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Land use mapping using visual vs. digital image interpretation of TM and Google earth derived imagery in Shrivan-Darasi watershed (Northwest of Iran)

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ABSTRACT

The availability of landuse/cover information allows decisionmakers to develop short and long term plans for the sustainable use,conservation and development of natural resources. This study was conducted to use Landsat and Google earth derivedimagery for land use /cover mapping in Shirvan-Darasi watershed in north of Ardabil province in Iran. ATM image by considering seasonality and phenological pattern was selected. Pre image processing stages such as atmospheric and geometric correctionwere conducted before image utilization. Moreover, image of the study area extracted from Google earth and imported to ArcGIS environment. Ancillary data such as DEM and slope were derived and added to the datasets of this study for controlling different land uses. Field visit and appropriate ground control points were collected for visual and training area selection, and finally land uses such as rangeland, horticultural land, irrigated and dry farming lands, residential and industrial areas, roads and out crops were considered and land use of the selected images were derived. Finally accuracy of the produced maps were computed and compared.Results show that, the produced map of the image of Google earth using visual interpretation showed high overall accuracy (0.94) and Kappa (0.90). On the other hand, results of the digital interpretation of TM image (unsupervised) showed very low overall accuracy (0.24) and Kappa (0.22) statistics.

Key words: Remote sensing; Visual and Digital interpretation; landuse pattern; TM; Google earth**,** Digital globe, Landcover

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INTRODUCTION

Land use and land cover havemany aspectsof understanding the interactions of human activities with the environment and their information are fundamental for monitoring; evaluating, sustainable managing, protecting, policy development and planning for earth resources, and the information on the existing land use is one of the prime pre-requisites for suggesting better use and modeling of terrain[13,18,15,27]. Land use also reflects the importance of land as a key and finite resource for activitiessuch as agriculture, industry, forestry, energyproduction, settlement, recreation, and water catchment and storage. With the growth of population and socio-economic activities, natural land cover is being modified for various development purposes. Often inappropriateland use is causing various forms ofenvironmental degradation. Land use is a study of natural potential of land utility with reference to the requirements of society's cultural and physical requirements [9,23].Land use refers to man's activities on earth, which are directly related to land, whereas land cover denotes the natural features and artificial constructions (observed bio- physical) covering the earth'ssurface[13]. Land use practices of a region are influenced by a number of parameters such as physical and chemical environments, socio-economic factors and requirements of the masses. For sustainable utilization of the land ecosystems, it is essential to know the natural characteristics, extent and location, its quality, productivity, suitability and limitations of various land uses [4, 26]. Land use is a product of interactions between a society's cultural background, state, and its physical requirements on the one hand,

and the natural potential of land on the other [9]. In order to improve the economic condition of the area without further deteriorating the bio environment, each part of the available land has to be used in the most rational way[4].
In recent years geo-spatial information technologies are becoming increasingly important in the development, management and monitoring of various earth resources. Advances in satellite sensor and their analysis techniques aremaking remote sensing systems realistic and attractive for use in research and management of natural resources. Remotely -sensed data collected from satellites provide a systematic, synoptic ability to assess conditions over large areas and on a regular basis [20]. Land use classification and evaluation surveys using visual and digital remote sensing have been conducted successfully for many studies 7,28,25,29,8,12,19,24,16,17,18,1,2,27,30]. With most image analysis applications, the aim is to produce classified end products through classification methods. Land use/cover classification refers to matching land use/cover classes identified particular features within the vicinity. It is a process that allows generating a land use/cover map with detailed information about the composition and physiognomy of the area of interest[13,15,27].

In Iran,in research projectsLandsat Multispectral Scanner (MSS),Thematic Mapper (TM) and Enhanced Thematic Mapper plus (ETM^+), etc.and Geographic Information System (GIS) used by pixel-based [21,3,6,5,14] and objected-based approaches [22]for land use surveys and map land use/cover.However, the best of our knowledge, there is no evidence of using the mentioned satellite imagery and procedures on the practical sectors such as the Bureau of Natural Resources and Watershed Management. On the other hand, there is increasing evidence that Google earth images extracted and imported to GIS and visually interpreted for land use mapping by different consulting engineering for implementation in the Natural Resources and Watershed Management sectors. It should be noted, different Bureaus emphasized to use the Google earth imagery for land use/cover mapping. However, there is no evidence of accuracy assessment process in these studies. Moreover, there is no reliable and robust information to control the produced maps and results, which are employed in the practical sectors. Furthermore,there is a view that, if digital Landsat or IRS data are used in land use /cover mapping, it is possible to get more reliable and cost effective results (time consuming issue for visual interpretation in comparison with digital image processing). In addition to, there is limitation from the existing images at the Google earth, which in some cases the image extracted from Google earth has no proper time and spatial resolution by the aim of a given study.

Besides, Sabaln Mountain, which is the third highest mountain in Iran with 4811 m asl, is one of the important rangeland resources, particularly in north west of Iran. This mountain is the summer rangelands for one of the main nomads of Iran (Shahsavn nomads). Additionally, by increasing human population, there is huge effectiveness on this mountainous land. The low altitude range of the mountain is changing from natural rangeland to agricultural, residential and recreational lands. The higher altitude lands are increasingly change for recreational facilities such as Telecabin, and hot spring (spa), road facilities, cold fish farming and recreation. To our knowledge, there is no attempt and recognition of the land use /cover pattern of this mountainous lands. By considering these issues, an area based on watershed concept with covering a profile of the north of Sabalan mountain was selected and this study aimed to examine and compare the capability of Landsat TM and derived imagery from Google earth for land use/ covermapping and land use/cover distribution in a mountainous environment using visual and digital interpretation based on the Shrivan-Darasi Watershed in North West of Iran.

MATERIALS AND METHODS

2-1. Study area

Shirvan-Daraciwith 14666 ha is located in North West of Iran (north of Ardabil province /47º 43' 15" to 47º 52' 49"E and 38º 35' 30" to 38º 35' 34" N / Figure 1). Altitude varies from 938 to 4781m. Annual precipitation varies from 217 to 524mm, mean annual temperature is 8.6 to 17.15ºC (by considering high elevation variation), and generally with cold semi-arid climate. Watershed is a mountainous area, the major land uses are rangeland and rest of the land uses are dry farming, irrigated farming, gardens(horticulture) and residential lands, respectively.

2-2. Image selection and preprocessing

By considering seasonality and phenological patterns of the study area, according to the 3843m altitude differences, there is no considerable seasonality variation, but phenological stages are different (there are 4 discernible seasons, but with different temperature and type of precipitation in different elevation, thus phenological stages are different).However, by considering these issues the best time of the image selection to cover both low and high altitude areas was to select an image in late July of each year. Because of the moisture effects on the image acquired data [10], 15 days before image selection werealso considered, however there was no considerable rainfall in this period. Therefore, an image by considering seasonality and phenological patterns and moisture content was selected.The c Landsat ETM+ copyright 2012 (166-34/ the available image/ TM 27/07/2010_c) was selected based on average of the full growth of annuals and perennials for this study (average of the watershed).

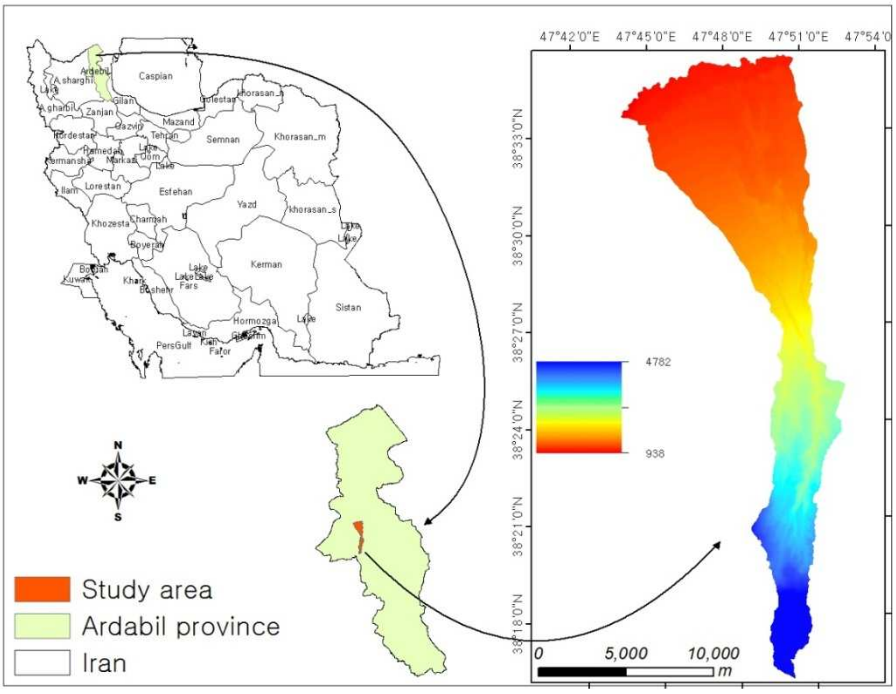

Figure 1.Study location in Iran and Ardabil province

Accurate registration of multi-spectral remote sensing data is essential for analyzing land use / cover conditions of a particular geographic location.Obtained image has been registered to the UTM map projection with a d*a*tum of the WGS84. However, according to the collected Ground Control Points (GCP) and other GIS layers such as registered topographic maps, acquired images were still required to be rectified by affine transformation model to the WGS84 to align accurately with the GIS layers and collected GPS points. In image rectification Root Mean Squire (RMS) errors of 41 points selected from 150 GCP were less than 2 pixels and total RMS was 0.25 pixels.Image preprocessing stages,including atmospheric, geometric and radiometric corrections, topographic normalization and image enhancements, were conducted before image utilization [11, 20]. Google earth imagery extracted and imported to ArcGIS using Stitch for Google earth software.Available ancillary data to support this work consisted of a 1: 50000scale topographicmaps and derived Digital Elevation Model (DEM) and slope maps at scale 1:25000, a geology map of 1:250000 scale.

2-3. Image Interpretation

Image interpretation carried out in two ways includingvisual interpretation and digital analysis.

2-3-1. Visual interpretation

Visual interpretation was the backbone of remote sensing when aerialphotographs were the only remotely sensed images available. Advances intechnology have made a tremendous contribution to remote sensing through theintroduction of new digital sensors and improved algorithms to processimagery.The classified map products, however, have not significantly increased inquality. Using visual cues, such as tone, texture, shape, pattern, and relationship toother objects, an observer can identify many features in an image. Methods tovisually interpret satellite images are very similar to methods developed tointerpret aerial photographs over 100 years ago. With the advent of fastcomputers and sophisticated algorithms for image classification, many users ofsatellite imagery are convinced that the only way to benefit from satellite imageryis to classify the image. Although there are certainly appropriate times to useclassified images, in many cases the image classification process reduces theinformation content and can introduce misleading errors. As there is increasing evidence of using Google earth derived imagery by different Bureaus and consulting engineers using visual interpretation instead of using multispectral digital data such as TM, ETM^+, etc. Thus, this study put this to practice to show the advantages and drawbacks of using visual interpretation versus digital one and also comparison of Landsat and Google earth derived imagery. Google earth derived and TM images visually interpreted using 7classes (Level 1) including: rangeland (R), dryfarming (DF),garden(horticulture) andwildtreecomplexes (GT), residential areas (Ria), irrigated farming (IR), out crops (OC), water ways (Ww).

2-3-2. Digital interpretation (TM image)

In the digital classification process, training areas for different classes are defined on the satellite imagery on spectral response pattern in different spectral bands. Based on these training areas satellite imagery is classified into different classes using parametric or non-parametric classifiers. Overall, selected TM image was classified usingunsupervised (7 classes) and supervised methods (7 classes based on training areas for those defined classes). Maximumlikelihoodalgorithmwas considered in supervisedclassification.

2-4. Field data collection

For accuracy assessment 148 samples on an area of 100×100m of different land uses/covers were recorded by considering field data collection precaution.Center of each sampling plot was recorded using Garmin etrex vista GPS. Land use and land cover data were recorded. The data from GPS to computer were transferred using OziExplorer3.95.4qsoftware.Out crop classes were not sampled due to road accessibility and minoreconomical importance in the Iran'sprogramming plans and economy.

2-5. Accuracy assessment

The classification accuracy is most important aspect to assess the reliability of mapsespecially when comparing different classification techniques.Equations 1and 2 were used foroverall accuracyandKappacoefficientcalculations.

$$OA = \frac{1}{N\left(\sum P_{ii}\right)}$$ Equation 1

Where: OA, overall accuracy; N. The total number ofpixels, the experimental; Pii. Class correctlyclassifiedpixelsintotal.

$$K = \frac{\left(OA - \frac{1}{q}\right)}{\left(1 - \frac{1}{q}\right)}$$ Equation2

Where: K-factor kappa; q-number of land coverclasses.

RESULTS

The classified maps from visual interpretation of TM and Google earth images are presented in Figure 2A&B. The classified maps from digital interpretation of TM image are presented in Figure 3A&B.Seven land uses fromtwo images including TM 2010 and Google earth derived image are extracted and mapped. Area of each land uses were calculated in hectare and percent (Table1). The thematic content of the classified image was quantitatively assessed foraccuracy by evaluating the correspondence between the class label assigned to apixel in the image and the ‘true’ class as measured on the ground. Accuracy assessment results of the produced maps are presented in Table 2. By considering the accuracy assessment results of the produced maps the Google earth derived image has the best result and unsupervised map has the worst. According to Google earth derived map the main land use is rangeland with about 10292 ha (70%) of the study area. Out crops with about 361 ha (2%) is the smallest land cover/use in this watershed.

DISCUSSION

During field work it was evident that extreme topography was the main influence factor on the distribution of land use /cover on the watershed. Examining the classified image reinforces this observation. Low-lying areas of alluvium with area covered by irrigated farming, dry farming, garden and wild trees (mixed horticulture) and water way. On the other hand, mountainous area covered by rangeland mainly and summit of the Sablan by out crop. There were some difficulties in distinguishing between different land uses, particularly between residential areas, waterway with rangeland using digital interpretation. First, their existence in small spatial units produces mixed classes with each other, which exist nearby. These results clearly suggest that the spectral and spatial characteristics of Landsat TM data could not serve to identify and map land use types using digital interpretation in Shrivan-Darasi watershed.

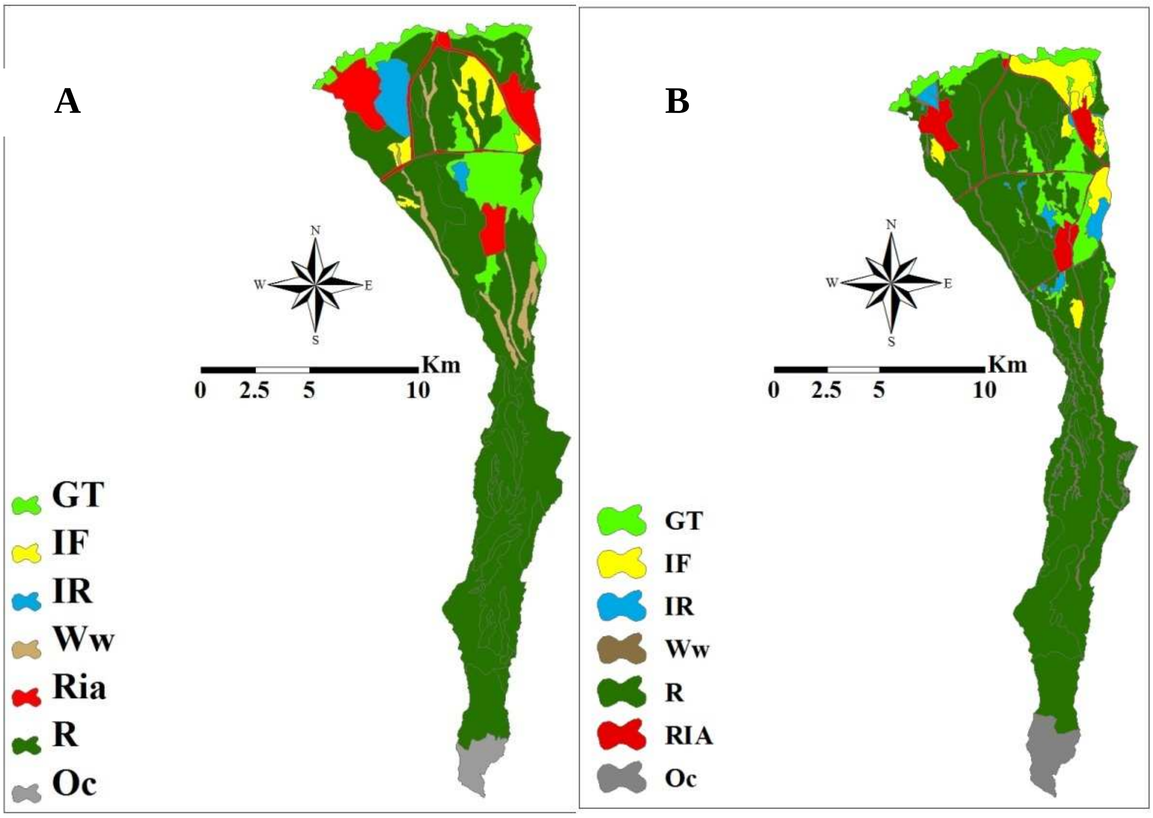

Figure2:Derived land use maps from visual interpretation: A) LandsatTM 2010image, B) Google earth derived image

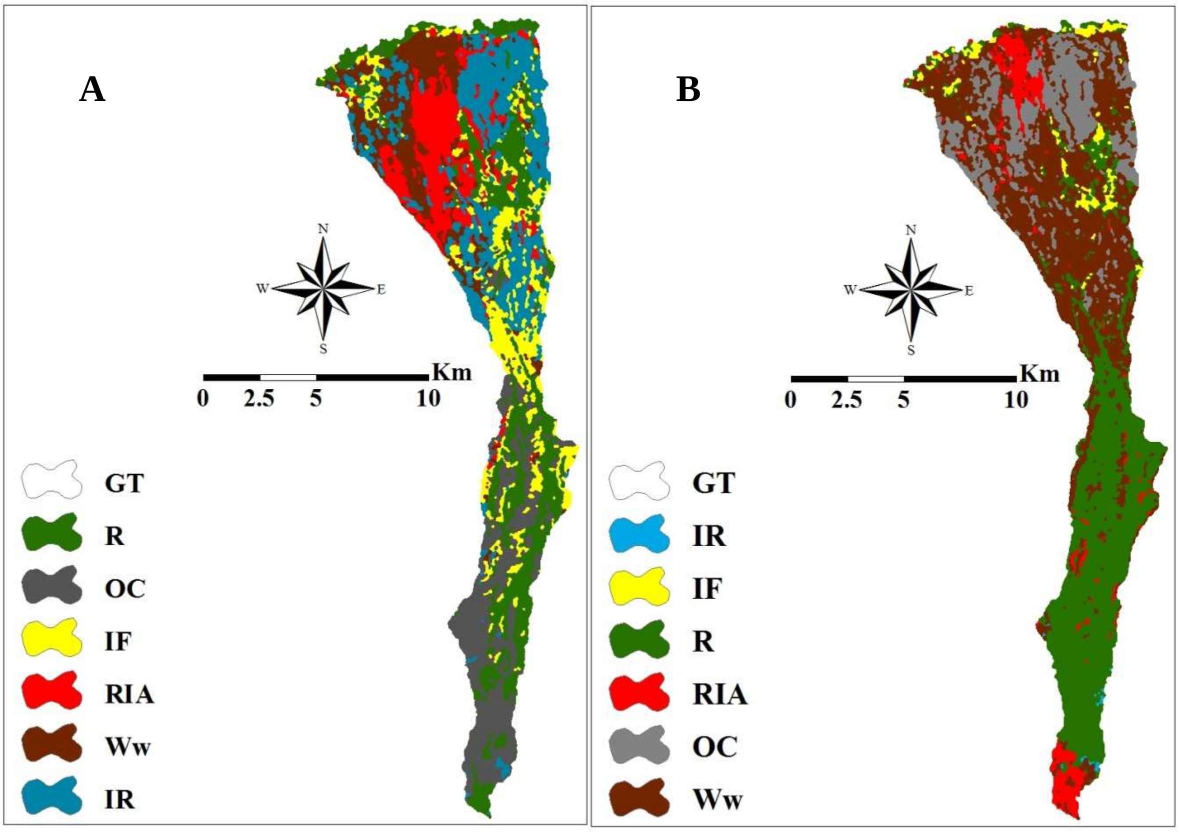

Figure3:Derived land use maps from digital interpretation: A) unsupervised classification (TM image), B) supervised classification (TM image)

Table1:Area information derived from 4 produced maps

	Visual interpretation				Digitalinterpretation(TM image)			
	TM 2010		Google earth derived image		Unsupervisedclassification		Supervisedclassification	
	Area (ha)	Area%	Area (ha)	Area %	Area (ha)	Area %	Area (ha)	Area %
Rangeland	9826.40	67.00	10292.20	70.18	5954.13	40.59	4417.16	30.11
Irrigated farming	530.89	3.44	319.21	2.18	60.10	0.40	1032.24	7.03
Dry farming	512.24	3.49	319.21	2.18	1477.33	10.07	1575.13	10.74
Garden & Wild tree	1719.23	11.72	1381.34	9.42	429.30	2.92	848.05	5.78
Out crop	361.38	2.46	566.58	3.86	51.79	0.30	2365.48	16.12
Water way	470.38	3.21	427.41	2.91	932.30	6.32	1775.96	12.10
Residential area	1272.48	8.68	787.94	5.37	5761.02	39.28	2651.96	18.08

Table2:Summarytableoferrormatrixand accuracyofvisual and digital interpretationformap classes

	No. of GCP	Visual interpretation				Digitalinterpretation (TM image)			
		TM 2010		Google earth derived image		Unsupervisedclassification		Supervisedclassification	
		Pro.A.	User A.	Pro. A.	User A.	Pro. A.	User A.	Pro. A.	User A.
Rangeland	81	0.71	0.87	0.77	0.93	0.19	0.55	0.26	0.54
Irrigated farming	5	0.20	0.20	0.71	0.71	0.33	0.08	0.20	0.50
Dry farming	13	0.62	0.57	0.69	0.5	0.50	0.22	0.46	0.33
Garden & Wild tree	34	0.85	0.73	0.90	0.93	0.12	1	0.15	0.63
Out crop	0	-	-	-	-	-	-	-	-
Water way	1	1	0.25	0/00	0/00	1	0.6	0	0
Residential area	14	0.79	0.52	1	0.66	0.38	0.08	0.71	0.13
Overall accuracy		0.74		0.94		0.24		0.43	
Kappa coefficient		0.71		0.90		0.22		0.41	

Visual interpretation required that the analyst knows aspects of the study area in addition to the spectral response of the image. Classification of Landsat and Google earth derived image because of prior knowledge of the relationship between the different land cover classes (context), texture and historical information of the study area. King [19] also emphasized to prior knowledge of interpreter in visual interpretation. This pre-knowledge helped to define classes that were more representative of the real terrain conditions in the level 1 of land use mapping. Although Di Gregorio and Jansen [13] and Gong et al. [15] highlighted more consideration and discrimination of land covers and land uses. However, as this study aimed to map land uses and land covers in the level 1, thus main land uses including rangeland, dry farming, irrigated farming, garden and wild tree, residential area as land use categories and out crops and water way as land cover were classified.When the interpreter used visual classification sometimes the tendency was to generalize, especially when study area was fragmented or composed of a mixture of land use cover classes. Small areas with grass and isolated tree groups normally were drawn inside a big polygon of rangeland or intervened area without taking account of small patches of land use or cover. Digital classification, on the other hand, recognized the two main classes of rangeland and irrigated farming, but drawing several polygons instead of only a few in the visual interpretation as the same as Puig et al. [24] concluded.Our results show that substantial difference between the two methods. However, if technicians want to analyze a satellite image using visual interpretation, they can utilize its many advantages and develop their studies with the same confidence as they have with a digital classification method.Visual interpretation was shown to have more quality compared to digital classification for analyzing medium-resolution satellite data. The lack of success for the TM data (supervised and unsupervised) in this application could be due to a number of reasons: 1), the spectral characteristics of land use/cover types are not distinctive enough to be used for the identification and separation of individual types. 2), the spatial distributions of different land use/cover types on the study area not allow to separate zones based on topography. 3), the spatial resolution of 30 × 30m seems cannot decrease internal variations within each single class. As a consequence, identifiable classes with uniform radiance values are not produced.Statistically, visual interpretation method yielded more precisionmeasures when difference of proportions tests wascarried out. Tests showed there are significant difference between the twomethodologies and visual interpretation having greateraccuracy. The Kappa test also showed the same tendency forvisual interpretation methodologies. Digital processing gave aKappa statistic of low, while visualinterpretation gave a value of high precision. May the low accuracy of digital interpretation methodologies influenced by the distribution of GPS control points. Additionally, the GCP points were collected using a low precision GPS receiver, a possible cause of misallocation of some points and potential confusion between some classes. Moreover, due to image filtering, small polygons of different classes were eliminated, which may cause low accuracy for digital interpretation. When statistical tests are applied some confusion occurs due to small polygons that are difficult to validate with GPS points taken in the field. Therefore, future experiments should avoid taking verification points over small areas (i.e. 4x4 pixel polygons). These small areas are suppressed by the filtering process.As was expected, the distribution of land uses and land covers on the lowland of the study area was more heterogeneous than the uplands of the study area. Roads, cold fish farming, Telecabin, hot water spring (spa) and other recreational facility according to their small size were not identified in this study, particularly using digital interpretation. The results also suggest that a raster-based GIS can facilitate the necessary digital analysis and manipulation, particularly using high spatial resolution imagery such as images, which were derived from Google earth for the study area. This includes data integration, geocorrections, introducing information and knowledge from other datasets into the classification process, handling the classification, performing statistical accuracy tests and calculating areas.Comparing time processing for both classification approaches, digital interpretation showed a better time performance than visual interpretation. In this sense, cost benefit for visual interpretation because of free image from Google earth and high accuracy was considerable.In conclusion, satellite remote sensing and GIS can be used to generate the necessary dynamic information for surveying and monitoring land use/cover on Shirvan-Darasi and similar success may be possible in other mountainous environments in this region. By considering the results consulting engineers by using Google earth derived imagery producing cost-effective map with high accuracy.

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