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DETERMINING POTENTIAL TOURISM AND SKIING AREAS IN ASALEM NAVROOD BASIN

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ABSTRACT
Navroud catchment's highlands in the Gilan province with suitable slope, snow cover with high thickness and density during 5 months of the year and the link road with good access, can be used as tourism area with snow ski tracks. Understanding characteristics of the region using satellite data and analysis of data using statistical and GIS software, important and accurate results can be obtained from natural status of the region in terms of winter tourism. In this work, in the first stage raw data (Satellite images of snow and water cover with HDF format for 9 years from 2001 to 2009) were received via internet and transferred to Erdas Imagine software environment. Following image processing, snow and snow equivalent water cover in catchment, sub-basin and its elevation zones were specified using codes prepared in Matlab Software. Data were controlled through field studies and were analyzed using ArcGIS software along with necessary layers. Potential areas for snow skiing and tourism were specified using positioning techniques. Results suggest existence of locations with appropriate features for constructing snow skiing tracks with steep and slow slopes for a variety of skiing sports in Navroud catchment. Good road links along these areas make easy access to it.

KEYWORDS: satellite imagery, snow skiing, Navroud catchment

INTRODUCTION
Tourism in today economy plays an effective role in growth and prosperity of the countries. The countries which are aware of this fact's importance attempt to understand geographical capabilities at different times in different regions and have suitable progress for tourism development with basic plans and necessary investments however, snowing provides suitable conditions for winter tourism and development of related sports.

Various studies have been conducted on tourism and positioning related activities in the world including Iran. Heydari (2008) argues that tourism industry can play crucial role in dynamisms of the various economic sectors in local communitiesrelying upon its economic features and effects in an effective manner, and ultimately help development of rural and less-developed areas. Thampi (2005) considers natural tourism as a new concept of tourism, which was triggered initially by the idea of true re-harmony with nature, and it was raised by natural tourism community as a responsible trip to natural areas which leads to preservation of natural environment and enhancement of local communities' welfare.

According to Tisdell (2003) natural tourism is a type of tourism which often claims it can be turned into one of the fastest component of the global tourism market. According to estimates, natural tourism accounts for about 27 percent of international trips and if it is managed properly, it can create local employment and opportunities for local development leading to preservation of natural environment (Githinji, 2006). Mahalati (2001) regards tourism as one of the major contemporary human activities which creates considerable changesin the appearance of the land, political, economic, and cultural situations as well as human life manner. On the other hand, the scholars maintain that the tourism industry is so important in the economic development of countries that economists have called it invisible export (Rezvani, 1995). Tourism Organization Studies show one direct tourist's dollar will increase in value three quarters compared to the industry. Increased employment by tourism will lead to increase of 5 job opportunities (Bin, 2008). Considering dimensions of tourism, trip of millions of natural tourists may be because of visiting plants, animals or ecological investigations, geological, mining and similar studies, and regional development and employment development are major effects of natural tourism development (Farajzadeh Asl, 2008). Allen et al. (1999) studied changes in land usage in tourist area in coastal South Carolina using Geographic Information System and attempted to specify the extent and type of change in lands of this area. Nouri and Nowrouzi (2007) in a work entitled *Evaluation of Environmental Capacity for Tourism Development in ChoghakhourVillage* used data layers such as slope, vegetation, soil, etc., and finally synthesized the available data layers, and classified Choghakhour Village into four tourism units in terms of focused and broad recreation type. Farajzadeh Asl and Karim Panah (2008) evaluated Kurdistan Province in terms of natural tourism development and classified the province lands for six natural tourism activity including mountaineering, climbing slopes, skiing, nature therapy, water sports and ecotourism. They found only one percent of the province area lacks any capability for natural tourism development. Taghvaee et al. (2011) in a study entitled *Locating Tourist Villages on the Shore of Lake Kafner Using GIS and SWOT Models* identified the best place to build a tourist village in the area by integrating 23 data layers in GIS environment. The advantage of this work is using satellite imagery of MODIS/Terra Snow Cover and snow water equivalent instrument, Amsr-e, which leads to increased accuracy and efficiency of operations to locate suitable areas for the development of a ski resort and making differentiation from other studies on this topic.

MATERIALS AND METHODS

Asalem Navroud catchment with area of about 321 km from the sea is located in the West Region of Gilan adjacent to Talesh City.

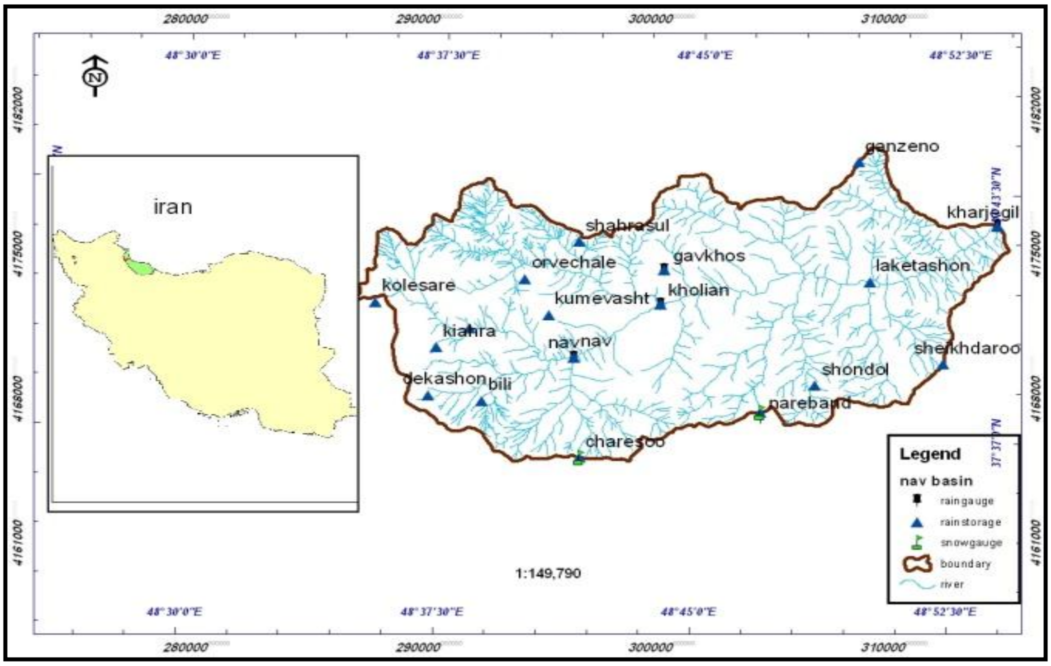

Fig 1. Map of Asalem Navroud catchment and sub-basins in Gilan Province

Due to the special geographical situation of the region, at altitudes above 1000 m within the catchment, rarely a village can be seen where people live all year round.

Extracting Data for Snow Cover

According to Hall et al. (2002), Moderate-resolution Imaging Spectroradiometer (MODIS)captures data in 36 spectral bands; 11 bands in the visible light range, 9 bands in the near infrared range, 6 bands in the thermal infrared range, 6 brands in shortwave infrared range, and 6 bands in the long wave infrared range. 216 satellite 8-day images from snow cover were received during 2000 to 2009 by MODIS from Navroud catchment. Raygani et al. (2008) studied MODIS snow cover in Rivgaran basin during 2000 to 2001. Average accuracy of MODIS snow cover map in non-cloudy conditions can be regarded as 88 percent. In order to extract snow cover level, satellite data for the eight-day snow cover were received by MOD10A2 in HDF format from WIST website. Images are related to sheet H21V05 from WIST website. The images were transformed into Tif format in Erdas Imagine software environment using Import Command. Then, reference land operation was made and at the end, catchment area was cut from the images.

Following these steps, all images were recalled by a program prepared in Matlab programming environment and snow cover for the whole catchment was examined in two sub-basins and elevation zones.

Height of Snow Water Equivalent

In this project, it was attempted to use snow water equivalent (SWE) data by AMSR-E instrument which is located on Aqua satellite in order to utilize snow depth and density data in better and more accurate estimation and position of the potential areas for skiing track. This instrument has been used since 2002 for measurement and estimation of SWE using its radar sensors.

These data are accessible daily, within 3-5 days, and monthly through internet sites and provide snow water equivalent level following processing in Erdas Imagine software environment. These data were measured and calibrated at province level with the data measured in field operations of snow measurement which is done annually by Hilan Regional Water Studies Office in winter months, and their accuracy was obtained at 70 percent level. Fig 2 shows an example of the processed images for snow and snow water equivalent cover at Erdas Imagine environment related to Navroud catchment, province, and Sefidroud catchment.

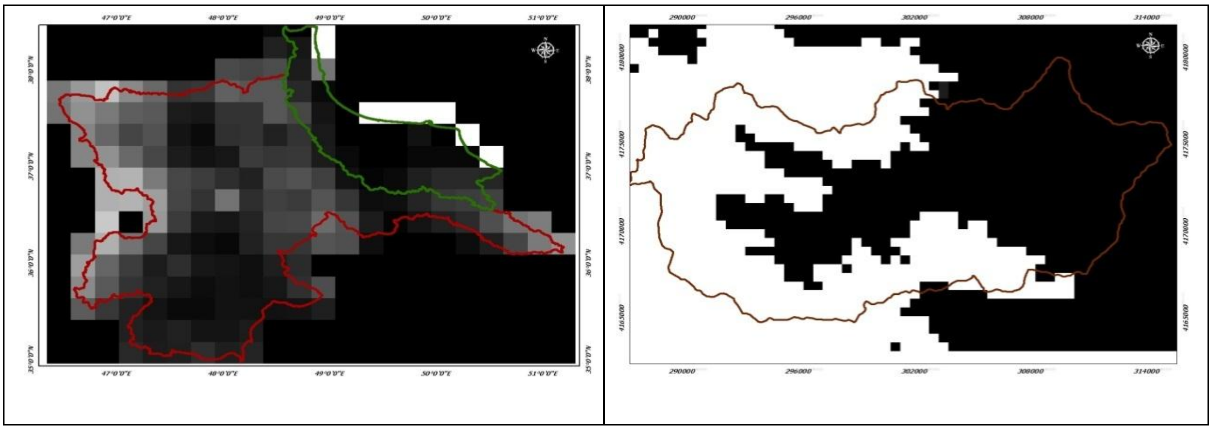

Fig 2. Images of snow and snow water equivalent cover

Snow Cover at Catchment, Sub-basins, and Elevation Zones

Hall *et al.* (1995) and Klein (1998) designed snow map algorithm in order to recognize surfaces covered by snow with local resolution 500 m as continuous in each rotation. Drawn diagrams for snow cover changes at catchment, two sub-basins and elevation zones in Nervous catchment during the respective years are shown in Fig. 3. Diagrams suggest increased snow cover at elevation zones above 1,500m so that the highest coverage is observed at zone 2,500-3,000 m and lowest coverage is observed at zone 0-500 m.

Snow Cover at Catchment and Heights above 1,500 m

Analysis on the snow cover maps at elevation zones of Navroud catchment shown in Fig 3 indicates the snow cover is concentrated mostly at the heights above 1,500 m. that is, in mountainous areas of the catchment which include less woodland. Due to severe reduction in sea humidity impact on these areas and high elevation leveling the temperature is decreased and falls are mostly as the snow.

Thus, snow cover has higher durability and allocates higher area in the catchment surface at this height. Therefore, the areas in the catchment with leveling above 1,500 m are considered and studied in the current work. Latitude of this part of the catchment is 122 km^2, which nearly accounts for 44 percent of the total catchment area.

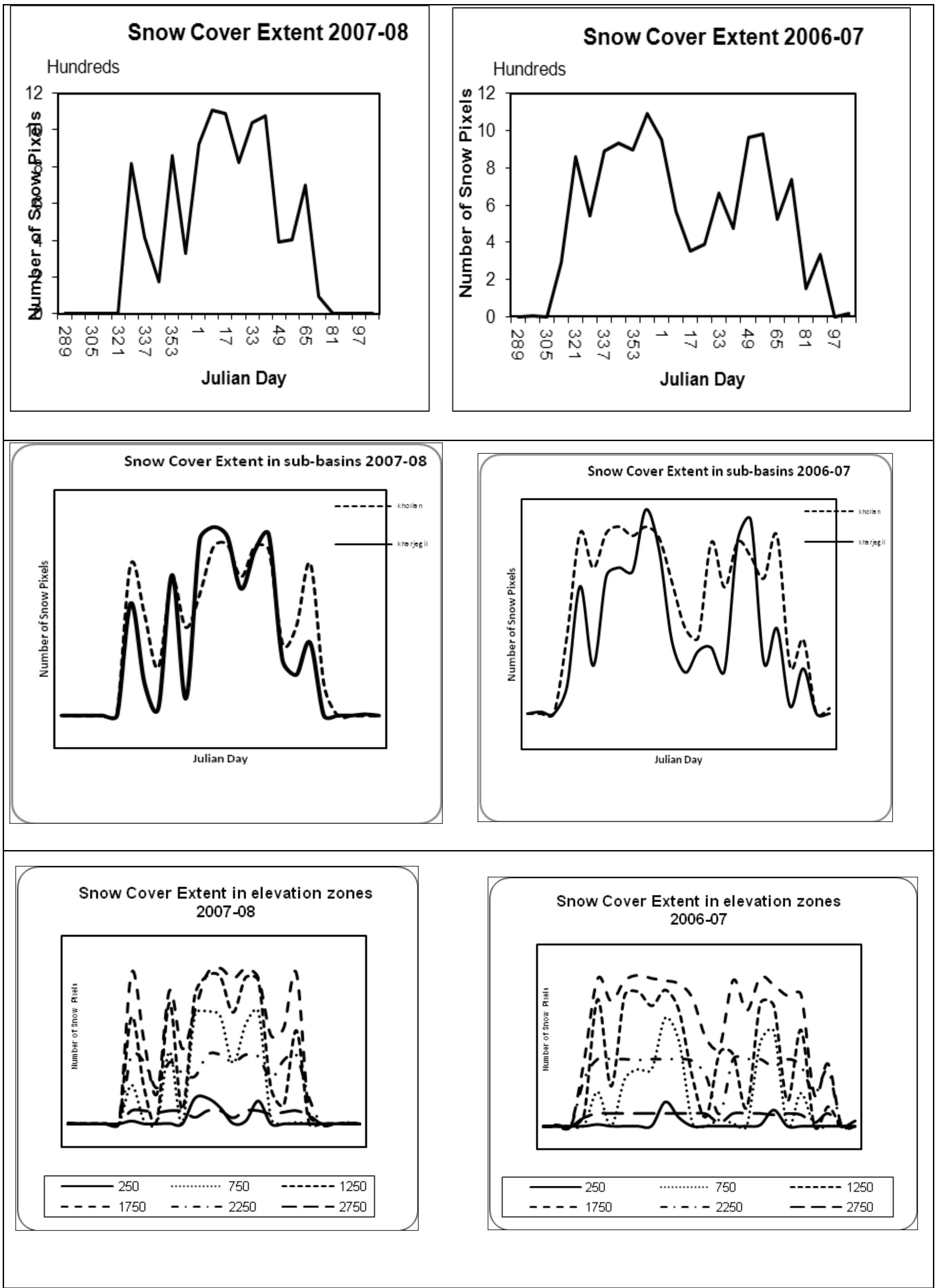

Fig 3. Snow covers extent change regimen in terms of catchment, two sub-basins and elevation zones

Table 1 gives a comparison of monthly average snow cover extent at the whole catchment and elevation zones above 1,500 m.

Table 1. Monthly average snow cover extent at the whole catchment and elevation zones above 1,500 m

Month	Range	1381	1382	1383	1384	1385	1386	1387	1388	Average
April	>1500	1	26	42	20	0.1	25	0	23	17
	The whole catchment	2	36	88	24	0.1	29	0.5	35	27
October	>1500	5	0	0	4	0	0.5	0	0	1
	The whole catchment	20	0	0	8.5	0	0.5	0	0	4
November	>1500	37	20	18	38	48	0	40	0	25
	The whole catchment	39	22	19	44	72	0	43	0	30
December	>1500	108	53	118	6	122	90	72	0	71
	The whole catchment	184	89	230	6	203	141	130	0	123
January	>1500	72	102	72	102	69	111	104	119	94
	The whole catchment	122	181	91	151	137	185	215	233	164
February	>1500	71	59	41	79	75	103	110	36	72
	The whole catchment	103	70	46	146	108	155	209	36	109
March	>1500	19	70	46	73	3	96	60	9	47
	The whole catchment	19	120	66	105	3	149	75	10	68

(Kilometer square)

Field Measurements in Snow Survey Stations

Measurements of snow parameters at fieldsurveys during 2008 to 2012 in snow survey stations of Navroud catchment (Table2) suggest lack of high dispersion in snow density especially at months February and March which is at range 4.1 –5.7. The only dispersion is related to January in 2010 (1.6) which shows recentness of the snow and its short durability. These values along with snow water equivalent measured at snow survey stations help calculating accuracy of the estimated values for snow water equivalent resulting from the AMSR-E images in cold months of the year.

Table 2. Measured parameters at Navroud snow survey stations

Year	Month	Snow water - mm	Snow depth- cm	Density- %
2008	February	4.7	11.5	**4.1**
2009	March	2	3.5	**5.7**
2010	January	11.9	77	**1.6**
2011	February	26.4	49	**5.4**
2012	March	34.6	71	**4.9**
Average		15.9	42.4	**4.4**

Snow Water Equivalent in AMSR-E Images

Following receiving images and transforming its coordinates to geographical system in hegWINv2.9 software, the images are transferred to ERDAS IMAGINE 9.1 software environment in order to cut Navroud catchment and extract snow water equivalent data. Values for snow water equivalent height at areas above 1,500 m and below 1,500 m at Navroud catchment were received separately from the images which are given in Table 3.

Table 3. Comparison of monthly average snow water equivalent at areas above 1,500 m and below 1,500 m

Month	Range	1381	1382	1383	1384	1385	1386	1387	1388	monthly average
April	>1500	0.5	3	1	1.5	0	1.5	0	1	1
	<=1500	0.5	2.5	1	2	0	2.5	0	0.5	1
October	>1500	0	0	0	0	0	0	0	0	0
	<=1500	0	0	0	0	0	0	0	0	0
November	>1500	0	0	0	1.5	2	0	0	0.5	1
	<=1500	0	0	0	2.5	1.5	0	1.5	0.5	1
December	>1500	10	6.5	9.5	1	10	6.5	2.5	2.5	6
	<=1500	8.5	4.5	6	0.5	8	5	3.5	2.5	5
January	>1500	11.3	16	12.5	17.5	10	22	19.5	10	15
	<=1500	7.8	8	9	10	6.5	14	14	8	10
February	>1500	18.5	20	16	26	21	21	26	13	20
	<=1500	12.3	12	10.5	13.5	14	11.5	17.5	9	13
March	>1500	4.8	20.5	1.5	10.5	8	13	9.5	6.5	9
	<=1500	5.3	16.5	2.5	9	8	12	6	6.5	8
Annual average	>1500	6.4	9.4	5.8	8.3	7.3	9.1	8.2	4.8	7.4
	<=1500	4.9	6.2	4.1	5.4	5.4	6.4	6.1	3.9	5.3

Snow depth thickness at areas above 1,500 m is given in Table 4. These values are obtained based on snow water equivalent height data and calculation ofaverage density factor 4.4 percent from data measured in snow survey. Maximum data (59.1 cm) are related to the tears 2005 and 2008, and minimum data (0 mm) are related to the months October and November in these years.

Table 4. Monthly average snow depth height (cm) in areas above 1,500 m in terms of year

Month	2002	2003	2004	2005	2006	2007	2008	2009	Annual average
April	1.1	6.8	2.3	3.4	0.0	3/4	0.0	2.3	**2.4**
October	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
November	0.0	0.0	0.0	3.4	4.5	0.0	0.0	1.1	**1.1**
December	22.7	14.8	21.6	2.3	22.7	14.8	5.7	5.7	**13.8**
January	25.6	36.4	28.4	39.8	22.7	50.0	44.3	22.7	**33.7**
February	42	45.5	36.4	59.1	47.7	47.7	59.1	29.5	**45.9**
March	10.8	46.6	3.4	23.9	18.2	29.5	21.6	14.8	**21.1**
Annual average	14.6	21.4	13.1	18.8	16.6	20.8	18.7	10.9	**16.9**

Locating Skiing Tracks

Overlap is the process of putting layers and classes of different digital spatial information on each other in order to obtain new combined layer or class resulting from sum of data, so that the resulting combination can be interpreted based on its constituting data[1]. Layered used in this research for locating include:

1. 8 to 65 percent slope

[1] . Instruction for using GIS capabilities in water resources studies

2. Elevation level 1500 m above
3. Slope direction
4. Minimum distance of 500 meters from the village
5. Minimum distance of 500 meters from river branches
6. Maximum distance of 1500 meters from the main road of Asalem to Khalkhal
7. Land usage for determining outside forest areas

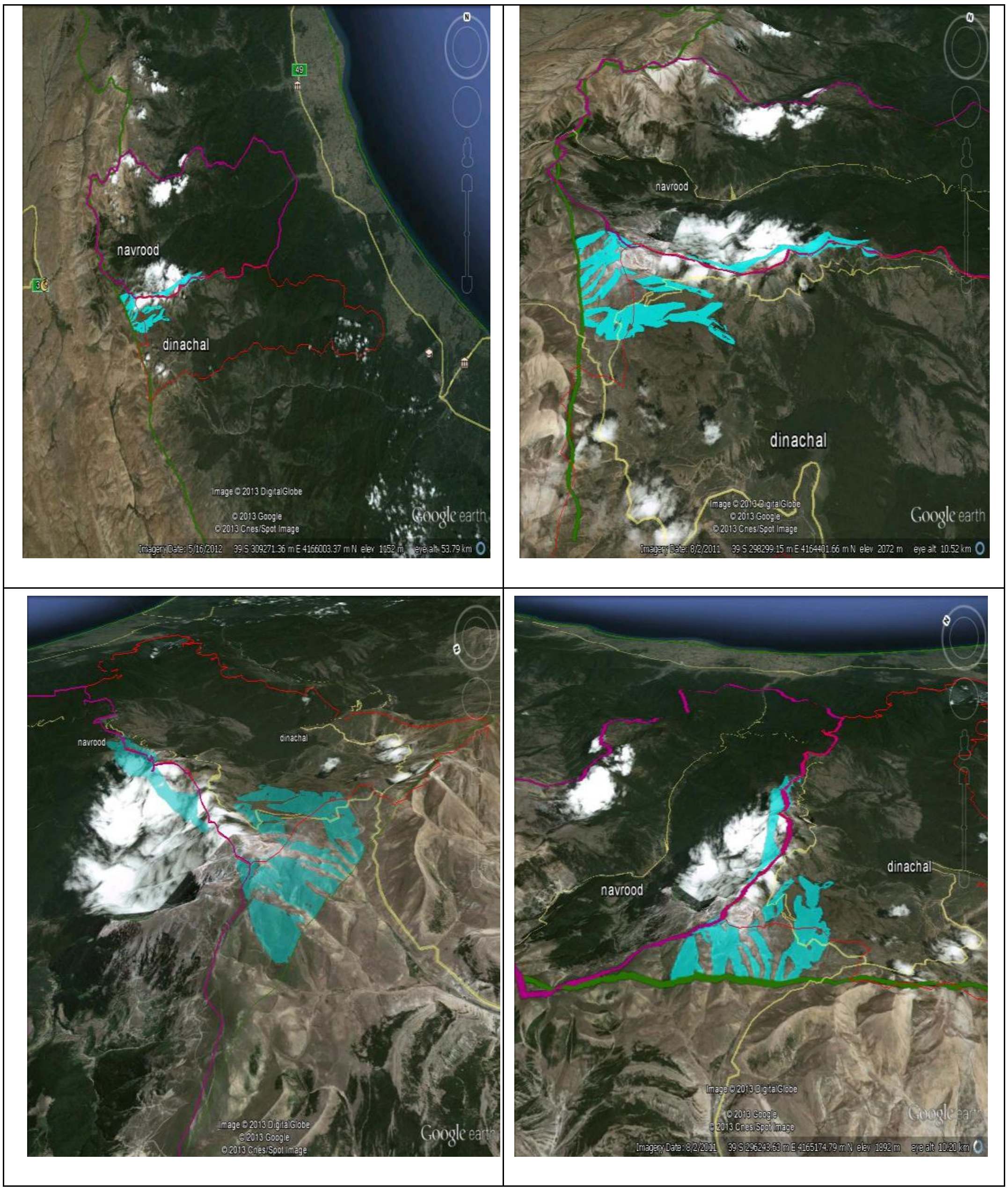

Figure 4. Overhead images of located areas for skiing track

In order to select the best slope direction, angle of solar radiation in the northern hemisphere and its impact on durability of snow on the land are considered. Suitable slope extent is specified considering various types skiing and this way fits for skiing in steep slopes. Low slopes are used for children and novices. Following preparing layers in GIS software, layers were overlapped to find the best location for skiing track. Finally, the outputs in kmz format were transferred to Goggle Earth. Some examples of these maps are shown in Fig (4).

DISCUSSION AND CONCLUSION

Considering importance of the topic and its role in economic development in the region, in this study potential in the region on potential areas for tourism and snow skiing was studied. It was attempted to examine and analyze the topic accurately using latest technologies as well as satellite data. To this end, following steps were conducted:

1. Estimating snow cover extent in three ways; in the whole catchment, in two sub-basins, and in elevation zones with 500 m distance.
2. Determining above 1,500 m leveling as an area with suitable snow water equivalent cover and height,
3. Using field snow surveys data for determining snow density,
4. Specifying potential areas for constructing skiing tracks.

According to Kammer (2002), one of the major parameters for research topic is having necessary information regarding snow depth thickness which should be between 30 to 50 cm and it should have at least durability for 100 days. Beside these criteria, there are also other criteria which influence determining potential areas for tourism including topography, slope, and slope direction, land use, distance from roads, distance from urban and rural areas. Thus, considering analysis in this work, it can be concluded:

1. Using satellite images data for snow cover and snow water equivalent height is useful to achieve more accurate results.
2. The survey was conducted on Navroud catchment’s elevation zonesat height above 1500m was a right choice in terms of coverage, water equivalent, thickness, density, snow durability and lack of aggression against forest areas.
3. Existence of link road from Asalem to Khalkhal in this region and locating most tourist and residential areas in its vicinity necessitates specifying tourism points in vicinity of this road.
4. Locating maps show presence of potential areas for construction of skiing tracks. According to Badri and Vosoughi (2009), precise selection of the selected areas is in the operational phase and it follows regional policies.
5. Findings indicate the best conditions for snow skiing is available only within three months of year (January, February and March)and it can be extended to four months by such measures as making snow or creating artificial snow.

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