IDENTIFICATION AND SEPARATION OF RICE FIELDS USING REMOTE SENSING

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ABSTRACT:

Rice is one of the main crops that plays an important role in world food security. Due to the suitable climate in the north of Iran, rice is the dominant crop of farmers in this region. In this study, rice paddies were identified and separated by using the relationship between NDVI and $LSWI_{2105}$ from the OLI sensor in the year 2014. To identify suitable fields, an algorithm was presented to identify the paddy fields of waterlogged soils during the stages of transplanting. According to the climate of the region, the factors of evergreen covers, water bodies, and altitude classes were identified. Finally, a spatial distribution map of rice paddies was created. 56 control points were used in rice and non-rice fields to evaluate the work. The results showed that the spatial distribution map of rice paddy fields for Amol city has an overall accuracy of 83.6364% and a kappa coefficient of 0.8108.

1. INTRODUCTION

As one of the main food products in the world, rice has an important contribution to ensuring the food security of more than half of the world's population (Gutaker et al., 2020; Kumar and Ladha, 2011). With the increase in population, the global demand for food supply has increased. This has reduced natural resources, which has created many challenges to the sustainability of agricultural systems (Bi et al., 2021; Iazzi et al., 2021; Panda et al., 2021). For this reason, careful monitoring of the growth process of the rice crop is very beneficial in the accurate management of rice fields (Yang et al., 2019). Leaf Dry Biomass (LDB), Leaf Area Index (LAI), and Leaf Total Nitrogen (LTN) are key indicators in identifying vegetation health and crop growth stages (Zhang et al., 2002). Unlike traditional methods that are expensive and time-consuming, Remote Sensing (RS) is a science that monitors the physical and chemical properties of plants and agricultural products using spectral and electromagnetic behavior (Behzadi and Alesheikh, 2014; Jafarian and Behzadi, 2020; Jalilzadeh and Behzadi, 2019; Jalilzadeh and Behzadi, 2020; Qiu et al., 2019). Finally, RS makes accurate data available at a low cost and in a short time (Norouzi and Behzadi, 2019; Norouzi and Behzadi, 2021). Vegetation mapping also provides valuable information for understanding natural and artificial environments (Mousavi and Behzadi, 2019a; Mousavi and Behzadi, 2019b). This information is done through the quantification of vegetation from a local to global scale at a specific time. On the other hand, it is very important to obtain the current status of the vegetation to start the protection and restoration programs of the vegetation (Egbert et al., 2002; SHIRAVAND et al., 2020).

2. STUDY AREA

Amol County is one of the most important county of Mazandaran province in Iran. Amol city is the center of this county. Amol city is located at 36°23'N latitude and 52°20'E longitude. Figure 1 presents the location of the study area. Amol city has more than 38450 hectares of land under rice cultivation. On the other hand, it has the variety of culture and varieties of rice in Haraz Plain Therefore, this area was chosen as the study area.

3. DATA COLLECTION

In this research, multi-temporal Landsat TM/OLI satellite images with a resolution of 30 meters were used. The collected data was obtained from the United States Geological Survey (USGS) (Chatrsimab et al., 2020a; Chatrsimab et al., 2020b). 9 series of Landsat images were acquired in 2014 (Table 1).
In this research, due to the higher spatial resolution of Landsat 8 compared to MODIS, these data are used for paddy mapping. Landsat 8 data include 11 bands in visible, near-infrared, short

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wave infrared (30 m spatial resolution), panchromatic (15 m spatial resolution), and thermal infrared (100 m spatial resolution) (Al-Saadi et al., 2005; Shiravand et al., 2019).

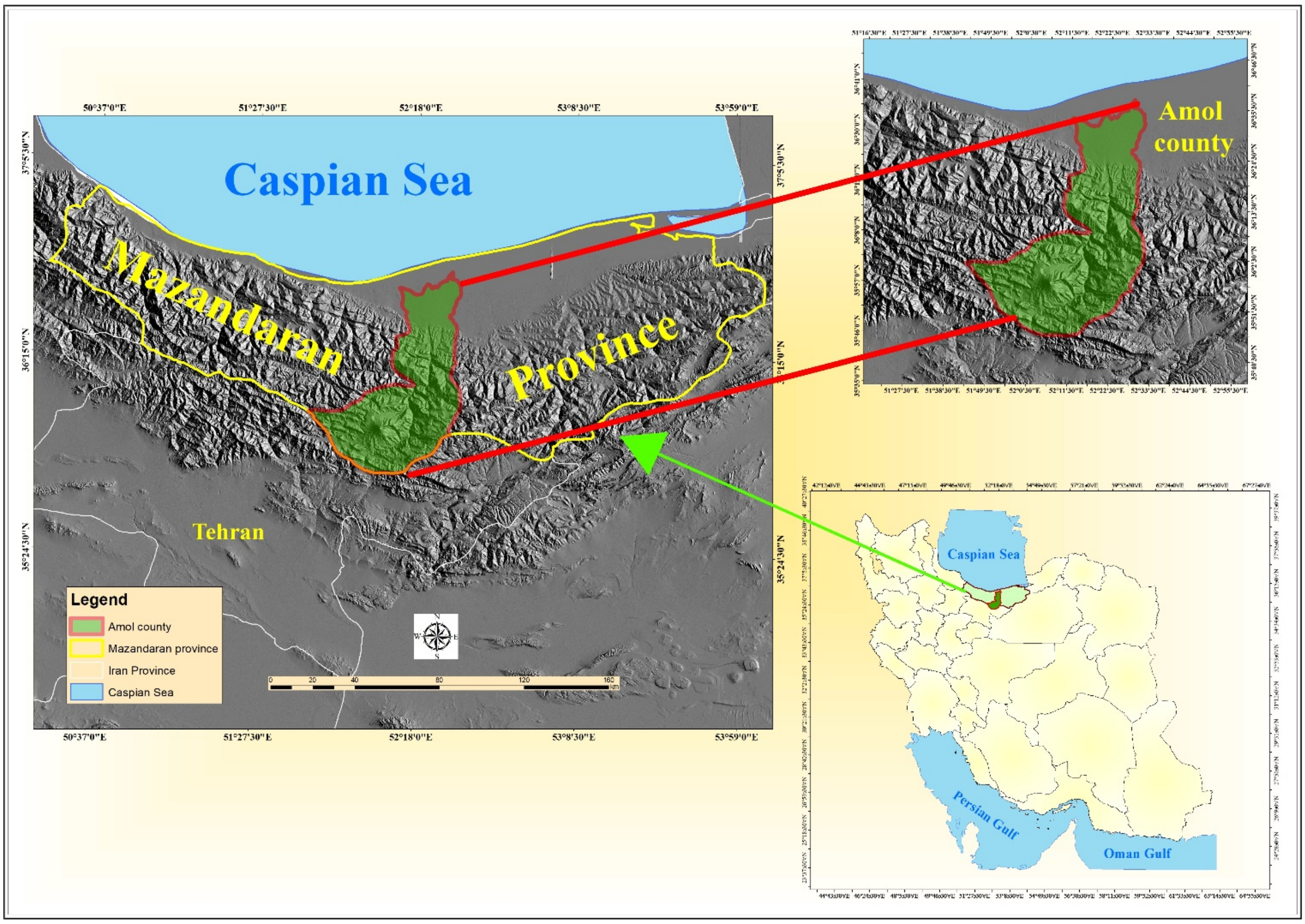

Figure 1. The location of the study area

Image Date	Sensors	Image Purpose
12-Apr-2014	OLI	Calculate vegetation indexes
14-May-2014	OLI	Calculate vegetation indexes
30-May-2014	OLI	Calculate vegetation indexes
15 -Jan-2014	OLI	Calculate vegetation indexes
17-Jul-2014	OLI	Calculate vegetation indexes
02-Aug-2014	OLI	Calculate vegetation indexes
18-Aug-2014	OLI	Calculate vegetation indexes
03-Sep-2014	OLI	Calculate vegetation indexes
19-Sep-2014	OLI	Calculate vegetation indexes

Table 1. Nine series of Landsat images

4. METHODOLOGY

In this research, an algorithm was developed for mapping, identifying and separating rice paddies. This model was obtained using time series data and vegetation indices (LSWI2105, NDVI). The overall separation process of rice paddies can be seen in Figure 2.
To identify the most valuable areas, 5 images were examined for a combination of 16 days at the beginning of the year. To identify rice paddy fields, the areas where the $LSWI_{2105}$ index value was higher than NDVI were determined and separated $((LSWI_{2105}) > (NDVI))$.

Due to the rapid growth of rice, in the first 2 months, the growth of the NDVI vegetation index increases in 3 or 4 images after the date of planting. This makes it possible to recognize rice paddy pixels from flooded pixels (Relation 1).

$$(NDVI)(t) < Max\,(NDVI\,(t+3), NDVI\,(t+4)) - 0.3792 \qquad (1)$$

In this regard, the areas that have $LSWI_{2105}$ more than NDVI are selected at time t. This process continues four times after that. In this way, the range that has more reflection in the moisture-sensitive index is identified at the beginning of the year. In this area, rice paddies, water areas (wetlands, dams, etc.), and high humidity areas are also identified (Figure 3).

5. SEPARATION OF FACTORS AFFECTING THE SEPARATION ALGORITHM

5.1 Permanent water

Early in the rice growing season, paddy fields are a mixture of green rice plants and water (Xiao et al., 2006). Therefore, water is one of the background errors in rice paddy identification.

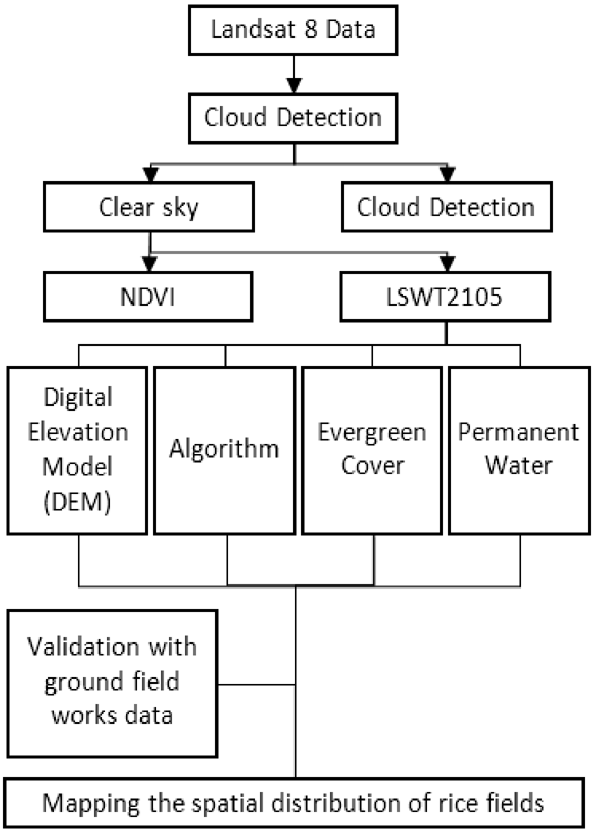

Figure 2. The overall separation of rice paddies process

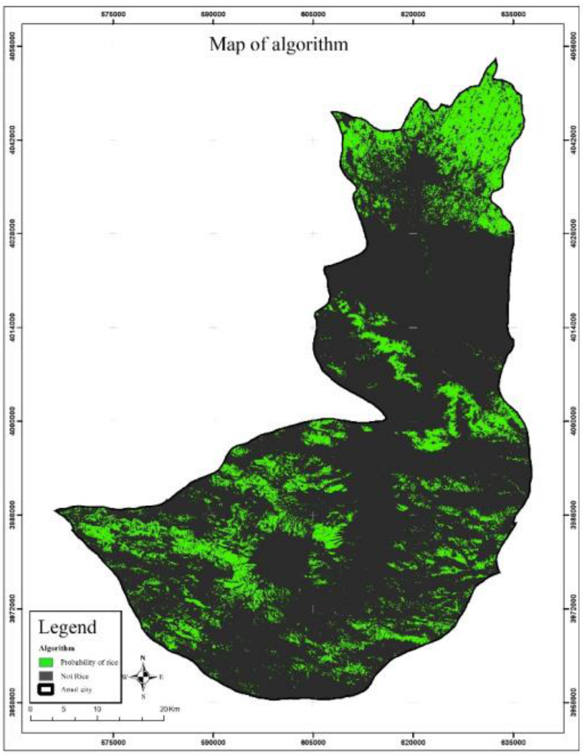

Figure 3. Results of Algorithm

Using equation 2, water is identified and separated from the images (Figure 4).

$$[NDVI(t5) < LSWI(t5)] \text{ AND } [NDVI(t6) < LSWI(t6)] \quad (2)$$

5.2 Evergreen cover

In the next step, evergreen vegetation was separated using $LSWI_{2105}$ and NDVI indices (Behzadi and Mousavi, 2019). Evergreen forest pixels are identified from pixels that have an NDVI value higher than 0.6 in at least 10 images with a 16-day composite during the year. Agricultural lands usually have bare soil during periods (such as after harvesting or during land preparation), at this time the $LSWI_{2105}$ index value is very low (Figure 5).

5.3 Digital Elevation Model (DEM)

In the north of Iran, most of the rice fields are cultivated in areas with slopes and low altitudes. According to the studies of the agricultural development plan of the Haraz catchment area, the height up to 100 meters is considered the plain area, from 100 to 500 meters above sea level is considered the intermediate area, and the height above 1100 meters is considered as the mountainous area (Behzadi and Jalilzadeh, 2020; Behzadi et al., 2019). Based on this, a Digital Elevation Model (DEM) was prepared, and using it, the areas with a height higher than 1000 meters were removed (Figure 6).

5.4 Isolation rice paddy

Finally, after these factors were masked the result of the algorithm, rice paddy areas were identified and the results are shown in Figure 7.

To verify the results, a total of 56 control points were taken using GPS during a field operation stage. These points include 26 control points of rice fields and 30 control points of non-rice lands. The overall accuracy and kappa coefficient for the resulting maps are 83.6364% and 0.8108, respectively.

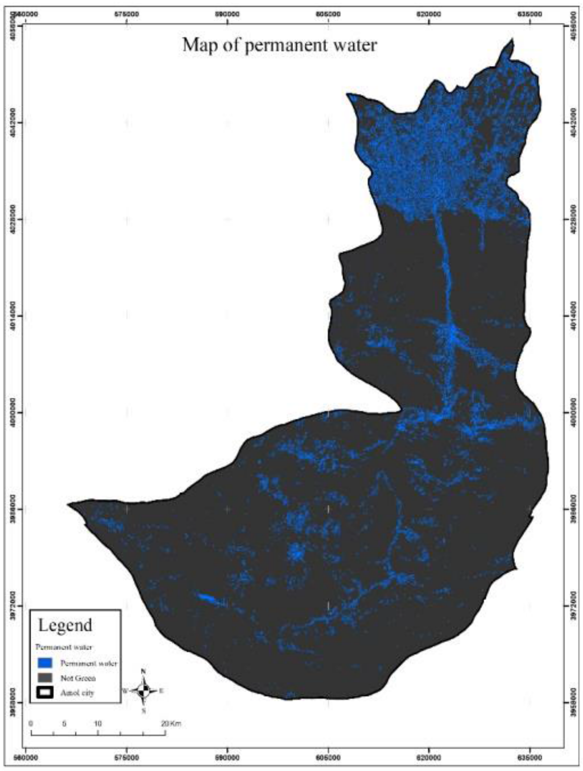

Figure 4. Permanent water area

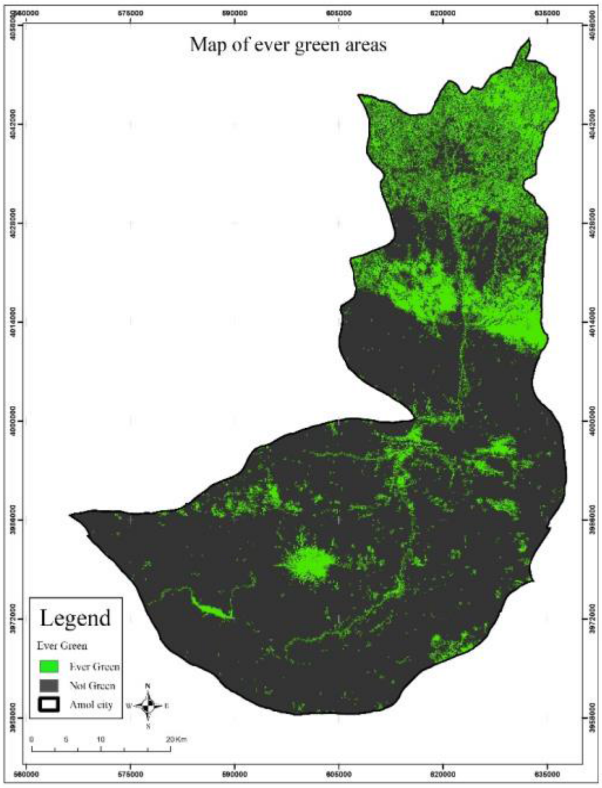

Figure 5. Evergreen cover area

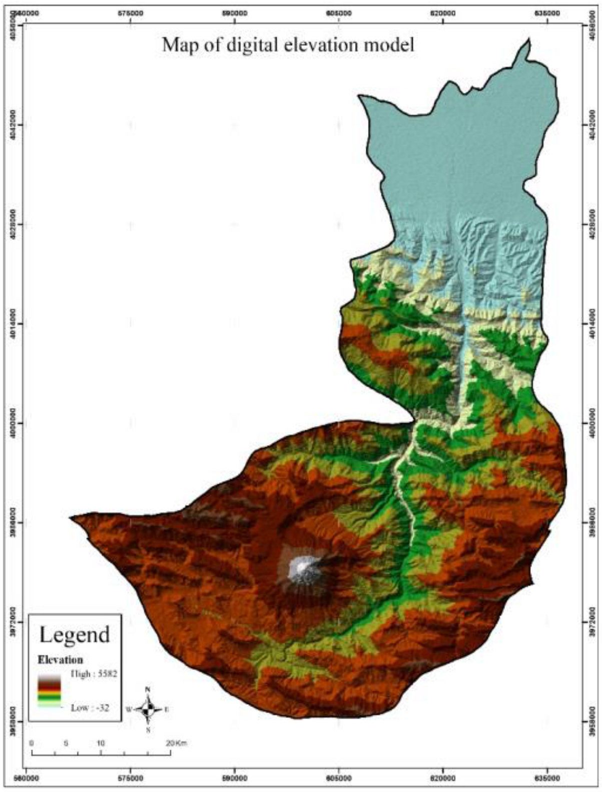

Figure 6. DEM

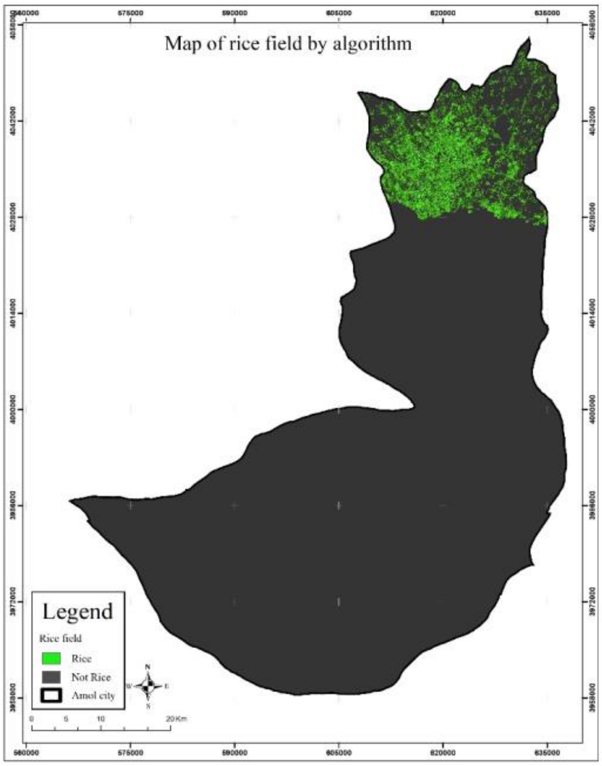

Figure 7. Rice paddy areas

6. CONCLUSION

Due to the lack of a spatial distribution map of rice fields in northern Iran, in this study, the proposed algorithm was used to identify and separate rice fields. The spatial distribution map of rice paddy fields resulting from this algorithm was also evaluated using ground control points recorded by GPS to determine the characteristics of rice paddy fields and non-rice lands. The results showed that the spatial distribution map of rice paddy fields in two classes of rice and non-rice for Amol city has an overall accuracy of 83.63% and a kappa coefficient of 0.81%. In the end, it can be concluded that using remote sensing techniques to improve the quality of strategic rice crop monitoring will help solve many problems for farmers and will help decision-makers with efficient planning.

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