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RESEARCH ARTICLE

Geodata mapping of snow cover via geoinformation system: as an example of Kashkadarya province, Uzbekistan

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Abstract. The use of modern land accounting techniques and the incorporation of field research findings into geodata have not been given top attention in Uzbekistan's various landscape areas. Additionally, there is still a lack of relevant investigations on the visualization, analysis, processing, process automation, and regulation of soil ecological conditions in the interpolation approach of GIS. This study uses GIS and remote sensing methods to identify snow cover in a mountainous area in Kashkadarya Province, Uzbekistan. The results of this study have an impact on how crops are grown and land resources are managed sustainably in this area. Using satellite images in ArsGIS software and remote sensing methods based on hydrometeorological data of geophysically connected field surveys relating to the study site, electronic maps for the experimental years of 2015–2018 were developed. Our findings pose possibilities to undertake geostatistical analysis, depict the contours dividing the soil separations, and incorporate the information discovered through field research into a geodatabase.

Keywords Snow cover • NDSI • GIS • Uzbekistan • Landsat • ArcMap

Introduction

Today, the use of state-of-the-art techniques and technologies plays a leading role in maintaining the index data on agricultural land [1]. Modularization of the automated land formation system accounts in geographical databases, using geographical software that requires further implementation and validation worldwide [2, 3]. In this regard, it is important to establish control over the use of irrigated lands, to keep land records in geodata, and to automate the formation system of land information.

A geographic information system (hereinafter referred to as GIS) is an internally positioned spatial information system designed to manage, map, and analyze spatial data [4]. In determining the water demand of the crop, using updated remote sensing technology, i.e. space imagery, significantly increases the efficiency of water use in field conditions. The organization of the formation and regular updating of information in the GIS database is hinged on the fact that geodesy and geoinformatics specialists conduct research in the field on a regular basis and update the information in the geodatabase [5, 6].

In different landscape regions of Uzbekistan, the use of present-day methods of land accounting and integration of field research results into geodata has been left out of the priority [7]. In addition, research on visualization, analysis, processing, process automation, and modulation of soil ecological conditions in the interpolation method has not yet been adequately studied [8, 9]. Therefore, there is an urgent need to automate the system of land accounting using electronic digital map of agriculture and modulate the sequence of all processes in Uzbekistan.

All data in various formats can be used in GIS. Since their structure is unique, it is up to the user to make an alteration [10]. The main tasks of GIS are a generalized computerized system under the supervision of expert analysts, which consists of the collection, storage, management, analysis, modeling, and depiction of spatial and geographical data [11]. According to remote sensing spatial surveys, it is possible to determine the crop water demand and forecast it over time and space [12]. The experience of implementing the technology of timely transmission of relevant remote sensing data from the forecast to water consumers and management specialists by mobile phone has been tested [13].

Considering all the above, the aim of this paper is to detect snow cover in a mountainous region of Kashkadarya province, Uzbekistan by applying GIS and remote sensing techniques. The output of this research will reflect on the sustainable management of land resources and crop production in this region.

Materials and methods

Analyses reveal that the main negative factors in the use of rainfed areas in the plains, hills, foothills and mountainous areas of Kashkadarya province in Uzbekistan are the complex relief structure, improper plowing and driving, crop rotation schemes, and cropland ratios in a timely and insufficient application [14]. In conducting geophysically linked field survey, an electronic map was developed using satellite imagery using ArsGIS software using remote sensing based on hydrometeorological data (Figure 1).

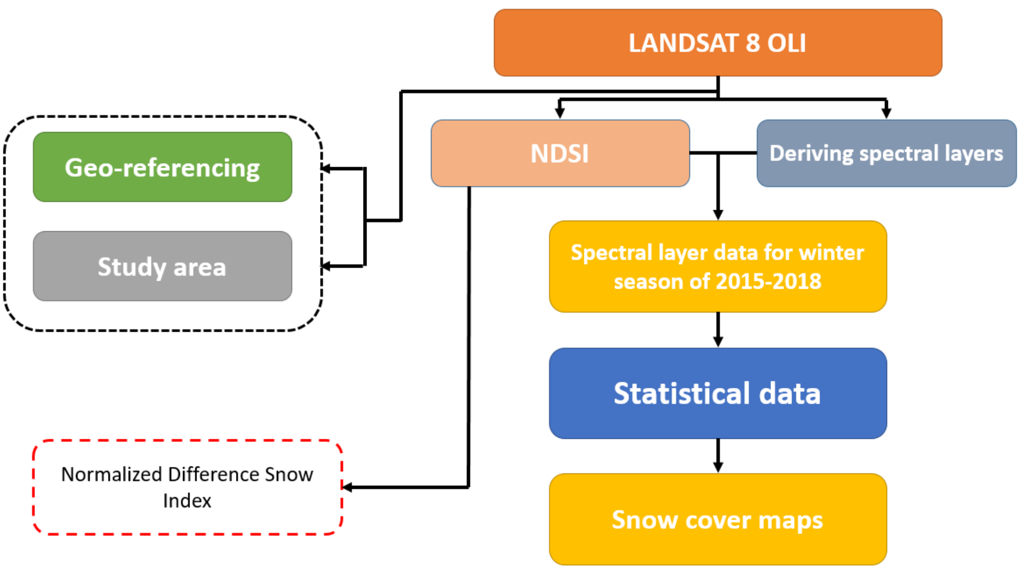

Figure 1. Analysis of spatial images on GIS technology.

The following observations and research were conducted during the experiments. Based on the results of field research, the stages of compiling a histogram and geostatistical analysis were developed and carried out in the following order (Figure 1):

- satellite images of snow cover for the study area were downloaded via the Landsat-8 OLI sensor;
- determination of the studied area and its connection to the geodetic coordinate (geo-referenceing) was performed using ArcMap;

- the boundaries of the area under study in space were determined;
- based on the results of field study, digitized the attributive data on snow cover identified on the ground;
- using the method of determining the snow cover (NDSI – Normalized Difference Snow Index);
- snow cover was obtained from layer spectra;
- based on the value of the selected data indicators of the spectra of the winter months in 2015-2018, the ArcMap program was visualized in an automated way in the form of cartographic quality colors;
- visualization of statistical data of the stages carried out in the process of geostatistical analysis;
- analyzed with a scale of work performed in the ArcGIS program window with geostatistical data;
- as a result of the analysis, a geostatistical analytical histogram was developed to determine the snow cover by regions.

The information identified as a result of field survey was integrated into the geodatabase, and geostatistical analysis was performed and contours were visualized in the relief section. Spatial images (Landsat 8 OLI) of the study area from 2015 to 2018 were taken at a winter time of the year and an analysis of local runoff water formation using the ArcMap program was performed. Geographic data mapping and remote sensing of the formation of local runoff using GIS technologies were analyzed on the basis of Table 1 below.

Table 1. Spectral layers of Landsat-8 OLI space images (source: www.usgs.gov)

Landsat-8 OLI and TIRS Bands (μm)		
30 m Coastal/Aerosol	0.435 - 0.451	Band 1
30m Blue	0.452 - 0.512	Band 2
30m Green	0.533 - 0.590	Band 3
30m Red	0.636 - 0.673	Band 4
30mNIR	0.851 - 0.879	Band 5
30m SWIR-l	1.566 - 1.651	Band 6
100m TIR-1	10.60 - 11.19	Band 10
100m TIR-2	11.50 - 12.51	Band 11
30m SWIR-2	2.107 - 2.294	Band 7
15m Pan	0.503 - 0.676	Band 8
30m Cirrus	1.363 - 1.384	Band 9

According to the analysis results, it is expedient to collect local runoff water and use water-saving technologies in the irrigation of vineyards in the foothills of Kashkadarya province in Uzbekistan.

The in-situ collected data were integrated into the geodatabase and geostatistical analysis was performed using Equation 1.

$$NDSI = \frac{(\text{Green} - \text{SWIR})}{(\text{Green} + \text{SWIR})} \quad (1)$$

NDSI is a measure of the relative magnitude of the reflector difference between visible (green) and shortwave infrared (SWIR) [15]. It controls the propagation of two bands (one near infrared or short-wave infrared, the other visible) [16]. This is useful when creating a snow map. Snow not only reflects in the visible parts of the electromagnetic spectrum, but also absorbs a high amount of dust in the near-infrared or short-wave infrared part of the spectrum, while the high reflectivity of clouds remains high in the same parts of the spectrum [17]. The ratio of the two ranges taken and plotted on the satellite image at a given time at the studied location was calculated.

Results and discussion

It is defined by thematic layers in the form of a separate field using the vector data obtained from the analysis. Attribute tables of vector data in the form of points on the area are filled, and the fields are automatically calculated by means of geometric calculations. Including the results of the studied spatial survey, the spectral layers of Landsat-8 OLI space images were developed from the above Equation 1 by analyzing the data of the Shakhrisabz and Yakkabog metrological stations in the study area.

The development of an electronic maps for the 2015-2018 experimental years was carried out using satellite imagery in ArsGIS software and remote sensing techniques based on hydrometeorological data of geophysically linked field survey belonging to the study area (Figures 2-4).

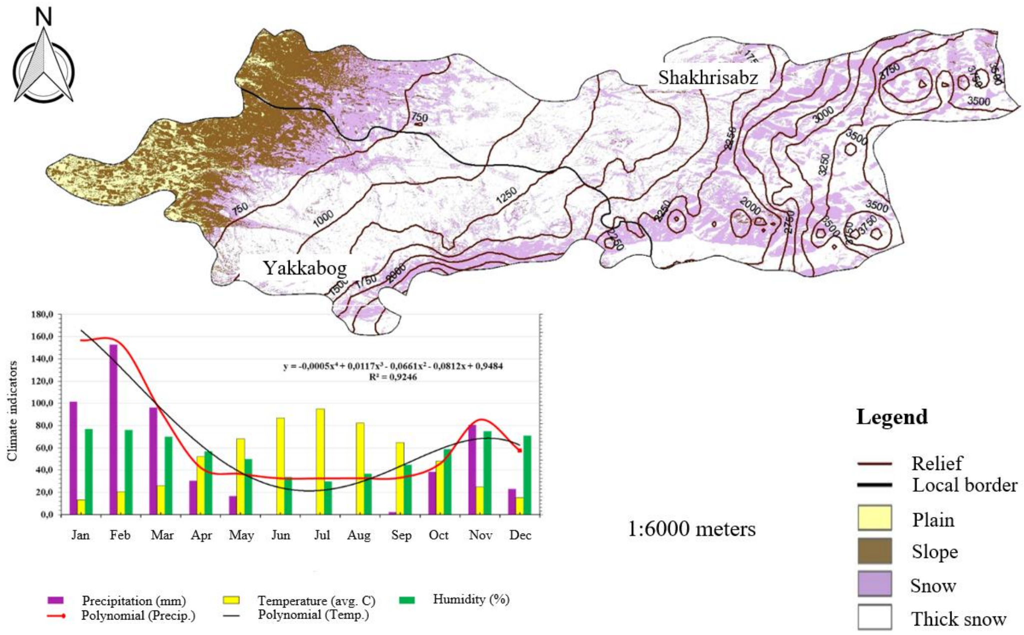

Figure 2. Creating a map of snow cover analysis with geophysical linking of a space image in ArcGIS (2015-2016).

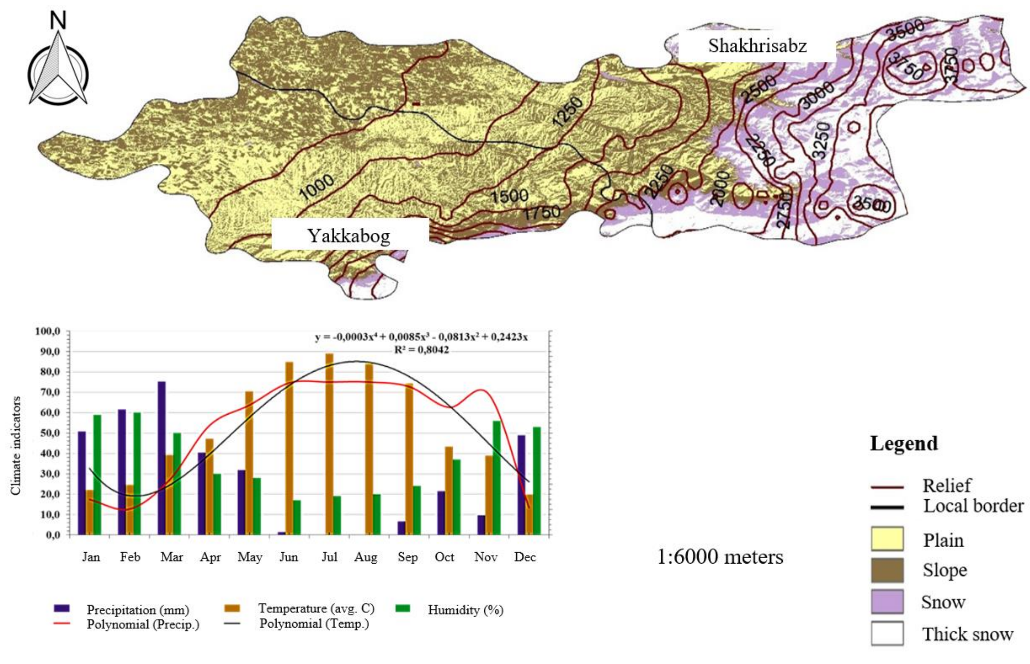

Figure 3. Creating a map of snow cover analysis with geophysical linking of a space image in ArcGIS (2016-2017).

According to these figures, in determining the presence of snow, satellite instruments include observations between 0.66 and 1.6 mm. Atmospheric wavelength transparency, while snow is not reflected at 1.6 mm, but reflected at a high level of 0.66 mm. The snow cover is as bright as clouds, so it's hard to separate them from the cloud. However, when the wavelength is 1.6 mm, the snow absorbs sunlight and therefore appears thicker than clouds. This allows for efficient separation of cloud and snow cover. Thus, the figures demonstrate the ability to separate clouds from snow using observations of this wavelength.

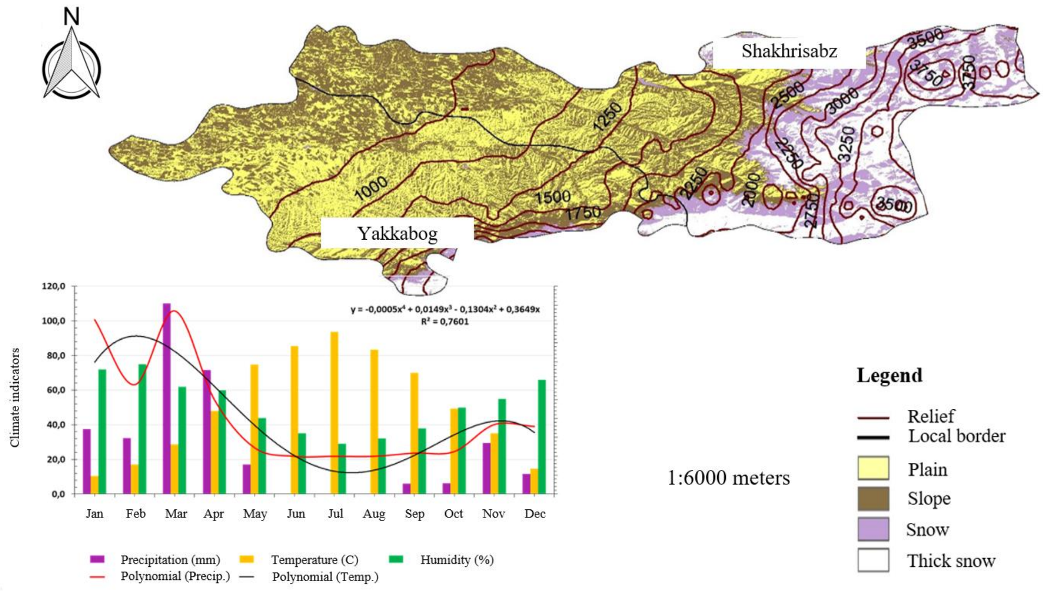

Figure 4. Creating a map of snow cover analysis with geophysical linking of a space image in the ArcGIS program (2017-2018).

The above figures serve as a basis for storing all types of data used in the process of working with geospatial applications. The geospatial database acts as an online and virtual cloud for storing various spatial data of the study area. Using a geodatabase can not only effectively manage data stored locally or on a server, but also create complex models while working with different industries and projects.

Conclusions

To summarize, our findings enable to integrate the information identified as a result of field study into a geobase, to perform geostatistical analysis, and to visualize the contours separating the soil separations. With the widespread use of remote sensing and aerial photography, the technology of equalization, transformation and renewal of electronic digital maps with a high degree of accuracy has been developed and applied in various sectors of the economy of Uzbekistan.

Our results could facilitate the land allocation, monitoring of agricultural crops, land management, land cadaster, soil mapping, clear indication of the location and boundaries of land used by land owners, assignment of cadastral numbers in the prescribed manner, and infrastructure of farms in the mountainous region of the study area. The location is based on the expediency of the correct choice of land plots, taking into account the relief of the area, the exposure of the slope, the biological characteristics of crops, and the technological characteristics of cultivation.

References

1. Bill R., Nash E., and Grenzdörffer G. 2011. GIS in Agriculture. In *Springer handbook of geographic information*, 461-476. doi: 10.1007/978-3-540-72680-7_24
2. Lee S. A. R. O. 2005. Application of logistic regression model and its validation for landslide susceptibility mapping using GIS and remote sensing data. *International Journal of remote sensing*, ***26***(7), 1477-1491. doi: 10.1080/01431160412331331012
3. Werner T. T., Bebbington A., and Gregory G. 2019. Assessing impacts of mining: Recent contributions from GIS and remote sensing. *The Extractive Industries and Society*, ***6***(3), 993-1012. doi: 10.1016/j.exis.2019.06.011
4. Fischer M. M., Scholten H. J., and Unwin D. 2019. Geographic information systems, spatial data analysis and spatial modelling: an introduction. In *Spatial analytical perspectives on GIS*, 3-20.

5. Hijazi I., Donaubauer A., and Kolbe T. H. 2018. BIM-GIS integration as dedicated and independent course for geoinformatics students: Merits, challenges, and ways forward. *ISPRS International Journal of Geo-Information*, ***7***(8), 319. doi: 10.3390/ijgi7080319
6. Bretterbauer K. and Weber R. 2003. *A primer of geodesy for GIS users*. Institute of Geodesy and Geophysics, Deptartment of Advanced Geodesy.
7. Abduraxmonov S. N., Inamov A., and Abdusamatov O. S. 2012. Use of ArcGIS program in development of agricultural maps and plans. *Republican scientific-practical conference of gifted students and young scientists*, 247-249.
8. Avezboyev S. and Avezboyev O. 2015. *Architecture and database of geodata*. Mekhnat Press, 170.
9. Sultanov M. 2009. Use of space imagery and GIS technology in the detection of landscape components. Acta Geography Association Uzbekistan, ***31***, 39-41.
10. Albrecht J. 1998. Universal analytical GIS operations: A task-oriented systematization of data structure-independent GIS functionality. *Geographic information research: Transatlantic perspectives*, 577-591.
11. Goodchild M. F. and Haining R. P. 2004. GIS and spatial data analysis: Converging perspectives. *Papers in Regional Science*, ***83***(1), 363-385. doi: 10.1007/s10110-003-0190-y
12. Gherboudj I. and Ghedira H. 2016. Assessment of solar energy potential over the United Arab Emirates using remote sensing and weather forecast data. *Renewable and Sustainable Energy Reviews*, ***55***, 1210-1224. doi: 10.1016/j.rser.2015.03.099
13. Laamrani A., Pardo Lara R., Berg A. A., Branson D., and Joosse P. 2018. Using a mobile device “app” and proximal remote sensing technologies to assess soil cover fractions on agricultural fields. *Sensors*, ***18***(3), 708. doi: 10.3390/s18030708
14. Conrad C., Lamers J. P. A., Ibragimov N., Löw F., and Martius, C. 2016. Analysing irrigated crop rotation patterns in arid Uzbekistan by the means of remote sensing: A case study on post-Soviet agricultural land use. *Journal of Arid Environments*, ***124***, 150-159. doi: 10.1016/j.jaridenv.2015.08.008
15. Kulkarni A. V., Srinivasulu J., and Manjul, S. S. 2002. Field based spectral reflectance studies to develop NDSI method for snow cover monitoring. *Journal of the Indian Society of Remote Sensing*, ***30***(1), 73-80. doi: 10.1007/BF02989978
16. Yamazaki F. and Matsuoka M. 2007. Remote sensing technologies in post-disaster damage assessment. *Journal of Earthquake and Tsunami*, ***1***(03), 193-210. doi: 10.1142/S1793431107000122
17. Kouchi K. I. and Yamazaki F. 2007. Characteristics of tsunami-affected areas in moderate-resolution satellite images. *IEEE Transactions on Geoscience and Remote Sensing*, ***45***(6), 1650-1657. doi: 10.1109/TGRS.2006.886968