MODIS images in the city of Varamin, and they said that the obtained model was able to estimate soil moisture in a wide geographic zone with acceptable accuracy. Also Kheradmand et al. (2015) evaluated NDMI and land surface temperature (LST) using satellite imagery in the city of Gonbad-e-Golestan, and they stated that the obtained soil moisture from this model was more accurate. Vaez Mousavi and Mokhtarzadeh (2015) performed LST mapping

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using MODIS data with high accuracy. Considering that the riparian areas have diverse species and different environmental processes, the assessment of soil moisture and surface temperature is essential in order to manage water and soil, especially for the riparian forest. Natural forests of the Karun River in Khuzestan province cover a vast area, unfortunately, in spite of their high significance, they have destructed heavily. The mismanagement, the construction of several dams reducing the water level, increasing the air temperature, in addition, the environmental pollution caused that these forests have been severely damaged. So according to the ecological importance of riparian forest in this region and forest management, land surface temperature and soil moisture were studied using data images of MODIS and Landsat 8. The aim of this study was to investigate and estimate LST and NDMI in Karun riparian forest using MODIS and Landsat images because the measurement of LST and soil moisture in this area is of great importance.

MATERIAL AND METHODS

Study area. Karun is the big and famous river in Iran which flows from the Khuzestan province. The study area is the riparian forest of Karun near Kushkkak in the vicinity of the city of Shushtar in Khuzestan province. The geographic location of the study area is between 32°10'48.0''N, 48°49'17.3''E and 32°06'51.7''N, 48°52'41.0''E. The indicative species are *Populus euphratica* Olivier, *Tamarix* sp., *Ziziphus spina-christi* (Linnaeus) Desfontaines, *Lycium shawii* R. Roem. & Schweinfurth, and *Capparis spinosa* Linnaeus. Fig. 1 shows the study area.

Research method. Remote sensing methods, like methods of estimation of temperature changes on the land surface, can be effective in responding to climate changes in the region (Bhamare, Agone 2011). Land surface temperature is a function of pure energy at the surface of the earth that depends on the amount of energy reaching the land surface, as well as on the emissivity, humidity, and atmospheric airflow (Feizizadeh et al. 2016). For preprocessing a quick atmospheric correction method was applied (Bernstein et al. 2012). In order to obtain a high spectral and spatial resolution image, the Gram-Schmidt spectral sharpening method was used for fusion bands (Latifi et al. 2007). To obtain training samples, 200 ground truths were taken and then the training data was selected. Class separation was done using the Jeffreys-Matusita distance. This method improves classification accuracies (Laliberte et al. 2012). The classification was performed based on support vector machine (SVM) methods, because this algorithm is better evaluated for similar riparian forests (Torahi et al. 2017). The SVM method is a non-parametric supervised learning statistical method and in this study the polynomial kernel was applied (Mountrakis et al. 2011) by four classes (forest, agriculture, river, and others). Eq. 1 shows the kernel function for the polynomial kernel of the SVM method:

$$k(X, y) = (X \times y + 1)^p \quad (1)$$

For the accuracy of classification kappa coefficient and overall accuracy were calculated (Congal-

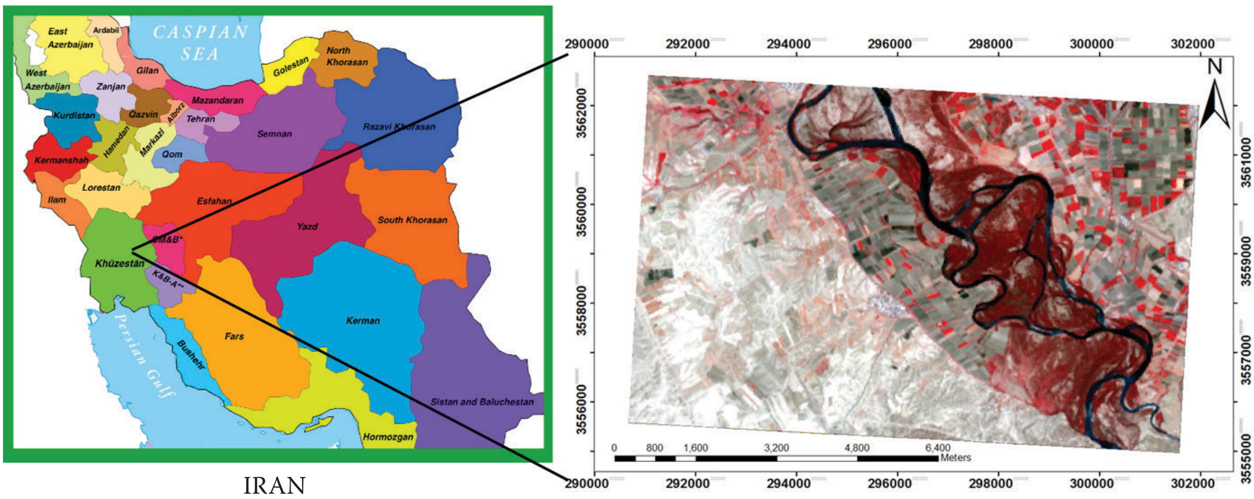

Fig. 1. Riparian forests in the study area

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ton, Green 1999). The LST mapping was based on the infrared thermal method and determination of spectral radiance, brightness temperature, normalized difference vegetation index (NDVI) and emissivity. NDVI index was calculated by Eq. 2:

$$\text{NDVI} = \frac{B_{\text{NIR}} - B_{\text{red}}}{B_{\text{NIR}} + B_{\text{red}}} \quad (2)$$

where:
B_{NIR} – near-infrared band,
B_{red} – red band.

Then the LST map was obtained by using Eq. 3:

$$\text{LST} = \frac{\text{BT}}{1} + w \times \left(\frac{\text{BT}}{p}\right) \times \ln(e) \quad (3)$$

where:
BT – brightness temperature,
w – wavelength,
p = 14,380.

To measure the linear correlation between LST and NDMI Pearson coefficients were used.

Spectral data used. In this research products of operational land imager (OLI), thermal infrared sensor (TIRS) data, MOD11A1 and MOD09A1 (Khanmohammadi et al. 2015; Kheradmand et al. 2015) were used in July 2018. Landsat 8 satellite characteristics are shown in Table 1. MOD11A1 has a pixel size of 1,000 (Table 2) and MOD09A1 provides MODIS band 1–7 surface reflectance at 500 m resolution (Table 3).

Table 1. The characteristics of Landsat 8

	Band, type	Bandwidth (μm)	Resolution (m)
OLI	1, coastal	0.43–0.45	30
	2, blue	0.45–0.51	30
	3, green	0.53–0.59	30
	4, red	0.63–0.67	30
	5, NIR	0.85–0.88	30
	6, SWIR 1	1.57–1.65	30
	7, SWIR 2	2.11–2.29	30
	8, pan	0.50–0.68	15
	9, cirrus	1.36–1.38	30
TIRS	10, TIRS 1	10.6–11.19	30 (100)
	11, TIRS 2	11.5–12.51	30 (100)

OLI – operational land imager, TIRS – thermal infrared sensor, NIR – near-infrared, SWIR – shortwave infrared

RESULTS

After classification with four classes (forest, agriculture, river, and others) and determination of accuracy (overall accuracy = 95%, kappa coefficient = 0.93) (Table 4), the map of the region was obtained (Fig. 2). The maximum, average and minimum temperature achieved was 51.32, 42.77, and 37.62°C for MODIS, and 56.72, 43.22, and 35.11°C for Landsat, respectively. LST mapping obtained from MODIS and Landsat data is shown in Figs 3a, b [root mean square error (RMSE) = 3.45, mean absolute error (MAE) = 2.09].

The NDMI mapping was prepared for both MODIS and Landsat data (Figs 4a, b), also the calcu-

Table 2. Data layer characteristics of MOD11A1

SDS name	Description	Units	Data type	Valid range	Scale factor
Emis_31	band 31 emissivity	N/A	8-bit unsigned integer	1–255	0.002
Emis_32	band 32 emissivity	N/A	8-bit unsigned integer	1–255	0.002

SDS – scientific data set

Table 3. Data layer characteristics of MOD09A1

SDS name	Description	Data type	Valid range
Sur_refl_b01	surface reflectance band 1 (620–670 nm)	16-bit signed integer	–100–16,000
Sur_refl_b02	surface reflectance band 2 (841–876 nm)	16-bit signed integer	–100–16,000
Sur_refl_b03	surface reflectance band 3 (459–479 nm)	16-bit signed integer	–100–16,000
Sur_refl_b04	surface reflectance band 4 (545–565 nm)	16-bit signed integer	–100–16,000
Sur_refl_b05	surface reflectance band 5 (1,230–1,250 nm)	16-bit signed integer	–100–16,000
Sur_refl_b06	surface reflectance band 6 (1,628–1,652 nm)	16-bit signed integer	–100–16,000
Sur_refl_b07	surface reflectance band 7 (2,105–2,155 nm)	16-bit signed integer	–100–16,000

SDS – scientific data set

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Table 4. Results of the confusion matrix of the support vector machine method for operational land imager (OLI) images

Class	Accuracy (%)	
	producer	user
Forest	99.8	87.8
Agriculture	76.19	80.9
River	98.92	97.18
Others	100	98.9

overall accuracy = 95%, kappa coefficient = 0.93

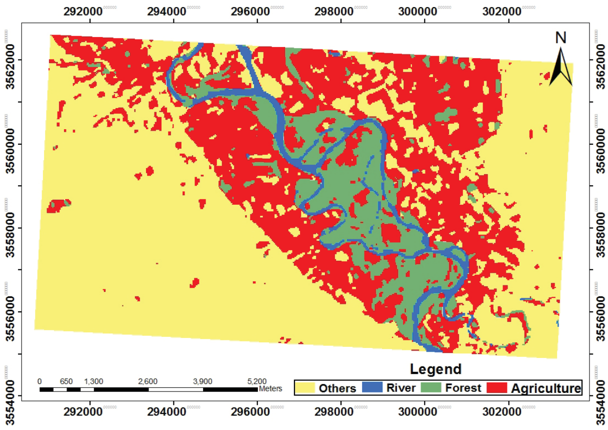

Fig. 2. Land use mapping with four classes by support vector machine method

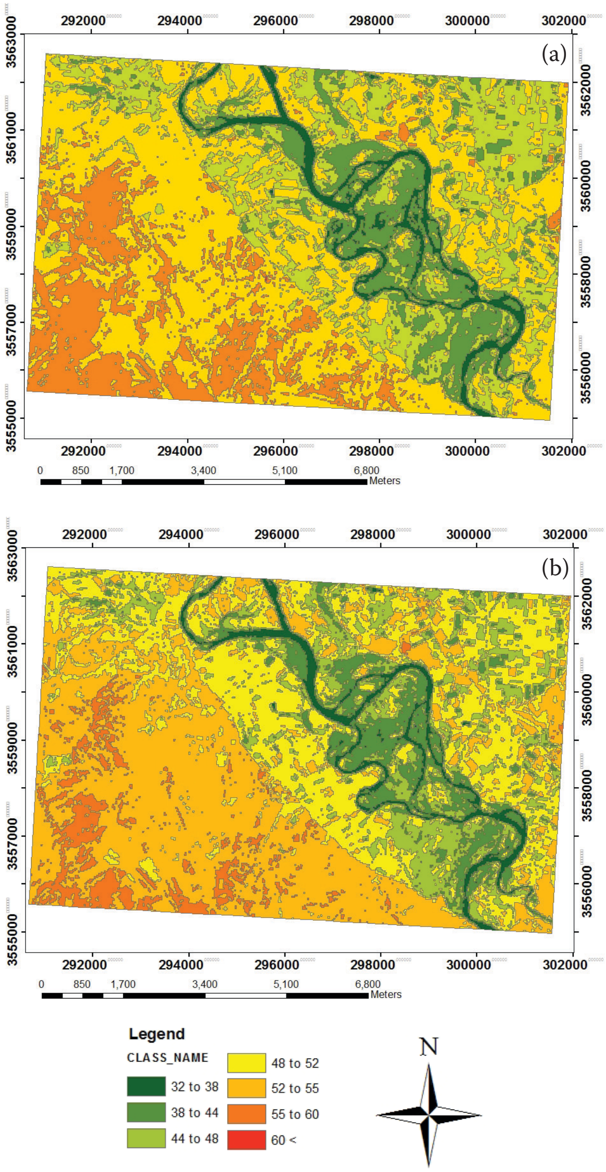

Fig. 3. Land surface temperature mapping using Moderate Resolution Imaging Spectroradiometer – MODIS (a), Landsat 8 (b) data

lated Pearson correlations were 0.95 and 0.88 for both of them. The regression between NDMI and LST is represented in Figs 5a, b.

DISCUSSION AND CONCLUSIONS

In recent years, air temperature has increased in the Khuzestan area, and the water level of Karun River has decreased. This could be due to construction of several dams, transfer of water and industrial activity, and the increase in air temperature under the influence of heat islands, and so temperature enhancement has been effective on vegetation changes (Firoozy Nejad, Zoratipour 2018). The riparian forest of Karun is substantial for the environmental sustainability of the region and requires extensive studies to protect and survive. Also, forest management necessitates forest mapping, and remote sensing can make it easier. Observations showed that the riparian Karun area is covered with dense scattered trees that are mostly enclosed with Tamarisk trees and *P. euphratica*, and so it makes sampling difficult in the area. After preprocessing, processing and classification, it was found that based on the confusion matrix, the accuracy of mapping was appropriate – similar to the study of Firoozy Nejad (2013). According to results of RMSE and MAE (RMSE = 3.45, MAE = 2.09), LST mapping provided a good accuracy (overall accuracy = 95%, kappa coefficient = 0.93), likewise Vaez Mousavi and Mokhtarzadeh (2015). Subsequently by the evaluation of the moisture index a linear relationship was found between indicators of temperature and moisture. Due to the high temperature in the area (51.32°C with MODIS, 56.72°C with Landsat 8), it was found necessary to more protect

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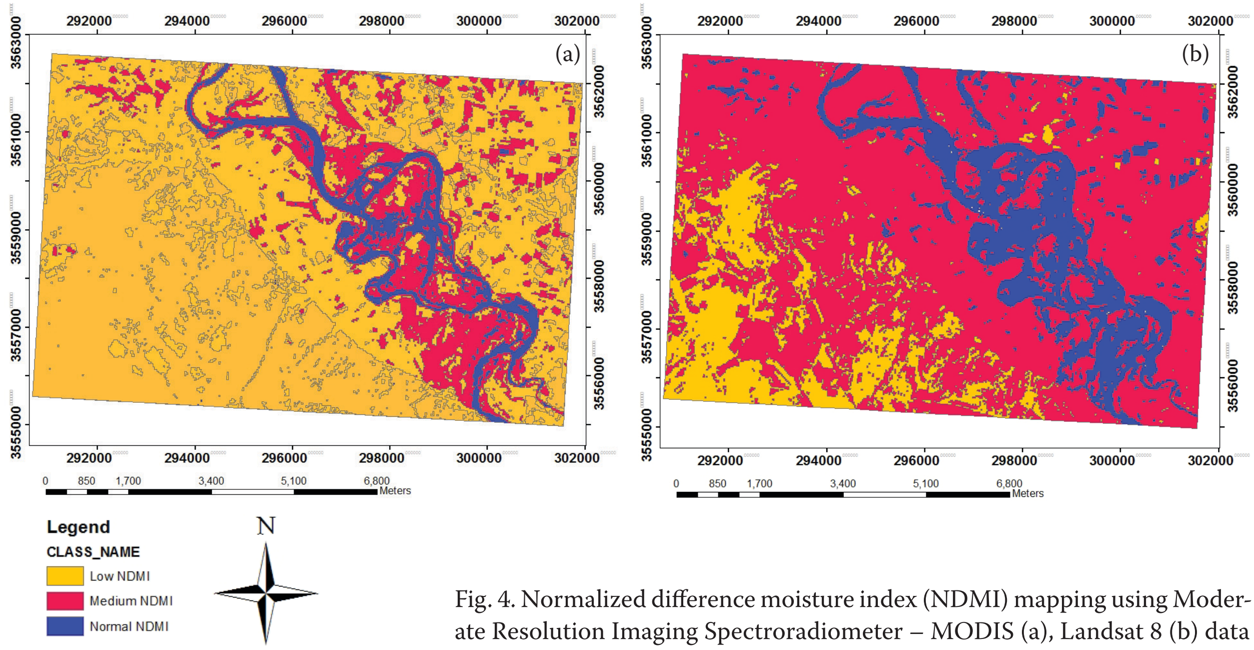

Fig. 4. Normalized difference moisture index (NDMI) mapping using Moderate Resolution Imaging Spectroradiometer – MODIS (a), Landsat 8 (b) data

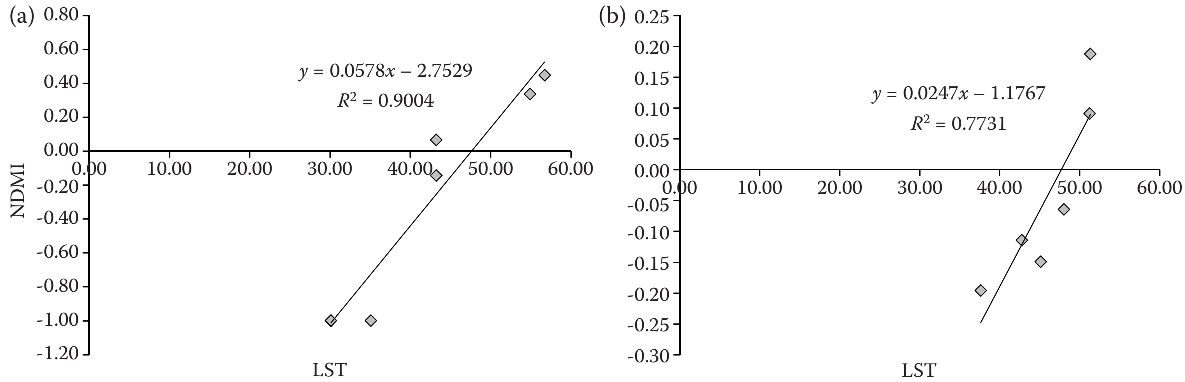

Fig. 5. Regression between normalized difference moisture index (NDMI) and land surface temperature (LST) using Landsat 8 (a), Moderate Resolution Imaging Spectroradiometer – MODIS (b)

this riparian forest against a reduction in soil moisture. Finally, based on the results, MODIS data are better than Landsat images to estimate these factors, but Landsat images can be more useful due to better spatial resolution in a smaller window than MODIS images for the study area. Also, after using the fusion process by the Gram-Schmidt spectral sharpening method for OLI and MODIS images better resolution was obtained for both of them, and this result is similar to the study of Firoozy Nejad et al. (2017).

References

Bernstein L.S., Jin X., Gregor B., Adler-Golden S.M. (2012): Quick atmospheric correction code: Algorithm description and recent upgrades. Optical Engineering, 51: 111719.

Bhamare S.M., Agone V. (2011): Change detection of surface temperature and its consequence using multi-temporal remote sensing data and GIS application to Tapi Basin of India. In: Proceedings of the Global Conference on Global Warming 2011, Lisbon, July 11–14, 2011: 1–12.

Congalton R.G., Green K. (1999): Assessing the Accuracy of Remotely Sensed Data: Principles and Practices. Boca Raton, Lewis Publishers: 160.

Emami H., Mojaradi B., Safari A. (2016): An alternative scaling method for cross-validation of land surface temperature from remote sensing data: A case study of Fars province. Journal of Geomatics Science and Technology, 6: 1–17. (in Persian)

Feizizadeh B., Didehban K., Gholamnia K. (2016): Extraction of land surface temperature (LST) based on Landsat satellite images and split window algorithm study area: Mahabad catchment. Scientific-Research Quarterly of Geographical Data (SEPEHR), 25: 171–181. (in Persian)

https://doi.org/10.17221/121/2018-JFS

Firoozy Nejad M. (2013): Evaluation of ETM+ and IRS-LISSIII sensor potential for riparian forest mapping (case study: Maroon River riparian forest, Khuzestan). [MSc Thesis.] Behbahan, Khatam University of Technology: 100.

Firoozy Nejad M., Zoratipour A. (2018): Interactions of land surface temperature (LST) in increasing or decreasing vegetation. In: Akrami M., Moazami S., Neamati A.R: Proceedings of the First Congress of Water, Soil and Environmental Sciences, Tehran, Mar 2, 2018: 1–10.

Firoozy Nejad M., Torahi A.A., Rai S.C. (2017): Comparing the capability of ETM+ and LISS-III imagery in riparian forest mapping: A case study of Maroon river, Iran. Lebanese Science Journal, 18: 226–233.

Hosseini Z., Zerang N., Hajilo M., Dadashi M., Tiba A. (2014): Investigating relationship between land surface temperature (LST) and vegetation using Landsat images (case study: Isfahan). In: Almodaresi S.A.: Proceedings of the First Conference on the Use of Advanced Models Spatial Analysis Remote Sensing and GIS, Yazd, Feb 24, 2015: 1–11.

Khanmohammadi F., Homaee M., Noroozi A.A. (2015): Soil moisture estimating with NDVI and land surface temperature and normalized moisture index using MODIS images. Journal of Soil and Water Resources Conservation, 4: 37–45.

Kheradmand V., Jalali Majidi M., Khazami S. (2015): Investigating the possibility of estimating soil moisture from satellite images using the thermal bands. In: Proceedings of the International Congress on the Ability of the Community in the Field of Management, Economics, Entrepreneurship and Cultural Engineering, Tehran, Nov 4, 2016: 1–11.

Kozlowski T.T. (2002): Physiological-ecological impacts of flooding on riparian forest ecosystems. Wetlands, 22: 550–561.

Laliberte A.S., Browning D.M., Rango A. (2012): A comparison of three feature selection methods for object-based classification of sub-decimeter resolution UltraCam-L imagery. International Journal of Applied Earth Observation and Geoinformation, 15: 70–78.

Latifi H., Oladi J., Saroei S., Jalilvand H. (2007): Evaluating ETM+ satellite data for mapping forest cover – shrubland-pasture classes (case study: Zalemrood, Mazandaran). Journal of Science and Technology of Agriculture and Natural Resources, 40: 439–447.

Mountrakis G., Im J., Ogole C. (2011): Support vector machines in remote sensing: A review. ISPRS Journal of Photogrammetry and Remote Sensing, 66: 247–259.

Naiman R.J., Décamps H. (1997): The ecology of interfaces: Riparian zones. Annual Review of Ecology and Systematics, 28: 621–658.

Torahi A., Firoozy Nejad M., Abdolkhani A. (2017): Evaluation of the performance of SVM algorithms and ML in land use mapping of riparian forests using OLI sensor (case study: Maroun Behbahan riparian forests). Iranian Remote Sensing & GIS, 9: 49–62. (in Persian)

Vaez Mousavi A., Mokhtarzadeh M. (2015): Estimation of land surface temperature using MODIS data. In: Gheragozlo A.: Geomatics 94 National Conference & Exhibition, Tehran, May 17, 2015: 1–9.

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