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Monitoring Gangotri Glacier Using Remote Sensing and GIS Technique

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Abstract: The Gangotri Glacier is the most important natural phenomena for the Indian civilization during ancient period. It monitoring in regular interval is difficult. The health of this Glacier involved a crucial role for the local and Himalayan ecosystem and climatic condition. So here a small approach to monitoring the Glacier 2001 and 2017 Landsat data used for the investigation. All type of correction (geometric, radiometric and atmospheric) have been done for to get actual reflectance value, then normalized snow index(NDSI) and normalized vegetation index(NDVI) have been calculated .the present condition of the Gangotri Glacier status have been analysis using base on NDVI and NDSI. The NDVI and NDSI are most prominent and popular band statistics method to observing snow cover and vegetation cover mapping. The maximum observed ndvi Values close to zero -0.1 to 0.1, it mean area rocks or snow and values approaching -1 mean water which indicate glacial small water body. After the comparison of the data set between 2001 and 2017 by NDVI and NSDI the Gangotri glacier is rerating during previous period the data clearly show that the differentiation of snow and vegetation porn areas.

Keywords: NDVI, NDSI, RS, GIS

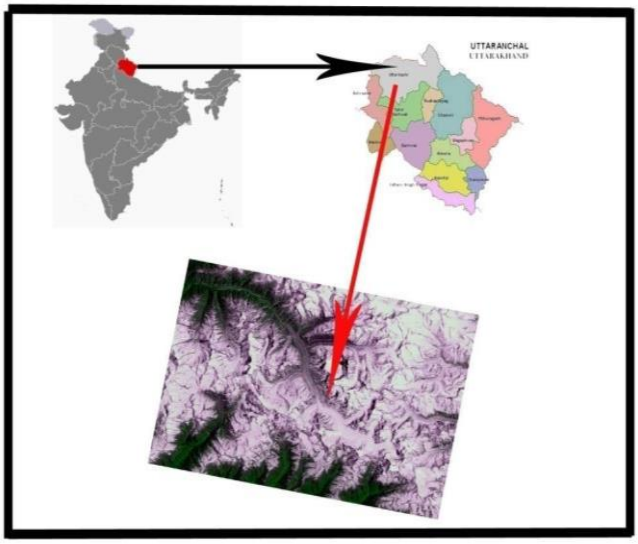
I. INTRODUCTION

I. Study area

The Himalayan region call third pole because many glacier are dominated in this region ,and Indian many major river are the source of in this region which help to Indian civilizing flora and fauna. This region also source of fresh water. Gangotri Glacier is the largest glacier (length ~ 30 km) in the Garhwal Himalayas.which situtated in northern portion of utterakhand state. It approximated height about 4000 mt. the holly river of india Bhagirathi River originated from snout (Gaumukh) of Gangotri Glacier (Ghosh 2017). Gangotri Glacier flows towards northwest direction of Gaumukh approximate 30 km.the all side of the glacier dominated by any other remarkable glacier Satyabala, (2016). The Gangotri glacier has an identification number as 50131 06 029 for glacier inventory purpose and it location between latitude 30043'20" to 31001'07"N and longitude 78059'42" to79017'10"E.(Srivastava,2012).In the elevation of 7138m the Chaukhamba mountant group the Gangotri glacier originated and continuous for 30.2 km toward northern direction. The ablation and accumulation zone length of the glacier 26.0 and 4.2 km. (Srivastava, 2012).Up to Devprayag the glacier contribute snow approximately 29%of the annual flow of Ganga,so the glacier affect the Indian major river system. The glacier flow toward the river Bhagirathi primarily pre meeting the Alaknanda river at devprayag. (Haq, Anul, Jain,and Menon2011).

In the accumulation zone nearly 2.15 km wide and ablation zone 1.35km wide.and average wide of glacier zone 1.5km.Kriti Bamak, Ghanohim Bamak,Swachhand Bamak andMaiank Bamak are the major tributary glacier which flow left bank and it join the right bank .(Srivastava,2012). For the location of Gangotri glacier in low altitude of the Himalaya the melting rate is high and its local climatic property is differ from other local glacier. The affect of south-west monsoon this glacier received huge amount of precipitation (Kundu, 2015).

Fig.1 Location map of study area



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II. DATA & METHODOLOGY

Data

It is difficult to monitoring the glacier by direct field methods such high altitude area, Remote Sensing has advantage of giving synoptic view of the region on regular basis (Kouh, et al.,2016) For this research Landsat series multispectral data (L1)were used whish has been download from USGS website. The sensor has different spectral band but here used only some specific band. Maximum cloud free data used for to get actual reflectance. For glacier monitoring same time in the year have been (may) chosen. Medium resolution satellite data (10 - 90 m) have become available for cryospheric studies since the early 1970s, with the launch of new space borne sensors: Landsat Multispectral Scanner (MSS), Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+)21 Optical sensors detect solar radiation reflected by the earth's surface in the visible (VIS) and near infrared (NIR) bands of the electromagnetic spectrum (0.35 – 2.5 nm) and the radiation emitted by the surface in the thermal infra-red (TIR) recorded as brightness temperature by the sensor, Snow and ice have special spectral signatures in the optical domain Throughout the season, glaciers display a unique sequence of optical properties in a yearly repetitive pattern. The seasonal evolution of a glacier can be tracked through time as the seasonal snow melts away revealing glacier ice in the ablation area and in the accumulation area. In this way, higher resolution time series of satellite images will increase the range of information available for glacier. The spectral signature of the snow has unique property of optical sensor to making snow mapping (Wang et al., 2015).

Table.1.Landsat data details

Sensor name	Spatial resolution(m)	Date	Band
Landsat 5	30	12-05-2001	2,5,3,4
Landsat8	30	15-05-2017	3,6,4,5

Table2.Landsat data details

Band		OLI	TM	Spectral range	
				OLI	TM
Blue	2	1	0.45–0.51	0.45–0.52	
Green	3	2	0.53–0.60	0.52–0.60	
Red	4	3	0.63–0.68	0.63–0.69	
NIR	5	4	0.85–0.89	0.76–0.90	
SWIR	6	5	1.56–1.66	1.55–1.75	
SWIR	7	6	2.10–2.30	2.08–2.35	
Pan	8		0.50–0.68		

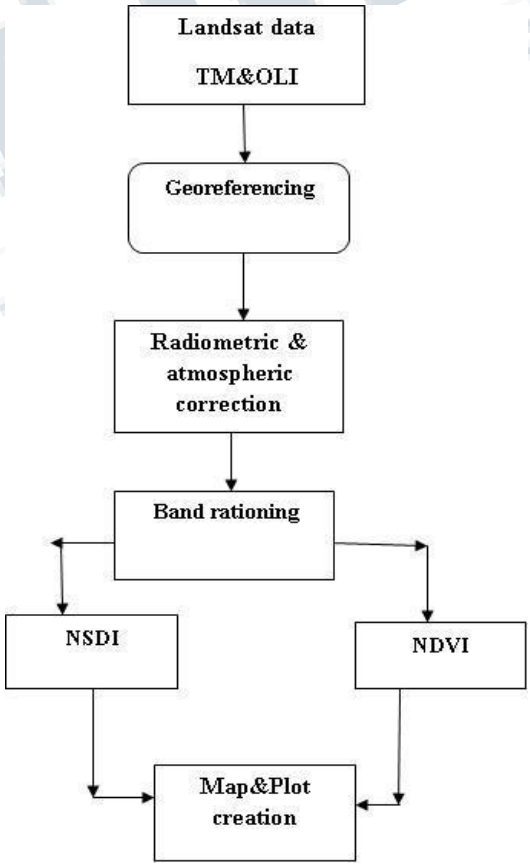

Fig.2.Methodology flow chart

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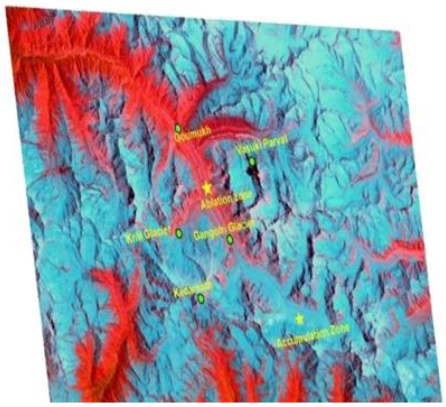
Fig .3. RGB composite of study area



DATA PROCESSING

After the download the data from USGS website geometric correction were performed WGS 1982, 44 north zone after the subset all multispectral band radiometric and atmospheric correction function have been performed, the atmospheric correction also done for to get actual spectral reflectance of the sensor. In this study outline two principal strategies distinguished by two time scales for exploiting glacier satellite image stacks, taking advantage of the Landsat TM and OLI archive (USGS).

Top of Atmosphere Reflectance:

The emitted energy of Atmosphere and the ground are closely related with their impact in the sensor observed radiance. Hence correction is necessary for retrieving reflectance from Landsat data set.

$$\rho\lambda = M_\rho * Qcal + A_\rho$$

$\rho\lambda$ = TOA Planetary Spectral Reflectance, without correction for solar angle. (Unitless)
$M\rho$ = Reflectance multiplicative scaling factor for the band (REFLECTANCEW_MULT_BAND_n from the metadata).
$A\rho$ = Reflectance additive scaling factor for the band (REFLECTANCE_ADD_BAND_N from the metadata).
Qcal = L1 pixel value in DN
Note that ρλ' is not true TOA Reflectance, because it does not contain a correction for the solar elevation angle. This correction factor is left out of the L1 scaling at the users' request; some users are content with the scene-centre solar elevation angle in the metadata, while others prefer to calculate their own per-pixel solar elevation angle across the entire scene. Once a solar elevation angle is chosen, the conversion to true TOA Reflectance is as follows:

$$\rho\lambda = \frac{\rho\lambda}{sin(\theta)}$$

ρλ = TOA Planetary Reflectance (Unitless)
θ = Solar Elevation Angle (from the metadata, or calculated).

NDVI&NDS

The band ratio method is the most common method for mapping optical multi spectral images .In this method a spectral band is used in the visible part of the spectrum, the bands are selected as the spectral reflectance of snow cover and vegetation cover cloud are similar to wave lengths below 1m approximately and they diverge in the near infrared and achieve a maximum different (as cloud is more reflective than snow)at wavelengths between 1055 to 1.75 is called the normalized different snow index (NDSI) for the discrimination of snow(it was originally defined in terms of the spectral bands of Landsat thematic mapper (TM) and OLI .

$$NDVI = \frac{\lambda_b - \lambda_i}{\lambda_{b+\lambda_i}}$$

Where

λ_b And λ_i is band 4 and 5 for Landsat8 &band 3and 4 for TM.

$$NDSI = \frac{\lambda_b - \lambda_i}{\lambda_{b+\lambda_i}}$$

Where

λ_b And λ_i is the band 3&6 for OLI and 2&5 for TM.

For the land observation NDVI is the mathematical algorithm to identify the greenness cover over land. Much expert exposed different type of algorithms for vegetation identifies but NDVI is most popular and effective method.ndi vale depended on the vegetation health and density. The combination of near infrared and red portion on the electromagnetic spectrum. More healthy chlorophyll reflected the red portion and absorbed in near-infrared of spectrum. Value range between +1.0 to -

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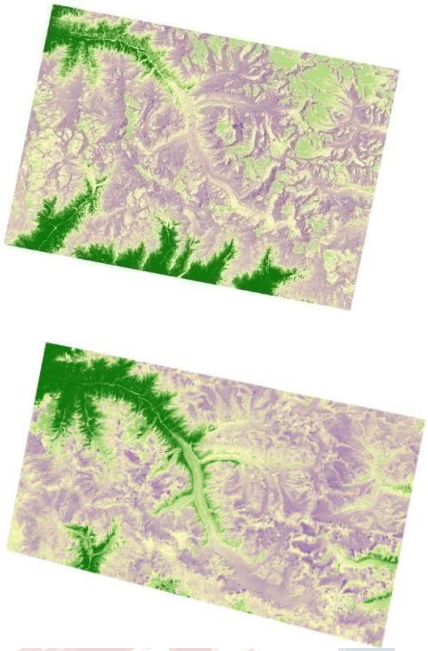
1.0.low NDVI value mean water or ice and high mean green vegetation.

Fig.4.NDVI&NDS



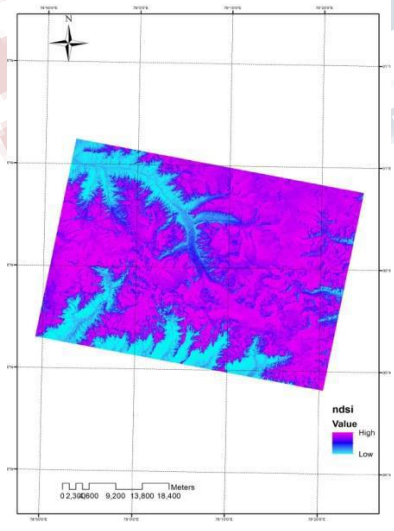


Fig.5. NDSI-2001

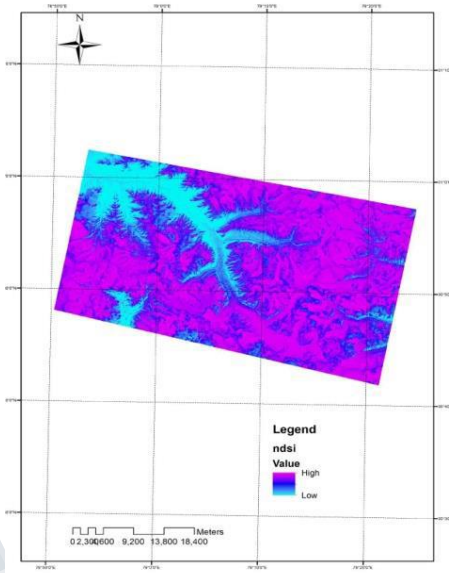


Fig.6. NDSI-2017

RESULT AND DISCUSSION

The climate change and global warming are significant for glacial physical condition, the trend of temperature rising trend affected the mountain glacier and local climate condition.

In the session of winter and pre monsoon precipitation play very crucial role to accumulation of snow and glacier (Kouh et al.216). In the present study the main resolution to monitoring the gangotri glacial during 2001 to 2017.the NSDI value of the proposed indicated that ambient change of gangotri glacial and their turbidity glacial. The pink colour show snow cover with high value and low value indicate the less snow in the same way the NDVI also indicate the same condition of the glacier the high value near <0.1 represent scarab Sparse vegetation such as shrubs and grasslands. And 0 indicate the snow or water body. In the recent way The ISRO study during last four decades has revealed that loss in area of Gangotri glacier during the years: (i) 1962 and 2005 was 3.19 sq km; (ii) 1990 and 2007 was 0.13 sq km and (iii) 2007 and 2016 was 0.15 sq km," the Hindu 217 July. The rate of retreat of the gangotri glacier 22m per year. The ndvi valu of ablation zone differ from 2011 to 2017 it mean retreat the glacier but the accumulation zone of 2001 to 2017 remaining same . Ndvi value of 2017 in the surrounding

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area of gangotri glacier much more then 2001(Kedarnat, Basuki parvat).

Year	Volume(Km3)	Total Area(Sq.km)
1990	37.967571806	162.458
2000	36.950265248	159.136
2010	36.1742746377	156.587

Soure:(Haq,*et al.* 2011).

The maximum observed ndvi Values close to zero -0.1 to 0.1, it mean area rocks or snow and values approaching -1 mean water which indicate glacial small water body.

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