Capability assessment of water indexes extracted from remote sensing data in order to water bodies classification (case study: Gorganroud River – North east of Iran)

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Abstract:

Normalized Difference Water Index (NDWI) has been widely used to detect water bodies and enhance them in the satellite imagery. In order to determine water bodies in Landsat TM, Mid-Infrared and Green bands are used but this combination is often encountered with vegetation, soil and build-up land noises and the water bodies area was not calculated accurately and most of the time the results are higher than the actual area and was overestimated, NDWI does not remove soil and vegetation noises completely because of using the NIR band reflection, therefore, to eliminate these noises, Modified Normalized Difference Water Index (MNDWI) with different bands in Landsat TM such as Shortwave and Near-Infrared bands has been used and best image that shows water bodies more accurate has been provided. We need to test different band combination and also different NDWI and MNDWI indexes in the range of Red, Near-Infrared, Shortwave Infrared and Mid-Infrared to determine the best performing index. For this purpose, Gorganroud river basin was selected as study area, which is located in north-east of Iran and is one of the largest rivers in Iran and because of 2 dams located in the river basin and long distance of river, studying water bodies could be easier in comparing with other river basins of Iran. we compared NDWI and MNDWI indices and results shown that MNDWI index using Landsat TM bands Green and Mid-infrared has higher accuracy than NDWI and other calculated indices with different bands of Landsat TM. It can remove the vegetation, soil and build-up noises better than NDWI and water bodies can be shown clearly. The MNDWI is more suitable to extract water bodies and study the information of water regions with dominating the soil, vegetation and build-up land noises because of its advantage in reducing or even removing those noises over NDWI.

Key words: Normalized Difference Water Index (NDWI), Modified Normalized Difference Water Index (MNDWI), Landsat 5, water bodies, Gorganroud river basin

Study area:

Gorganroud basin with more than 10000km² area is located in north east of Iran between 54°10' to 56°25' longitude and 36°35' to 38°10' latitude. Figure 1 shows the location of the study area in Iran.
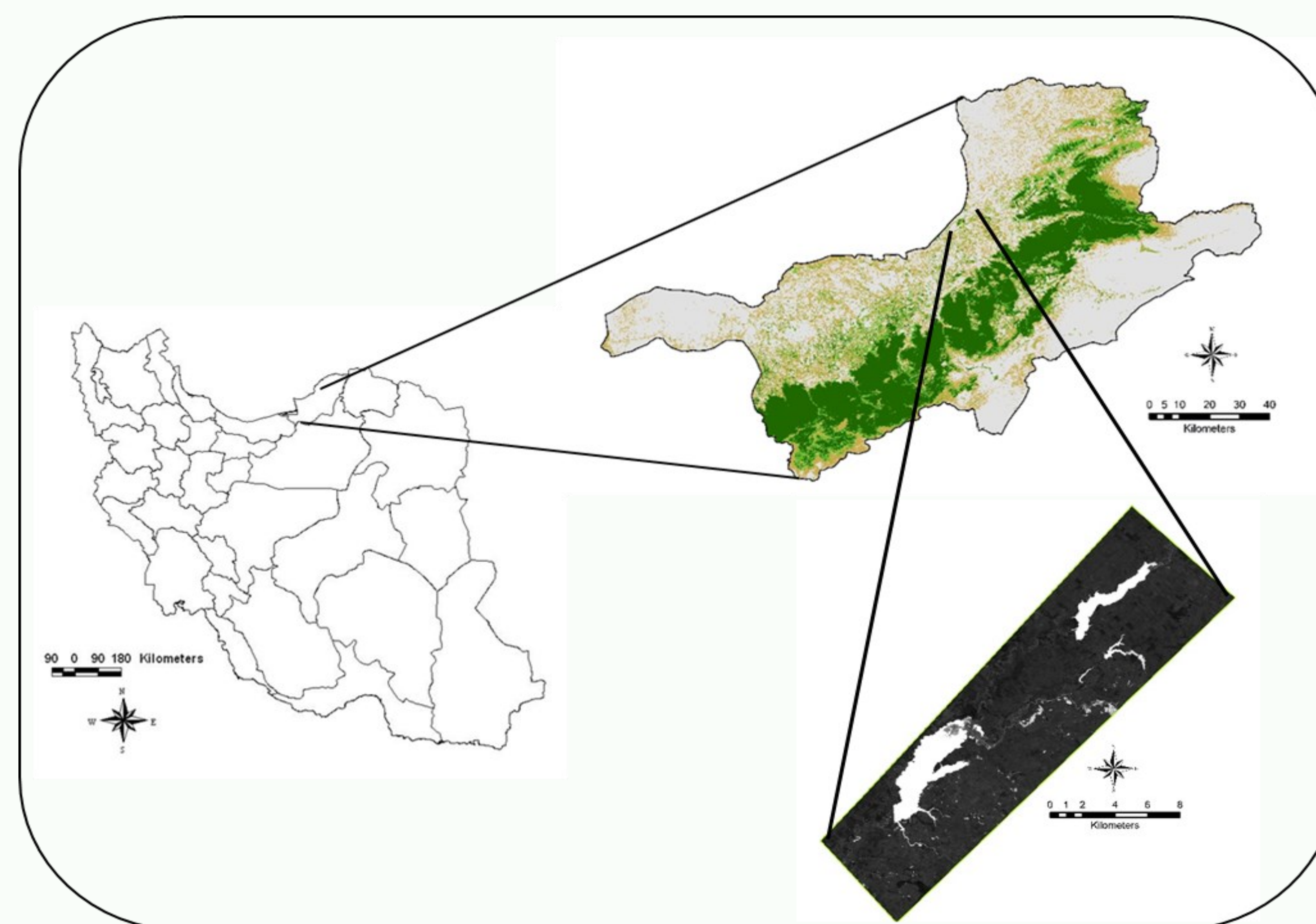

Figure 1: study area location in Iran

Materials and methods:

Table 1: Landsat TM 2010 bands used details

Landsat TM bands chart	μm	Resolution	Band name
1	0.45 – 0.52	30m	Blue
2	0.52 – 0.60	30m	Green
3	0.36 – 0.69	30m	Red
4	0.76 – 0.90	30m	NIR
5	1.55 -1.75	30m	SWIR1
6	10.4– 12.5	120m	Thermal
7	2.08 – 2.35	30m	SWIR2

Table 2: Water indexes equations

Water Indexes	Equations
NDWI$_{bands2,4}$	$\dfrac{0.52\,\mu - 0.76\mu}{0.52\,\mu + 0.76\mu}$
NDWI$_{Gao\ bands4,5}$	$\dfrac{0.76\mu - 1.55\mu}{0.76\mu + 1.55\mu}$
MNDWI$_{bands2,5}$	$\dfrac{0.52\mu - 1.55\mu}{0.52\mu + 1.55\mu}$
MNDWI 1$_{bands2,7}$	$\dfrac{0.52\mu - 2.08\mu}{0.52\mu + 2.08\mu}$

Landsat TM 2010 satellite imagery (Table 1) was used in order to study and extract water bodies from the satellite images, we used NDWI (Normalized Difference Water Index) and MNDWI (Modified Normalized Difference Water Index), the NDWI is as follows which first expressed by McFeeters, 1996. To extract the vegetation water content another NDWI was used by Gao, 1996 which used different band composite and the equation is as shown in Table 2. In NDWI there are regions that have land, vegetation noises that have reflectance similar to water, therefore, to minimize these noises (Xu, 2006), instead of NIR band (band 4 in TM), the SWIR band is used, and the NDWI index has been modified to MNDWI as seen in the figure 3 MNDWI 1 the SWIR band is Landsat TM band 2.08μ (band 7) and in MNDWI index the SWIR band is Landsat TM band 2.55μ (band 5) (Ji *et al*, 2009; Li *et al*, 2013; Watson *et al*, 2018).

Results showed that band 5 TM can better eliminate the build-up noises in the water index and water bodies are better extracted in compare with band 7 in TM (Figure 3). The vegetation and land noises in the NDWI and also in MNDWI (used band 7 in TM bands) have grey tone and can be mixed with water bodies but when using band 5 TM these noises are removed and are black tone which helped us to extract water bodies from the index and all water bodies in the MNDWI (used band 5 TM) are white and have large contrast with these water features (Figure 1 to 4).

The method is used to compare the accuracy of the water indexes in order to figure out the best index that separates water bodies from surrounding areas.

Results:

The results of water indexes derived from Landsat TM data showed that the values of MNDWI has a great ability to demonstrate the difference between water bodies and surrounding cover such as plant cover and land.
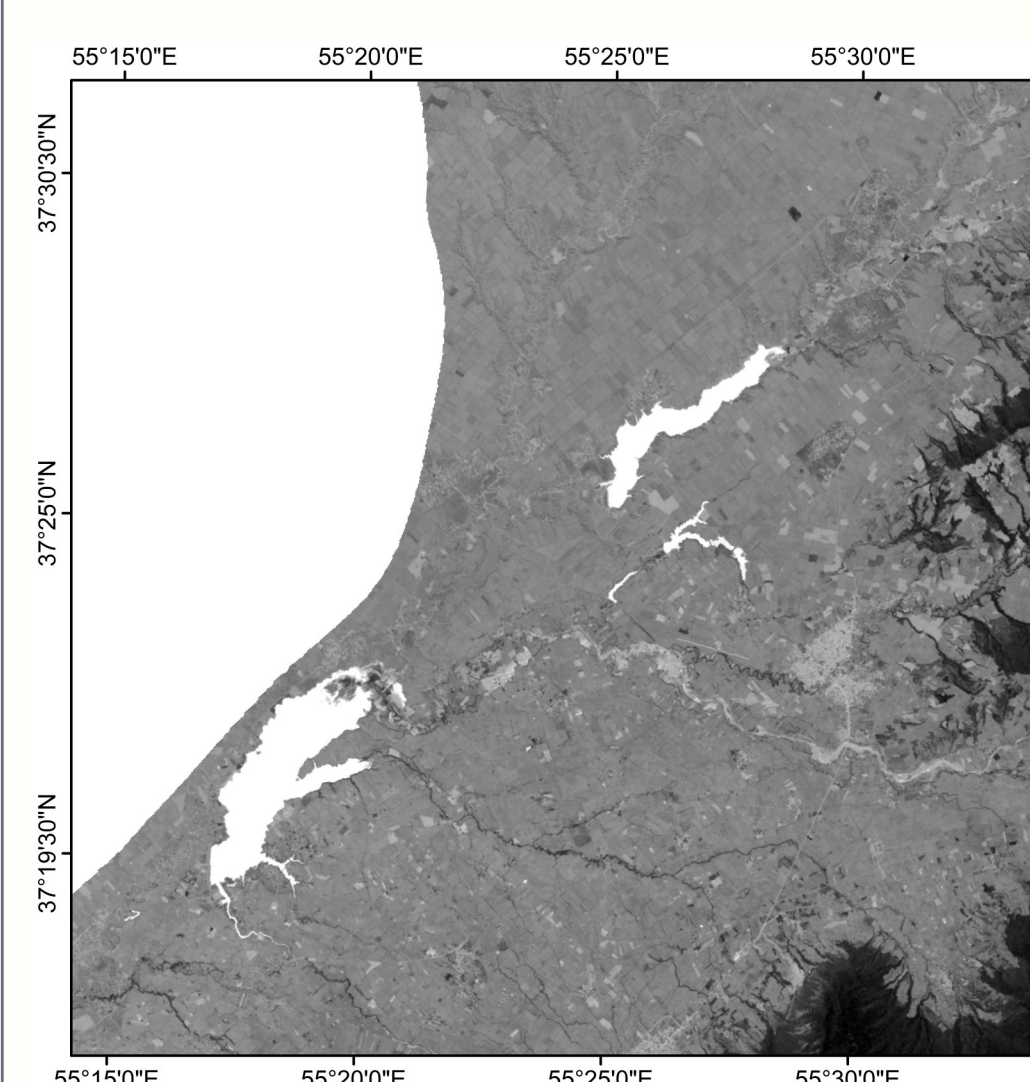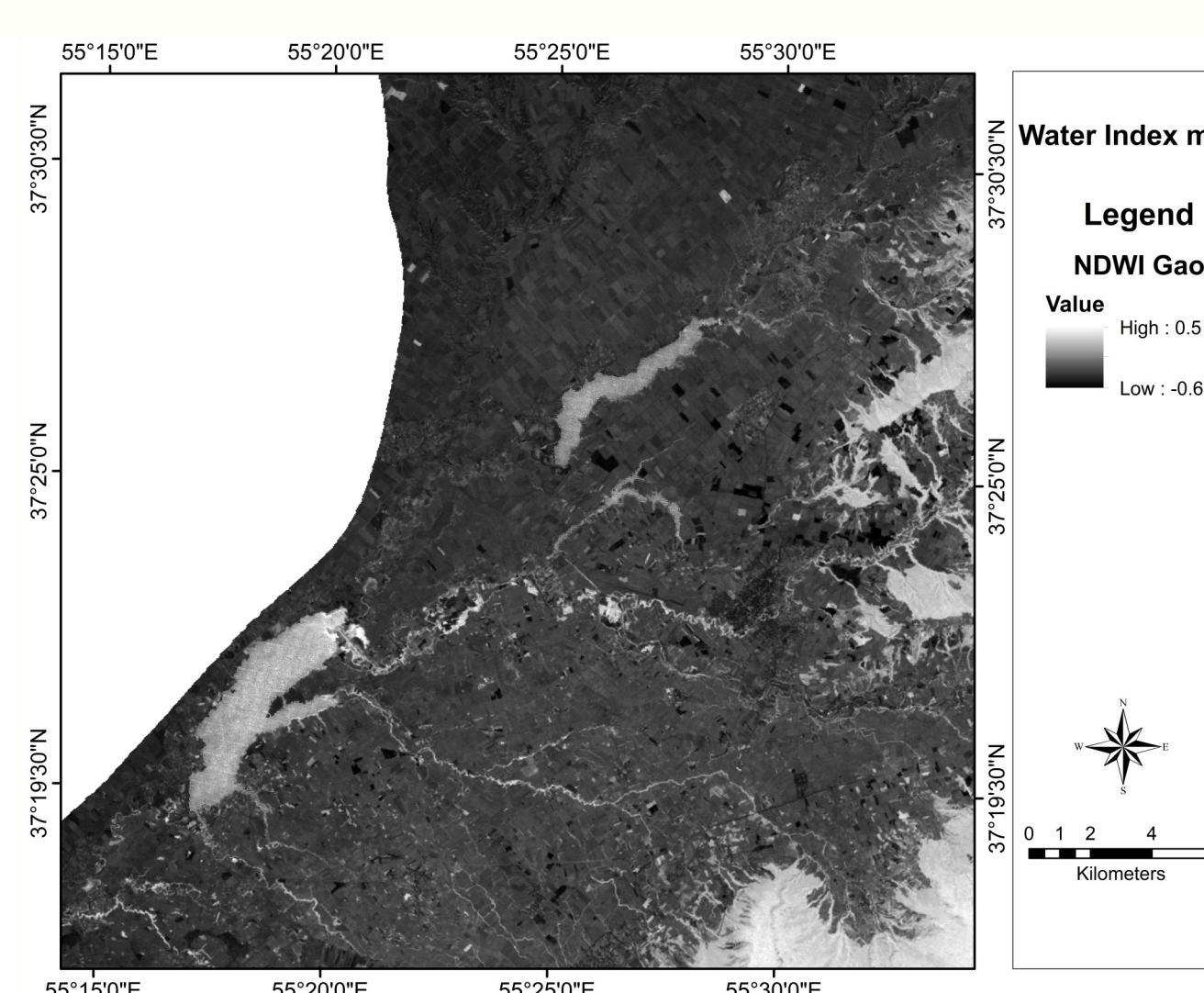

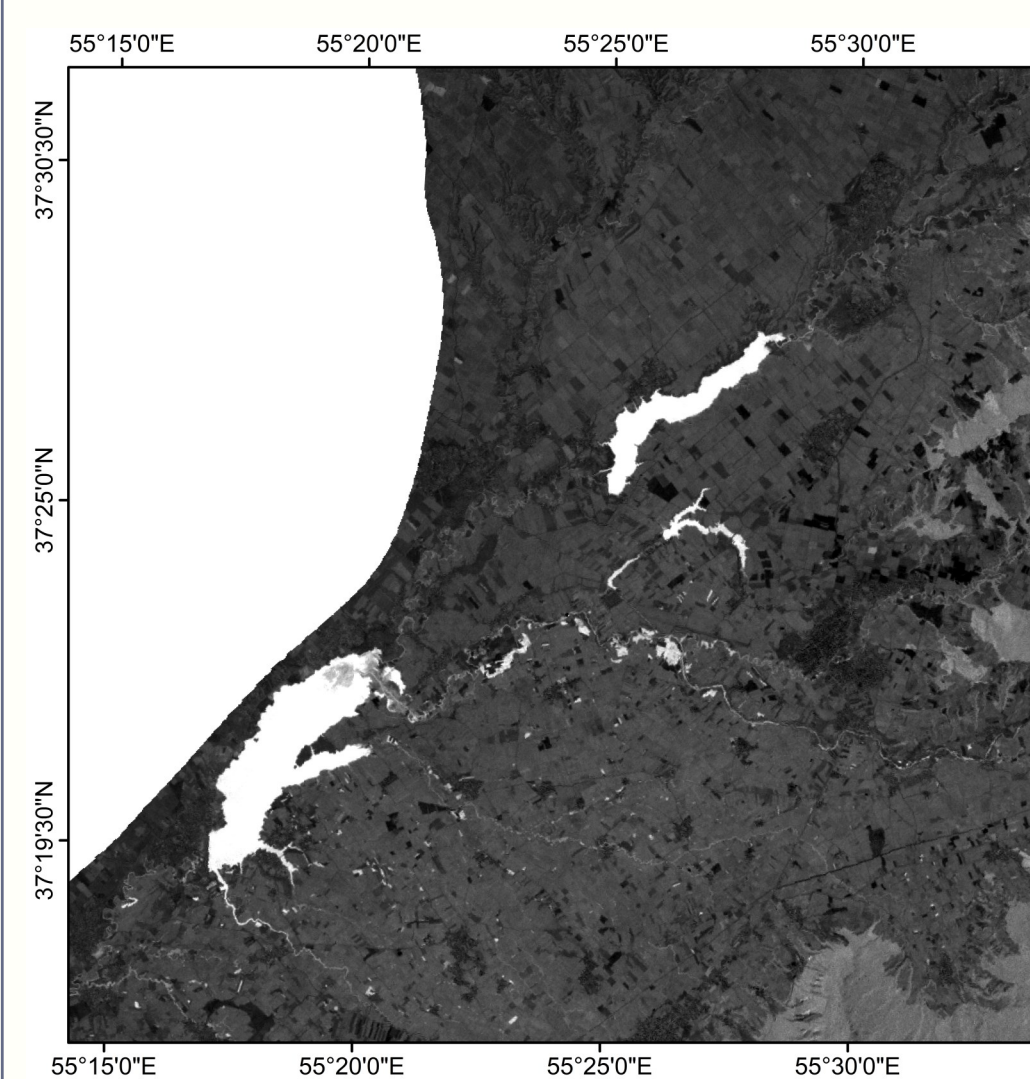Figure 1: NDWI index

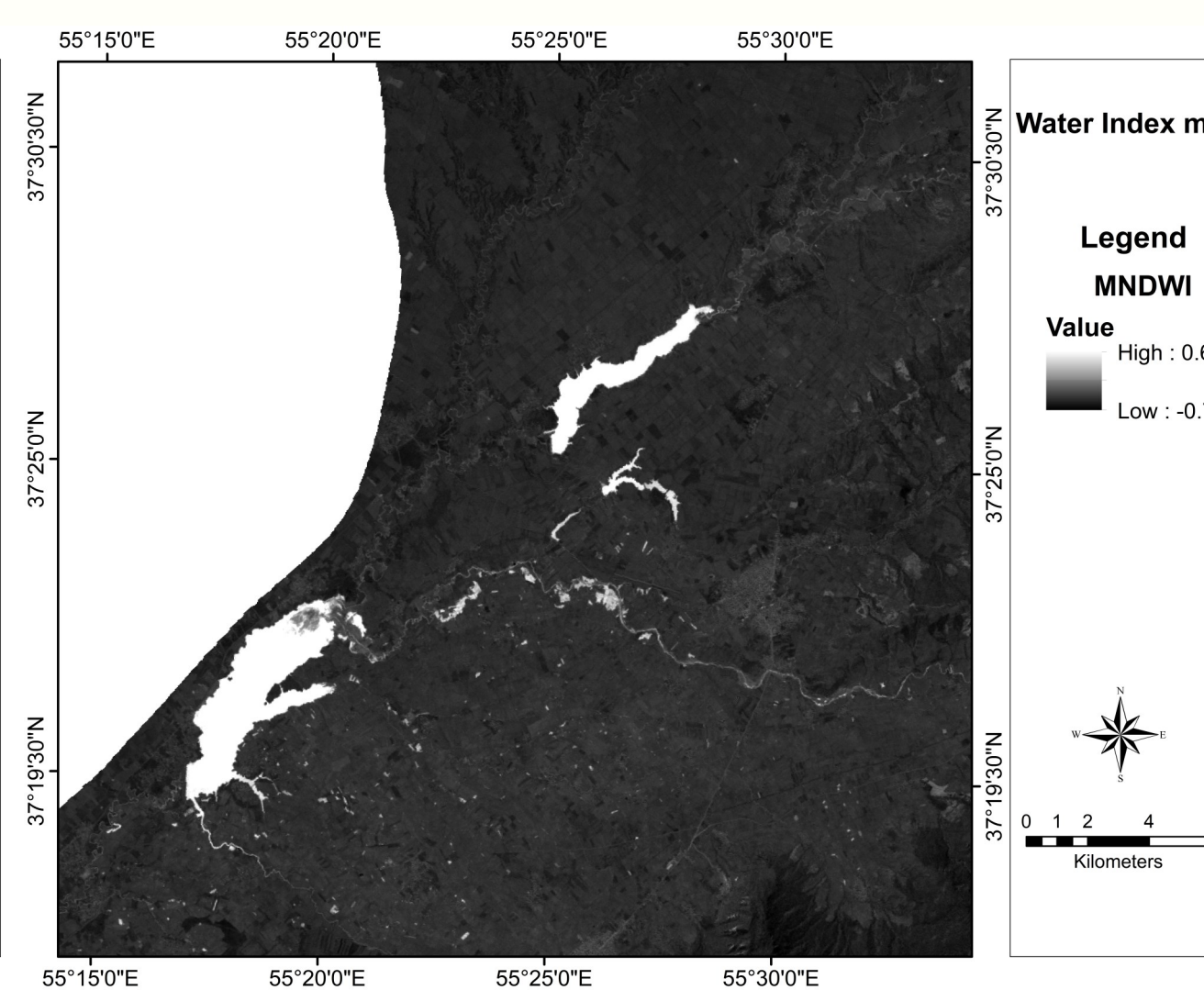Figure 2: NDWI $_{Gao}$ index

Figure 3: MNDWI 1 index

Figure 4 : MNDWI index

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