Assessing potential of MODIS NDWI in detecting irrigation water in the Aral Sea basin

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1. Introduction

Irrigation water is an important part of the hydrology cycle and has thus been included in recently developed hydrological models both at the basin and global scale (Boucher et al., 2004; Gordon et al., 2005; Ozdogan et al., 2006). In Central Asia it is difficult to get a correct report of the irrigation regime (Dukhovny et al., 2004; Micklin, 2000). This has proven to be difficult even to the local institutes especially because collecting data in a wide region is difficult in developing countries. In addition, this basin is characterized by excessive use of water with low conveyance and application efficiency as seen in Figure 1.1 below.

Figure 1.1 Furrow irrigation in Uzbekistan (FAO, 2006)

Moreover, land use changes dynamically in this region as a result of drought or creeping salinity further necessitating a change in water use. Normalized Difference Water Index (NDWI), an indicator sensitive to the changes in water is used in this study. This index is employed for the detection of the presence of surface water in irrigated land such as paddy rice but in this study we will attempt to detect soil moisture in this arid area.

2. Methodology

MOD09GA product from the MODIS sensor was used for the computation of NDWI in this study. MODIS is aboard the Terra and Aqua satellites which collect daily global observations at approximately UTC 11:30 a.m. and 11:30 p.m. equatorial crossing time for Terra, and 1:30 a.m. and 1:30 p.m. for Aqua satellite. NDWI is a normalized value of the Green band to the Near infra-red (NIR) band ratio. This can be expressed as shown in equation 1 below.

$$NDWI = (Green - NIR) / (Green + NIR) \quad (1)$$

These bands have been corrected for atmospheric conditions such as gasses, aerosols, and Rayleigh scattering (Vermote, Kotchenova, & Ray, 2011). NDWI is used in this study to assess the potential of this index in identifying water on the surface of the soil from irrigation or rainfall effect.

NDWI has been used in the past to detect rice paddy agricultural practices including identifying and mapping the spatial extent of such fields (Xiao et al., 2005). In this study, we attempt to examine the ability of this index to detect the irrigation regime.

3. In situ observation

This testing farm is instated in Uzbekistan in collaboration with ICARDA as shown by the red dot in Figure 3.1 below (Touge et al., 2015). There are two other testing farms in Uzbekistan; Kyzylkesec, and Nukus. Bayavut site is in a semi-arid climate under saline conditions. Cotton, rice, and sorghum were grown under irrigation on this site during the period of observation 2011-2013. In-situ data used for this analysis was retrieved from a TDR sensor that was installed 20cm below the soil surface. The crop growing during the period used for this analysis (Mid-June to end of August) was cotton.

Figure 3.1 Aral Sea basin (Micklin 2000) in situ site

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4. Results and discussion

Results from the NDWI time series analysis shows the potential of this index in capturing surface water. A comparison of the NDWI results with the in-situ data of soil moisture (including both rainfall and irrigation water) shows a peak in soil moisture occurring after a peak in NDWI as shown in Figure 4.1 below. This, however, was not consistent in all cases during the observation period. The reason for this could be because of the satellite's temporal and spatial resolution which is much coarse as compared to the scale of water management in farms. One of the water management techniques employed in this study area includes alternative furrow irrigation which involves changing the furrow used to provide irrigation water to the farm in order to prevent salinity build up in the farm land. This scale is much too small to be detected by a satellite with a coarse spatial resolution such as the Terra and Aqua satellites. These satellites also have coarse temporal resolution and the reading time could have registered before a rainfall event or even hours after one has occurred, hence the lag time in the comparison of soil moisture and NDWI. There could also be a lag time in detection of moisture by the soil moisture sensor.

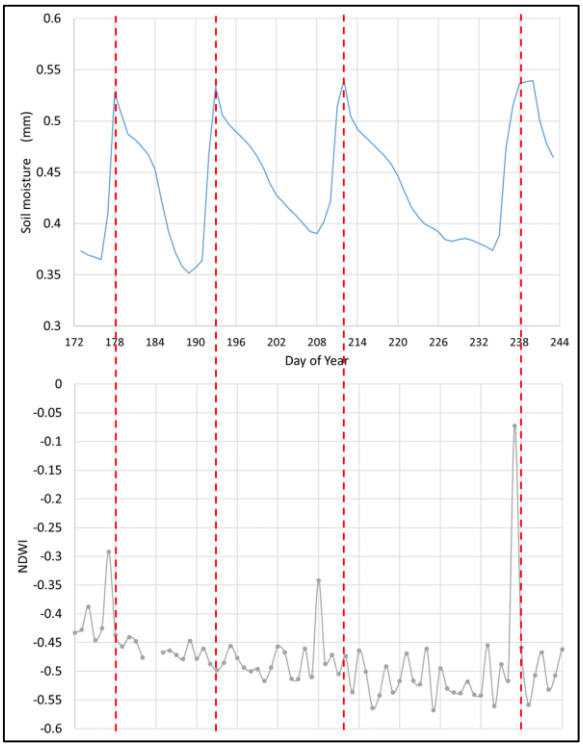

Figure 4.1 Soil moisture and NDWI comparison in Bayavut site in 2012

5. Conclusion

Although NDWI shows potential in detecting surface water in irrigated areas, the spatial and temporal resolution of MODIS is limiting in detecting the irrigation regime. The different land uses were however dominant under varying index values showing a potential for use in land use classification.

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7. Reference

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