Remote sensing analysis on land surface temperature and soil salinity in agricultural area in Bukhara province, Uzbekistan

ウズベキスタン国ブハラ州における農地の表面温度と塩害のリモートセンシング解析

Aziz Omonov*, Atiqotun Fitriyah**, Tasuku Kato***

○アジズ オモノフ*、アティコツン フィトリヤ**、加藤 亮***

1. Introduction

Soil salinity is one of the widespread environmental threats in the world, especially in arid and semi-arid areas where heavy irrigated agriculture is common. Reduced vegetation growth and crop failure are the common consequences of salinization. Central Asia has large expansion on salinized lands. About 50% of this region's (around 7.8 million hectares) irrigated land is saline of which 29% has a moderate to high salinity level.

Advanced technologies such as Geographic information system (GIS) and remote sensing (RS) data has become an economically and efficient tool for assessing, detecting, mapping, and monitoring saline areas along with its spatial and temporal variations. Nowadays innovative technologies are widely implemented in agriculture in order to increase yields and monitor any changes occurring at any given areas timely. Therefore, the main objective of the present study is to apply GIS and satellite imagery technology for assessing and monitoring salinity in the irrigated lands of Bukhara region, Uzbekistan, where soil salinity has been considered as one of the biggest issues.

2 Study area and methods

The study area is located in Bukhara Province of Uzbekistan. Bukhara Province is located in the downstream of Aral Sea basin and irrigated by Amu Darya and Zarafshan rivers (Fig. 1), with the range altitude of 206 – 229 m ASL. The province has mean annual temperature of -7°C in winter and +34°C in summer and an average annual precipitation of 280-350 mm. The province located in arid and continental climatic zone.

Fig.1 The map of Bukhara province, Uzbekistan

2.1 Satellite Imagery Analysis

For our study, we employed the Land Surface Temperature (LST) images from 2017, captured by the Moderate Resolution Imaging Spectroradiometer (MODIS). The MODIS is a payload-imaging sensor built by Santa Barbara Remote Sensing, which was launched into Earth orbit by NASA in 1999 on board the Terra satellite, and in 2002 on board the Aqua satellite. For our study, we analyzed the LST images recorded by Terra satellite with product code MOD11A2. The reason for selecting the Terra satellite instead of the Aqua is that (Bouaziz et al. 2011 and Fallah et al. 2013)

* 東京農工大学連合農学研究科， United Graduate school of Agriculture, Tokyo University of Agriculture and Technology. ** 東京農工大学GIR、*** 東京農工大学農学研究院
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investigated better correlation between Terra based MODIS images and soil salinity, rather than Aqua based MODIS images.

2.2 Soil Salinity Map

In this study, the past soil salinity data of Uzbekistan was used in accordance with methodological guidelines by FAO (2017). The LST from the MODIS (MOD11A2) product was analyzed in relation with the soil salinity classes (slightly saline, moderate saline, highly saline, salonchaks, sands with solonchak plots). All datasets were clipped to the extent of the study area and masked with the croplands area based on MODIS Land Cover Type product (MCD12Q1) and two dataset of time-series LST images for winter and summer crops were generated (Fig. 2).

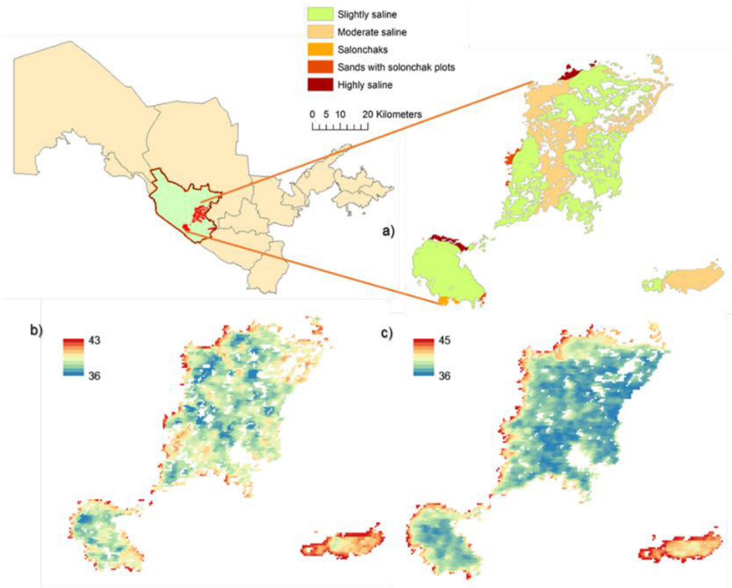

Fig.2 Map of soil salinity in 2017 and LST for Bukhara province

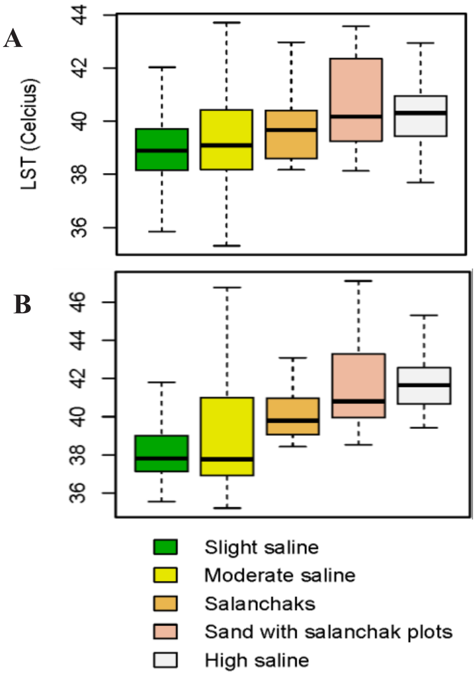

Fig.3 Boxplot of LST data versus soil salinity level (A- winter crop; B- summer crop)

3. Ongoing Result and discussion

The highest temperatures are observed in highly saline areas and the lowest temperatures in slight saline areas. We have applied a statistical analysis (mvtest of means and Barlett's test) to check the variance heterogeneity for the variance among the variables. Full and detailed results of statistical analyses can be found in supplementary materials. Overall, almost all LST images from both winter and summer crops present some potential in terms of soil salinity detection and monitoring. By looking at (Fig. 3), we can observe that LST values among soil salinity classes was overlapping, but the mean value are significantly different as confirmed by the statistical analysis. Moreover, we observed very small differences of LST between the slight and moderate salinity classes. It is difficult to distinguish these classes for monitoring and soil salinity level detection using LST data. Our results proposed that the best relation between the soil salinity map and LST can be observed at the end of the March and in the middle of the June for winter crops, and for summer crops are middles of the June, July and September months. This shows that remote sensing data can be effectively and efficiently applied to model and map the spatial variations of soil salinity in (or Bukhara) irrigation areas.