JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Micro Climate Assessment of Glaciers of the Baspa Basin, Himachal Pradesh Using NCEP/NCAR Reanalysis Data

Dr.Devesh Saharan & Dr. Shweta Nehra
Assistant Professor, Govt. Dungar College, Bikaner (Raj.)

Abstract: Snow is a widespread global meteorological phenomenon that is recognized as an important component of the hydrological cycle. Snow and melt dominate regional climate and hydrology in many mountainous places across the world. Snow and glacier melt provide water to one-sixth of the world's population. The regional and temporal distribution of snow cover is also a valuable climate record for hydrologists, climatologists, ecologists, and other scientists and resource managers. Detailed snow distribution information can be useful in hydropower generation systems, water management, tourism, agricultural land use, forestry, civil engineering, river fisheries, fresh water supply for consumptive use, strategic planning, and a variety of other development activities in any region. It has the potential to improve local and regional management approaches.

Key Words: Glaciers, Himalayan glaciers, Micro Climate

1.Introduction

Permanent snow fields and glaciers at high altitudes in the Himalayan mountain ranges are a major national and global resource, containing the highest concentration of frozen fresh water outside of the Polar Regions. They are a vital supply of water, particularly for our perennial north Indian rivers during the critical summer season, because all rivers originating in the higher Himalayas receive almost 30-50% of their yearly flow from snow and glacier melt run off. As a result, scientific knowledge of the current or near future status of glacial dimensions is required to manage these perennial sources of water, as water availability is directly related to the development of our economy's agriculture, industries, energy, and domestic sectors, and can affect the nation's development, planning, and growth. The entire ecology and biodiversity of the Himalayas and foothills, including some extremely rare unique flora and wildlife, is dependent on snow melt water from these frozen reservoirs.

Himalayan glaciers are situated in the Tropical climate belt and they are spread between 36° N and 27° N. This mountain belt is near Tropic of Cancer and receives more heat than by Arctic and temperate climatic mountain belts. Therefore, Himalayan glaciers are more sensitive to climate change than other mountain glaciers in the world (Ahmad et al., 2004). This high level of sensitivity makes it essential to do micro level (sub-basin level) study to get accurate relationship between glacier behavior and local climate.

2.Study Area

The study area comprises of glaciated basin of Baspa river which is a part of Satluj basin and lies in wet zones of Himachal Pradesh in western Himalayas. The Baspa basin lies between 31°10’01.00”–31°30’17.16”N lat. and 78°10’26.52”–78°52’41.75”E long. and is located in the southeast corner of Kinnaur District, HP. It occupies an area of 1100 sq. km, with elevation ranging from 1770 to 6465 m asl. The Baspa river which rises near the Indo-Tibetan border, flows through Kinnaur, forming famous Baspa valley (it also known as Sangla valley) from Chitkul (3475 m) to the point of confluence with the Sutlej river i.e. at Karchham (1770 m asl).

The Baspa River is a fifth-order drainage basin formed by the Baspa-Bamak glacier. Melting snow and ice are significant contributions to the river. A substantial portion of this 75-kilometer-long valley is either agricultural land or woodland. The Baspa Valley is distinguished by steep snow peaks and 35 significant north and south-facing glaciers that encompass an aerial extent of 167 km. Valley glaciers and small permanent snow/ice fields are among the glaciers. These glaciers had erosional and depositional geomorphic characteristics, indicating that the valley was active after the glaciers melted.

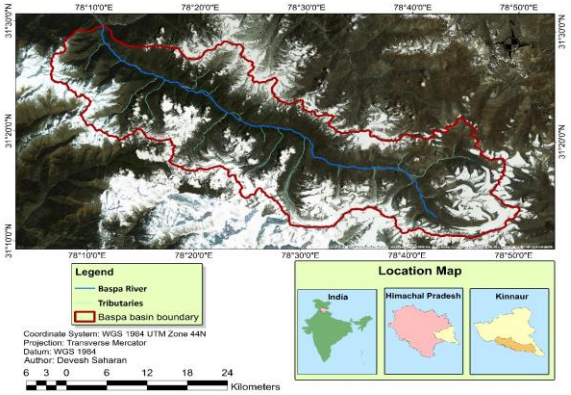


Figure 1. Location map of Baspa Basin, Kinnaur District, Himachal Pradesh.

Karu, Shanchay, Jorya Garang, Janpa Garang, Nardu Garang, Shaune Garang, Hurba Khad, Rokti Khad, Shaung Khad, and Baura Khad are the left bank tributaries of Baspa. The streams that join Baspa on its right bank are smaller than the streams on its left side. Tumar, Rimdarang, Shilpya, Shushang, Mangsa, and Gor Garang are some notable tributary streams on the right bank. The basin has been geomorphologically subdivided into river terrain, fluvio-glacial terrain, alpines/meadows, and rocky terrain.

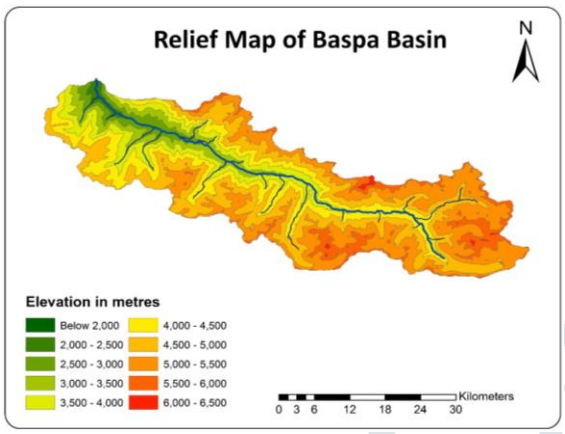


Figure 2. Relief map of Baspa basin showing increasing trend in elevations from west to east.

3.Materials and Methodology

Obtaining snow cover information on repetitive basis from vast snow-covered areas of Himalaya using conventional snow courses and mapping techniques are very difficult due to high altitude, inaccessible and rugged mountain terrain and it only provide the point measurements of snow.

Alternatively, remote sensing offers a new and valuable tool for obtaining snow data. In the recent years, this technique has emerged as a popular viable substitute for real-time, year-round and large spatial coverage for monitoring and process studies over vast, rugged and remote areas [7, 8].

In this research work, a methodology based on the NDSI index obtained from radiometrically corrected images with a threshold > 0.4 is used to determine snow cover over a large and heterogeneous area of Baspa basin by means of remotely sense data of Landsat-8 OLI (Operational Land Imager), Landsat 7 ETM+ and Landsat 5 TM Surface Reflectance product images.

A set of 10 Landsat 8 OLI Surface Reflectance product images of path 146 and rows 38 downloaded from Earth Explorer of USGS for Sept-2014 to May-2015 have been chosen to perform seasonal snow cover study. For temporal snow cover study a set of 6 images of surface reflectance product of Landsat 8 OLI, Landsat 7 ETM+ and Landsat 5 TM, related to peak ablation period of the concerned year has been used. Cloud-free images have been selected to cover all months of the year to consider different seasonal situations.

The methodology used in this research work for determining the snow cover area and dynamics of snowline of study area is described in the following steps:

• Preparation of base map by delineation of Baspa river watershed boundary using Arc Hydro Tools with the help of ASTER GDEM v 2.0.

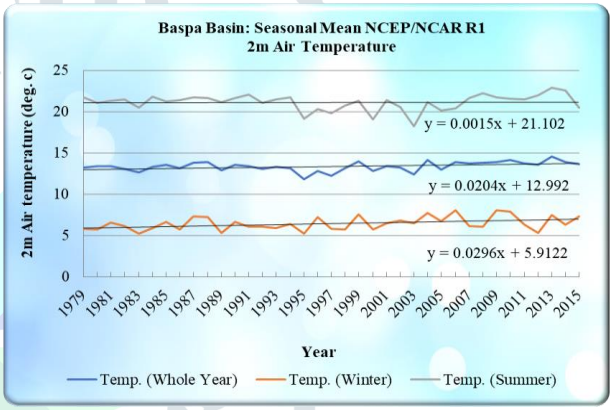
• Image pre-processing (a) Ortho-rectification (b) Radiometric Calibration.

• Computation of various Spectral Indices (NDVI, NDWI etc.) and Masks (masks for vegetation, cloud, water body, shadows, rocks etc.)

• Computation of NDSI using Green and SWIR band of Landsat Images.

4.Results and Discussions

The climate of Baspa basin is governed by its unique geographical location, altitude and topography. The climate is varying with elevations but as a whole climate of the basin is cold and temperate and classified as Dsb by Köppen and Geiger. The weather here can be divided into four seasons, Pre-monsoon (April-June), monsoon (July-September), Post-monsoon (October-December) and winter (January-March). This is typical climate of monsoon-arid transition zone where both the summer Asian monsoon and the winter mid-latitude westerlies influence the climate. Hence, two distinct precipitation regimes are prevalent in this basin. The Baspa basin is comparatively drier than the southern slopes of the Dholadhar range. This is the leeward effect of the main ridge mostly oriented west - east, thus preventing part of the monsoon flux from reaching the valley.



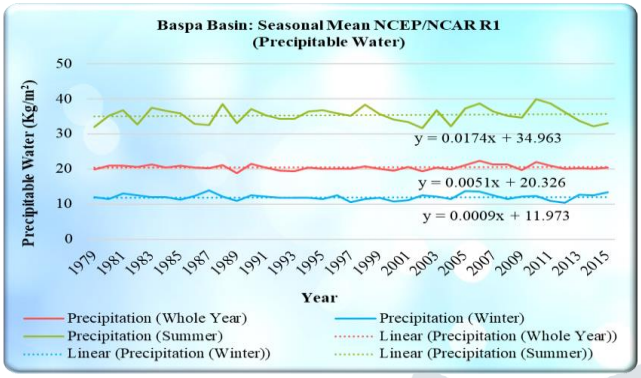
Source: NCEP Reanalysis Derived data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd

Figure 3: Inter- annual seasonal mean temperature variation pattern from 1979 to 2015 at Baspa basin.

Trends in annual, winter and summer seasonal mean temperature were investigated for Baspa basin from 1979 to 2015. The records have been analysed by fitting linear trend line to assess the behaviour of temperature during a period of 36 years. The analyses show that mean annual, winter and summer temperatures during 1979–2015 had a slightly increasing trend. Moreover, if we compare trend line equations, it shows that the winter temperature has more increasing trend over the period than the summer temperature. Infact summer temperature is more or less stagnant over the period. Whatever increasing trend has been shown by annual temperature is largely contributed by winter temperature.

The analyses show that mean annual, winter and summer precipitation during 1979–2015 had a marginal increasing trend. Moreover, if we compare trend line

equations, it shows that the summer precipitation has more increasing trend over the period than the winter precipitation. Infect winter precipitation is more or less stagnant over the period. Whatever increasing trend has shown by annual precipitation is largely contributed by summer precipitation.



Source: NCEP Reanalysis Derived data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd

Figure 4: Inter-annual seasonal mean precipitation variation pattern from 1979 to 2015 at Baspa basin.

When we compare the above results of this study with the meteorological data which is obtained from Rakcham observatory, located at 3050 m.a.s.l then we found a close impact of these two meteorological variables on the glacier recession.

Impact of glacier ice mass loss due to ice melting is chiefly marked in the snout and lower lateral margins of the glacier. These regions of glacier are good indicators for assessing the impact of micro climate on glaciers.

5.Conclusions

Cryosphere related disasters such as glacier/snow melt floods, glacial lake outburst floods (GLOF), ice jam floods, avalanches etc. are directly related to snow accumulation or ablation pattern of the region. Therefore, enhanced knowledge about the behavior of glaciers or snow cover area of the region can contribute to adapted disaster management strategies in the region which potentially represent serious impacts while interacting with human systems. Again, the local economy of these regions is also based mainly on Agriculture and Tourism, which have strong positive correlation with snow cover and glaciers of the region.

Snow melt fed rivers of Himalayas have enormous hydro- power potential and at present many hydro-power projects are working in this region. The fate of these power projects depends upon availability of snow melt runoff water. Therefore, it is essential to study and monitor Himalayan glaciers and snow cover for nation's energy security.

References

[1] Barnett, T. P., Adam, J. C. and Lettenmaier, D. P. 2005. Potential impacts of a warming climate on water availability in snow-dominated regions. *Nature* 438, 303–309.

[2] Kulkarni, A. V. *et al.*2007. Glacial retreat in Himalaya using Indian Remote Sensing satellite data. *Curr. Sci.* **92,** 69–74.

[3] Salomonsona, V.V., and I. Appel. 2004. Estimating fractional snow cover from MODIS using the normalized difference snow index. *Remote Sensing of Environment* 89: 351–360

[4] Stieglitz, M., A. Ducharne, R. Koster, and M. Suarez. 2001. The impact of detailed snow physics on the simulation of snow cover and subsurface thermodynamics at continental scales. *Journal of Hydrometeorology* 2(3): 228–242.

[5] Solberg, R. et al. Multi-Sensor / Multi-Temporal Approaches for Snow Cover. *EARSeL eProceedings.*

[6] Quincey, D. J. et al. 2007. Early recognition of glacial lake hazards in the Himalaya using remote sensing datasets. *Glob. Planet Change* 56, 137–152.

[7] Konig, M. et al. 2001. Measuring snow and glacier ice properties from satellite. *Review of Geophysics* 39/1, 1-27.

[8] Bhushan S. Deota1,*, Y. N. Trivedi , A. V. Kulkarni , I. M. Bahuguna and B. P. Rathore , RS and GIS in mapping of geomorphic records and understanding the local controls of glacial retreat from the Baspa Valley, Himachal Pradesh, India, CURRENT SCIENCE, VOL. 100, NO. 10, 25 MAY 2011

[9] Kulkarni, A. V. and Bahuguna, I. M., Role of satellite images in snow and glacial investigations. Geol. Survey of India Spec. Publ., 2001, 53, 233–240

[10] Hall, D.K., R.E.J. Kelly, J.L. Foster, and A.T.C. Chang. 2005. Hydrological applications of remote sensing: surface states: snow. *In Encyclopedia of hydrological sciences*, ed. M.G. Anderson, 34–56.