

A TECHNICAL REPORT ON THE MONITORING OF GLACIAL LAKES/ WATER BODIES IN SATLUJ CATCHMENT USING RS AND GIS TECHNIQUES (2022)



Submitted to

**Satluj Jal Vidyut Nigam Ltd. (SJVNL)
DAM (O & M) NJHPS, Nathpa, Kinnaur, Himachal Pradesh**

Prepared by

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DOCUMENT CONTROL AND DATA SHEET

Report Number	SCSTE/HPSCCC/Const/SJVNL/2022
Month & Year of Publication	March, 2023
Title	Monitoring of Glacial lakes/water bodies in the Satluj catchment using RS & GIS Techniques
Type of Report	Scientific Report
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Abstract	The recent trends of climatic variations over the Himalayan region led to undergo various changes in the cryospheric regimes. Various in-situ as well as space based studies reveals that spatial extent of majority of glaciers is changing very fast leading to the formation of moraine dammed lakes or the supra glacier lakes over the Himalayan regions. Susceptibility of the State of Himachal Pradesh to vagaries of these climatic variations is now been well documented and appreciated. Scientific insight gained from the analysis of multi spectral satellite images carried out by various authors suggests that there has been a considerable increase in the number of such lakes in each basin in the State of Himachal Pradesh, posing potential threat to the infrastructure and human life thriving in the downstream areas of many drainage systems originating from the snow clad mountains ranges in the State and can be disastrous in the event of any break due to one or the other reasons. As per one of the studies carried out in Himachal Himalaya, the number of such lakes has been found to be on the increasing side in the present era of climatic variations. Based on the study carried out using LISS III satellite data for the year 2019 for H.P., a total of 242 lakes in Chenab basin, 93 in Beas Basin, 38 in Ravi and 562 lakes in Satluj Basin have been delineated in Himachal Himalaya and adjoining Tibetan Himalaya. The present study has been carried out using AWiFS, LISS III and LISS IV and Sentinel satellite data for the year 2022 in the Satluj catchment of SJVNL Hydro Electric Project. The interpretation was carried out using ERDAS Imagine 9.3 software. The results obtained for the year 2022 have been compared with that of 2021 to assess the temporal changes in the water spread of the lakes. Regular monitoring of Parechhu Lake was also been done separately using LISS IV and LISS III data from April to September during 2022. Based on the AWiFS satellite data for 2022, 414 lakes could be delineated comprising 58 from Spiti, 59 from Lower Satluj and 297 from Upper Satluj basin. Likewise from LISS III data total number of lakes /wetlands mapped varies from 769 (2018) to 562 (2019) to 993 (2020) to 880 (2021) to 995 (2022) in the Satluj catchment during 2022. Using LISS IV satellite data , a total of 1953 lakes/high altitude wetlands have been mapped in the Satluj catchment in comparison to 1632 (2021) and 1359 (2020). Basin wise distribution of 1953 lakes /wetlands reveals that 368 (19%) lakes are from Spiti basin, 250 (13%) from the Lower Satluj basin and 1335 (68%) from the Upper Satluj basin i.e. basin 3, out of which 37 lakes have been classified as high-altitude wetlands and the remaining 1916 as from the glacial origin. Water bodies have also been observed along the river course which can be potentially vulnerable and needs regular monitoring by virtue of their size, location and nature. In view of the recent events in Uttrakhand Himalaya, a proper monitoring of all such lakes is very much essential in the Himalayan region in view of the recent NDMA Guidelines for the Management of GLOFs and LLOFs in order to avoid any eventuality like in Uttrakhand in future, which will not only save the precious human life but also the public and Govt. property.
Security classification	Unrestricted

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ACKNOWLEDGEMENT

The HP Council for Science Technology & Environment, Govt. of H.P. acknowledges Satluj Jal Vidyut Nigam Ltd. for entrusting the study for monitoring of all glacial lakes/water bodies in the Satluj Catchment as part of their disaster preparedness program in their projects. The author is also thankful to the Additional Chief Secretary (Env, S & T) Govt. of H.P., Member Secretary (EC) and the Joint Member Secretary, H.P. Council for Science, Technology & Environment, HIMCOSTE for constant support and allowing us to undertake the investigation as part of the disaster management activities in the State Center on Climate Change of the H.P. Council for Science Technology & Environment (HIMCOSTE) using space technology.

A TECHNICAL REPORT ON THE MONITORING OF GLACIAL LAKES/WATER BODIES IN SATLUJ CATCHMENT USING RS, GIS & IMAGE INTERPRETATION TECHNIQUES

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Monitoring of Glacial Lakes/Water Bodies in Satluj Catchment using Remote Sensing & GIS Techniques

1. Introduction:

Himachal Pradesh a small hilly state in the Western Himalayan Region has made a remarkable progress over the years in almost all sectors withstanding the challenge posed by the specificities such as fragile topography, hostile climate, inaccessibility, scattered habitations, marginal and small land holdings. Being predominantly a mountainous state of the north-western Himalaya, it shares many common watersheds with the neighboring region of Tibet. It represents a unique physio-climatic and ecological profile, such that it can be easily taken as a representative sample of Himalayan Eco-System as a whole. The perpetual snow clad mountain ranges are followed by alpine meadows acting as sponge for regulating the snow and glacier melt run-off into five major river systems i.e. Chena, Ravi, Beas, Satluj and Yamuna that drain the Middle and Lower Himalayan ranges and after piercing through softer sediments of Shiwalik hills before debouching into the plains of Punjab.

Based on the agro climatic zonation, the State has been divided into four distinct zones viz. Sub-Mountain-Low Hills Sub tropical, Mid Hills- Sub Humid, High Hills -Temperate wet and High Hills -Temperate Dry Zones.

1.1 Zone-I: Sub –Mountain-Low Hills, Sub tropical

The terrain in this part of the zones is characterized low relief mountains. Rainfall varies between 800mm to 1600mm. The areas suffers perpetual summer shortage of water due to high run off. The valleys are generally narrow with flat areas where agriculture grows. The altitude ranges between 350 to 650m amsl and includes areas falling in Chamba, Kangra, Hamirpur, Sirmour and Bilaspur districts. It occupies about 33% of the total geographical area of the State and 33% of the cultivated area.

1.2 Zone-II: Mid Hill, Sub –Humid

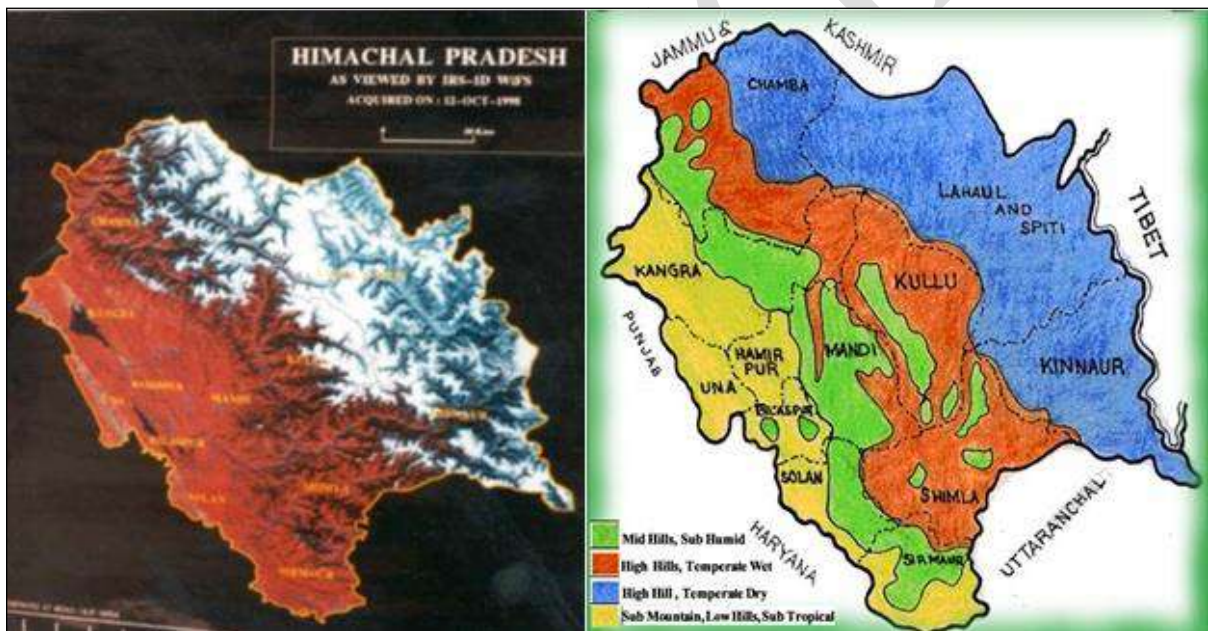
This zone comprises of areas of Lesser Himalaya, south west of the Dhauladhar and the valley areas of Ravi, Beas and the Chenab Rivers. It occupies about 32% of the total geographical area and 53% of the total cultivated area. Altitude ranges between 651 m to 1800m amsl. Average rainfall is about 1800mm.

1.3 Zone-III: High Hills, Temperate Wet

This zone occupies 25% of the total geographical area and 11% of the cultivated area of the State. Altitude ranges between 1801m to 2200m amsl. The annual rainfall ranges between 1000 -1500mm. This zone comprises of Chamba, Kangra, Mandi, Sirmour and most parts of the Shimla and Kullu districts. The zone is characterized with humid temperate climate.

1.4 Zone-IV: High Hills, Temperate Dry

The Trans –Himalayan zone lying between Great Himalayas and the Zaskar Ranges, altitude is generally above 2200m amsl and due to the rain shadow effect of the Great Himalayan Range, the annual rainfall is less than 200mm. This zone occupies 8% of the total geographical area and 3% of the cultivated area of the State. This zone includes areas of Lahaul & Spiti and Kinnaur districts and Pangi Tehsil of Chamba and northern parts of the Kullu districts of the State.



(Source: Department of Agriculture, H.P.)

Mountains cover close to 20 percent of the Earth's surface, providing a home to approximately one-tenth of the global human population. With their steep and varied topography, and distinct altitudinal ecological zones, mountains support a high diversity of species and ecosystems and a large percentage of global endemic species. Mountainous areas throughout the world provide essential resources such as timber, minerals, recreational escapes, and a significant portion of the freshwater consumed by humans. They are rich sites for cultural diversity. Mountains have a special role in showing the effects of climate change. The Himalayan ecosystem has 51

million people who practice hill agriculture and whose vulnerability is expected to increase on account of climate change.

The recent IPCC reports warns that mountain ecosystem is much more susceptible to the vagaries of climate change than the other regions of earth and poses serious challenge to the people of mountain regions in dealing with this global threat for sustaining their economic and social development. The state of Himachal Pradesh, which forms a part of the Northwestern Himalaya, is environmentally fragile and ecologically vulnerable. Occurrence of natural hazards emanating from the effects of climatological variations are a matter of immediate concern to the state of Himachal Pradesh, as every year the state experiences the fury of nature in various forms-like cloudburst, flash floods, landslides, snow avalanches droughts etc. The fragile ecology of the mountain state coupled with large variations in physio-climatic conditions has rendered it vulnerable to vagaries of climate. The incidence of cloudbursts in the last few years has baffled both the meteorologist and the common man equally. Notwithstanding, continuous efforts made by the Government to cope with such hazards through relief and rehabilitation measures, the recurrence of uncertainties continue to inflict widespread harm and damage to human life as well as property. The roads that are the state's lifeline are repeatedly damaged, blocked or washed away by one or the other acts of nature. The Snow and glaciers which are considered to be best indicators of changing climate have been affected by the rising temperature throughout the Himalayan belt. It has been observed that the estimates on the magnitude of glacial retreat and their impact on natural resources have been varying considerably. However the impact of climate change and rising temperature has been noticed even by a common man in far flung parts of the Himalayan ecosystem. Depletion of small glacierets in the Himachal Himalaya which were providing the sustained discharge to many rivulets for irrigation to agriculture fields and sustaining the water resources in downstream areas has been reported by the villagers.

2. Background:

Mountain ecosystems harbor a wide range of significant natural resources and play critical role in the ecological and economic processes of the Earth. Deforestation, landslides, land degradation, desertification and Glacier Lake Outbursts Flooding (GLOF) are some of the common environmental issues in the mountain regions. The major challenge currently faced by the mountain environment is the escalation of these issues through atmospheric as well as man-induced changes.

Mountain systems are particularly sensitive to climate changes. Since industrialization, human activities have resulted in steadily increasing concentrations of greenhouse gases-particularly carbon dioxide (CO₂), methane (CH₄), chlorofluorocarbons (CFCs) and nitrous oxide (NO_x)- in the atmosphere. As these gases absorb some of the radiation emitted by the Earth rather than allowing it to pass through the atmosphere to space, there is general consensus that the Earth's atmosphere is warming.

The fifth Intergovernmental Panel on climate change (IPCC 2013) report states with 95 percent confidence that humans are the main cause of the current global warming. Most of the observed increase in global average temperatures since the mid-20th century is very likely [90 percent confidence] due to the observed increase in anthropogenic greenhouse gas concentrations. Global warming is the rise in the average temperature of Earth's atmosphere and oceans since the late 19th century and its projected continuation. Since the early 20th century, Earth's mean surface temperature has increased by about 0.8 °C (1.4 °F), with about two-thirds of the increase occurring since 1980. Warming of the climate system unequivocal, and scientists are 95-100% certain that it is primarily caused by increasing concentrations of GHGs produced by human activities such as the burning of fossil fuels and deforestation. Climate model projections were summarized in the 2007 Fourth Assessment Report (AR4) by the (IPCC). They indicated that during the 21st century the global surface temperature is likely to rise a further 1.1 to 2.9 °C (2.0 to 5.2 °F) for their lowest emissions scenario and 2.4 to 6.4 °C (4.3 to 11.5 °F) for their highest.

Analysis of the temperature trend in the Himalayas and its vicinity shows that temperature increases are greater in the uplands than lowlands areas. Regional changes in climate have already affected diverse physical and biological systems in many parts of the mountain regions. Shrinkage of glaciers, thawing of permafrost, late freezing and earlier break up of ice on rivers and lakes, pole ward and altitudinal shifts of plant and animal species, declines of some plant and animal population, and earlier emergence of insects have been observed (IPCC, 2001). Climate influences weathering processes, erosion, sediment transport, and hydrological conditions. It also affects the type, quantity, quality, and stability of vegetation cover and, thereby, biodiversity. Mountain systems are particularly sensitive to climate changes. Small changes in climate can produce significant regional or larger-scale effects. In particular, marginal environments are under high stress. Small changes in water availability, floods, droughts, landslides and late frosts can have drastic effects on agriculture economics. The most likely scenario in the mountain

environment due to climate change will be as that the Mountain environments are likely to be among the most severely impacted ecosystems as a result of climate change.

- A warmer climate will cause lower-elevation habitats to move into higher zones encroaching on alpine and sub-alpine habitats.
- High-elevation plants and animals will lose habitat area as they move higher with some 'disappearing' off the tops of mountains. Rising temperatures thus increase the importance of connections between mountain areas.
- Rising temperatures may cause mountain snow to melt earlier and faster in spring shifting the timing and distribution of runoff. This in turn affects the availability of freshwater for natural systems and for human uses. Earlier melting leads to drier conditions with increased fire frequency and intensity.
- Glaciers around the world have been shrinking. Retreating glaciers decrease the reliability of water flows and change habitats.

2.1 Changing weather Pattern over the Himalayan Region:

Both precipitation and temperature are considered significant indicators of State of Climate on account of their relation with earth's energy system. The hilly, undulating terrain with large relative relief variations experience significant variability both in precipitation and temperature. Comprehensive studies have been carried out by (Bhutiyan et.al. 2007) on long term trends in maximum, minimum and mean annual air temperature across the north western Himalayas during the 20th century. The studies published in a series of research papers in international journals such as International Journal of Climatology, Climate change and Current Science, have established that the north-western Himalayan region has 'warmed' significantly during the last century at a rate, which is disturbingly higher than the global average. Effects of climate change are evident on decreasing winter snowfall component in total winter precipitation on the windward side and some portions of the leeward side of the Pir Panjal Range since 1991, leading to delay in onset of winter and early spring and effective reduction in snowfall duration period. Coupled with rising summer temperatures, the glaciers are affected and they are in recession mode. This has given rise to a change in the nature of natural hazards in the area. Earth-flows and mud-flows, which were hitherto uncommon occurrences in the area, have been observed

to occur in high altitude regions (>4500 m) over the glaciers. Consequently, these factors in combination have altered the discharge patterns in the Himalayan Rivers leading to an overall decreasing discharge in majority of NW Himalayan Rivers. These changes are attributed to enhanced anthropogenic (human related) activities in this region

In one of the studies carried out by (Bhutiya et.al.) reveal that significant rise in the air temperature in the NW Himalayan region by 1.6°C in the last century with winter warming at a faster pace. The study included observations from Shimla station for the period (1901-2002) which indicates increasing trend in temperature at (significant 95% confidence level) and this trend has been consistent in case of mean maximum, mean minimum and mean annual temperatures. The warming is particularly conspicuous during winter season. Out of three stations which were monitored i.e. Leh, Shimla and Srinagar: Shimla experienced higher rate of warming in comparison to the other two stations. Analysis on decade to decade rates demonstrates that barring the decade of 1911-1920, the temperature rose comparatively at a lower rate till 1930, which period was followed by a cooler episode of decreasing or insignificant rise in temperatures. They further observed that real warming with modest rate manifested only during the decade of 1961-1970 and with an exception of 1981-1990 decade continued till the end of century. Warming rate was higher during the period from 1991-2002 as compared to the earlier decades and gross rise in the mean air temperature during 1980-2002 periods in the north western Himalaya as a whole was about 2.2°C .

Rates of increase of winter, monsoon and annual air temperature in $^{\circ}\text{C}$ in last century computed by linear regression slope (Bhutiya et. al.2007)

Station	Season	Winter bX100	Monsoon bX100	Annual bX100
Shimla	Mean Maximum	2.6*	2.8*	2.4*
	Mean Minimum	1.0*	-0.01	0.5
	Average Annual	1.8*	1.5*	2.0*
Srinagar	Mean Maximum	1.1*	0.2*	0.5*
	Mean Minimum	1.2*	0.2	1.0*
	Average Annual	1.1*	0.2	0.8*
Leh	Mean Maximum	1.3*	1.0*	1.7*
	Mean Minimum	0.4*	1.1*	1.3*
	Average Annual	0.6*	1.1*	1.6*
NW Himalaya	Mean Minimum	1.7*	0.4*	1.1*
	Average Annual	1.7*	0.9*	1.6*

(*Significant at 95% confidence level)

The other interesting observation that was recorded from the short term analysis which included 5 stations data from different altitudinal zones in Himachal indicates that the rate of increase in maximum temperature at higher altitudes was more than at the lower altitudes in the last century and the north western Himalayan region has warmed significantly higher than the global average.

Likewise the results of the trend analysis of annual, winter and monsoon precipitation in the Northwestern Himalaya (Bhutiya et al 2009) are as under:

Sr.No.	Station	Data Span	Trend Analysis	
			Mann-Kendall's non-parametric test	Linear regression coefficient 'b'
a)	Total Annual precipitation			
1	Shimla	1866-2006	(-)*	(-)*
2	Srinagar	1901-1989	(+)*	(+)*
3	Leh	1901-1989	(-)*	(-)*
4	NWH	1866-2006	(-)*	(-)*
b)	Total winter precipitation			
1	Shimla	1866-2006	(-)*	(-)*
2	Srinagar	1901-1989	(+)*	(+)*
3	Leh	1901-1989	(-)*	(-)*
4	NWH	1866-2006	(+)*	(+)*
c)	Total Monsoon precipitation			
	Shimla	1866-2006	(-)*	(-)*
	Srinagar	1901-1989	(-)*	(-)*
	Leh	1901-1989	(-)*	(-)*
	NWH	1866-2006	(-)*	(-)*

(+) increasing trend, (-) decreasing trend,

* Significant at 95% confidence level.

Similarly the trend obtained for the snow fall at different altitude in Himachal Pradesh as per the study carried out by (Bhutiya et al. 2007) are as under:

Sr. No.	Station	Snowfall Depth	
		Time period	Time period
1	Bhang	(-) (1974-2005)	(-)*(1991-2005)
2	Solang	(-) (1982-2005)	(-)*(1991-2005)
3	Dhundi	(-) (1989-2005)	(-) (1991-2005)
4	Gulmarg	(+) (1976-2005)	(-) (1991-2005)
5	Haddan Taj	(-) (1974-2005)	(-) (1991-2005)
6	Kanzalwan	(-) (1973-2005)	(+) (1991-2005)
7	Patseo	(-) (1983-2005)	(-) (1991-2005)

(+) increasing trend, (-) decreasing trend,

* Significant at 95% confidence level.

The increasing winter temperature at different stations in NW Himalayas as per (Bhutiya et al 2007) area as under:

Winter mean air temperature in the last two decades in Himachal Pradesh

Sr. No.	Station	Mean Max.in $^{\circ}$ C	Mean Mini. In $^{\circ}$ C	Average winter $^{\circ}$ C
1	Bhang (2192)	4.0	1.8	3.8
2	Solan (2480)	4.4	2.0	3.8
3	Dhundi(3050)	5.6	1.0	3.2
4	Patseo (3800)	3.0	-3.0	0.0
5	Shimla(2200)	2.8	2.2	2.4
Average		3.2	0.8	2.2

In a study by Bhutiya et al. (2009) on climate change and the precipitation variations in the northwestern Himalaya based on precipitation data from 1866-2006, no change in winter precipitation was observed but significant decreasing trend in the monsoonal precipitation was captured. Negative relationship between mean winter air temperature and snow fall amount recorded at different meteorological stations during this period reveal slow effect of rising temperature on the decreasing snowfall component in total winter precipitation and reduction in effective duration of winter on the windward side of Pir Panjal Range. Interestingly meteorological stations of Himachal Pradesh like Shimla, Bahang, Solang and Patseo which were part of this study were all located on the windward side of the Pir Panjal Range. The trend analysis of annual, winter and monsoonal precipitation of Shimla indicate a decreasing trend as opposite to the significant rising trend in winter, monsoon and annual temperatures. The cumulative winter fresh snow fall depths and temperature data records for the last three decades (prior to 2006) at Bahang, Solang, and Dhundi in Himachal Pradesh show significant trends from 1991-2005 onwards which period also recorded increase in winter air temperature.

2.2 Glaciation in the Himalaya:

During its geological history, the earth has experienced alternate cycles of warm and cold climates. During cold climate, glaciers and ice sheets have formed on the surface of the earth. Geological evidence suggests that the earth has experienced glaciations during, Perm-Carboniferous and in the Pleistocene period (Embleton and King, 1975). Precambrian tillites and boulder-beds are reported from many parts of the world, such as Scotland, U.S.A. Clear evidence of Carboniferous-Carboniferous ice age is also established in India and South Africa. The Carboniferous-Carboniferous glaciation was followed by Mesozoic era, during which the world temperature was higher than that of today and no evidence of glaciation was observed in the

geological formations of that period. In Cenozoic era, large-scale glaciation was experienced, which includes glaciation during Pleistocene and Quaternary periods (Smith *et al.*, 2005). It has also influenced the present distribution of glaciers on the earth's surface. During Pleistocene the earth's surface had experienced repeated glaciation over a large land mass. During the peak of glaciation, the area covered by the glaciers was 46 Million sq. km. (Embleton and King, 1975). This was more than three times the present ice cover of the earth. Available data indicates that during the Pleistocene, the earth has experienced four or five glaciation periods separated by an interglacial periods. During an interglacial period, climate was warmer and deglaciation occurred on a large scale. The most recent glaciation reached its maximum advance about 20,000 years ago when the Himalayan snow line was depressed from 600 to 1000 meters lower than the present elevation due to fall of temperatures by 5 to 8°C. At present total glaciated area on the earth is about 14.9 million sq. km. Out of this 2.5 million sq. km is located in Arctic and 1.7 million sq. km in the Greenland ice sheet (Flint, 1971). The remaining 0.7 million sq. km area is distributed in the other parts of the World. Himalaya has one of the largest concentrations of glaciers outside the Polar Regions and some estimates suggest that the number could be as high as five thousand (Kulkarni and Bahuguna, 2001).

In the Himalaya, glaciers cover approximately 33000 sq. km area, and this is one of the largest concentrations of glacier-stored water outside the Polar Regions. Melt water from these glaciers forms an important source into run-off of North Indian Rivers during critical summer months. This makes these rivers perennial and has helped to sustain and flourish the Indian civilization along the banks of Ganga and Indus. This supply is available during dry periods and naturally regulates the flow of large rivers thus compensating extremes of precipitation. Glacial activity also generates sediments. However there have been several evidences in recent geological history about the glacier mass fluctuations resulting in the stream runoff originating from them. Stream runoff is an important component in planning of water resources and micro and mini hydroelectric projects. Glacier mass fluctuations are also indicators of global climatic changes. In the context of the Himalayan glaciers, which are source of many giant north Indian rivers, systematic monitoring of Himalayan glaciers is of paramount importance in view of their large number and area covered.

Global warming has already caused a significant glacier ice loss since the Little Ice Age (AD 1550-1850) (Denton and Hughes, 1981) resulting in both glacier retreat and thinning

(loss of ice volume). Many glaciers in the Himalayan mountain chain are reported to be gradually retreating (Mayeswki and Jeschke, 1979; Li *et al.*, 1998; Kulkarni and Bahuguna, 2002; Raina, 2004; Kulkarni and Alex, 2003; Kulkarni *et al.*, 2005; Kulkarni *et al.*, 2006). Catastrophic natural processes triggered by these glacier changes were responsible for considerable death and destruction throughout the mountains. These processes included ice avalanches, landslides and debris flows, outbursts from moraine-dammed lakes and also outbursts from glacier dammed lakes. Glacier avalanches have occurred where glaciers have retreated up steep rock slopes. Sources of debris flows are frequently moraine complexes exposed during glacier retreat, which may be ice-cored. Outbursts from moraine dammed lakes result from the catastrophic breaching of the moraine dam - a process that is commonly initiated by glacier avalanches - generated waves that overtop the moraine. Himalayan and Trans-Himalayan glaciers are in general state of retreat since 1850 AD. Most of the Himalayan glaciers are covered by debris, which slows down their melting.

2.3 The Present Scenario:

It is estimated that the Himalayan glaciers provide around $8.6 \times 10^6 \text{ m}^3$ of water annually. The three great rivers of India-the Indus, the Ganges, and the Brahmaputra collectively provide close to 50% (320 Km^3) of the total country's utilizable surface water resources (690 Km^3). Since the mid-1970s the average air temperature measured at 49 stations of the Himalayan region rose by 1° C with high elevation sites warming the most (Hasnain 2000). This is twice as fast as the 0.6° average warming for the mid -latitudinal northern hemisphere over the same time period (IPCC 2001b), and illustrates the high sensitivity of mountain regions to climate change (Oerlemanns et.al, 2000).

Monitoring the snout of glaciers using in-situ and remote sensing methods has received the bulk of attention. More than 50 glaciers have been monitored over different time periods. In consonance with the global trend, the majority of glaciers in the Indian Himalaya have been retreating since the recording began around the middle of the nineteenth century (Raina 2009). Karakoram Himalaya is an exception to this trend (Hewitt, 2005): Fowler and Archer, 2006). There are temporal and spatial variations in the rates of retreat, the rates varying from $< 5 \text{ m/year}$ to about 50 m/year (Raina and Srivastava, 2008). The retreat was generally around $5\text{-}10 \text{ m/year}$ till up to late 1950s: the rate of retreat increased during mid-seventies, which continued up to mid-nineties, touching a value of $25\text{-}30 \text{ m/year}$ in some glaciers. It is contended by some that there is a general

slowing down in the rate of retreat in the late nineties and in the decade of 2000(Raina, 2009; Bali et al., 2010). But there is no consensus (Naithani et al, 2001, Bhambri et al, 2011a).

Based on the various studies carried out, it has been found that Himalayan glaciers are in a state of general retreat since 1850 (Mayewski & Jeschke 1979). The Khumbu glacier, a popular climbing route to the summit of Mt. Everest, has retreated over 5 km from where Sir Edmund Hillary and Tenzing Norgay set out to conquer the world's highest mountain in 1953. Gangotri glacier which is one of the best documented glaciers in the Indian Himalaya as far as its snout position demarcation is concerned. The snout of the glacier "Gaumukh" is about 18KM from the holy shrine of Gangotri. The snout of the glacier has been under the state of continuous recession since 1935 (Auden, 1937). GSI has monitored the snout of the glacier since 1935 till 1996. The data reveal that the glacier has retreated by 1147m, with an average rate of 19m/year between 1935 and 1996. The total area vacated by the glacier during 1935 to 1996 is estimated to be 5, 78,100 m² or 0.58Km² (Srivastava 2004).

Bara Sigri glacier a north westerly facing glacier in the Chandra valley with surface area of about 137 Sq. km. and 27 Km length is one of the largest glaciers in Himachal Himalaya. Snout of the glacier, at present, is far away from the Chandra River, but in times past, as is revealed by the glacier landforms and the trim line, it must have extended right up to the present river valley. This glacier , as per the available records, had in the year 1793 AD, extended up to the river, and, in fact had blocked the course of the Chandra river (Egerton ,1864).Average retreat and the area vacated by the glacier along snout front, over the last nine decades-1906 to 1995 is 4.33 sq. km. During 1906-1956, the area vacated was the highest till data (3.44sq.km) and during the period 1963-1977 it was at the minimum (0.24sq.km.) and could be attributed to the positive trend in the snow cover variation in the Himalayas that resulted in the positive mass balance recorded by some of the glaciers in the adjacent areas of Himachal Pradesh. The glacier recession once again accelerated during 1977-1995 and likewise could be attributed to the conditions that led to the negative trends in the snow cover variation and the mass balance recorded in adjacent Chhota Sigri glacier by the DST teams and in adjacent parts of Himachal Pradesh by the GSI.

Zemu glacier is the largest glacier in the eastern Himalayas with a total surface area of about 42 km².and a linear length of about 20 km. The glacier, as compared to the snout position, as fixed by La Touche, revealed a linear shrinkage of about 414m between 1909 and 1965 (Raina

& Bhattacharya, 1973). This glacier was under continuous observation of the GSI teams from 1977 to 1986 and is reported to have vacated an area of about 52,443m² along the snout front from 1965 onwards. There have, however, been periods -1979-80 and 1984-85, when the glacier snout has been reported to have shown slight advance.

At present the rivers have shown 3-4% surplus water due to a 10% increase in the melting of the glaciers of the western Himalayas, and a 30% increase in the eastern Himalayan glaciers. But, after 40 years, most of these glaciers will be wiped out and then South Asia will have water problems. In March 2002, UK's Department of International Development funded a project called Sagarmatha (Snow and Glacier Aspects of Water Resources Management in the Himalayas) to assess the impact of deglaciation on the seasonal and long term water resources in snow-fed Himalayan rivers. This study was vital for policy-makers and especially those working on interlinking of rivers, as the flows available in rivers are likely to change dramatically over the decades depending on the region. The study which reveals some major facts about the melting mountain majesties and warming glaciers, is an eye-opener.

In Upper Indus, the study sites show initial increases of 14% and 90% in mean flows over the next few decades which will be followed by decreasing flows by 30% and 90% of baseline in the subsequent decades in a 100-year scenario. For Ganges, the response of the river near the glacier in Uttarkashi is different from downstream Allahabad. At Uttarkashi, flows peak at between 20% and 33% baseline within the first few decades and then recede to 50% of baseline after 50 years.

Near the source of the Brahmaputra, there is a general decrease in decadal mean flows for all temperature scenarios as glaciers are few in the area and flows recede as the permanent snow cover reduces with increasing temperature. The catchments in the eastern Himalayas which benefit from high precipitation of the summer monsoon, are more vulnerable to impacts of deglaciation than those in the west where the monsoon is weaker.

In short, the deglaciation in the Himalayas is influenced by various factors, climatic, regional etc. However, the main underlying factor is ever increasing warming on the mountains, chiefly because of excess emission of greenhouse gases and Asian brown cloud. The ongoing ice melting is only the tip of the iceberg that will hit us in the near future. As the Indian economy

depends to a great extent on agriculture- a highly climate sensitive sector and the knowledge about potential climate change impacts on agriculture has special significance. Agriculture productivity is sensitive to two broad classes (a) direct effects from change in temperature and (b) indirect effects through changes in soils, distribution and frequency of infestation by pests, insects, diseases or weeds etc. Several studies predict that rice and wheat yield would decline considerably with climatic changes in India. As the mountain areas accounts only 21% of the total geographical area of India, where about 60-70% population largely depends on agriculture, horticulture and animal husbandry related activities for their livelihood. If the present trend of climate change continues, this will have an adverse effect on their lifestyles.

In the Himalayas, during the retreating phase a large number of lakes are being formed either at the snout of the glacier as a result of damming of the morainic material known as moraine dammed lakes or supra glacial lakes formed in the glacier surface area. A glacial lake is defined as a water mass existing in a sufficient amount and extending with a free surface in, under, beside and/or in front of a glacier and originated by glacier activities and/or retreating processes of a glacier. Most of these lakes are formed by the accumulation of vast amounts of water from the melting of snow and by blockade of end moraines located in the down valleys close to the glaciers. In addition, the lakes can also be formed due to landslides causing artificial blocks in the waterways. The sudden break of a moraine/block may generate the discharge of large volumes of water and debris from these glacial lakes and water bodies causing flash floods namely GLOF. A Glacial Lake Outburst Flood (GLOF), also known as a jökulhlaup in Icelandic (A jökulhlaup is technically a sudden and often catastrophic flood that occurs during a volcanic eruption, but is also used to describe other sorts of glacial flooding), can occur when a lake contained by a glacier or a terminal moraine dam fails. This can happen due to erosion, a buildup of water pressure, an avalanche of rock or heavy snow, an earthquake, or if a large enough portion of a glacier breaks off and massively displaces the waters in a glacial lake at its base. Many countries has a series of monitoring efforts to help prevent death and destruction that are likely to experience due to these events. The importance of this situation has magnified over the past century due to increased population, and the increasing number of glacial lakes that have developed due to glacier retreat. There are a number of GLOF events that have been reported worldwide. There are number of such events that have happened in Nepal Himalayas but no such event has been reported so far from Indian Himalayas. On the basis of mapping carried out in Himachal Himalayas in Satluj basin,

there are about 38 such lakes in entire Satluj basin out of which 14 falls in Himachal part. Similarly 50 moraine dammed lakes in Chenab basin and 5 supra glacial lakes have been mapped using remote sensing based on the studies carried out in the past.

The state of Himachal Pradesh invariably experience flash floods, the cause of which is unknown. In the year 2000, the Satluj valley experiences the heaviest floods causing loss of more than 800 crores. It is still a matter of investigation whether the floods were caused by cloud bursting or due to Glacier Lake Outburst Floods (GLOF) phenomena. The formation of landslide dammed lakes in high altitude zones such as Parechhu in the upper catchment of Spiti basin in Tibet caused tremendous threat to the life and property located in the downstream areas. It is therefore necessary that a constant and repeated monitoring of the upper catchment areas having international dimensions required to be carried out on a regular basis.

The present study has been carried out with the help of remote sensing data. As with the modernization of technology, the application of Remote Sensing data in the mapping of Natural Resources like the land use / land cover, ground water targeting, mineral resources, urban planning, disaster management, flood protection, and monitoring of glacier lake out bursts floods and the snow cover studies are gaining importance day by day in the world. Since this technology helps in having the synoptic coverage of any desired area and having better spatial resolution, it can be used as a very effective tool for planning and development. With the advancement of the technology, now it has become possible even to map an object of less than one meter in its dimensions. This technology attains significant importance when the area under investigation is inaccessible as in the present case where the monitoring of glacial lakes formed in the upper catchments is not possible by any other conventional method, so this technology has been successfully used for the mapping and monitoring of such water bodies in the entire Satluj catchment right from Mansarovar to downstream up to Nathpa in Kinnaur district of Himachal Pradesh. In this study a total of 197 lakes which were identified earlier by the National Remote Sensing Agency Hyderabad were considered as the base line data for the year 2007 and since 2009 the State Council for Science Technology & Environment has been monitoring all such lakes in the entire Satluj catchment during the ablation period regularly for Satluj Jal Vidyut Nigam Ltd Shimla as part of their disaster management plan. Besides this the main threat i.e. the Parechhu lake has been monitored regularly and the water spread status of the lake during 2021 was assessed and the conveyed to the State Government as well as to the SJVNL. Besides this during the year 2021, all glacial lakes/water

bodies have been monitored using IRS/AWiFS satellite data as well as IRS RS2-LISS 3 satellite data for the entire catchment and water spread has been compared with that of the water spread area during 2020 for both AWiFS and LISS -3 satellite data

2.4 Distribution of Glacial lakes in Himachal Himalaya

Based on the IRS-RS2-LISS-III satellite data having spatial resolution of 23.5mts and Landsat 8 MSS satellite data having spatial resolution of 30mts for the year 2019, the study area was analyzed in order to make an updated inventory of moraine dammed glacial lakes known as GLOFs (Glacial lake Outbursts Floods) in Himachal Himalaya comprising the Satluj, Chenab, Beas and Ravi basins. The Satluj basin has been studied in detail right from its origin from the Tibetan Himalaya, whereas the other basins have been analyzed for their areas of interest in Himachal Pradesh.

The results based on the analysis thus obtained reveals that in Satluj basin, a total of 562 lakes from the Satluj catchment covering 8 satellite imageries(96-48, 96-49, 97-48, 97-49, 98-48, 98-49, 99-49, 100-49) having spatial resolution of 23.5 mts. have been mapped during 2019. Further based on the LISS-III satellite data analysis for 2019 in Satluj basin, a total of 562 lakes have been delineated out of which about 81% (458) lakes are the small one with area less than 5ha, about 9% (53) falls within the aerial range of 5-10ha and about 9% (51) are the big one with area more than 10ha. The comparative analysis based on LISS III data reveals that total number of lakes in the Satluj catchment varies from 642 (2017) to 769 (2018) to 562 (2019) reflecting an overall increase of about 19% between 2017-18 and a reduction of about 26% between 2018-19, which is mainly due to the non-availability of good quality LISS III data products in 2019. Out of the 562 lakes/wetlands mapped in 2019 using LISS III satellite data, basin 1 i.e. Spiti basin constitutes about 12% (73) of the total lakes mapped (562) which is about 58% less than 2018 (176). Likewise basin 2 i.e. the Lower Satluj basin constitutes 9% (52) of the total lakes mapped which is about 46% less than 2018 (98) and the Upper Satluj basin i.e. the basin 3 constitutes of 77% (437) lakes in 2019 which is about 11% less than 2018 (495).

As far as the big lakes based on LISS III satellite data is concerned, the analysis reveals that the number varies from 52 (2017) to 49 (2018) to 51(2019) reflecting an overall increase of about 4% between 2018-19. The Parechhu Lake in the Tibetan Himalayan Region was also monitored separately during the ablation period of 2019 and does not show any major change in

its water spread and seems to be stable based on the observations made which have been reported to SJVNL as well as to the Government during 2019. Besides this, the landslide on the upstream side of the lake depression was also monitored in order to assess any change in the water level by virtue of the landside which may block the river course causing major threat like that of the Parechhu formation during the year 2004.

Along the course of main Satluj River, few isolated pockets have also been observed which shows accumulated water in the upper catchment of the Tibetan Himalayan Region and within the Spiti basin i.e. sub basin 1. In Spiti basin the lakes with ids 1682RS (0.40ha), 1683RS (1.09ha), 1684RS (1.95ha), 1685RS (1.44ha), 1686RS (1.59ha) and 1687RS (1.57ha) are some of the water bodies which have been developed along the nala section coming along the village Chicham just upstream of Kaza on the left bank formed in series (Fig.13.1). All these water bodies are although small but needs monitoring as this is along the river course and can cause major damage in case if it bursts. Thus the lakes/water bodies coded with abbreviation *RS with their ids* are some of the locations where accumulated water could be seen and these are the permanent features which needs regular monitoring in order to assess any temporal change in their behavior in the time to come.

Table 2.4.1: Distribution of lakes in different sub basins in Himachal Pradesh based on LISS III satellite data analysis for 2019.

No	Name of the basin	No. of lakes with area >10ha	No. of lakes with area between 5-10ha	No. of lakes with area <5ha	Total No. of lakes
1	Chenab	04(2018)05(2019)	10(2018)11(2019)	240(2018) 226(2019)	254(2018) 242(2019)
	Bhaga	01(2018)02(2019)	04(2018)03(2019)	79(2018) 46(2019)	84(2018) 51(2019)
	Chandra	02(2018)02(2019)	03(2018)03(2019)	59(2018) 47(2019)	64(2018) 52(2019)
	Miyar	01(2018)01(2019)	03(2018)05(2019)	102(2018) 133(2019)	106(2018) 139(2019)
2	Beas	03(2018) 04(2019)	04(2018) 4(2019)	58(2018) 85(2019)	65(2018) 93(2019)
	Jiwa	00(2018)00(2019)	00(2018)00(2019)	15(2018) 41(2019)	15(2018)41(2019)
	Parvati	03(2018) 03(2019)	01(2018)02(2019)	23(2018) 32(2019)	27(2018)37(2019)
	Beas	00(2018)01(2019)	03(2018) 02(2019)	20(2018)12(2019)	23(2018)15(2019)
3	Ravi	03(2018) 01(2019)	02(2018)02(2019)	61(2018)34(2019)	66(2018)37(2019)
4	Satluj	49(2018)51(2019)	57(2018) 53(2019)	663(2018)458(2019)	769(2018)562(2019)

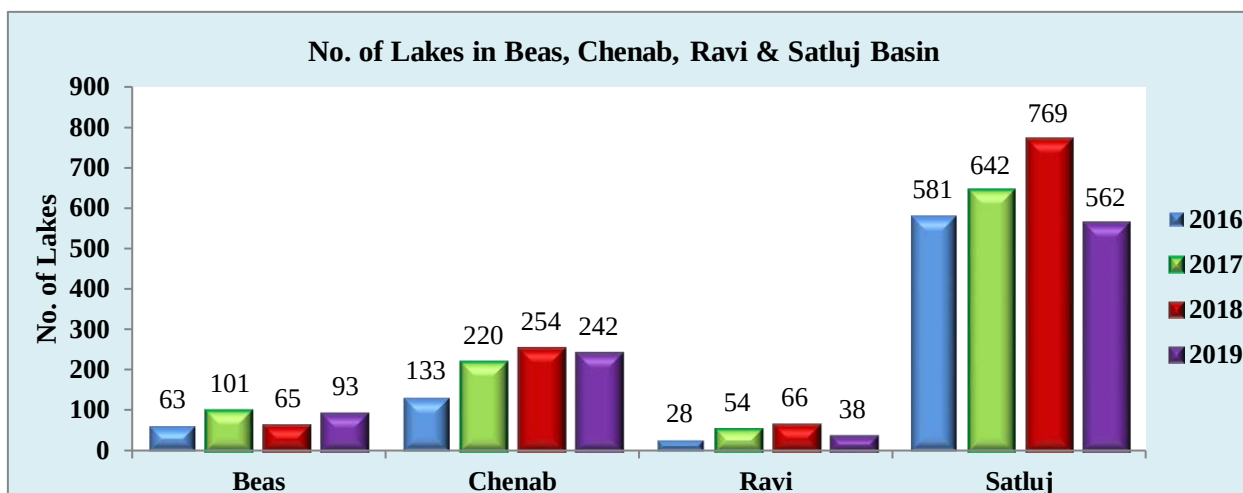


Fig.2.4.1. Distribution of lakes in Chenab, Beas, Ravi & Satluj basin

3. Distribution of lakes with area more than 10ha

Based on the satellite data interpretation for the year 2019, the study area has been studied to understand the temporal variation of all such lakes with area more than 10 ha. In Satluj basin the total number of such lakes has increased from 40 (2013) to 42 (2015) to 55 (2016) to 52 (2017) to 49 (2018) to 51 (2019) respectively based on LISS III satellite data. Likewise in other basins, i.e. in Chenab, the number of lakes varies from 3 (2013) to 4 (2015) to 2 (2016), 5 (2017) to 4 (2018) and 5(2019). In Beas basin the number varies from 2 (2013) to 2 (2015) to 3 (2016) to 4 (2017) to 3 (2018) and 4 (2019). In the Ravi basin, the number of lakes varies from 2 (2013) to 3 (2015) to 3 (2016) to 3 (2017) and 3 (2018) respectively (Table 12.1 & Fig 12.1). The lakes with HWL are mainly the high altitude wetlands in high altitude regions.

Table 3.1: Distribution of lakes with area more than 10ha in different sub basins in Himachal Pradesh based on LISS III satellite data analysis.

Sr. No.	Lake Id.	2015	2016	2017	2018	2019
Bhaga						
1	6	----	6.21	10.23	9.92	10.94
2	11	10.39	7.92	9.84	11.21	10.40
Chandra						
3	1	90.51	90.18	115.51	95.03	98.68
4	3	151.42	131.58	179.64	160.99	162.07
Miyar						
5	209	----	----	16.08	15.06	15.97
Jiwa						
	----	----	----	----	----	----
Parvati						
1	21	12.68	13.81	12.88	13.14	14.56

2	26	13.52	11.28	15.47	13.82	15.21
3	50	----	10.01	14.58	13.30	11.83
Upper Beas						
4	6	----	7.54	10.86	9.82	10.47
Ravi						
1	10	16	12.05	14.42	14.63	----
2	16	30.97	27.28	34.50	11.35	----
3	31	11.72	11.2	12.16	12.38	----
Satluj						
1	49HWL	23	----	----	38	24.58
2	67	12	13.04	8.06	8	24.58
3	85	----	----	----	----	34.89
4	86	9	10.88	10.11	10.06	10.10
5	87	9	10.06	9.38	10.5	10.41
6	99	19	18.37	17.12	18.8	14.72
7	101	24	24.65	21.37	22.8	21.10
8	122	7	16.16	15.34	16.5	16.86
9	173	3	9.32	7.65	----	13.20
10	184	----	----	----	----	23.32
11	209	33	36.38	----	----	33.76
12	145(HWL)	41584	41646.22	41498.50	41233.9	41640.43
13	179	25	26.26	25.07	25.6	24.26
14	184	27	19.51	19.15	25.5	19.96
15	210(HWL)	57	64.32	59.43	59.17	63.72
16	894	10	----	9.90	9.7	10.15
17	1063HWL	45	39.79	----	----	44.09
18	138(HWL)	26065	26538.79	25891.56	25634.8	25920.91
19	178	205	190.71	204.05	206.39	201.14
20	181	13	13.72	18.07	19.28	12.39
21	1093(HWL)	5515	5676.31	5787.38	5854.36	5992.49
22	1094HWL	16	13.83	12.82	12.62	14.85
23	1128	23	24.45	23.95	25.14	25.00
24	1133	17	15.23	16.09	15.86	16.18
25	1153	63	64.41	66.74	69.2	74.10
26	1155	16	16.38	16.14	17.47	14.27
27	1156(HWL)	11	11.85	11.56	11.69	11.74
28	1164	15	15.12	14.94	14.86	16.08
29	1092HWL	----	14.69	13.63	----	14.13
30	1363HWL	----	28.25	17.77	----	22.24
31	1375HWL	----	47.91	43.26	----	28.96
32	1510	----	54.52	54.37	54.38	52.93
33	1512	----	23.53	23.62	24.23	21.47
34	1518	----	13.78	12.53	14	12.19
35	1527	----	11.17	10.47	11.43	11.37
36	1548	----	17.95	14.62	19.91	17.41
37	1557RS	----	69.88	96.36	80.87	92.85
38	1349HWL	----	352.60	292.13	322.95	335.79
39	1095(HWL)	----	17.26	14.31	15.58	17.22
40	1565	----	16.38	18.11	17.36	19.13
41	1566(HWL)	----	22.81	24.35	18.76	10.77
42	1782(HWL)	----	----	----	29.1	30.65
43	1774RS	----	----	----	11.69	12.93
44	1771RS	----	----	----	12.22	14.99
45	1776RS	----	----	----	----	13.98
46	1654	----	----	----	----	22.28

47	2180	----	----	----	----	23.56
48	1039HWL	----	----	----	----	12.16
49	1144HWL	----	----	----	----	89.47
50	2167HWL	----	----	----	----	214.31
51	1146	----	----	----	----	10.60

(HWL-High Altitude Wetlands)
(RS-River Section)

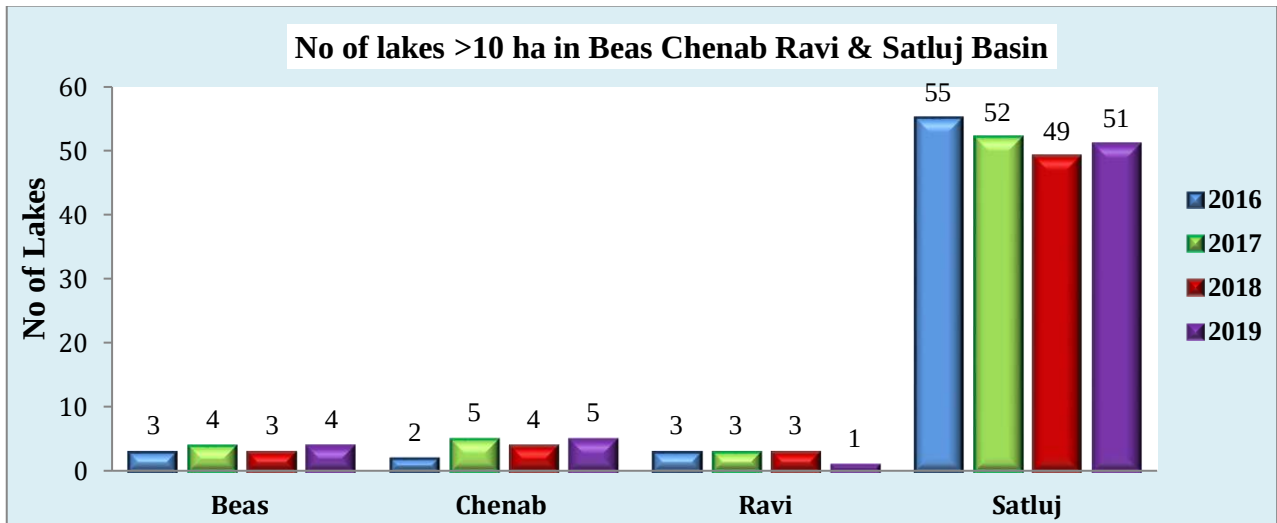


Fig.3.1 Distribution of lakes with area >10 Ha in Chenab, Beas, Ravi& Satluj basin in 2016- 2019

4.0 Objectives of the present study

The main objectives of the study is to monitor the water spread area of the all the moraine dammed glacier lakes/ water bodies on monthly basis in the entire Satluj Basin during April to November 2022 based on the inventory of the lakes during the preceding year prepared using space data.

4.1 Study area and data used

The investigations have been carried out in the Sutlej basin right from its origin from the Mansarovar Lake in Tibetan Region. The river Sutlej is one of the main tributaries of Indus and has its origin near Mansarovar Lake and Rakas Tal in Tibetan Plateau at an elevation of about 4,500 m (approx.). The study area has been divided into three major sub basins i.e. Spiti as sub basin number 1, Lower Satluj as sub basin number 2 and Upper Satluj in Tibet catchment as basin 3 (Fig 4.1). The Satluj River travels about 300 km (approx.) in Tibetan plateau in North-Westerly direction and changes direction towards South-West and covers another 320 km. (approx.) up to Bhakra gorge where 225m high straight gravity dam has been constructed. This western Himalayan basin is highly rugged terrain with abundant natural water resource in the form of snow pack. The

Satluj basin is geographically located between 30° 00' N, 76° 00' E and 33° 00' N, 82° 00' E. The Nathpa dam is a 62.5 m high concrete dam located on Satluj River at Nathpa. The dam is a main component of the 1,500 MW Nathpa Jhakri Hydro-Electric Project – NJHEP. The project is located in the state of Himachal Pradesh and derives its name from the names of two villages in the project vicinity - Nathpa in Kinnaur district and Jhakri in Shimla district - in the interiors of Himachal Pradesh. The project was conceived as a run-of-river type hydro power development, harnessing hydro-electric potential of the middle reaches of the river Sutlej. The project's dam has been constructed near village Nathpa and its power house has been constructed on the left bank of the river Satluj at village Jhakri. The project stretches over a length of about 50 Km from the dam site to the power house site, on the Hindustan- Tibet Road (NH-22). Characteristics of the Sutlej basin and inaccessibility of the major part of it make remote sensing application ideal for hydrologists to monitor glacial lakes and water bodies in the basin (Fig. 4.1). Most of the area in the present study falls in the inaccessible high mountain region of Himalayas (Fig. 4.2). Hence, the monitoring of glacial lakes / water bodies was done using remote sensing method. The images acquired by AWiFS (Advanced Wide Field Sensor) sensor , LISS III and LISS IV of IRS-RS2& RS2A (Indian Remote Sensing) Satellite were used in the present study. The path-row of satellite coverage is shown in (Fig. 4.3). Table 4.1 shows the satellite data used for the study purpose during 2022.

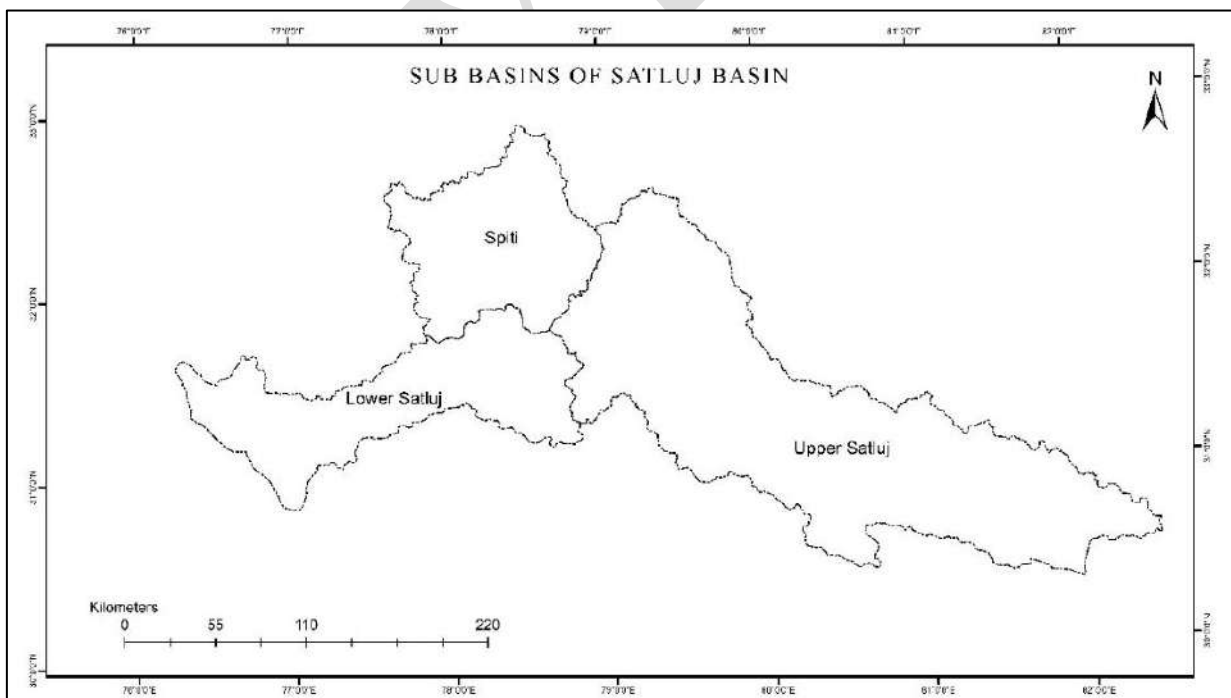


Fig. 4.1: Different regions in Satluj basin

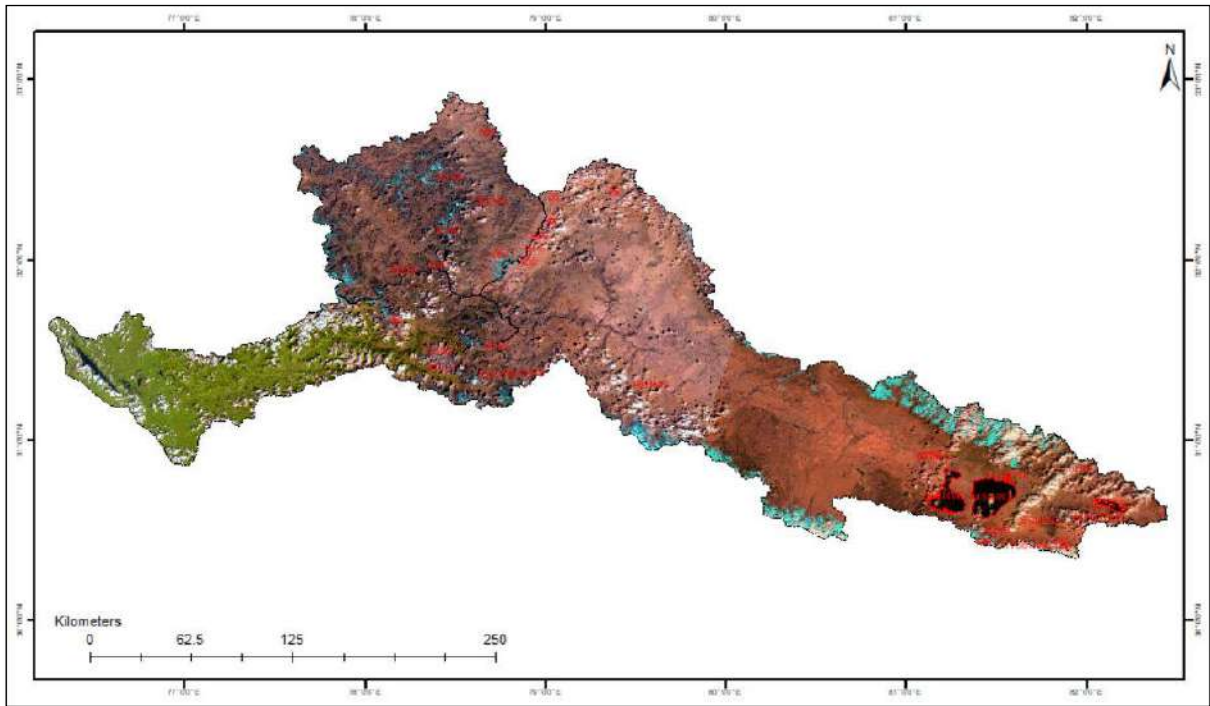


Fig. 4.2: False Colour Composite of Satellite images covering Satluj basin

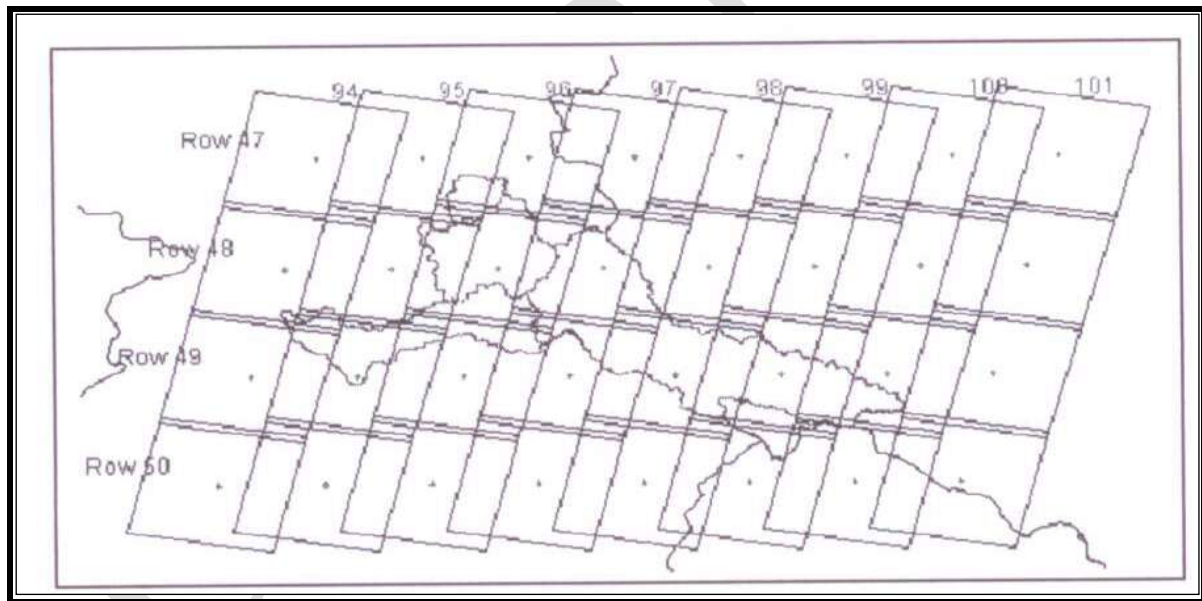


Fig. 4.3 IRS-P6 LISS-III Data Coverage over Sutlej Basin

Table 4.1: Satellite data used for monitoring in the study area

AWiFS Satellite data used for monitoring in the study area			
Sr. No.	Date of Pass	Path –Row	Satellite Sensor
1	01 April 2022	95-49	Resourcesat2/AWiFS
2	11 April 2022	97-49	Resourcesat2/AWiFS
3	05 May 2022	97-50	Resourcesat2A/AWiFS

4	19 May 2022	95-48	Resourcesat2/AWIFS
5	03 June 2022	98-47	Resourcesat2/AWIFS
6	13 June 2022	100-49	Resourcesat2/AWIFS
7	02 July 2022	97-47	Resourcesat2A/AWIFS
8	04 July 2022	97-47	Resourcesat2A/AWIFS
9	31 Aug 2022	99-48	Resourcesat2A/AWIFS
10	31 Aug 2022	99-48	Resourcesat2A/AWIFS
11	07 Sep 2022	98-49	Resourcesat2/AWIFS
12	07 Sep 2022	98-49	Resourcesat2/AWIFS
13	11 Sep 2022	94-49	Resourcesat2A/AWIFS
14	12 Sep 2022	99-49	Resourcesat2A/AWIFS
15	26 Sep 2022	97-49	Resourcesat2A/AWIFS
16	06 Oct 2022	99-48	Resourcesat2A/AWIFS
17	15 Oct 2022	96-49	Resourcesat2A/AWIFS
18	25 Oct 2022	98-49	Resourcesat2/AWIFS
19	27 Oct 2022	96-48	Resourcesat2/AWIFS
20	27 Oct 2022	96-48	Resourcesat2/AWIFS
21	30 Oct 2022	99-49	Resourcesat2/AWIFS
22	03 Nov 2022	95-49	Resourcesat2/AWIFS
23	13 Nov 2022	97-49	Resourcesat2/AWIFS
24	22 Nov 2022	94-49	Resourcesat2/AWIFS
25	23 Nov 2022	98-49	Resourcesat2/AWIFS

LISS-III Satellite data used for monitoring in the study area

Sr. No.	Date of Pass	Path –Row	Satellite Sensor
1	28 Aug 2022	96-48	Resourcesat2/LISS III
2	28 Aug 2022	96-49	Resourcesat2/LISS III
3	31 Aug 2022	99-48	Resourcesat2A/LISS III
4	31 Aug 2022	99-49	Resourcesat2A/LISS III
5	02 Sep 2022	97-48	Resourcesat2/LISS III
6	05 Sep 2022	100-49	Resourcesat2A/LISS III
7	12 Sep 2022	99-48	Resourcesat2/LISS III
8	12 Sep 2022	99-49	Resourcesat2/LISS III
9	16 Sep 2022	95-47	Resourcesat2/LISS III
10	29 Sep 2022	100-49	Resourcesat2A/LISS III
11	05 Oct 2022	94-48	Resourcesat2/LISS III
12	15 Oct 2022	96-48	Resourcesat2A/LISS III
13	17 Oct 2022	94-48	Resourcesat2A/LISS III
14	08 Nov 2022	96-48	Resourcesat2/LISS III

LANDSAT-8 Satellite data used for monitoring in the study area

Sr. No.	Date of Pass	Path –Row	Satellite Sensor
1	26 Aug 2022	146-38	OLI+
2	27 Aug 2022	145-38	OLI+
3	12 Sep 2022	145-38	OLI+
4	29 Sep 2022	144-38	OLI+
5	29 Sep 2022	144-39	OLI+
6	22 Oct 2022	145-39	OLI+

LISS-IV Satellite data used for monitoring in the study area

Sr. No	Date of Pass	Path –Row	Satellite Sensor
--------	--------------	-----------	------------------

1	28 Aug 2022	96-48A	Resourcesat2/LISS IV
2	28 Aug 2022	96-48C	Resourcesat2/LISS IV
3	02 Sep 2022	97-48A	Resourcesat2/LISS IV
4	07 Sep 2022	98-49A	Resourcesat2/LISS IV
5	07 Sep 2022	98-48C	Resourcesat2/LISS IV
6	07 Sep 2022	98-49C	Resourcesat2/LISS IV
7	26 Sep 2022	97-49B	Resourcesat2/LISS IV
8	29 Sep 2022	100-49C	Resourcesat2A/LISS IV
9	03 Oct 2022	96-48C	Resourcesat2/LISS IV
10	15 Oct 2022	96-48A	Resourcesat2/LISS IV
11	15 Oct 2022	96-48C	Resourcesat2/LISS IV
12	20 Oct 2022	97-48C	Resourcesat2/LISS IV
13	01 Aug to 31 October, 2022	Sentinel data	Google Earth engine

5. Methodology

The satellite data covering Sutlej basin during the months of April to November 2022 was browsed. The cloud free AWiFS satellite data for the year 2022 for monitoring of lakes during 2022 and the LISS-III & LISS –IV images for further monitoring based on high resolution data for the year 2022 from IRS-RS2 & RS2-A satellite were procured. With the spatial resolution of AWiFS (56 m) the monitoring of lakes was done by identifying all the water bodies irrespective of their aerial extent and was compared with that of the lake area mapped during 2021 from AWiFS satellite data. Each of these satellite data sets was individually rectified with the reference image master AWiFS data sets. The geometric rectification was done using polynomial transformation of third order with resulting Root Mean Square (RMS) error less than one pixel. The Sutlej river basin boundary is superimposed on the satellite image of the basin and the lakes which are visible and clearly demarkable were delineated using ERDAS software. The lake boundaries were digitized using ERDAS /Imagine vector module tools. The digitized polygons have been cleaned for open ends and built into a polygon layer. All the polygons have been assigned polygon ID's. Water spread area is considered to represent the boundary of lake. The process of procurement of satellite data, geometric rectification, lake area digitization and comparison is repeated for all the data sets during April to November 2022. The flowchart explaining the methodology is given in (Fig. 5.1).

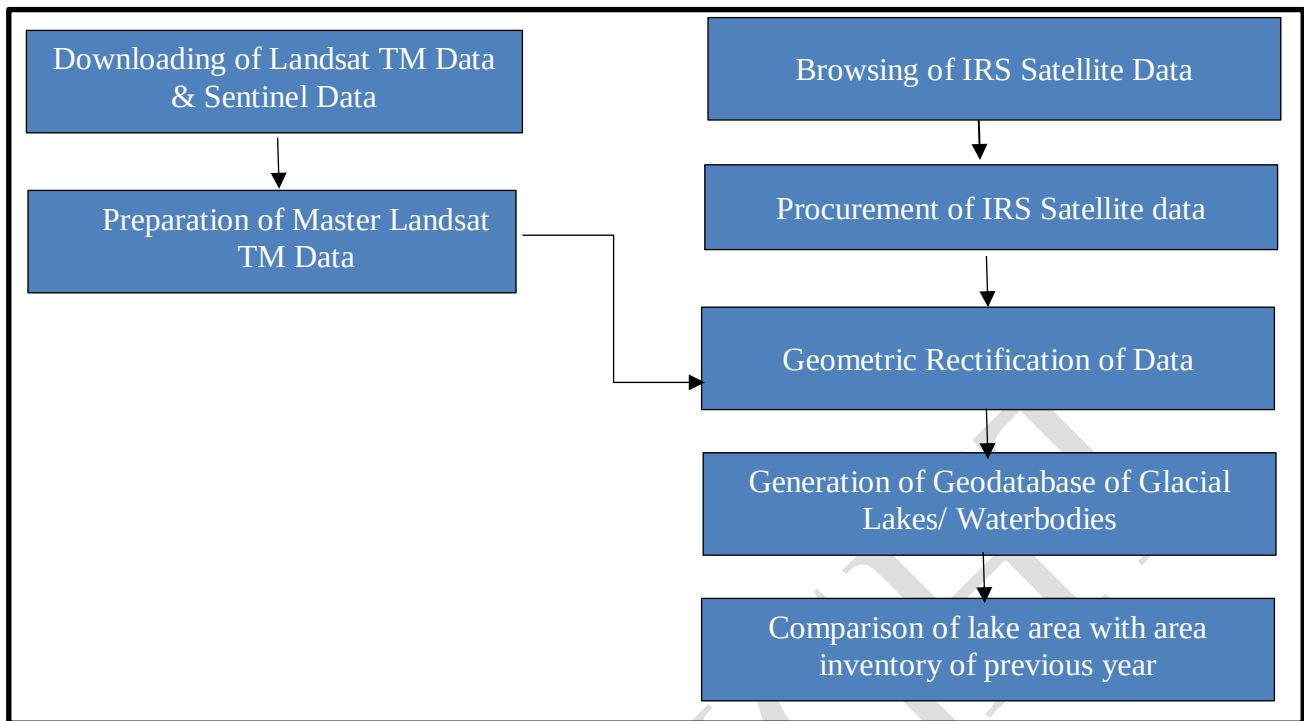


Fig.5.1: Flow Chart Methodology

Besides this, as the AWiFS has the spatial resolution of 56 m, the lake inventory prepared using LISS-III which has the spatial resolution of 23.5 m, was compared with that of an updated inventory using high resolution LISS-III satellite data for the year 2022. All the cloud free satellite images for the month of July to September 2022 were selected for making an updated inventory and were compared for their spatial variation with respect to that for the year 2021. The methodology adopted is same as that of the AWiFS data product in the study area and the following LISS III satellite data has been used for updating the inventory in the entire Satluj Basin.

During the year 2022, another set of database based on very high resolution of 5.8mts from LISS IV sensor was prepared. Using LISS IV sensor data, it has become possible all such lakes which could not be mapped in LISS III and thus gives a highly accurate information of the even smaller lakes which are coming up in the high altitude region of the Satluj catchment. This database thus prepared was compared with that of the baseline data generated for 2021 for having a real time temporal analysis of the glacial lakes in the region. The methodology adopted is same as that of the AWiFS data product in the study area and the following LISS III satellite data has been used for updating the inventory in the entire Satluj Basin.

6. Monitoring of Parechhu Lake during 2022

Parechhu Lake is a small geomorphic depression along the Parechhu River that joins the Spiti River on its left bank near Sumdo in Spiti Sub Division of District Lahaul & Spiti. The fragile geology of the area and the Sumdo Kaurik fault passing nearby cause's activation of the landslides which results in chocking of the river course in the downstream and causes accumulation of the water in the depression. This lake has been known for its damage history and since 2001 is being monitored every year during the ablation season from April to September. During the year 2022, the lake was regularly monitored and its findings about the water spread were reported to the SJVNL as well as to the Govt.

Observations derived from the satellite data analysis during 2022:

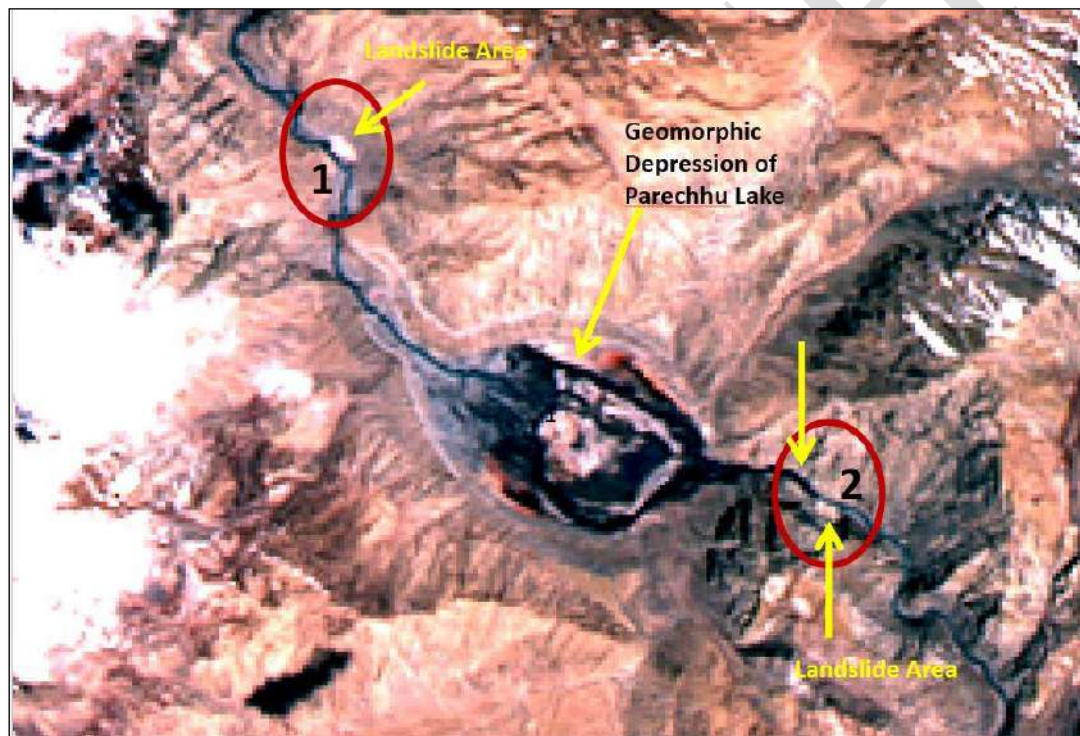


Fig.6.1: IRS-R2A-LISS III, 96-48, 18 April 2022

Observations:

Based on the analysis of IRS-R2A-L3-96-48- 18 April, 2022 satellite data having spatial resolution of 23.5mts, the following observations are made:-

- The accumulated water in the lake depression could be seen through the peripheral sides of the depression and extending downstream upto the point where landslide seems to have caused slight blockade of the river course i.e. about 728.09 mts from the lower point of the lake depression.

- Based on the tonal difference in the river flow, near the landslide 2, the slide seems to have caused a slight blockade in the river course resulting to have the accumulation of the river flow that extends upwards all along the peripheral side in the frontal portion of the lake depression.
- The river flow near the landslide 1 also seems to have some effect on the river flow as a result of which the accumulated water could be seen backwards.
- Besides this, the accumulation could also be seen in the central part of the depression indicating shallow accumulation on the upstream side of the depression, whereas the braiding channels reflecting thick accumulation could be seen on the downstream side along the periphery.
- Although the inflow and the outflow seems to be normal but slight changes like thick accumulation up to the landslide 2 and slightly reduced inflow due to the landslide 1 could be seen.
- Thus as on day these two landslides may affect the water spread in Parechhu lake i.e. one on the upstream side and the other on downstream of depression and thus needs to be monitored regularly in the coming months in view of the melting of the snow cover from the higher catchments.
- As such based on the satellite data interpretation for the month for April 2022, there does not seem to be any threat from the Parechhu Lake as on day, but needs regular monitoring as it is the beginning of the ablation season and also needs the landslide monitoring in order to assess any further changes in the river flow/ blockade etc..

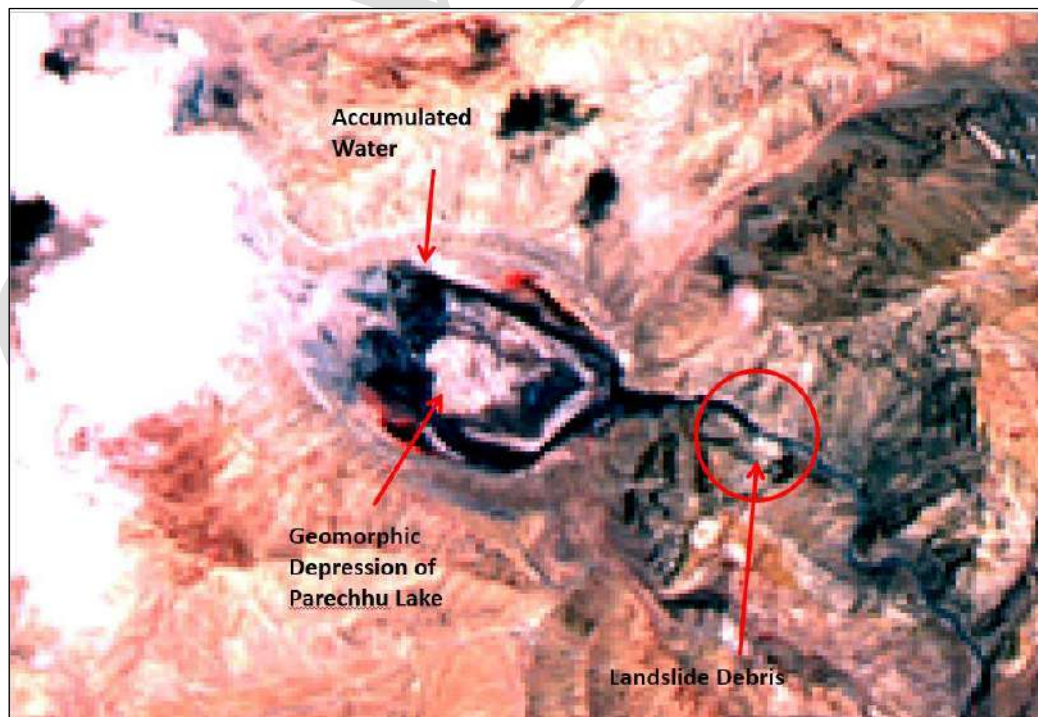


Fig.6.2: IRS-R2A-LISS III, 96-48, 12 May, 2022

Observations:

Based on the analysis of IRS-R2A-L3-96-48- 12 May, 2022 satellite data having spatial resolution of 23.5mts, the following observations are made:

- The accumulated water in the lake depression could be seen through the peripheral sides of the depression and extending downstream up to the point where landslide seems to have caused slight blockade of the river course i.e. about 728.09 mts from the lower point of the lake depression.
- No observation could be made in the upper part of the depression due to cloud cover.
- Based on the tonal difference in the river flow, near the landslide, the slide seems to have caused a slight blockade in the river course resulting to have the accumulation of the river flow that extends upwards all along the peripheral side in the frontal portion of the lake depression.
- The accumulated water along the river course in the frontal side and in the depressions seems to be more or less same except minor change on the upper part where accumulation may have slightly increased than as on 18 April 2022
- Besides this, the accumulation could also be seen in the upper central part of the depression, whereas the braiding channels reflecting thick accumulation could be seen on the downstream side along the periphery.
- Although the inflow could not be interpreted due to cloud cover but the outflow seems to be normal but with slightly reduced outflow due to slide debris blockade in the frontal side near the landslide on the right bank.
- Thus as on day the landslide may have affected the water spread in Parechhu lake on the downstream of depression and thus needs to be monitored regularly in the coming months in view of present status and the melting of the snow cover from the higher catchments in the coming months.
- As such based on the satellite data interpretation for the month from 12 May 2022, there does not seem to be any threat from the Parechhu Lake as on day, but needs regular monitoring as it is the beginning of the present status and ongoing ablation season and also needs the landslide monitoring in order to assess any further changes in the river flow/ blockade etc..

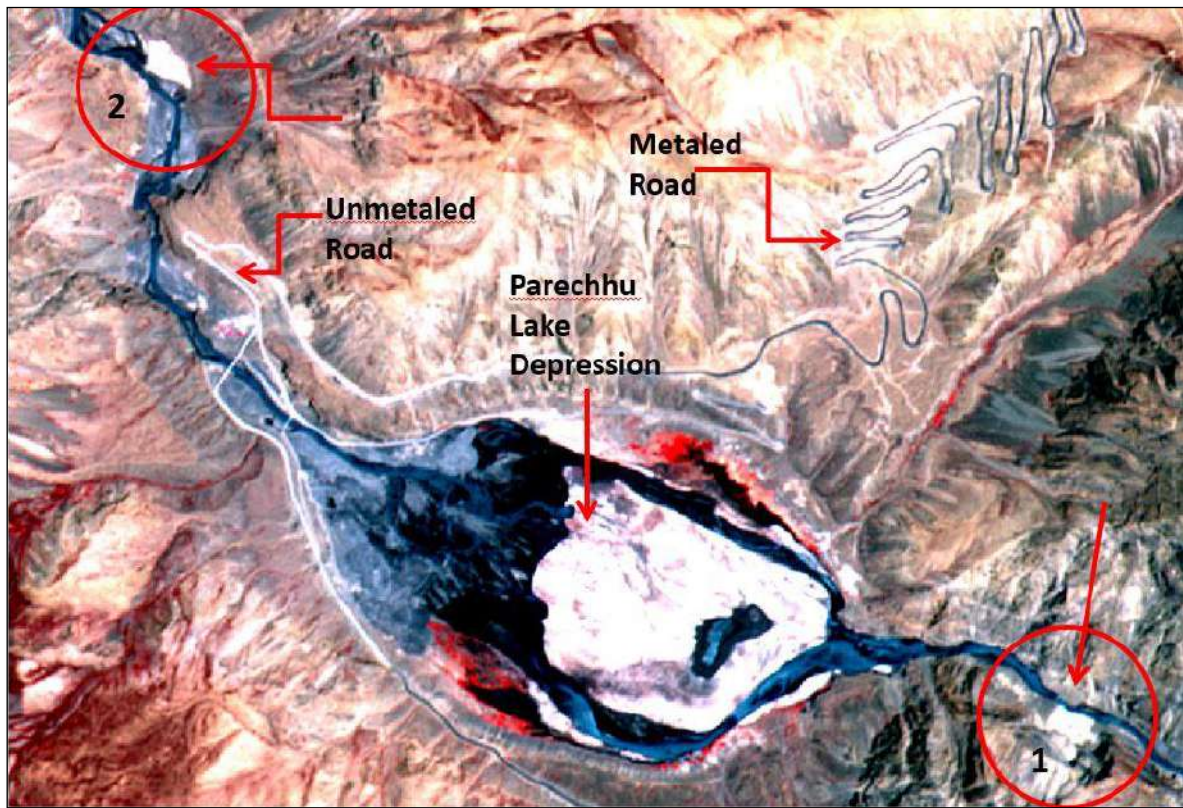


Fig.6.3: IRS-R2A-LISS IV, 96-48B, 5 June 2022

Observations:

Based on the analysis of IRS-R2A-L4-96-48B, 05 June, 2022 high resolution satellite data having spatial resolution of 5.8mts, the following observations are made:-

- The accumulated water in the lake depression could be seen along the river course through the peripheral sides of the depression and extending downstream up to the point where landslide seems to have caused slight blockade of the river course i.e. about 728.09 mts from the lower point of the lake depression.
- Slight accumulation could also be seen along the braded channels in the upper part along with a small patch on the frontal part of the depression.
- Based on the tonal difference in the river flow, near the landslide number 1, the slide seems to have caused a slight blockade in the river course could be seen resulting to have the accumulation of the river flow that extends upwards all along the peripheral side in the frontal portion of the lake depression.
- The accumulated water along the river course in the frontal side and in the depressions seems to be more or less same except minor change where accumulation may have slightly reduced in comparison to as on 12 May 2022.

- The effects of the landslide number 2 on the upper part along the Parechhu River could also be seen reflecting some accumulation along the braided channels.
- The inflow and outflow seems to be comparatively normal as on 05th June 2022.
- Thus as on day the 02 landslide which appears to be quite clear and significant from the satellite image and thus may affect the outflow in the frontal part and inflow from the upper part needs to be monitored regularly in the coming months in view of present status and the melting of the snow cover from the higher catchments in the coming months.
- As such based on the satellite data interpretation for the month from 05 June 2022, there does not seem to be any threat from the Parechhu Lake as on day, but needs regular monitoring as the ablation process is still undergoing and also needs the landslide monitoring in order to assess any further changes in the river flow/ blockade etc.

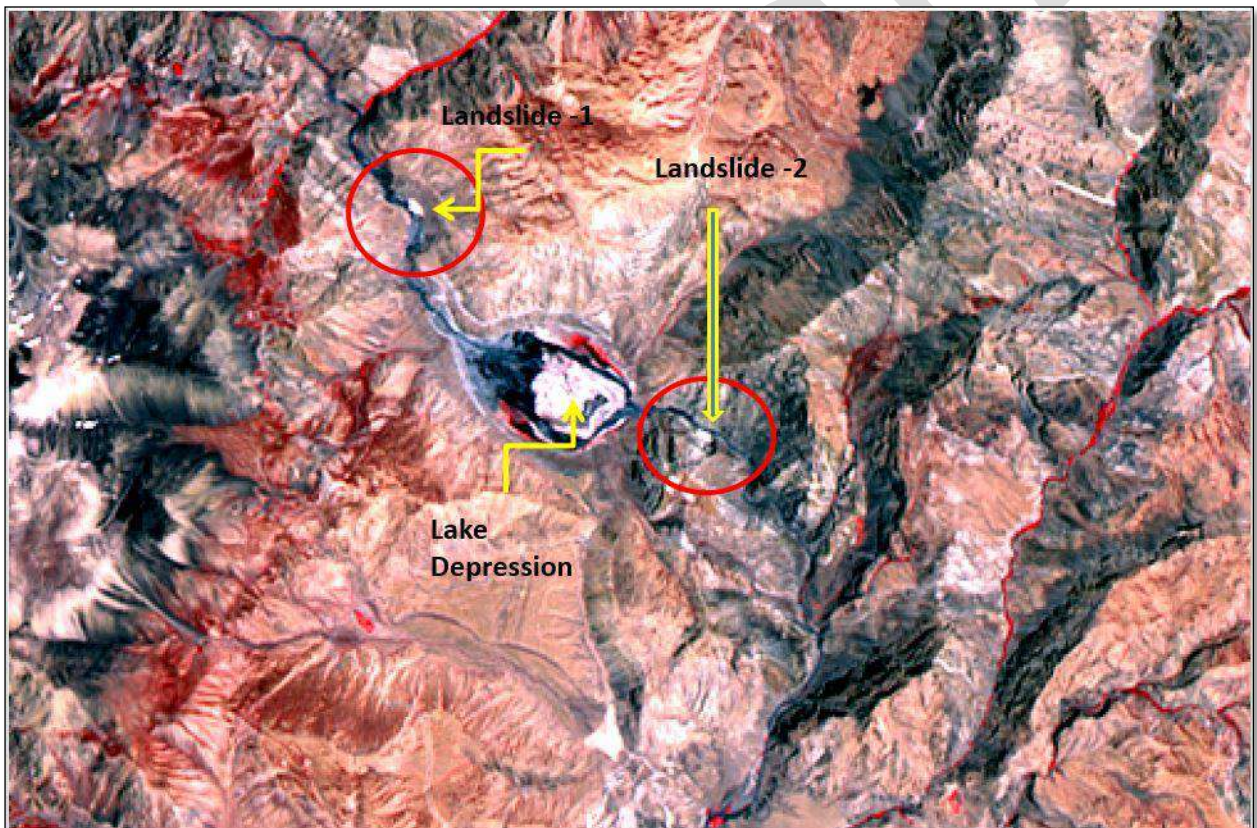


Fig.6.4: IRS-R2A-LISS III, 96-48, 29 June, 2022

Observations:

Based on the analysis of IRS-R2A-L3-96-48-29 June 2022 high resolution satellite data having spatial resolution of 23.5mts, the following observations are made:-

- The accumulated water in the lake depression could be seen along the river course through the peripheral sides of the depression and extending downstream up to the point where landslide seems to have caused slight blockade of the river course i.e. about 728.09 mts from the lower point of the lake depression.
- Slight accumulation could also be seen along the braded channels in the upper part of the depression.
- Based on the tonal difference in the river flow, near the landslide number 2, the slide seems to have caused a slight blockade in the river course could be seen resulting to have the accumulation of the river flow that extends upwards all along the peripheral side in the frontal portion of the lake depression.
- The accumulated water along the river course in the frontal side due to the landslide seems to be comparatively more prominent in comparison to its status as on 05th June 2022.
- The effects of the landslide number 1 on the upstream of the depression are also prominent in the form of accumulation in the river flow on the upstream of the landslide resulting to have signatures of the accumulated water along the river course.
- The inflow and outflow seems to be comparatively normal as on 29th June 2022 but with reduced discharge due to accumulation.
- As such based on the satellite data interpretation for the month from 29 June 2022, there does not seem to be any threat from the Parechhu Lake as on day, but needs regular monitoring as the ablation process is still undergoing and also needs the landslide monitoring in order to assess any further changes in the river flow/ blockade etc.

7.0: Monitoring of glacial lakes and other water bodies using AWiFS Satellite data in Satluj catchment during 2022

Based on the satellite data analysis for the period January to December 2007 on monthly basis, the total 197 lakes which were identified by the National Remote Sensing Agency Hyderabad earlier using satellite data for the year 2007 were used as the base line data. Thereafter all these 197 lakes were further analyzed and monitored for the year 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 and 2022. In the present study the lakes which were mapped during 2022 have been used to assess the temporal variation with that of the lakes mapped during the preceding years. The status of lakes mapped during 2022 and their temporal variation with respects to 2021 is as per the following observations derived from the AWiFS satellite data analysis using visual interpretation techniques. The lakes which are fully visible in the satellite image and the lake boundaries are clearly remarkable, only in such cases the lake is mapped and its area computed. In cases where the lakes are under fully/partly cloudy shadow or fully/partly cloudy covered or fully/partly snow covered the areas of such lakes are not reported. Further the lakes have been categorized into two categories i.e. one which are having their origin from the glaciated terrains i.e. near or in front or within the glacier bodies, are known as the moraine dammed glacial lakes or supra glacial lakes, whereas the other category is that of all the lakes which are formed within the depressions are classified as high altitude wetlands formed in the Tibetan region because of the one or the other reason.

7.1: Status of lakes as on April 2022.

During the month of April 2022, two scene could be obtained of AWiFs data products of 1st and 11th April (Fig: 7.1 (a) & (b)). The interpretation of satellite data reveals that 26 lakes could be mapped out in total because of snow cover comprising 1 lake each from Spiti and Lower Satluj i.e. sub basin number 1 & 2 and 24 lakes from the Upper Satluj basin i.e. sub basin number 3 (Fig: 7.1(c)). The more detailed analysis reflects that 2 lakes identified are smaller with area less than 5ha in upper Satluj Basin, 4 lakes are with areal range 5-10 ha and 20 lakes are with area greater than 10 ha (Fig: 7.1(d)). Further analysis of 26 lakes reveals that 17 lakes are the High Altitude wetlands out of which 16 from Upper Satluj basin and 1 from Spiti sub basin. Based on the areal distribution of these 17 high altitude wetlands, 15 are with area more than 10 ha, 1 lies

within range of 5 - 10 ha and 1 with area less than 5 ha (Fig: 7.1(e)). Besides this, out of 26 lakes, 6 lakes have been formed along the different river sections with ids RS (Table 7.1).

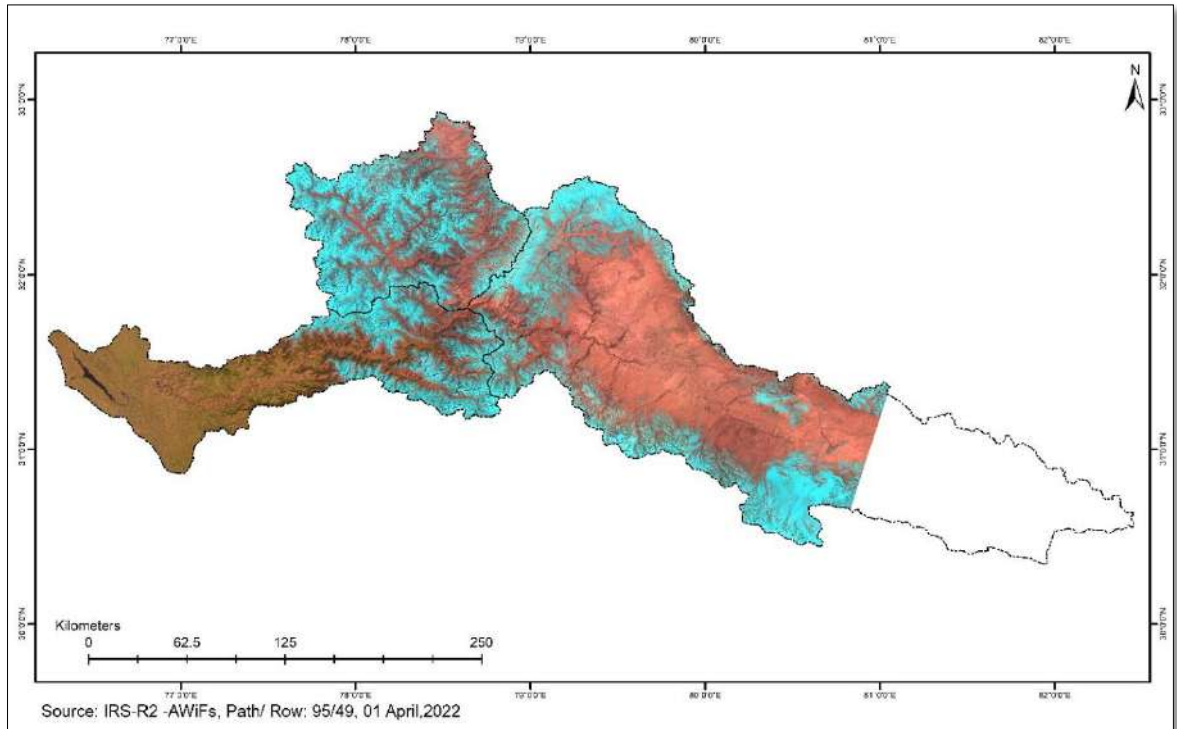


Fig.7.1 (a): IRS-R2-AWiFS, 95/49, 01st April, 2022

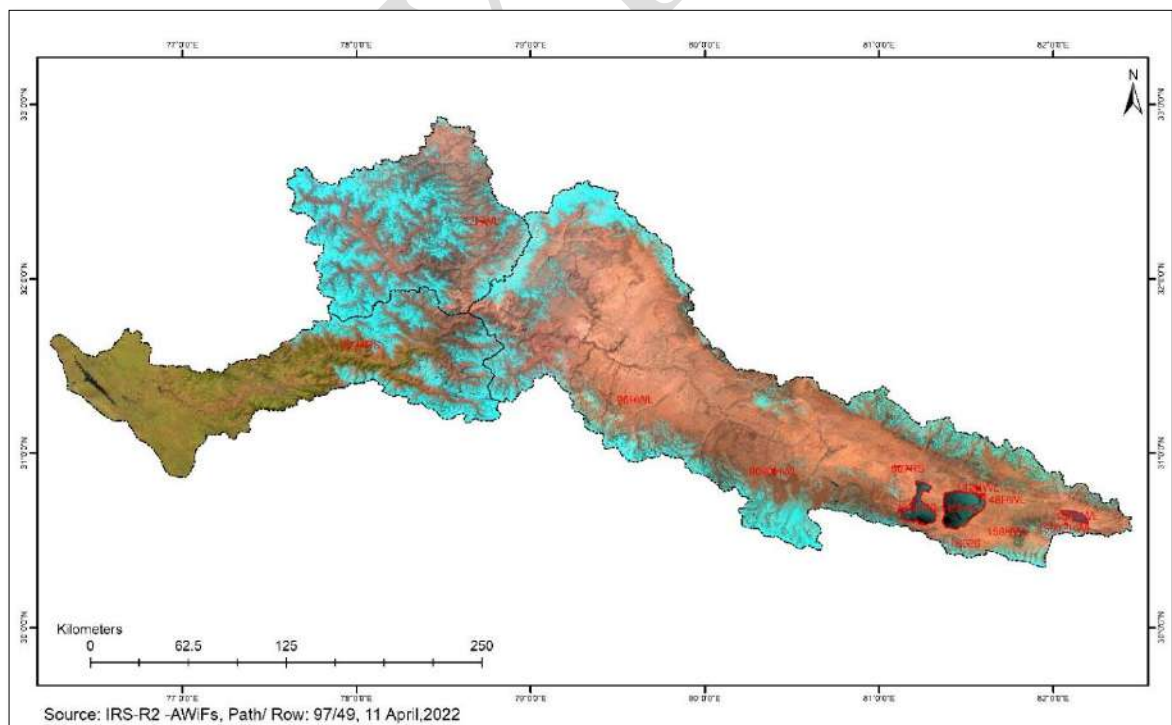


Fig.7.1 (b): IRS-R2-AWiFS, 97-49, 11th April, 2022

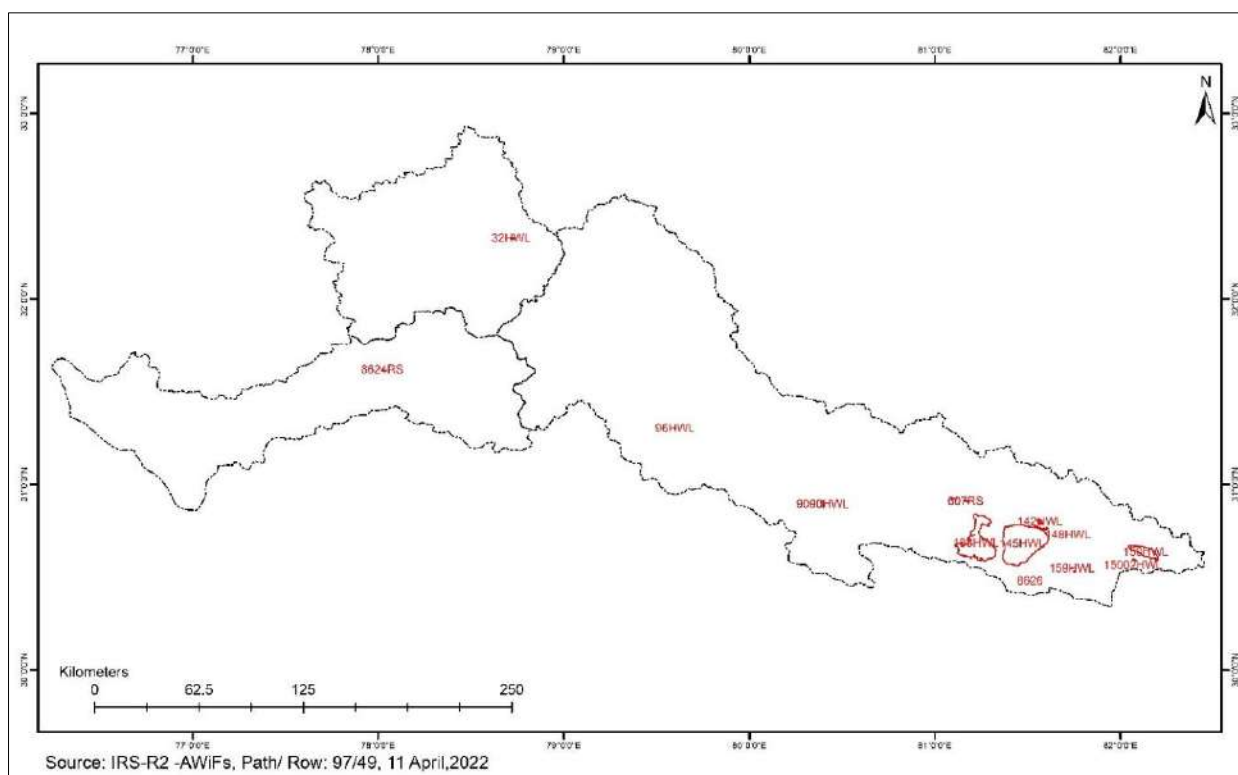


Fig.7.1 (c): IRS-R2-AWiFS, 97-49, 11th April, 2022, Interpreted layers.

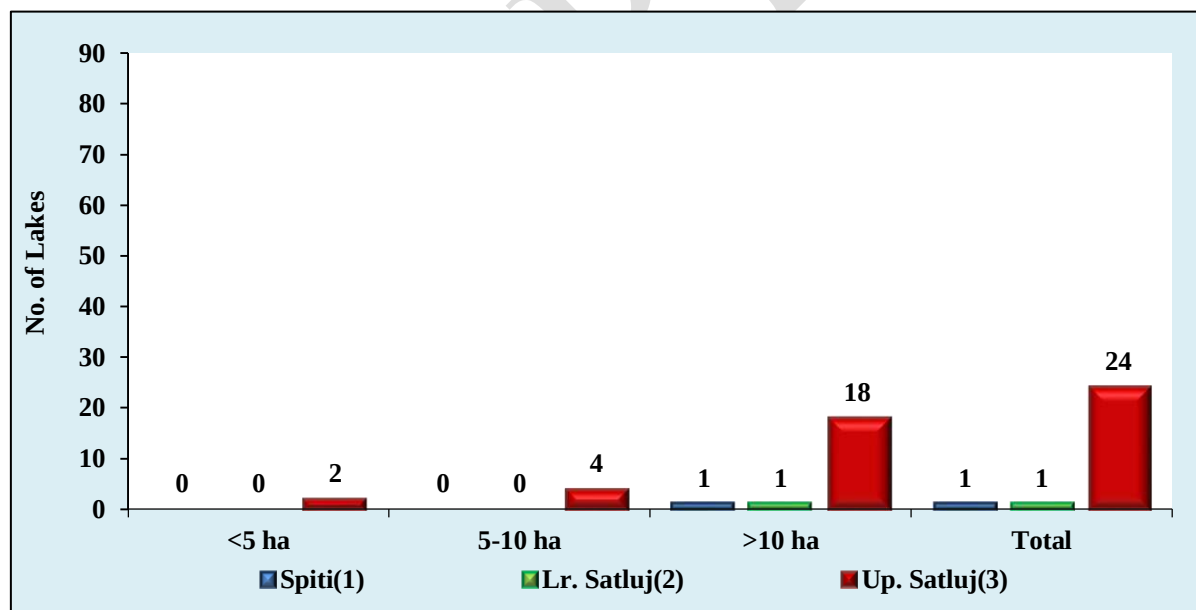


Fig.7.1 (d): No. lakes based on IRS-R2-AWiFS, 97-49, 11th April, 2022

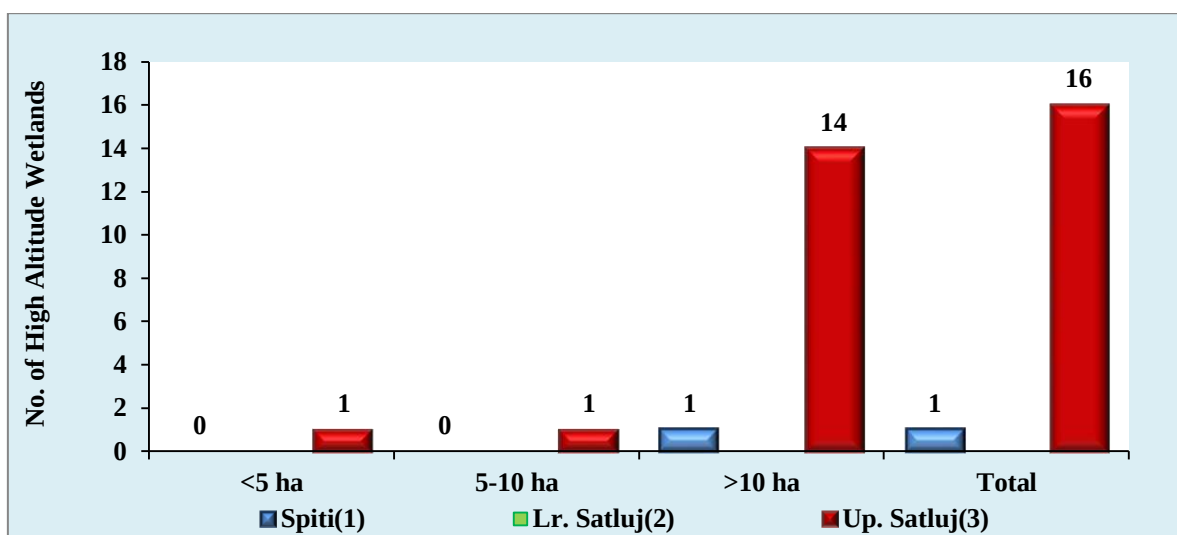


Fig.7.1 (e): No. of High Wetland Lakes based on IRS-R2-AWiFS, 97-49, 11th April, 2022

Table: 7.1 Aerial Extent of lakes as on April, 2022

Sr. No.	Lake Id.	Basin Number	Longitude	Latitude	Aerial Extent on 11 April 2022 (ha.)
1	443	3	81.5135	30.4766	6.26
2	8626	3	81.5126	30.4813	9.34
3	1022RS	3	81.1087	30.9229	4.21
4	138HWL	3	81.2309	30.6814	25949.62
5	142HWL	3	81.5638	30.8032	358.46
6	145HWL	3	81.4904	30.6993	41391.82
7	147HWL	3	81.5642	30.7657	10.41
8	148HWL	3	81.5869	30.7625	252.60
9	15002HWL	3	82.0684	30.5956	23.05
10	15003HWL	3	82.0807	30.5936	15.39
11	150HWL	3	82.1455	30.6432	5850.61
12	159HWL	3	81.7389	30.5492	18.44
13	205HWL	3	81.5650	30.7879	5.87
14	209HWL	3	81.5421	30.7716	28.70
15	210HWL	3	81.5532	30.7718	67.89
16	32HWL	1	78.7180	32.3293	71.47
17	607RS	3	81.1657	30.9110	46.72
18	608RS	3	81.0929	30.9250	28.16
19	616RS	3	81.1161	30.9241	15.11
20	8258HWL	3	81.7092	30.5590	2.79
21	8263RS	3	81.1048	30.9237	2.35
22	8511HWL	3	81.7521	30.5311	17.86
23	8624RS	2	78.0228	31.6196	10.28
24	8627RS	3	81.1804	30.9069	45.53
25	9090HWL	3	80.3950	30.8990	300.36
26	96HWL	3	79.5998	31.3058	26.59

7.2: Status of lakes as on May 2022.

During the month of May 2022, two data products could be obtained which were partially cloudy of 5th and 19th May (Fig: 7.2 (a) & (b) & Table: 7.2). From the satellite data analysis as the area is under the impact of snow cover and cloud cover only 5 lakes could be identified (Fig : 7.2 (c) & Table: 7.2). Out of these 5 lakes, two lakes having area more than 10ha are in Spiti and Lower Satluj sub basin respectively (Fig: 7.2 (d). One lake has been identified in river section in Lower Satluj sub basin. The lakes identified in the month of May 2022 could not be compared with the previous year.

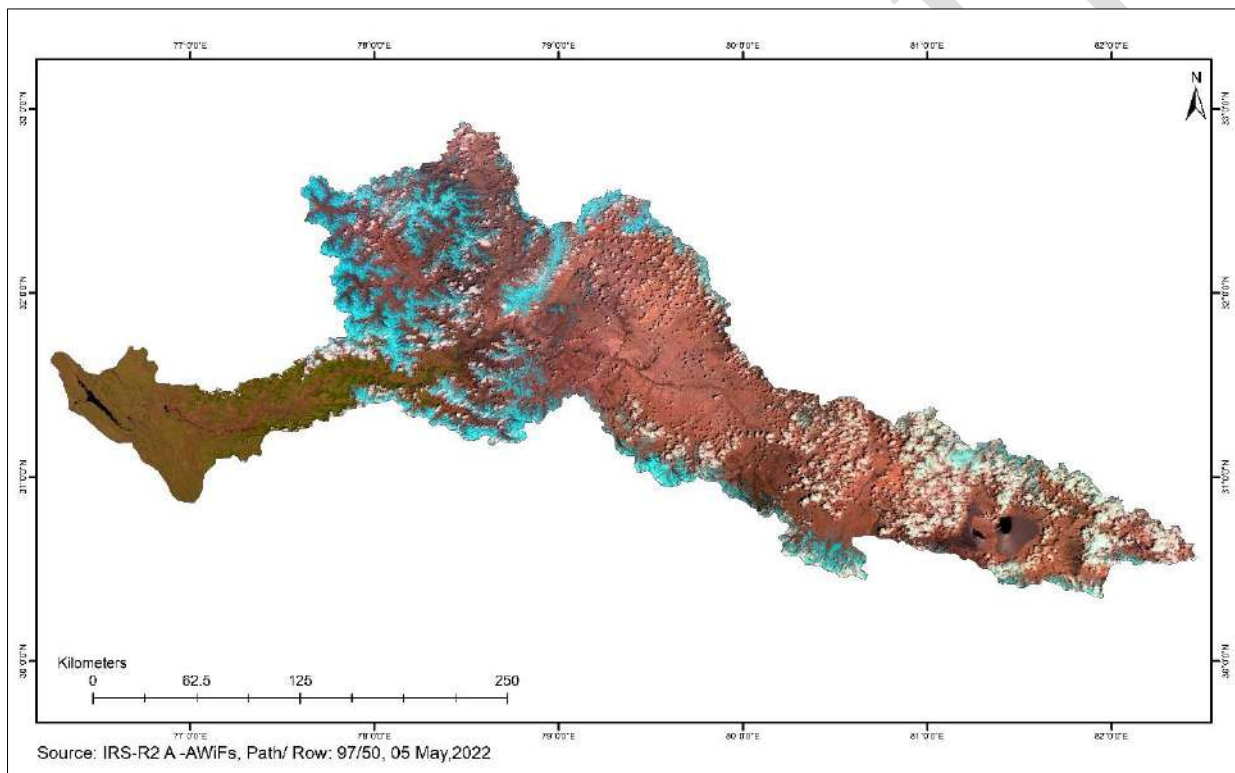


Fig.7.2 (a): IRS-R2 A-AWiFS, 97/50, 05th May 2022

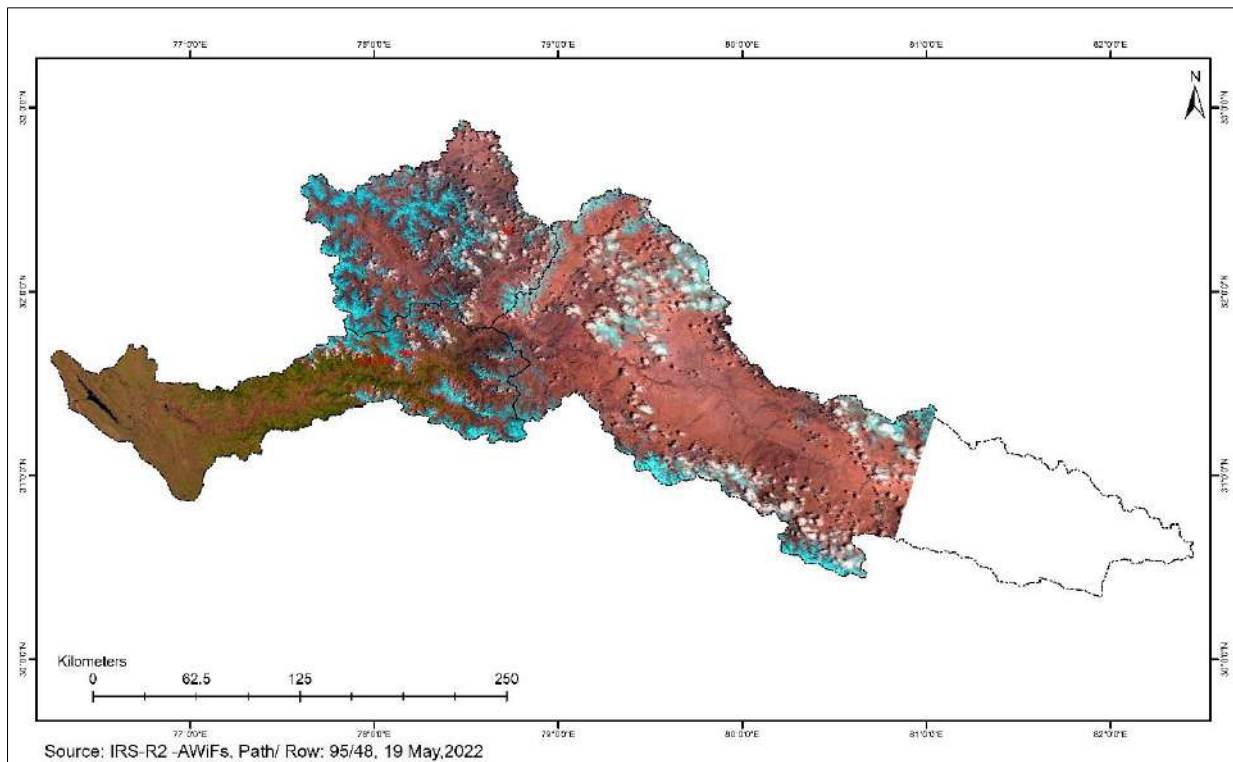


Fig.7.2 (b): IRS-R2-AWiFS, 95/48, 19th May 2022

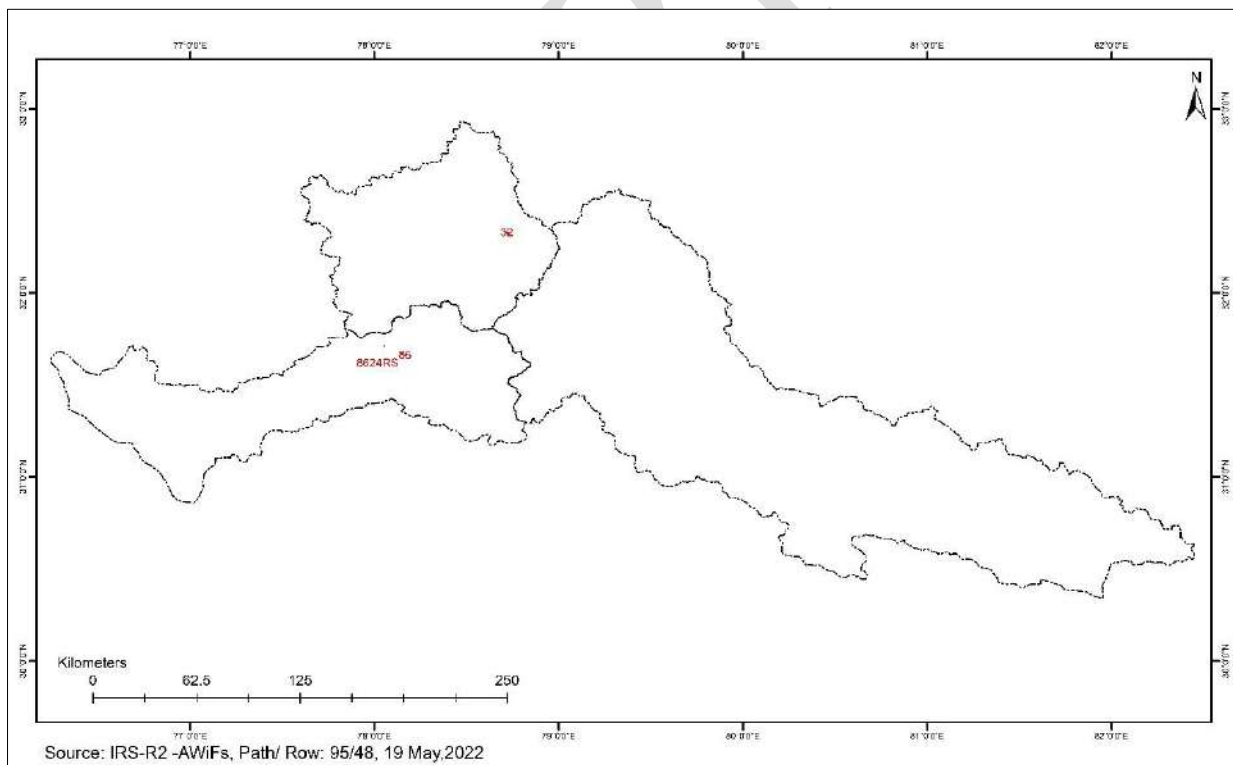


Fig.7.2 (c): IRS-R2-AWiFS, 97-49, 19th May 2022, interpreted Layer.

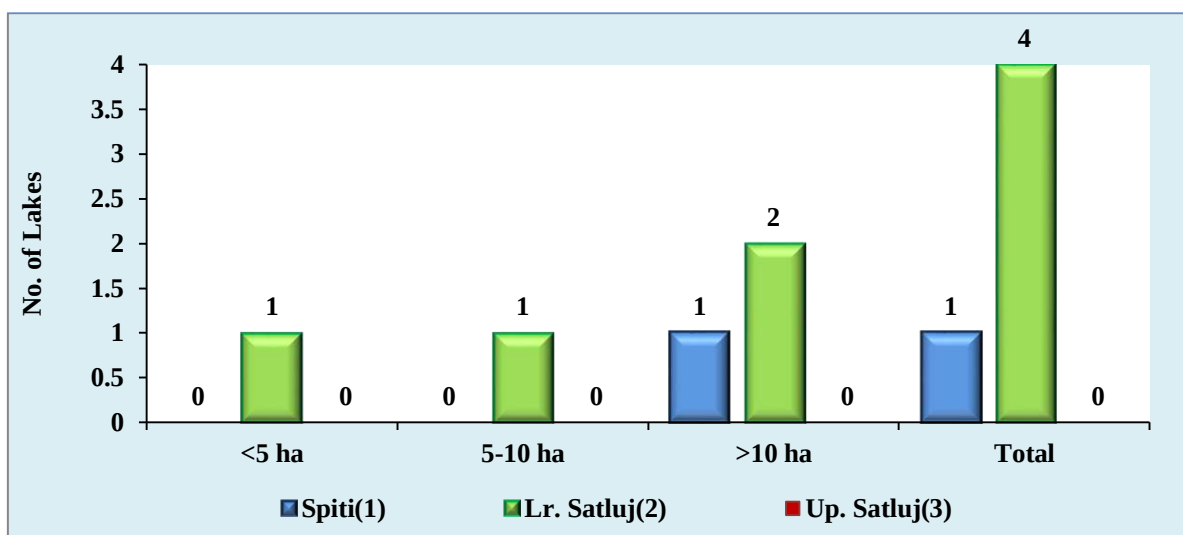


Fig.7.2 (d): No. lakes based on IRS-R2-AWiFS, 97-49, 19th May 2022

Table: 7.2 Aerial Extent of lakes as on May, 2022

Sr. No.	Lake Id.	Basin Number	Longitude	Latitude	Aerial Extent on May 2022 (ha.)
1	32	1	78.7184	32.3284	23.10
2	85	2	78.1667	31.6609	41.58
3	10091	2	78.0530	31.7110	5.30
4	10092	2	78.1470	31.6700	10.08
5	8624RS	2	78.0208	31.6194	4.18

7.3: Status of lakes as on June 2022

During the month of June 2022, only one AWiFs data product of 13th June was available (Fig: 7.3 (a)) with partial coverage. On analyzing the satellite data, a total of 338 lakes could be mapped out, of which 38 from Spiti sub basin i.e. basin number 1, 14 from Lower Satluj i.e. sub basin number 2 and 286 from the Upper Satluj basin i.e. sub basin number 3 (Fig: 7.3(b)). Further analysis of the data reflects that 192 lakes are small one with area less than 5ha, 71 are with areal range 5-10 ha and 75 lakes are with area greater than 10 ha (Fig: 7.3(c)). Likewise, 338 lakes shows that 38 are the High Altitude wetlands in Upper Satluj basin having 20 wetlands as the small with area less than 5ha, 5 are within the areal range of 5-10 ha and 13 wetlands are having area more than 10 ha (Fig: 7.3 (d)). Comparative analysis could not be done due to non-availability of data during 2022 and thus this forms the base line data for its monitoring during 2023.

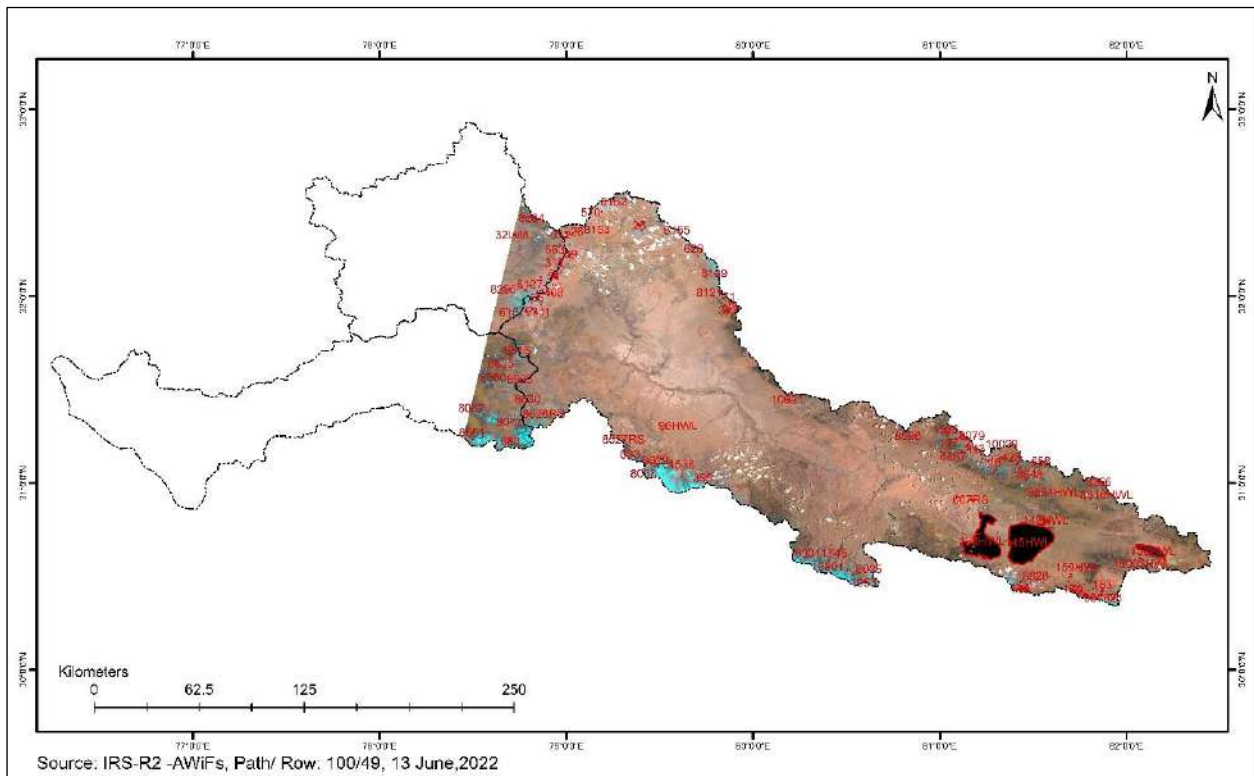


Fig.7.3 (a): IRS-R2-AWiFS, 100/49, 13th June 2022.

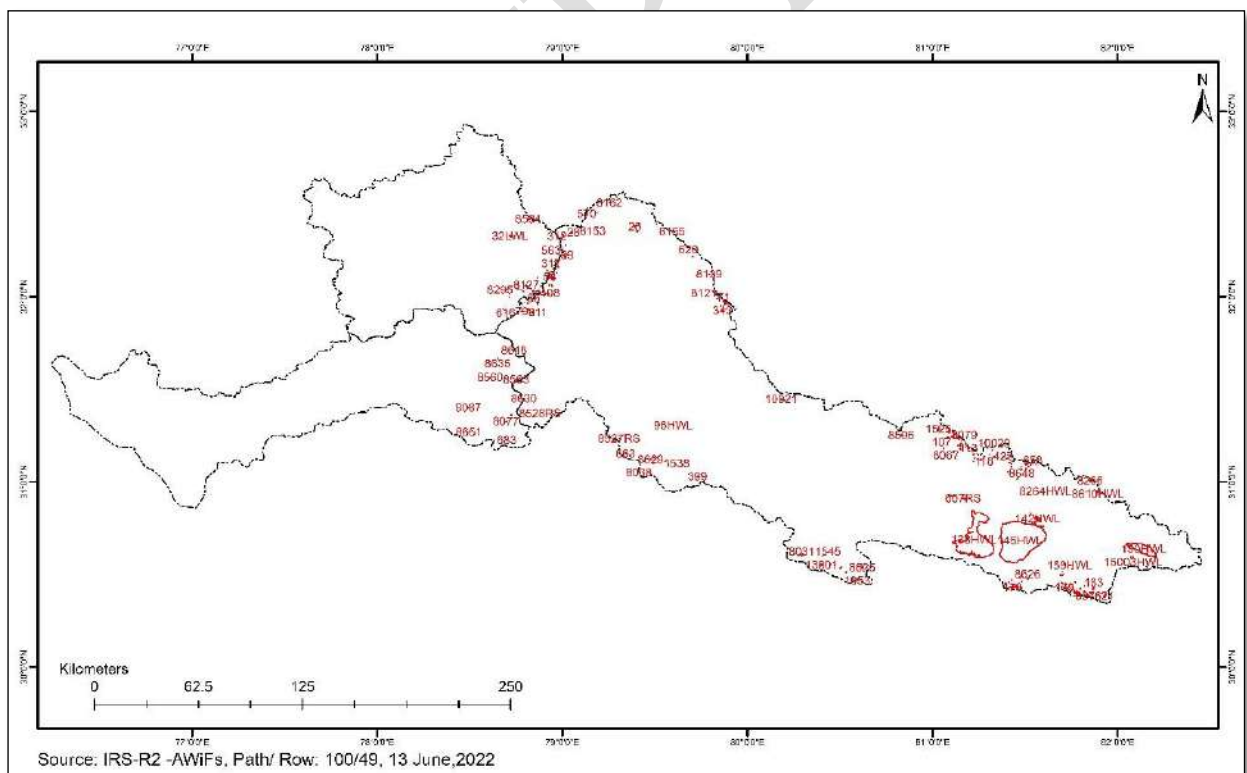


Fig.7.3 (b): IRS-R2-AWiFS, 100/49, 13th June 2022, interpreted layers.

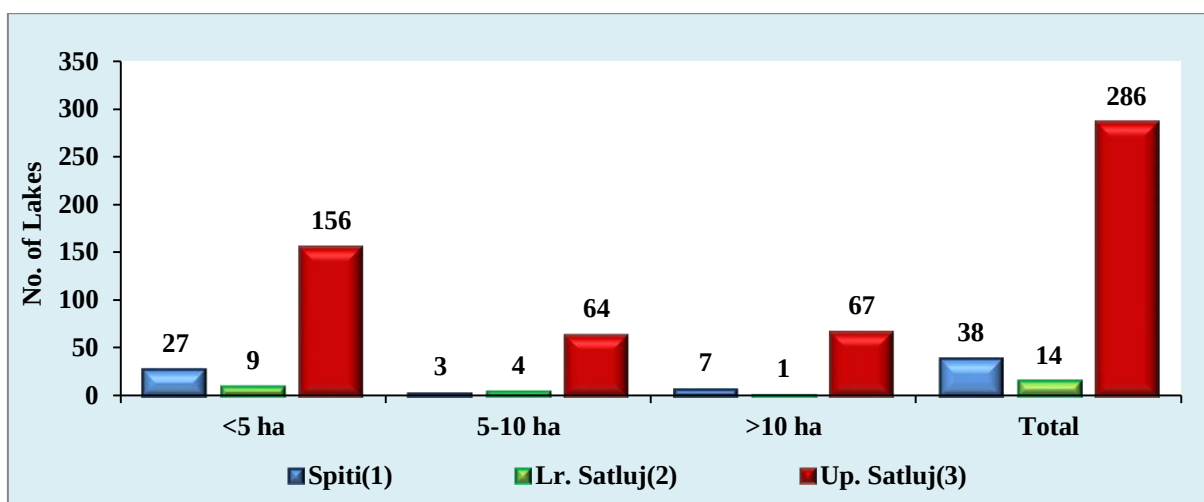


Fig.7.3 (c): No. of lakes based on IRS-R2-AWiFS, 100/49, 13th June 2022.

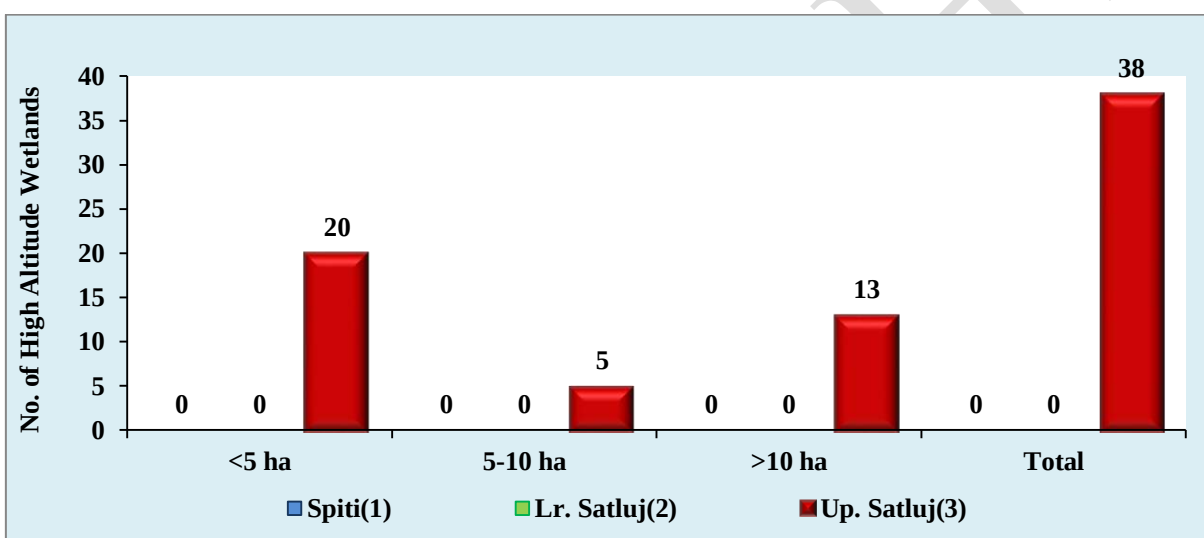


Fig.7.3 (d): No. of High Altitude Wetland lakes based on IRS-R2-AWiFS, 100/49, 13th June 2022.

Table: 7.3 Aerial Extent of lakes as on June, 2022

Sr. No.	Lake Id.	Basin Number	Longitude	Latitude	Aerial Extent on June 2022 (ha.)
1	23	3	79.4166	32.3897	12.98
2	25	3	79.3916	32.378	28.38
3	28	3	79.0532	32.3464	4.69
4	31	3	79.0007	32.3385	3.53
5	39	3	79.0269	32.2243	10.66
6	51	3	78.9423	32.1226	6.31
7	54	3	78.9313	32.1074	15.77
8	55	3	78.9416	32.108	12.22
9	60	1	78.873	32.0319	11.01
10	61	1	78.8444	32.0296	22.73
11	62	1	78.8738	32.017	10.18

12	63	1	78.8758	32.0201	1.94
13	65	3	78.8454	31.9924	23.16
14	71	3	79.8718	31.9773	10.76
15	73	3	79.8821	31.9699	4.19
16	74	3	79.8752	31.9674	4.2
17	79	3	78.7811	31.9198	24.48
18	106	3	81.1018	31.2434	5.49
19	107	3	81.0821	31.2396	8.13
20	112	3	81.1471	31.1985	10.23
21	113	3	81.1921	31.1817	66.32
22	114	3	81.1502	31.1783	20.51
23	118	3	81.2798	31.1372	12.02
24	119	3	81.2262	31.1295	8.12
25	122	3	81.4334	31.114	7.84
26	173	3	81.6747	30.4485	10.97
27	174	3	81.432	30.4488	8.19
28	178	3	81.429	30.4317	238.75
29	179	3	81.7134	30.4305	22.71
30	181	3	81.4614	30.4307	26.17
31	183	3	81.8706	30.4274	30.35
32	184	3	81.7221	30.4201	18.89
33	193	3	81.8653	30.3998	15.52
34	196	3	81.8933	30.3899	15.61
35	312	1	78.9716	32.3255	12.31
36	313	1	78.9777	32.3185	8.32
37	315	1	78.9719	32.1908	6.9
38	317	3	78.9791	32.1608	12.25
39	319	3	78.8381	31.9807	9.97
40	343	3	79.8652	31.9247	38.11
41	399	3	79.7312	31.028	14.2
42	408	3	78.91	32.0184	8.74
43	413	3	79.0058	32.2245	3.94
44	414	1	78.9754	32.2584	1.52
45	415	3	79.0035	32.3298	2.53
46	416	3	79.1868	32.4519	1.94
47	417	3	79.706	32.2153	2.24
48	422	3	81.0671	31.2338	2.66
49	426	3	81.503	31.0942	9.92
50	427	3	81.3816	31.1392	14.34
51	431	3	81.5014	31.1121	10.57
52	432	3	81.5178	31.0829	2.2
53	438	3	81.7398	30.4031	7.85

54	439	3	81.7214	30.4281	6.24
55	442	3	81.6979	30.4391	2.45
56	443	3	81.5135	30.4771	4.02
57	445	3	81.4814	30.4619	3.79
58	448	3	81.4562	30.4377	5.42
59	562	3	79.0171	32.2774	3.77
60	563	1	78.9825	32.2261	2.26
61	570	3	79.1305	32.4463	8.41
62	571	3	79.1328	32.4632	1.87
63	592	3	79.8039	32.1165	2.56
64	607	3	81.1329	31.245	4.96
65	610	3	78.9474	32.0931	6.32
66	611	3	78.9439	32.06	7.24
67	616	1	78.6962	31.9125	5.14
68	620	3	79.6816	32.2539	3.1
69	621	3	81.9301	30.3838	88.29
70	622	3	81.0842	31.2724	2.09
71	625	3	79.8767	31.9558	2.67
72	632	3	79.3657	31.1436	5
73	634	3	81.1428	31.2463	8.08
74	634	3	81.1393	31.2462	3.33
75	636	3	81.1092	31.2693	6.68
76	637	3	81.839	30.385	17.65
77	638(1)	3	81.8378	30.3912	4
78	638(2)	3	81.8292	30.3808	3.08
79	640	3	78.9698	32.129	3.86
80	641	3	79.8941	31.9586	5.26
81	645	3	81.0888	31.2664	7.95
82	646	3	81.1154	31.2638	3.29
83	647	3	81.1159	31.2606	7.11
84	648	3	81.1241	31.2374	5.49
85	649	3	81.1299	31.2442	7.34
86	651	3	81.4012	31.1278	7.24
87	652	3	81.4238	31.1378	8
88	655	3	81.512	31.0988	5.37
89	656	3	81.5299	31.0956	1.63
90	657	3	81.5446	31.1034	6.7
91	658	3	81.5419	31.1168	12.08
92	663	3	79.3412	31.1529	5.79
93	683	2	78.6999	31.2243	10.01
94	688	3	81.8192	30.4085	6.41
95	695	3	81.8438	30.3785	6.88

96	811	3	78.8391	31.9151	21.07
97	816	3	79.8793	31.9632	1.8
98	825	3	81.1132	31.2502	1.87
99	827	3	81.1372	31.1955	6.87
100	828	3	81.1528	31.2077	5.22
101	839	3	81.8026	30.3915	3.84
102	840	3	81.7834	30.4003	8.54
103	865	3	81.7746	30.3992	4.3
104	870	1	78.9269	32.1291	2.25
105	884	3	79.8898	31.9669	11.17
106	885	3	79.8816	31.9324	3.44
107	888	3	81.1478	31.204	1.4
108	964	3	81.7653	30.4077	3.1
109	1005	3	81.4805	30.4281	3.4
110	1006	3	81.4739	30.4275	3.68
111	1030	3	81.1775	31.1889	1.74
112	1052	3	80.5966	30.5444	9.95
113	1053	3	80.593	30.4776	17.25
114	1133	3	81.8683	30.4199	22.13
115	1142	3	81.7731	30.4043	1.56
116	1149	3	81.768	30.3973	10.24
117	1155	3	79.8356	31.9882	2.72
118	1510	3	81.5603	31.0945	1.71
119	1511	3	81.4253	31.0843	3.72
120	1512	3	81.4241	31.0802	2.48
121	1515	3	81.4161	31.1024	4.34
122	1516	3	81.4071	31.1441	2.26
123	1519	3	81.2149	31.1637	4.19
124	1522	3	81.1144	31.1677	3.31
125	1524	3	81.0327	31.2927	4.47
126	1525	3	81.0309	31.2852	23.52
127	1531	3	78.8695	31.97	8.33
128	1532	3	78.8658	31.9576	5.24
129	1538	3	79.5698	31.0927	5.77
130	1543	3	81.3913	30.4545	5.02
131	1545	3	80.4031	30.5963	2.97
132	1546	3	79.5125	31.1312	6.31
133	1552	1	78.9906	32.255	4.33
134	1585	1	78.862	32.0866	1.63
135	6001	3	78.8209	31.9327	2.45
136	6021	3	81.2618	31.1231	2.16
137	6060	3	78.8183	31.9295	3.2

138	7004	3	78.8155	31.9334	12.09
139	8006	3	81.7917	30.3972	7.78
140	8008	3	81.7767	30.3983	1.7
141	8011	3	80.5684	30.4773	2.32
142	8024	3	80.508	30.5413	2.23
143	8025	3	80.6221	30.5401	25.7
144	8026	3	80.4483	30.5535	3.1
145	8026	3	79.8116	32.0297	1.68
146	8027	3	80.4717	30.5534	11.8
147	8028	3	80.6159	30.5559	2.48
148	8028	3	78.972	32.1701	2.44
149	8029	3	80.6308	30.5546	4.74
150	8031	3	80.2922	30.6042	22.28
151	8038	3	79.4143	31.0598	4.07
152	8047	3	79.4896	31.1311	2
153	8054	3	81.5291	31.0931	3.89
154	8056	3	81.412	31.1034	5.48
155	8057	3	81.2575	31.1174	4.43
156	8058	3	81.4218	31.1144	3.71
157	8065	1	81.2217	31.1481	1.65
158	8065	3	78.712	31.9992	11.22
159	8067	3	81.111	31.16	3.63
160	8076	3	81.145	31.2309	2.76
161	8077	2	78.6952	31.3259	4.37
162	8079	3	81.1366	31.2344	15.15
163	8083	3	81.0301	31.2759	1.83
164	8087	2	78.4917	31.4004	4.29
165	8096	1	78.6978	31.9187	1.1
166	8107	3	79.898	31.9637	4.95
167	8117	1	78.7591	32.0417	3.23
168	8118	1	78.7626	32.0409	1.12
169	8121	3	79.8256	32.0185	5.43
170	8127	1	78.8061	32.0586	13.55
171	8137	1	78.9179	32.142	4.41
172	8138	3	78.9619	32.1497	2.29
173	8139	3	79.7924	32.1212	7.08
174	8141	1	78.9609	32.1849	1.9
175	8142	3	79.0195	32.2082	2.15
176	8143	3	79.0111	32.2146	3.95
177	8153	3	79.101	32.3542	3.31
178	8154	3	79.4048	32.3498	2.2
179	8155	3	79.5934	32.3524	5.16

180	8159	3	79.508	32.3919	1.98
181	8162	3	79.2535	32.5063	5.31
182	8236	3	79.7534	31.0399	11.25
183	8249	3	81.8521	30.3998	27.37
184	8252	3	81.428	30.4711	9.02
185	8253	3	81.4738	30.4825	3.71
186	8265	3	79.4899	31.097	2.72
187	8266	3	81.8511	31.0055	26.42
188	8286	3	78.9022	32.0439	1.87
189	8292	3	79.9193	31.9337	3.02
190	8293	3	79.856	31.9495	2.77
191	8295	1	78.7018	32.036	2.99
192	8296	3	79.8163	32.0211	1.69
193	8299	3	78.9475	32.1228	2.47
194	8507	3	81.7736	30.395	1.49
195	8508	3	81.7741	30.4013	1.76
196	8514	3	81.4094	30.4561	2.47
197	8517	3	80.532	30.512	10.1
198	8518	3	80.5033	30.5324	1.62
199	8523	3	79.4379	31.1112	3.03
200	8524	3	79.3574	31.1499	1.15
201	8531	2	78.7228	31.3627	2.28
202	8560	2	78.6113	31.5638	5.49
203	8562	2	78.7359	31.5187	6.48
204	8563	2	78.7508	31.5533	6.63
205	8566	3	78.8215	31.9307	0.86
206	8567	3	78.812	31.9652	5.97
207	8568	3	78.7974	31.9715	1.77
208	8571	1	78.781	32.0332	1.58
209	8574	1	78.8623	32.0711	2.52
210	8575	3	78.926	32.0147	3.4
211	8576	3	78.9513	32.1201	1.64
212	8580	3	78.9926	32.3164	3.05
213	8584	1	78.8163	32.4179	15.6
214	8596	3	80.8306	31.2518	5.67
215	8600	3	81.1146	31.2405	2.28
216	8603	3	81.4059	31.0557	2.77
217	8604	3	81.48	31.0805	2.9
218	8613	3	81.6969	30.4314	6.93
219	8614	3	79.5142	31.1042	1.99
220	8616	2	78.739	31.7096	2.22
221	8625	3	81.4115	30.4595	6.41

222	8626	3	81.5128	30.4814	8.9
223	8628	3	80.2747	30.6047	2.36
224	8629	3	79.4765	31.1208	7.91
225	8630	2	78.7924	31.4498	6.8
226	8631	2	78.662	78.662	2.49
227	8634	2	78.7325	78.7325	2.22
228	8635	2	78.6506	78.6506	1.63
229	8636	1	78.7453	78.7453	1.07
230	8639	3	79.8445	79.8445	3.08
231	8640	3	81.0181	81.0181	3.66
232	8641	3	81.0848	81.0848	1.14
233	8642	3	81.087	81.087	4.35
234	8647	3	81.428	81.428	2.29
235	8648	3	81.4812	81.4812	9.19
236	8650	3	81.4982	81.4982	4.11
237	8651	2	78.4956	78.4956	1.7
238	8666	2	78.7007	78.7007	2.2
239	8667	3	81.0589	81.0589	6.93
240	8668	3	81.2241	81.2241	3.1
241	8670	3	81.4598	81.4598	2.71
242	9004	3	81.5048	81.5048	1.66
243	9064	1	78.8845	78.8845	1.13
244	9091	3	81.9166	81.9166	9.41
245	9092	3	81.7841	81.7841	3.23
246	9093	3	81.7524	81.7524	7.22
247	9094	3	81.7968	81.7968	4.69
248	9095	3	81.7295	81.7295	14.98
249	9096	3	81.7081	81.7081	19.05
250	9098	3	81.716	81.716	6.08
251	9098	3	81.452	81.452	1.75
252	9099	3	80.5012	80.5012	2.17
253	10000	3	79.492	79.492	4.53
254	10001	1	78.6987	78.6987	0.87
255	10002	3	78.6814	31.9344	1.7
256	10003	1	78.7048	32.023	2.52
257	10004	1	78.701	32.0378	1.43
258	10005	1	78.7796	32.0341	1.13
259	10006	1	78.7911	32.0273	1.94
260	10007	1	78.8309	32.0436	1.58
261	10008	1	78.8604	32.0288	1.89
262	10009	1	78.8742	32.0246	2.95
263	10010	1	78.8646	32.1025	2.41

264	10011	3	78.9438	32.0572	2.73
265	10012	3	78.9278	32.0633	1.38
266	10013	3	78.9475	32.1069	1.35
267	10014	1	78.9246	32.1244	2.17
268	10015	1	78.9547	32.1679	2.13
269	10017	3	78.9018	32.0049	3.5
270	10018	3	78.8092	31.936	2.77
271	10019 (1)	3	79.1337	32.4419	2.37
272	10019(2)	3	79.8267	32.0114	1.04
273	10020	3	79.9024	31.9273	2.24
274	10021	3	80.1831	31.4467	15.86
275	10022	3	80.1963	31.4427	12.81
276	10023	3	81.1555	31.2237	2.73
277	10024	3	81.1993	31.1656	1.62
278	10025	3	81.3113	31.148	2.49
279	10026	3	81.312	31.1495	1.11
280	10027	3	81.3259	31.1383	3.89
281	10028	3	81.3205	31.1731	1.95
282	10029	3	81.2963	31.1817	3.01
283	10030	3	81.4568	31.0144	1.66
284	10031	3	81.778	30.3912	1.48
285	10032	3	79.44	31.1141	1.54
286	10093	3	81.1993	31.1656	1.54
287	13801	3	80.3992	30.552	48.74
288	18701	3	81.8461	30.3862	4.77
289	18901	3	81.8182	30.3908	17.04
290	185001	3	81.7454	30.4095	12.28
291	1012HWL	3	81.5425	30.8183	2.52
292	1022RS	3	81.1093	30.9233	2.73
293	1101HWL	3	81.7482	30.4475	2.28
294	1124HWL	3	81.8203	30.438	3.92
295	1136HWL	3	81.7768	30.4112	10.1
296	138HWL	3	81.2558	30.6737	25828.16
297	142HWL	3	81.5693	30.7998	360.31
298	145HWL	3	81.5002	30.7315	41481.9
299	148HWL	3	81.5874	30.7597	96.48
300	15002HWL	3	82.0718	30.5969	13.08
301	15003HWL	3	82.0841	30.5927	18.25
302	150HWL	3	82.1528	30.6397	5870.23
303	159HWL	3	81.74	30.5492	15.36
304	205HWL	3	81.5653	30.7874	3.01
305	206HWL	3	81.5494	30.7838	2.72

306	207HWL	3	81.5531	30.784	2.31
307	208HWL	3	81.555	30.7813	5.39
308	209HWL	3	81.5426	30.7716	19.5
309	210HWL	3	81.5525	30.7718	56.02
310	211HWL	3	81.6992	30.5138	4.79
311	32LWL	1	78.7263	32.3255	33.25
312	385HWL	3	81.5375	30.778	4.99
313	437HWL	3	81.6914	30.4968	3.93
314	440HWL	3	81.7194	30.4473	2.72
315	441HWL	3	81.6978	30.4545	4.74
316	607RS	3	81.1646	30.9118	43.11
317	608RS	3	81.0931	30.9249	13.9
318	608RS	3	81.1007	30.9253	3.72
319	616RS	3	81.1169	30.9241	7.88
320	677HWL	3	81.7063	30.5019	1.46
321	8055SG	3	81.2212	31.1104	2.29
322	824HWL	3	81.7613	30.4204	6.72
323	8258HWL	3	81.7107	30.5596	6.19
324	8264HWL	3	81.6673	30.9498	3.88
325	844HWL	3	81.7703	30.4589	5.07
326	8501HWL	3	82.1566	30.5428	4.21
327	8502HWL	3	82.1799	30.5848	3.06
328	8511HWL	3	81.7545	30.5317	13.76
329	8527RS	3	79.3067	31.233	6.36
330	8528RS	3	78.7975	31.3694	3.36
331	8610HWL	3	81.8923	30.9534	4.47
332	8611HWL	3	81.8904	30.9464	3.91
333	8611HWL	3	81.8935	30.9469	1.97
334	8627RS	3	81.181	30.9057	39.11
335	8663HWL	3	81.6935	30.4978	1.39
336	8664HWL	3	81.7002	30.4947	1.76
337	9010HWL	3	81.5294	30.8304	9.63
338	96HWL	3	79.5998	31.3051	22.05

7.4: Status of lakes as on July 2022.

During the month of July 2022, only two AWiFS data products of 2nd & 4th July could be obtained (Fig: 7.4 (a) & (b)) having partial coverage in both products. The data is partially cloudy and after thorough analysis of the data, a total of 122 lakes could be mapped out of which 21 from Spiti sub basin i.e. basin number 1, 16 from Lower Satluj i.e. sub basin number 2 and 85 from the Upper Satluj basin i.e. sub basin number 3 (Fig: 7.4(c)). The close analysis reveals that

57 lakes are small one with area less than 5ha, 30 lakes are with areal range 5-10 ha and 35 lakes are with area greater than 10 ha (Fig: 7.4(d)). Further analysis of 122 lakes shows that 26 are the High Altitude wetlands forming part of the Upper Satluj basin out of which 11 wetlands are with area more than 10 ha. (Fig: 7.4 (e)). The temporal analysis reveals that only 14 could be compared w.r.t 2021, out of which 9 lakes/wetlands have shown a reduction in their water spread, whereas 5 lakes/wetlands showed a positive trend, whereas the remaining lakes/wetlands could not be compared with that of 2021 due to non-availability of information and thus forms the base line data for next year monitoring (Table: 7.4).

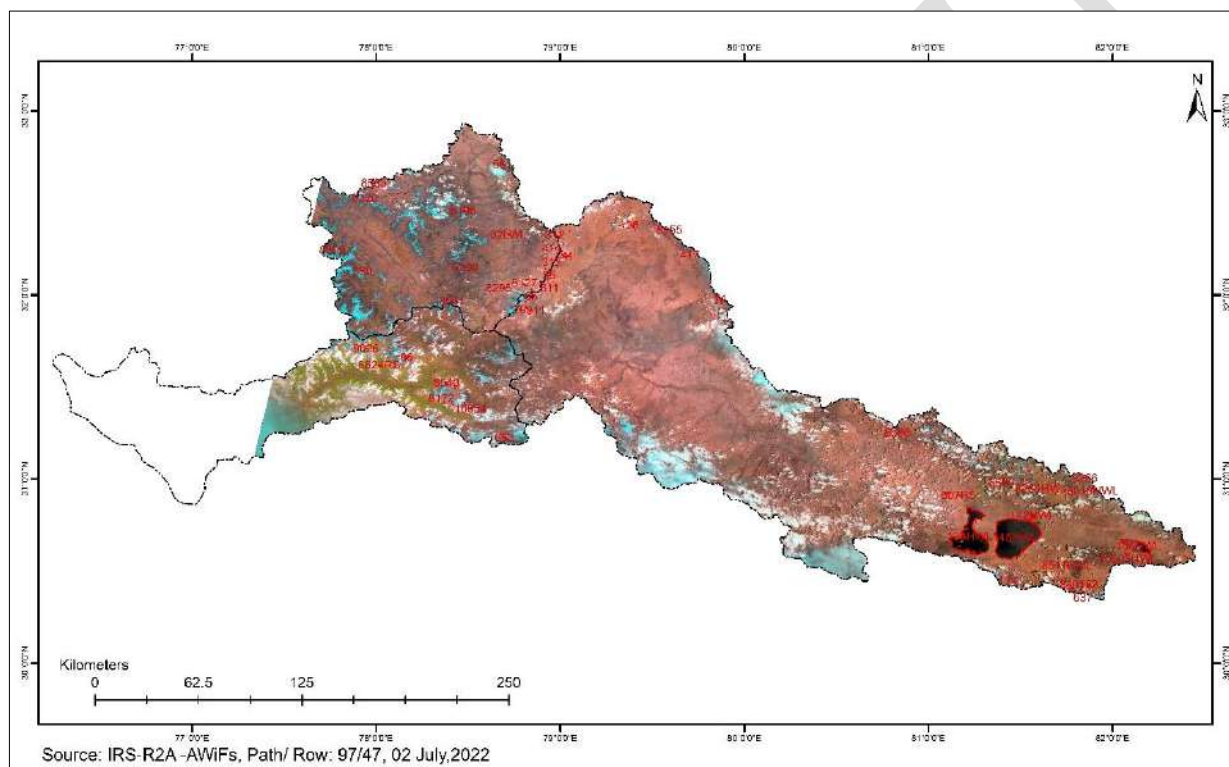
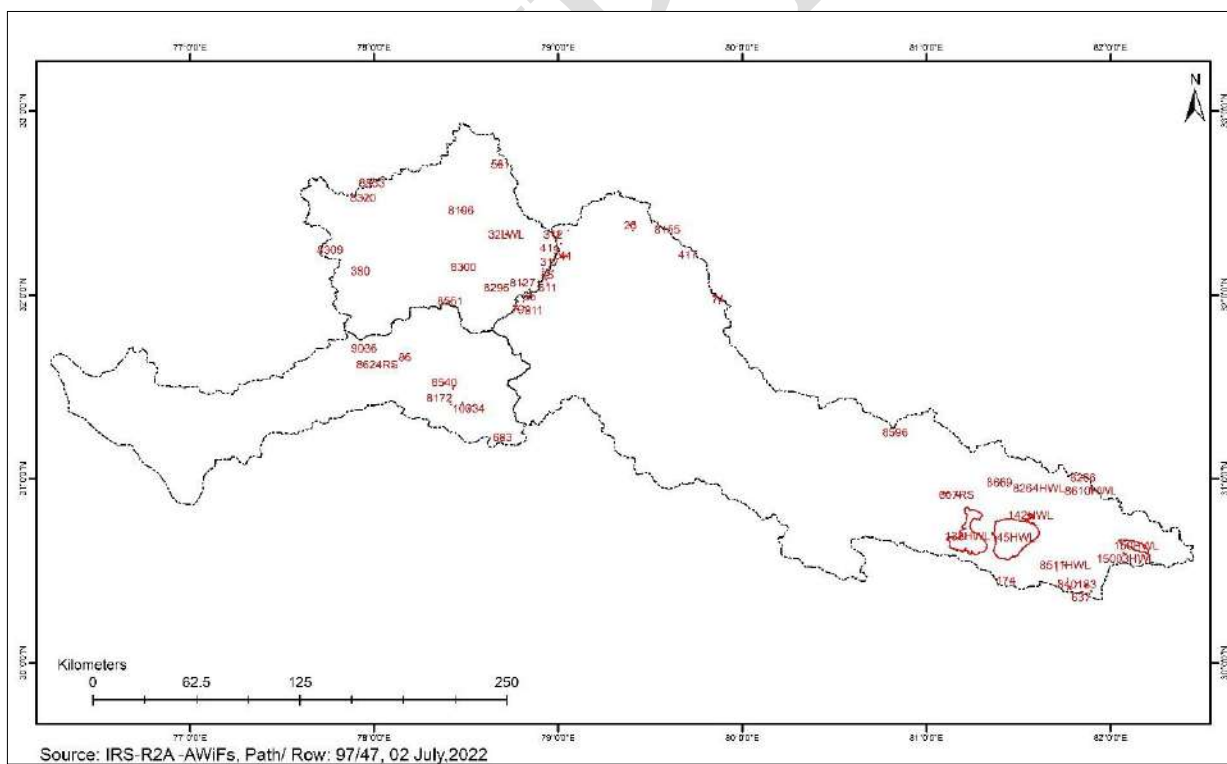
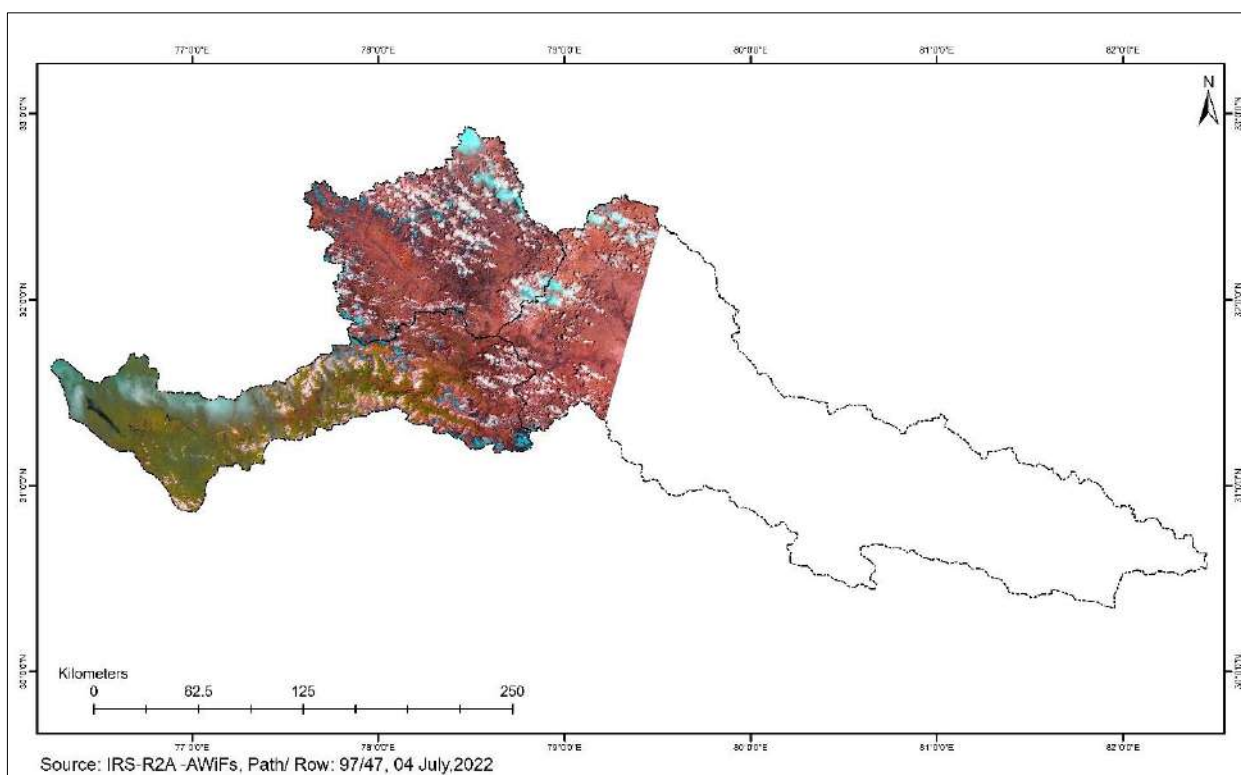


Fig.7.4 (a): IRS-R2 A-AWiFS, 97/47, 2nd July, 2022



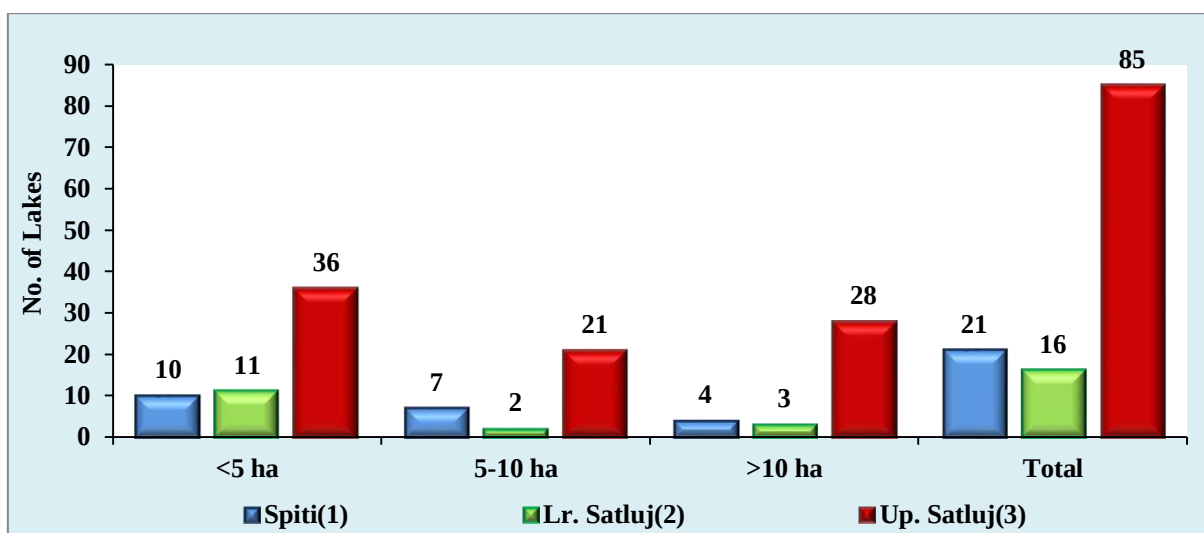


Fig.7.4 (d): No. lakes based on IRS-R2 A-AWiFS, 97/47, July, 2022

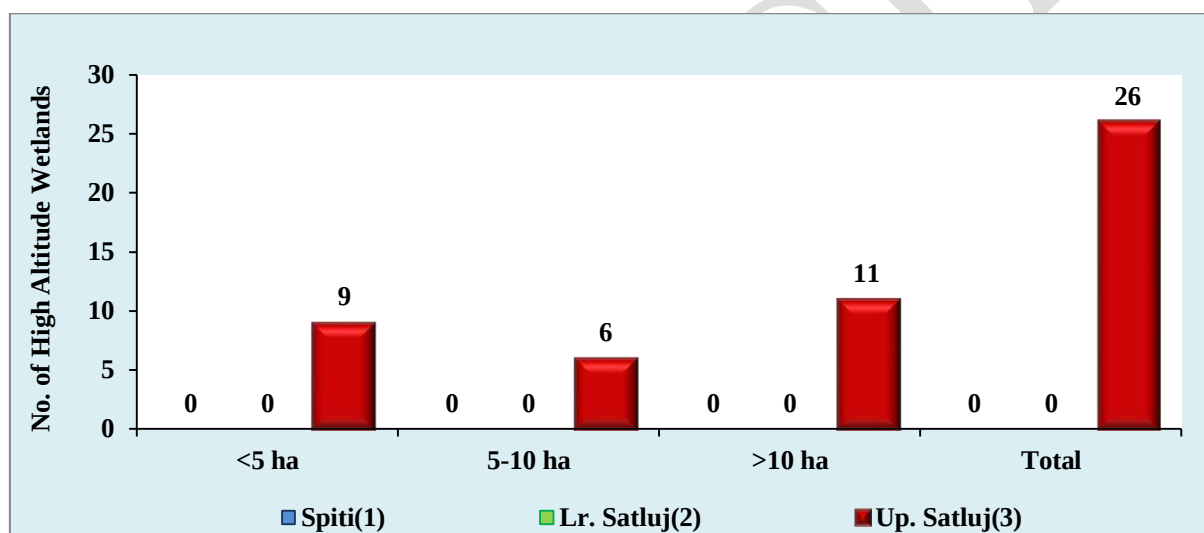


Fig.7.4 (e): No. of High altitude wetland lakes based on IRS-R2 A-AWiFS, 97/47, July, 2022

Table: 7.4 Aerial Extent of lakes as on July, 2022

Sr. No.	Lake Id.	Basin Number	Longitude	Latitude	Aerial Extent on July 2021 (ha.)	Aerial Extent on July 2022 (ha.)	Change in Area w.r.t. July 2021 (ha.)
1	23	3	79.4157	32.3901	-----	11.55	-----
2	25	3	79.3918	32.3776	-----	24.24	-----
3	28	3	79.051	32.347	-----	5.68	-----
4	31	3	79.0009	32.3385	-----	2.42	-----
5	41	3	79.0456	32.2093	-----	25.73	-----
6	51	3	78.9423	32.1226	-----	6.08	-----
7	55	3	78.9416	32.108	-----	11.86	-----
8	61	1	78.8444	32.0296	-----	14.45	-----
9	65	3	78.8454	31.9924	-----	21.18	-----

10	71	3	79.8709	31.9773	-----	8.53	-----
11	73	3	79.8809	31.9697	-----	4.84	-----
12	74	3	79.8745	31.968	-----	4.9	-----
13	79	3	78.7811	31.9198	22.62	23.97	(+)1.35
14	85	2	78.1675	31.6616	43.06	43.28	(+)0.22
15	174	3	81.433	30.448	-----	7.52	-----
16	183	3	81.8706	30.4274	-----	27.5	-----
17	196	3	81.8933	30.3899	-----	15.02	-----
18	312	1	78.9706	32.3256	-----	10.71	-----
19	313	1	78.9781	32.3192	-----	6.09	-----
20	315	1	78.9729	32.1914	-----	6.13	-----
21	317	3	78.977	32.161	-----	11.22	-----
22	319	3	78.8369	31.9806	11.95	16.2	(+)4.25
23	330	1	77.9256	32.1288	-----	2.75	-----
24	413	3	79.0046	32.2248	-----	2.43	-----
25	414	1	78.9768	32.2581	-----	2.38	-----
26	415	3	79.0001	32.3296	-----	1.59	-----
27	417	3	79.7049	32.2157	-----	2.2	-----
28	561	1	78.6872	32.7083	-----	3.31	-----
29	562	3	79.0158	32.2769	-----	5.36	-----
30	563	1	78.9824	32.2263	-----	1.99	-----
31	610	3	78.9474	32.0931	-----	6.25	-----
32	611	3	78.9439	32.06	-----	9.24	-----
33	625	3	79.8755	31.9557	-----	4.19	-----
34	637	3	81.8392	30.3856	-----	13.83	-----
35	638	3	81.8305	30.3802	-----	3.55	-----
36	640	3	78.971	32.1292	-----	2.96	-----
37	683	2	78.6973	31.225	-----	18.84	-----
38	695	3	81.8424	30.3794	-----	2.22	-----
39	811	3	78.8391	31.9151	-----	14.47	-----
40	840	3	81.7834	30.4003	-----	8.15	-----
41	1133	3	81.8683	30.4199	-----	10.56	-----
42	1149	3	81.7682	30.3977	-----	8.01	-----
43	6001	3	78.8196	31.9326	-----	2.69	-----
44	6045	2	78.4325	31.5034	-----	2.47	-----
45	6060	3	78.8185	31.9298	1.52	2.77	(+)1.25
46	7004	3	78.8155	31.9334	3.08	6.43	(+)3.35
47	8127	1	78.8061	32.0586	-----	15.54	-----
48	8137	1	78.9181	32.142	-----	3.86	-----
49	8141	1	78.9592	32.1855	-----	1.35	-----
50	8142	3	79.0191	32.2085	-----	3.69	-----
51	8143	3	79.0094	32.2155	-----	2.98	-----

52	8154	3	79.4055	32.35	-----	4.89	-----
53	8155	3	79.5931	32.3528	-----	7.52	-----
54	8159	3	79.5076	32.3919	-----	1.72	-----
55	8170	2	78.4195	31.4035	-----	1.93	-----
56	8171	2	78.4117	31.415	-----	0.82	-----
57	8172	2	78.4087	31.4383	-----	2.21	-----
58	8196	1	78.4732	32.4584	-----	9.12	-----
59	8266	3	81.8518	31.0037	-----	29.14	-----
60	8295	1	78.7005	32.0361	-----	2.97	-----
61	8299	3	78.9471	32.1227	-----	1.42	-----
62	8300	1	78.4863	32.1495	-----	7.63	-----
63	8309	1	77.7607	32.2425	-----	6.93	-----
64	8320	1	77.9397	32.5254	-----	6.23	-----
65	8538	2	78.4285	31.4915	-----	3.59	-----
66	8539	2	78.3844	31.516	-----	3.38	-----
67	8540	2	78.3814	31.5227	-----	8.65	-----
68	8551	1	78.4129	31.9655	-----	9.08	-----
69	8552	1	77.9159	32.1367	-----	3.64	-----
70	8553	1	77.9871	32.6074	-----	4.8	-----
71	8566	3	78.8215	31.9307	-----	1.68	-----
72	8567	3	78.812	31.9652	-----	6.31	-----
73	8569	3	78.8475	31.9954	-----	1.37	-----
74	8576	3	78.9501	32.1195	-----	1.39	-----
75	8580	3	78.9925	32.317	-----	3.32	-----
76	8596	3	80.8311	31.2521	-----	4.84	-----
77	8632	2	78.4798	31.4145	-----	1.49	-----
78	8638	3	79.5321	32.3708	-----	2.71	-----
79	8638	3	78.9364	32.0822	-----	6.61	-----
80	8639	3	79.8443	31.9923	-----	4.78	-----
81	8657	2	78.1041	31.6107	-----	1.13	-----
82	8669	3	81.3986	30.9803	-----	1.21	-----
83	9035	2	77.9006	31.7207	-----	2.53	-----
84	9036	2	77.946	31.7079	-----	3.01	-----
85	10033	2	77.9034	31.722	-----	1.92	-----
86	10034	2	78.5129	31.3833	-----	23.55	-----
87	10094	1	77.966	32.534	-----	3.66	-----
88	18701	3	81.8475	30.3859	-----	5.07	-----
89	1022RS	3	81.1097	30.9231	-----	1.48	-----
90	1124HWL	3	81.8203	30.438	-----	4.49	-----
91	1136HWL	3	81.7768	30.4112	-----	9.55	-----
92	138HWL	3	81.2558	30.6737	26103.69	26018.37	(-)85.32
93	142HWL	3	81.5693	30.7998	313.84	344.55	(+)30.71

94	145HWL	3	81.5002	30.7315	41442.63	41326.85	(-)115.78
95	148HWL	3	81.5767	30.7614	104.78	41.57	(-)63.21
96	15002HWL	3	82.0718	30.5969	-----	11.27	-----
97	15003HWL	3	82.0841	30.5927	-----	11.8	-----
98	150HWL	3	82.1528	30.6397	-----	5920.01	-----
99	159HWL	3	81.7405	30.5483	-----	12.68	-----
100	205HWL	3	81.5653	30.7868	7.81	3.9	(-)3.91
101	206HWL	3	81.549	30.7837	-----	5.25	-----
102	209HWL	3	81.5437	30.7723	6.19	8.81	-----
103	210HWL	3	81.5537	30.7714	58.16	37.16	(-)21.00
104	32LWL	1	78.718	32.3273	-----	39.73	-----
105	385HWL	3	81.5375	30.7778	5.02	2.59	(-)2.43
106	440HWL	3	81.7195	30.4482	-----	5.81	-----
107	607RS	3	81.1646	30.9118	22.92	40.98	(+)18.06
108	608RS (1)	3	81.0998	30.9253	-----	12.37	-----
109	608RS (2)	3	81.093	30.9244	-----	2.58	-----
110	616RS	3	81.1169	30.9241	10.28	7.05	(-)3.23
111	677HWL	3	81.7069	30.502	-----	1.77	-----
112	8264HWL	3	81.6673	30.9498	-----	4.71	-----
113	844HWL	3	81.7697	30.4588	-----	3.84	-----
114	8501HWL	3	82.1559	30.5421	-----	5.22	-----
115	8502HWL	3	82.1791	30.5843	-----	1.35	-----
116	8511HWL	3	81.754	30.5309	-----	18.81	-----
117	8515HWL	3	81.36	30.7037	-----	44.64	-----
118	8610HWL	3	81.8923	30.9534	-----	5.89	-----
119	8611HWL	3	81.8905	30.9467	-----	3.4	-----
120	8611HWL	3	81.8945	30.9471	-----	1.79	-----
121	8624RS	2	78.0227	31.6192	-----	6	-----
122	8627RS	3	81.1813	30.9072	-----	32.52	-----

7.5: Status of lakes as on August 2022.

From the analysis of the satellite data for the month of August 2022, two data products for 31st August were mosaicked having partial coverage of the Satluj Basin (Fig: 7.5(a) & (b)). From the analysis of these two products of 31st August, it have been become possible to delineate a total of 350 lakes in the entire catchment in comparison to 414 lakes (2021) comprising 76 from Spiti, 61 from Lower Satluj and 213 from Upper Satluj sub basin (Fig: 7.5 (c)). On analyzing 350 lakes further, it is interpreted that 229 lakes are such which have the area less than 5ha comprising 55 from Spiti, 44 from Lower Satluj and 130 from Upper Satluj basin. Further 73 lakes are such which falls within the areal range of 5-10ha comprising 15 from Spiti, 11 from Lower Satluj and

47 from Upper Satluj basin. In like manner 48 lakes are such which have the area more than 10ha and are considered big lakes comprising 6 from Spiti, 6 from Lower Satluj and 36 from Upper Satluj basin (Fig. 7.5 (d)). Further, out of 350 lakes, only 2 lakes are observed as the high altitude wetlands in which 1 wetland having area less than 5ha and another one is more than 10ha and forming part of the Upper Satluj basin (Fig. 7.5 (e)). On analyzing further, when these 350 lakes seen temporally w.r.t 2021 data, only 245 lakes out of 350 lakes could be compared for their temporal variation and out of which 166 lakes/wetlands have shown an increasing trend in their water spread, whereas 79 lakes/wetlands shown a reducing trend in their water spread with reference to 2021 data (Table: 7.4). The remaining lakes/wetlands which could not be compared form the base line data for their monitoring during the next ablation season, which may be due to the fact that either these lakes /wetlands were either not mapped during 2021 due to snow cover impacts or are the new one and thus mapped this year only. The 11 lakes with ids RS are mainly formed due to the accumulation of water along the main Satluj river course in the Upper Satluj sub basin (10 Lakes) and lower Satluj sub basin (1 Lake).pp

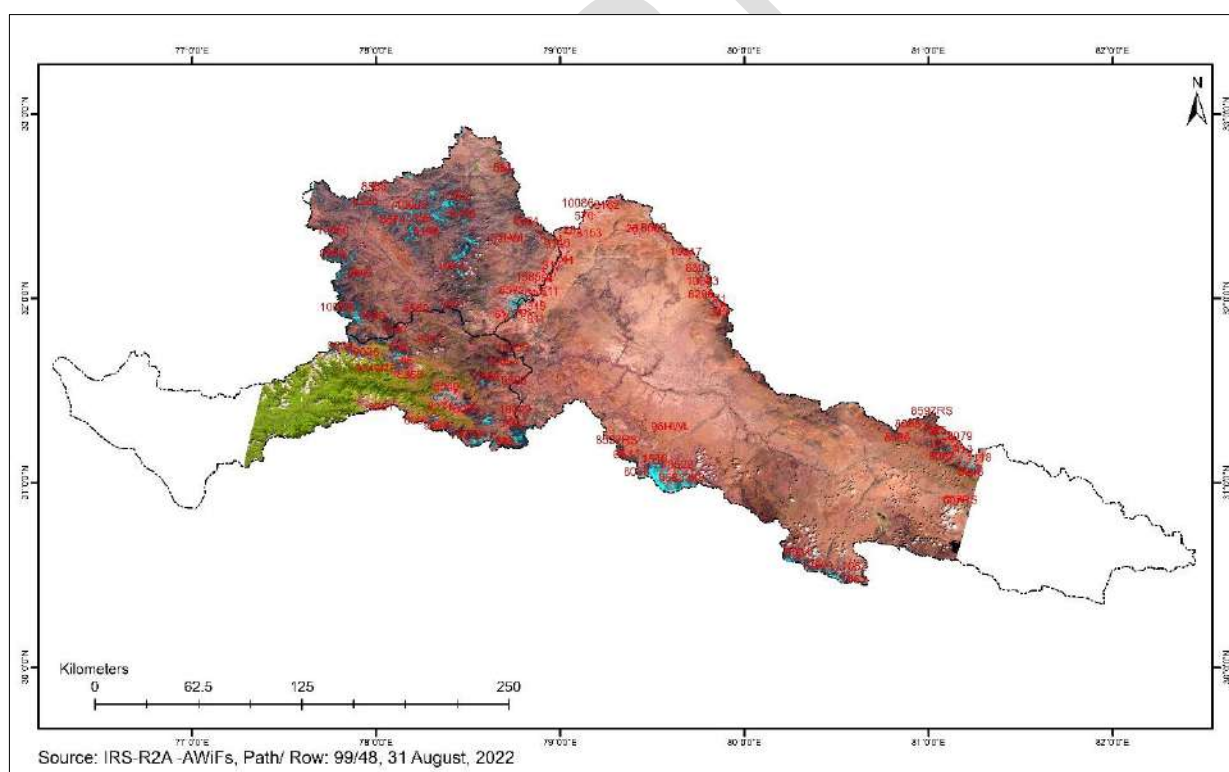


Fig.7.5 (a): IRS-R2 A, AWiFS, 99/48, 31st August, 2022

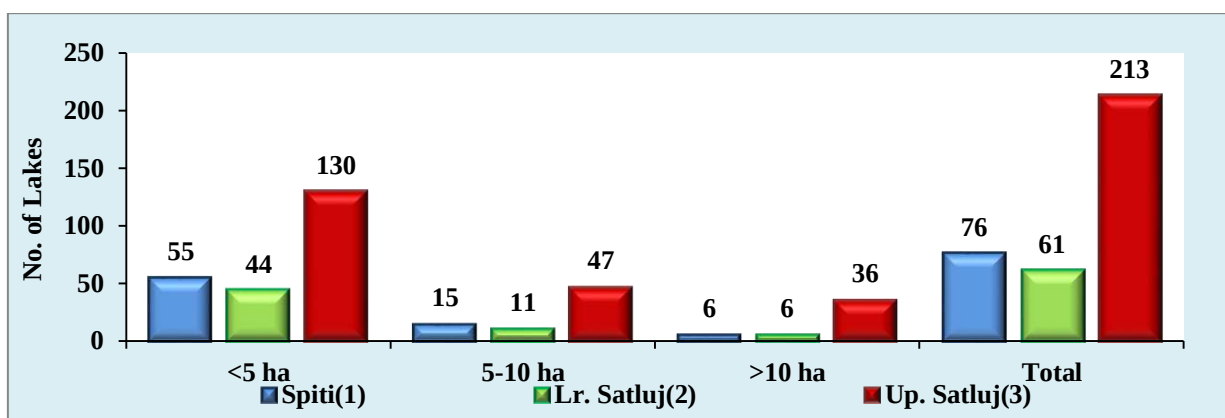


Fig.7.5 (d): No. of lakes based on IRS-R2 A, AWiFS, 99/48, 31st August, 2022

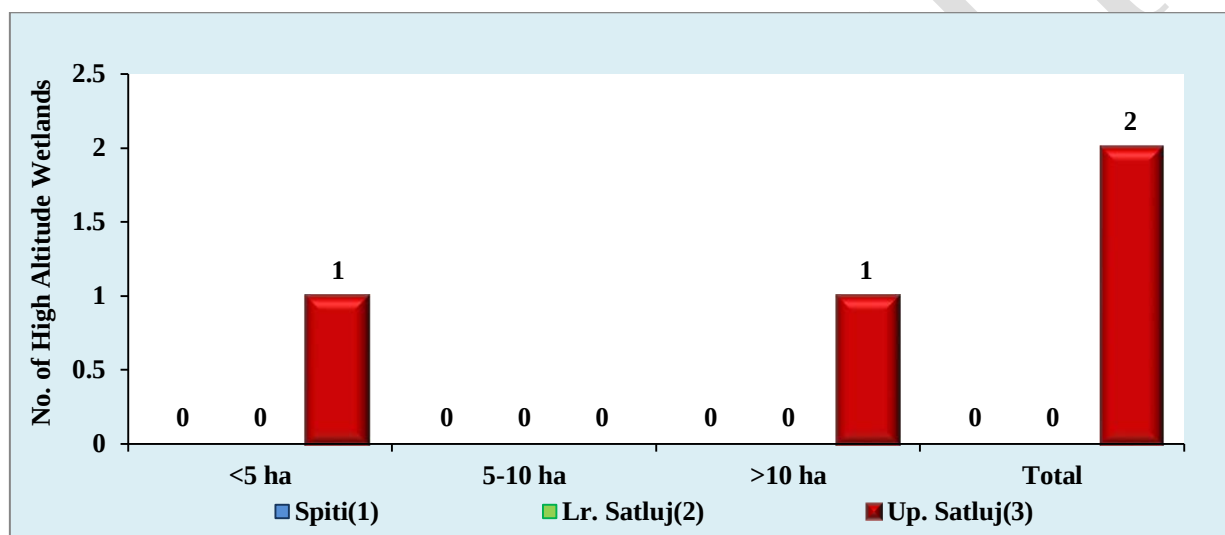


Fig.7.5 (e): No. of High altitude wetland lakes based on IRS-R2, AWiFS, 99/48, 31st Aug. 2022

Table: 7.5 Aerial Extent of lakes as on 99/48, 31st August, 2022

Sr. No.	Lake Id.	Basin Number	Longitude	Latitude	Aerial Extent on August 2021 (ha.)	Aerial Extent on August 2022 (ha.)	Change in Area w.r.t. August 2021 (ha.)
1	23	3	79.4155	32.3908	10.48	12.90	(+)2.42
2	25	3	79.3925	32.3774	25.28	33.29	(+)8.01
3	28	3	79.0515	32.3468	5.76	5.76	-----
4	31	3	79.0008	32.3385	11.63	4.80	(-)6.83
5	39	3	79.0256	32.2253	6.09	9.03	(+)2.94
6	41	3	79.0435	32.2104	24.84	27.37	(+)2.53
7	51	3	78.9417	32.1230	7.88	7.05	(-)0.83
8	54	3	78.9303	32.1079	10.92	17.63	(+)6.71
9	55	3	78.9418	32.1073	11.43	12.78	(+)1.36
10	60	3	78.8721	32.0318	6.27	12.88	(+)6.60
11	61	1	78.8448	32.0299	27.05	24.56	(-)2.50

12	62	3	78.8741	32.0172	11.50	13.54	(+)2.03
13	63	3	78.8760	32.0200	4.68	2.85	(-)1.83
14	71	3	79.8715	31.9776	9.29	12.93	(+)3.64
15	74	3	79.8809	31.9698	5.19	5.98	(+)0.79
16	79	3	78.7828	31.9190	22.70	24.19	(+)1.49
17	85	1	78.1675	31.6606	40.86	44.60	(+)3.74
18	106	3	81.1014	31.2439	5.83	5.91	(+)0.08
19	107	3	81.0832	31.2397	8.03	7.80	(-)0.23
20	112	3	81.1477	31.1999	14.69	17.87	(+)3.18
21	113	3	81.1932	31.1819	53.32	58.03	(+)4.71
22	114	3	81.1513	31.1777	24.34	32.01	(+)7.67
23	118	3	81.2787	31.1377	13.54	10.77	(-)2.76
24	119	3	81.2272	31.1297	6.22	8.58	(+)2.35
25	312	3	78.9722	32.3247	6.68	7.60	(+)0.92
26	313	3	78.9776	32.3201	10.92	10.51	(-)0.41
27	315	1	78.9722	32.1912	4.92	5.96	(+)1.04
28	317	3	78.9772	32.1612	11.89	10.82	(-)1.06
29	319	3	78.8369	31.9803	13.69	17.85	(+)4.16
30	330	1	77.9241	32.1289	1.87	1.64	(-)0.23
31	343	3	79.8637	31.9264	32.41	35.42	(+)3.01
32	399	3	79.7305	31.0285	12.67	11.69	(-)0.97
33	402	2	78.1240	31.7395	5.25	5.24	-----
34	408	3	78.9110	32.0178	6.97	9.06	(+)2.09
35	413	3	79.0049	32.2250	1.83	4.70	(+)2.87
36	414	1	78.9762	32.2591	3.66	2.84	(-)0.82
37	415	3	79.0004	32.3295	2.49	3.21	(+)0.71
38	416	3	79.1868	32.4518	4.21	5.15	(+)0.94
39	422	3	81.0675	31.2337	2.67	3.86	(+)1.19
40	423	3	81.1598	31.2171	9.16	14.50	(+)5.34
41	559	1	78.7058	32.7075	3.03	4.21	(+)1.17
42	561	1	78.6890	32.7082	8.23	8.43	(+)0.21
43	562	3	79.0172	32.2774	3.65	4.19	(+)0.54
44	563	1	78.9823	32.2264	2.75	2.84	(+)0.09
45	570	3	79.1303	32.4460	6.39	7.46	(+)1.07
46	571	3	79.1293	32.4631	3.86	5.16	(+)1.30
47	592	3	79.8036	32.1170	1.91	4.82	(+)2.91
48	607	3	81.1325	31.2453	3.13	4.83	(+)1.70
49	610	3	78.9462	32.0927	5.54	7.35	(+)1.82
50	611	3	78.9418	32.0606	5.75	9.21	(+)3.46
51	616	1	78.6975	31.9132	4.85	6.99	(+)02.15
52	622	3	81.0842	31.2722	2.56	1.95	(-)0.61
53	632	3	79.3658	31.1435	6.10	4.41	(-)1.69
54	634	3	81.1421	31.2459	8.73	10.03	(+)1.30
55	635	2	78.2531	31.3408	15.10	24.08	(+)8.98

56	636	3	81.1080	31.2700	4.72	4.28	(-)0.43
57	640	3	78.9698	32.1297	3.39	3.39	-----
58	641	3	79.8935	31.9589	4.33	4.73	(+)0.40
59	645	3	81.0887	31.2662	7.90	7.90	-----
60	646	3	81.1156	31.2643	2.09	2.68	(+)0.59
61	647	3	81.1163	31.2598	4.90	4.92	(+)0.02
62	648	3	81.1240	31.2377	2.15	5.32	(+)3.17
63	649	3	81.1294	31.2445	3.02	3.92	(+)0.90
64	663	3	79.3417	31.1534	6.14	6.66	(+)0.52
65	683	2	78.6996	31.2241	10.70	13.30	(+)2.60
66	811	3	78.8399	31.9146	29.59	12.32	(-)17.26
67	825	3	81.1122	31.2508	2.19	2.46	(+)0.27
68	827	3	81.1373	31.1943	9.27	10.63	(+)1.35
69	828	3	81.1532	31.2089	2.47	2.11	(-)0.35
70	870	1	78.9264	32.1297	1.87	1.96	(+)0.08
71	884	3	79.8887	31.9669	6.14	5.30	(-)0.84
72	885	3	79.8811	31.9327	2.45	3.26	(+)0.81
73	888	3	81.1472	31.2040	1.56	1.54	(-)0.02
74	1030	3	81.1777	31.1888	3.15	1.67	(-)1.48
75	1038	3	79.7955	32.1277	4.87	6.28	(+)1.41
76	1052	3	80.5969	30.5455	5.94	8.77	(+)2.84
77	1053	3	80.5910	30.4763	9.91	16.20	(+)6.29
78	1155	3	79.8354	31.9884	2.44	2.84	(+)0.40
79	1519	3	81.2153	31.1641	1.93	2.25	(+)0.32
80	1522	3	81.1152	31.1678	3.14	2.89	(-)0.25
81	1524	3	81.0323	31.2929	5.50	5.42	(-)0.08
82	1525	3	81.0314	31.2851	21.87	20.10	(-)1.77
83	1531	3	78.8688	31.9707	8.33	11.28	(+)2.96
84	1532	3	78.8659	31.9581	5.24	4.83	(-)0.40
85	1538	3	79.5695	31.0925	3.34	4.23	(+)0.88
86	1546	3	79.5126	31.1321	6.12	6.20	(+)0.08
87	1552	1	78.9906	32.2550	2.12	2.67	(+)0.55
88	1568	3	78.8437	32.0121	3.59	3.59	-----
89	1585	1	78.8633	32.0864	2.42	3.19	(+)0.78
90	1604	3	78.9016	32.0048	2.20	4.33	(+)2.13
91	1606	3	78.9972	32.2248	1.81	2.36	(+)0.56
92	6001 (1)	3	78.8209	31.9326	2.41	2.66	(+)0.25
93	6001(2)	3	78.8226	31.9328	-----	2.51	-----
94	6021	3	81.2620	31.1239	1.81	1.97	(+)0.16
95	6045	2	78.4332	31.5072	2.91	2.04	(-)0.88
96	6060	3	78.8183	31.9295	2.45	2.45	-----
97	7004(1)	3	78.8171	31.9326	4.86	4.98	(+)0.12
98	7004(2)	3	78.8142	31.9342	3.05	2.72	(-)0.34
99	8011	3	80.5687	30.4777	3.54	6.37	(+)2.83

100	8024	3	80.5085	30.5411	1.53	1.10	(-)0.44
101	8026	3	79.8122	32.0297	4.16	3.74	(-)0.42
102	8027(1)	3	80.4708	30.5527	3.33	2.29	(-)1.04
103	8027(2)	3	80.4751	30.5562	10.55	15.78	(+)5.23
104	8028	3	78.9715	32.1706	2.80	1.57	(-)1.23
105	8031	3	80.2930	30.6064	16.01	23.03	(+)7.02
106	8037	3	79.4110	31.0606	4.94	5.55	(+)0.61
107	8038	3	79.4150	31.0599	7.72	6.58	(-)1.14
108	8047	3	79.4899	31.1317	1.83	2.60	(+)0.77
109	8048	3	81.2300	31.0598	3.70	14.74	(+)11.04
110	8057	3	81.2571	31.1166	5.37	4.54	(-)0.83
111	8059	3	81.2665	31.1241	1.21	1.07	(-)0.14
112	8062	3	81.1820	31.1376	4.10	2.78	(-)1.31
113	8063	3	81.2574	31.1397	3.40	2.21	(-)1.19
114	8065	3	81.2214	31.1481	11.55	14.51	(+)2.95
115	8067	3	81.1111	31.1598	4.03	4.27	(+)0.24
116	8071	2	78.8030	31.2946	4.60	3.17	(-)1.44
117	8074	3	81.1282	31.2187	3.72	4.93	(+)1.21
118	8076	3	81.1443	31.2314	3.31	3.58	(+)0.27
119	8077	2	78.6954	31.3257	2.47	3.51	(+)1.04
120	8079	3	81.1365	31.2353	11.00	14.10	(+)3.10
121	8083	3	81.0276	31.2769	3.05	2.29	(-)0.76
122	8086	3	81.0120	31.2949	4.43	3.38	(-)1.05
123	8087	2	78.4900	31.4009	6.16	6.04	(-)0.12
124	8088	3	80.9546	31.3188	2.18	3.69	(+)1.51
125	8096	1	78.7004	31.9185	0.90	1.79	(+)0.89
126	8101	1	78.6833	31.9342	2.46	1.70	(-)0.76
127	8107	3	79.8982	31.9646	4.82	4.88	(+)0.06
128	8117	1	78.7572	32.0421	3.39	2.90	(-)0.49
129	8120	1	78.7795	32.0536	2.33	1.74	(-)0.59
130	8121	3	79.8252	32.0181	4.50	5.07	(+)0.57
131	8123	3	78.8853	32.0721	4.47	4.47	-----
132	8125	3	79.8139	32.0277	2.99	3.56	(+)0.57
133	8129	3	79.8019	32.0783	5.48	4.89	(-)0.59
134	8131	3	78.9464	32.1199	3.28	7.68	(+)4.40
135	8137	1	78.9163	32.1422	4.08	5.26	(+)1.18
136	8138	3	78.9617	32.1499	1.82	2.43	(+)0.61
137	8139	3	79.7934	32.1213	6.08	7.57	(+)1.49
138	8140	3	79.7682	32.1334	3.13	5.24	(+)2.11
139	8141	1	78.9599	32.1851	2.73	3.98	(+)1.25
140	8142	3	79.0184	32.2085	3.34	4.52	(+)1.17
141	8143	3	79.0092	32.2151	3.98	3.78	(-)0.21
142	8146	3	78.9832	32.2994	15.54	15.31	(-)0.24
143	8153	3	79.1033	32.3545	5.09	5.09	-----

144	8154	3	79.4042	32.3505	2.75	5.24	(+)2.49
145	8159	3	79.5078	32.3924	1.18	2.48	(+)1.30
146	8162	3	79.2537	32.5066	5.94	4.97	(-)0.97
147	8170	2	78.4185	31.3994	3.37	2.24	(-)1.14
148	8171	2	78.4085	31.4121	3.08	3.08	-----
149	8172	2	78.4094	31.4376	3.44	2.39	(-)1.05
150	8173	2	78.3699	31.4580	1.24	2.87	(+)1.62
151	8194	1	78.2716	32.3631	14.13	16.64	(+)2.52
152	8196	1	78.4729	32.4575	11.11	9.47	(-)1.64
153	8265	3	79.4902	31.0984	3.37	3.55	(+)0.19
154	8272	3	81.2503	31.1166	1.85	1.30	(-)0.55
155	8277	2	78.0680	31.4197	3.72	2.65	(-)1.07
156	8280	2	78.0098	31.4065	7.71	6.30	(-)1.41
157	8281	2	78.0265	31.4088	5.99	11.09	(+)5.10
158	8282	3	80.9832	31.3128	1.91	2.26	(+)0.35
159	8286	3	78.9026	32.0439	1.53	2.96	(+)1.43
160	8287	2	78.1756	31.5848	2.78	2.30	(-)0.48
161	8288	2	78.1833	31.5854	8.82	10.38	(+)1.57
162	8289	1	78.7159	31.9008	2.73	3.45	(+)0.72
163	8292	3	79.9191	31.9341	1.60	1.61	(+)0.01
164	8293	3	79.8561	31.9499	1.77	2.68	(+)0.91
165	8295	1	78.7020	32.0361	2.40	3.64	(+)1.23
166	8296	3	79.8167	32.0212	2.48	5.41	(+)2.94
167	8299	3	78.9476	32.1225	1.49	2.00	(+)0.51
168	8300	1	78.4876	32.1497	5.43	7.22	(+)1.79
169	8302	1	78.4613	32.1609	2.44	3.58	(+)1.14
170	8304	1	78.4128	32.1762	12.82	16.40	(+)3.58
171	8307(1)	1	79.7501	32.1447	3.63	4.90	(+)1.27
172	8307(2)	3	78.4169	32.2049	5.83	5.38	(-)0.44
173	8309	1	77.7625	32.2421	3.64	3.56	(-)0.08
174	8310	3	79.0428	32.2520	2.47	1.34	(-)1.13
175	8320	1	77.9423	32.5252	6.65	6.65	-----
176	8323	1	78.7093	32.6959	4.55	4.13	(-)0.42
177	8324	1	78.7179	32.6983	1.18	2.27	(+)1.08
178	8325	1	78.7322	32.6984	2.85	4.21	(+)1.36
179	8326	1	78.6988	32.7046	7.17	9.13	(+)1.96
180	8327	1	78.7085	32.7109	3.29	4.84	(+)1.56
181	8517	3	80.5320	30.5111	5.48	5.48	-----
182	8518	3	80.5040	30.5328	2.52	3.03	(+)0.50
183	8520	3	79.6537	31.0743	2.13	1.31	(-)0.82
184	8521	3	79.6503	31.0722	2.42	1.96	(-)0.46
185	8522	3	79.6478	31.0774	2.17	3.01	(+)0.84
186	8523(1)	3	79.6079	31.0308	1.53	1.53	-----
187	8523(2)	3	79.4386	31.1113	1.20	1.20	-----

188	8524	3	79.3573	31.1508	2.16	2.79	(+)0.63
189	8529	3	78.8040	31.3183	0.85	1.74	(+)0.89
190	8530	3	78.7915	31.3125	0.94	1.25	(+)0.31
191	8531	2	78.7233	31.3627	4.59	3.56	(-)1.04
192	8532	2	78.7027	31.3601	3.61	2.91	(-)0.70
193	8534	2	78.5816	31.3747	2.17	1.15	(-)1.03
194	8535	2	78.4307	31.4317	1.51	3.22	(+)1.71
195	8536	2	78.4306	31.4951	1.88	0.71	(-)1.17
196	8537	2	78.4296	31.4937	1.17	1.86	(+)0.69
197	8538	2	78.4282	31.4912	1.86	4.63	(+)2.77
198	8539	2	78.3851	31.5158	4.55	4.08	(-)0.47
199	8540	2	78.3827	31.5225	6.74	8.40	(+)1.67
200	8541	2	78.1616	31.3722	2.75	3.68	(+)0.93
201	8542	2	78.1902	31.5848	1.27	1.11	(-)0.16
202	8543	2	78.1393	31.6706	1.24	1.73	(+)0.49
203	8544	2	78.1165	31.7492	1.19	1.19	-----
204	8545	2	78.1041	31.7783	3.05	3.05	-----
205	8546	2	78.1017	31.7774	4.89	4.89	-----
206	8547	2	78.1044	31.8317	6.98	6.98	-----
207	8548	1	77.9795	31.8896	5.99	3.42	(-)2.56
208	8549	1	78.3023	31.7901	2.77	3.41	(+)0.64
209	8550	1	78.2173	31.9445	3.56	3.79	(+)0.23
210	8551	1	78.4164	31.9644	9.19	8.03	(-)1.16
211	8552	1	77.9150	32.1370	2.40	2.56	(+)0.16
212	8553	1	77.9888	32.6069	5.77	5.77	-----
213	8554	1	78.0913	32.4267	-----	6.31	-----
214	8555	1	78.0850	32.4223	5.20	5.06	(-)0.14
215	8556	1	78.0729	32.4045	4.91	5.48	(+)0.57
216	8557	1	78.0692	32.4015	2.47	3.58	(+)1.11
217	8558	1	78.2196	32.4158	3.35	3.62	(+)0.27
218	8559	2	78.6024	31.5764	3.71	5.28	(+)1.57
219	8560	2	78.6091	31.5649	4.27	4.79	(+)0.52
220	8561	2	78.7172	31.5310	3.57	6.16	(+)2.59
221	8563	2	78.7502	31.5539	5.58	6.47	(+)0.89
222	8564	1	78.7058	31.9072	1.23	1.83	(+)0.61
223	8565	1	78.7039	31.9998	1.86	1.24	(-)0.62
224	8566	3	78.8218	31.9307	1.28	1.82	(+)0.54
225	8567	3	78.8117	31.9651	8.88	6.85	(-)2.03
226	8568	3	78.7967	31.9717	1.24	0.88	(-)0.36
227	8569	3	78.8485	31.9944	1.77	3.35	(+)1.59
228	8570	1	78.8225	32.0139	1.89	1.89	-----
229	8571	1	78.7795	32.0337	1.85	3.12	(+)1.27
230	8572	1	78.7619	32.0442	2.99	5.22	(+)2.23
231	8573	1	78.8061	32.0804	1.24	1.43	(+)0.19

232	8574	1	78.8633	32.0708	1.23	1.23	-----
233	8575	3	78.9256	32.0148	1.52	2.04	(+)0.53
234	8576	3	78.9505	32.1206	1.87	1.87	-----
235	8577	1	78.9050	32.1449	1.25	2.36	(+)1.11
236	8579	3	78.9945	32.2787	1.20	1.73	(+)0.53
237	8580	3	78.9933	32.3170	2.44	2.79	(+)0.35
238	8581	1	78.8961	32.3259	1.20	3.28	(+)2.08
239	8582	1	78.8798	32.3526	-----	2.50	-----
240	8583	1	78.8986	32.3518	3.33	4.85	(+)1.52
241	8584	1	78.8140	32.4195	11.66	10.11	(-)1.55
242	8585	3	79.1195	32.4397	2.68	1.27	(-)1.41
243	8586	3	79.2781	32.4778	7.46	3.30	(-)4.16
244	8587	3	79.4162	32.3735	3.39	3.42	(+)0.02
245	8588	3	79.5074	32.3829	2.78	5.11	(+)2.33
246	8589	3	79.5197	32.3768	1.17	1.27	(+)0.10
247	8590	3	79.8006	32.1259	3.33	3.56	(+)0.23
248	8593	3	79.7971	32.1060	1.79	1.88	(+)0.09
249	8594	3	79.8093	32.0747	1.81	3.01	(+)1.20
250	8595	3	79.7991	32.0590	2.47	3.34	(+)0.87
251	8596	3	80.8310	31.2521	4.44	3.54	(-)0.90
252	8599	3	81.0467	31.2869	1.79	1.96	(+)0.18
253	8600	3	81.1135	31.2406	1.25	2.37	(+)1.12
254	8601	3	81.1400	31.1695	2.50	1.43	(-)1.07
255	8614	3	79.5122	31.1049	3.36	2.37	(-)0.99
256	8616	2	78.7398	31.7094	3.66	2.90	(-)0.76
257	8639	3	79.8443	31.9923	-----	5.95	-----
258	8654	2	77.8707	31.7181	-----	5.38	-----
259	9017	3	80.4498	30.5542	-----	4.52	-----
260	9018	2	78.7699	31.3613	-----	2.90	-----
261	9028	2	78.3286	31.3116	-----	32.51	-----
262	9031	2	78.4798	31.4140	-----	2.76	-----
263	9032	2	78.4184	31.4043	-----	4.99	-----
264	9034	2	77.8588	31.7450	-----	2.83	-----
265	9035	2	77.9035	31.7200	-----	2.37	-----
266	9036	2	77.9471	31.7071	-----	8.69	-----
267	9037	2	78.2909	31.7801	-----	4.59	-----
268	9044	1	78.8147	32.0332	-----	4.57	-----
269	9047	3	78.7812	31.9297	-----	8.85	-----
270	9048	3	78.7829	31.9275	-----	2.27	-----
271	9052	2	78.7007	31.3268	-----	2.58	-----
272	9053	2	78.7933	31.2982	-----	2.18	-----
273	9058	3	79.8752	31.9682	-----	6.01	-----
274	9059	3	79.8769	31.9560	-----	6.35	-----
275	9060	3	79.8780	31.9628	-----	5.50	-----

276	10035	1	78.7011	32.7054	-----	6.08	-----
277	10036	3	78.7386	32.7068	-----	1.45	-----
278	10037	3	79.9011	31.9271	-----	3.04	-----
279	10038	3	79.8920	31.9604	-----	1.63	-----
280	10039	3	79.8738	31.9595	-----	3.79	-----
281	10040	3	79.8540	32.0008	-----	2.73	-----
282	10041	3	79.8095	32.0282	-----	1.55	-----
283	10042	3	79.8023	32.0618	-----	1.81	-----
284	10043	3	79.7730	32.0945	-----	10.75	-----
285	10044	3	79.8016	32.1131	-----	1.80	-----
286	10045	3	79.7880	32.1751	-----	1.66	-----
287	10047	3	79.6825	32.2544	-----	8.12	-----
288	10048	2	78.7617	31.3607	-----	3.26	-----
289	10049	2	78.7548	31.3974	-----	12.82	-----
290	10050	2	78.7544	31.3238	-----	1.72	-----
291	10051	2	78.7558	31.3214	-----	1.46	-----
292	10052	2	78.4802	31.2608	-----	1.10	-----
293	10053	2	78.5824	31.3656	-----	1.20	-----
294	10054	2	78.6891	31.6567	-----	3.37	-----
295	10055	2	78.7493	31.6615	-----	1.83	-----
296	10056	3	78.7418	31.7339	-----	4.41	-----
297	10057	2	77.9064	31.7204	-----	1.55	-----
298	10058	2	77.8809	31.7120	-----	1.78	-----
299	10059	1	77.7812	31.9536	-----	4.34	-----
300	10059	3	77.7376	32.2637	-----	1.43	-----
301	10060	1	77.7646	32.3685	-----	3.09	-----
302	10061	1	78.4320	32.1813	-----	1.08	-----
303	10062	1	78.4310	32.5552	-----	4.86	-----
304	10063	3	78.1919	32.4946	-----	2.74	-----
305	10064	1	78.9074	32.3507	-----	1.65	-----
306	10065	1	78.9086	32.3341	-----	2.87	-----
307	10066	1	78.9073	32.3319	-----	2.84	-----
308	10067	3	78.9895	32.3155	-----	1.87	-----
309	10068	3	79.0325	32.2380	-----	2.79	-----
310	10069	1	78.9469	32.1390	-----	1.15	-----
311	10070	1	78.9445	32.1401	-----	1.32	-----
312	10071	3	78.9464	32.1072	-----	1.10	-----
313	10072	3	78.9289	32.0928	-----	1.50	-----
314	10073	3	78.9231	32.1046	-----	1.29	-----
315	10074	1	78.9067	32.0989	-----	1.37	-----
316	10075	1	78.8846	32.0572	-----	1.78	-----
317	10076	3	78.9276	32.0633	-----	2.98	-----
318	10077	3	78.9194	32.0165	-----	1.46	-----
319	10078	1	78.8307	32.0436	-----	1.93	-----

320	10079	1	78.8029	32.0810	-----	2.91	-----
321	10080	1	78.7780	32.0344	-----	1.20	-----
322	10081	1	78.7437	32.0476	-----	1.18	-----
323	10082	1	78.7507	32.0430	-----	1.66	-----
324	10083	3	78.8273	31.9306	-----	1.15	-----
325	10084	1	78.7114	31.8984	-----	2.10	-----
326	10085	1	78.7013	31.8881	-----	1.62	-----
327	10086	3	79.1708	32.4919	-----	3.39	-----
328	10087	3	79.2115	32.4698	-----	2.52	-----
329	10089	3	79.2905	32.5133	-----	3.67	-----
330	10090	3	79.2967	32.5123	-----	3.19	-----
331	10095	3	79.8030	32.1070	-----	2.92	-----
332	10096	3	78.8930	31.9830	-----	7.05	-----
333	13801	3	80.3993	30.5514	44.20	50.65	(+)6.44
334	10046HWL	3	79.7056	32.2154	-----	4.02	-----
335	1022RS	3	81.1094	30.9241	2.49	2.08	(-)0.41
336	32LWL	1	78.7184	32.3297	43.43	127.21	(+)83.78
337	607RS	3	81.1624	30.9137	32.05	148.86	(+)116.81
338	608RS(1)	3	81.0929	30.9256	12.51	16.51	(+)4.00
339	608RS(2)	3	81.1001	30.9261	6.73	9.04	(+)2.31
340	616RS	3	81.1173	30.9249	9.30	9.79	(+)0.48
341	8055SG	3	81.2217	31.1105	3.12	5.50	(+)2.38
342	8263RS	3	81.1057	30.9243	1.00	3.57	(+)2.58
343	8516RS	3	81.1323	30.9225	6.52	6.06	(-)0.46
344	8527RS	3	79.3074	31.2327	2.78	4.98	(+)2.20
345	8528RS	3	78.7965	31.3699	2.19	3.03	(+)0.84
346	8597RS	3	81.0199	31.3749	1.82	2.75	(+)0.94
347	9021 (1)	2	78.7321	31.3587	-----	3.43	-----
348	9021 (2)	2	78.7321	31.3587	-----	4.59	-----
349	9049RS	2	78.0255	31.6186	-----	5.28	-----
350	96HWL	3	79.5987	31.3055	43.44	58.06	(+)14.62

7.6: Status of lakes as in September 2022.

From the analysis of the satellite data for 7th, 11th, 12th and 26th September 2022, only partial coverage could be seen comprising basin area (Fig: 7.6 (a)-(d)). Based on the quality of the data, some of them having good quality and some with partial coverage, a total 414 lakes could be mapped in comparison to 97 lakes which were mapped in 2021 due to only partial coverage of the satellite data. Further these 414 lakes as mapped in 2022 comprising 58 lakes from the Spiti basin, 59 from the lower Satluj and 297 lakes from the Upper Satluj basin (Fig: 7.6 (e)). In depth analysis of 414 Lakes, it is found that 249 lakes are such which have the area less than 5ha comprising 39 from Spiti, 38 from Lower Satluj and 172 from Upper Satluj basin. Further 89 lakes

are such which falls within the areal range of 5-10ha comprising 12 from Spiti, 15 from Lower Satluj and 62 from Upper Satluj basin. Likewise 76 lakes are such which have the area more than 10ha and are considered big lakes comprising 7 from Spiti, 6 from Lower Satluj and 63 from Upper Satluj basin (Fig. 7.6 (f)). Further analysis of 414 lakes reveals that 39 lakes are as the high altitude wetlands comprising 14 wetlands having area less than 5ha, 13 are within the areal range of 5-10ha and 12 having area more than 10ha and all these high altitude wetlands forms part of the Upper Satluj basin (Fig. 7.6 (g)). On further exploration, when these 414 lakes seen temporally w.r.t 2021 data, 324 lakes out of 414 lakes could be compared for their temporal variation and out of which 205 lakes/wetlands have shown an increasing trend in their water spread, whereas 119 lakes/wetlands shown a reducing trend in their water spread with reference to 2021 data. The lakes which could not be compared forms the base line data for next year monitoring (Table: 7.6). It is also observed that the lakes with area more than 10ha has increased to 76 (2022) from 66 (2021) reflecting that the lakes with ids 71, 312, 423, 611, 658, 827, 1053, 1531, 8280, 8288, 8517, 211 HWL and 616 RS having area between 5-10 ha has increased to next higher category i.e. >10ha as a result of which the total number of lake with area more than 10 ha has increased in 2022. The remaining lakes/wetlands which could not be compared form the base line data for their monitoring during the next ablation season, which may be due to the fact that either these lakes /wetlands were either not mapped during 2021 due to snow cover impacts or are the new one and thus mapped this year only. The 12 lakes with ids RS are mainly formed due to the accumulation of water along the main Satluj river course in the Upper Satluj sub basin (11 lakes) and lower Satluj sub basin (only one lake). The lakes/wetlands which could not be compared were either new one or could not be mapped due to technical reasons like the data quality or the cloud cover or the snow cover.

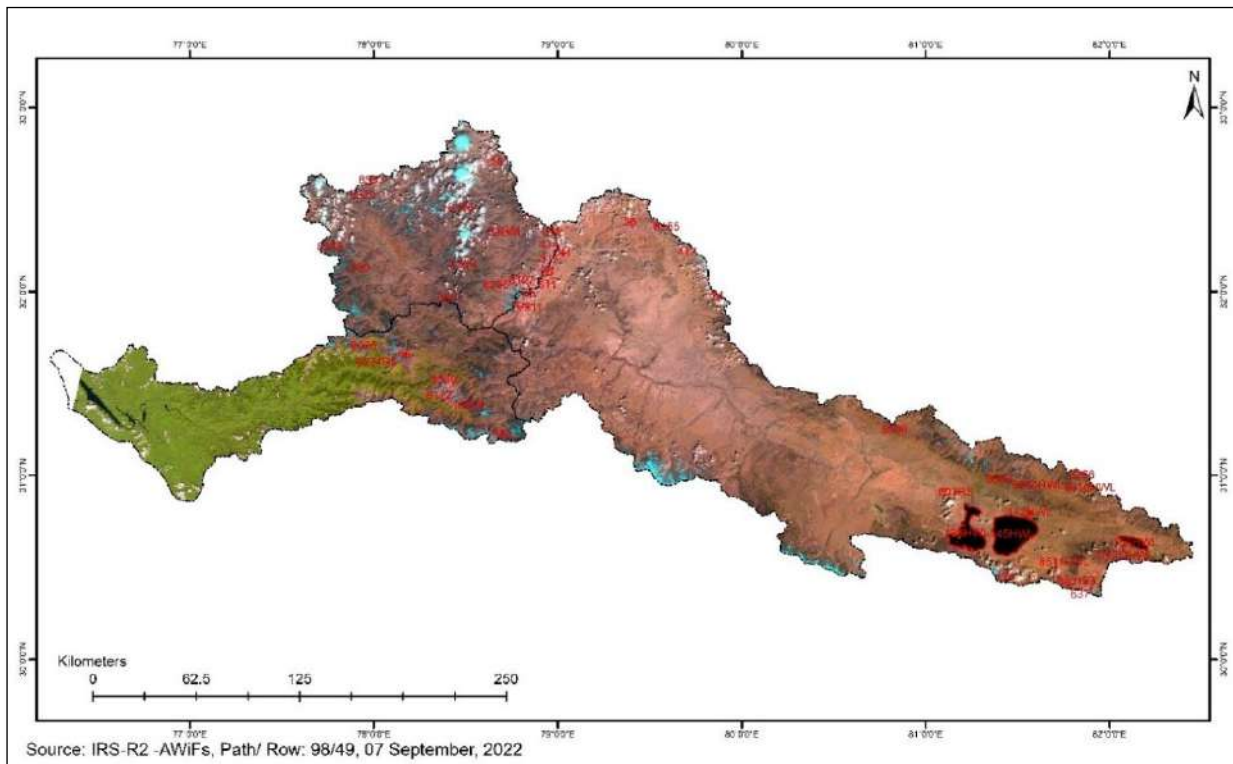


Fig.7.6 (a): IRS, R2, AWiFS, 98/49, 07th September, 2022

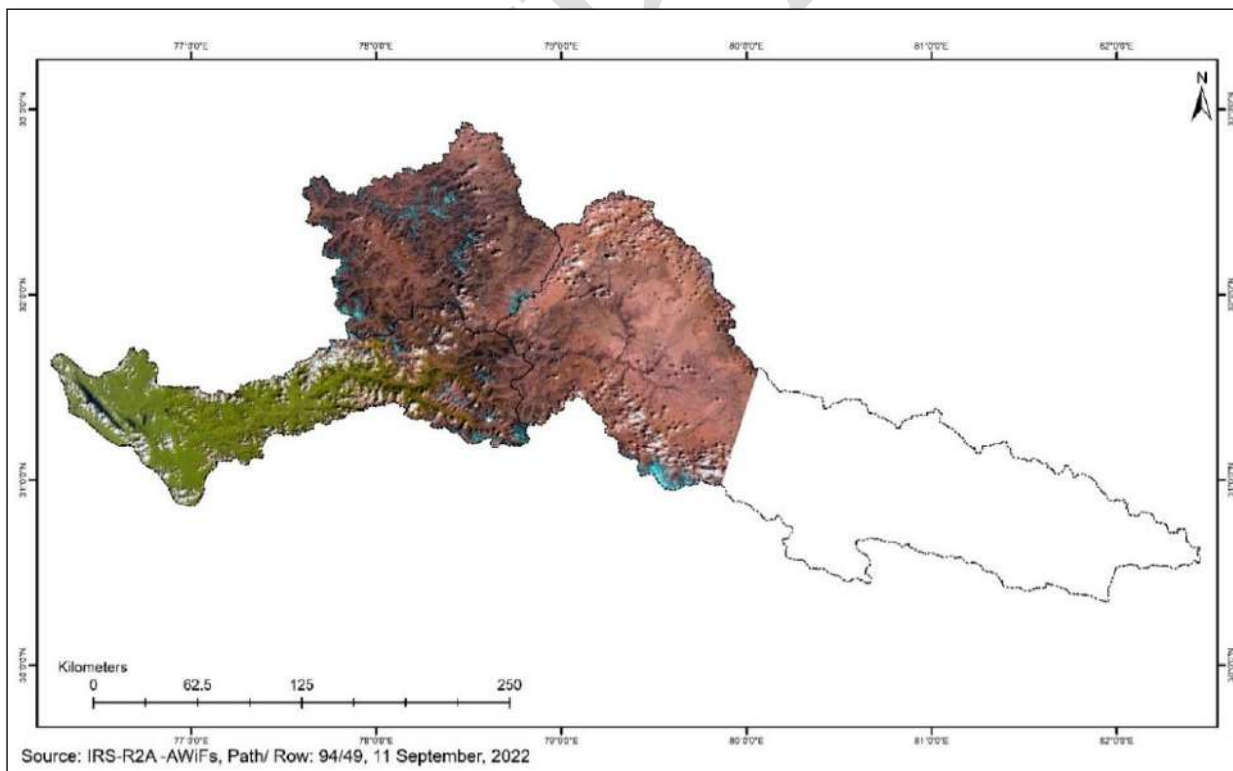


Fig.7.6 (b): IRS, R2A, AWiFS, 94/49, 11th September 2022

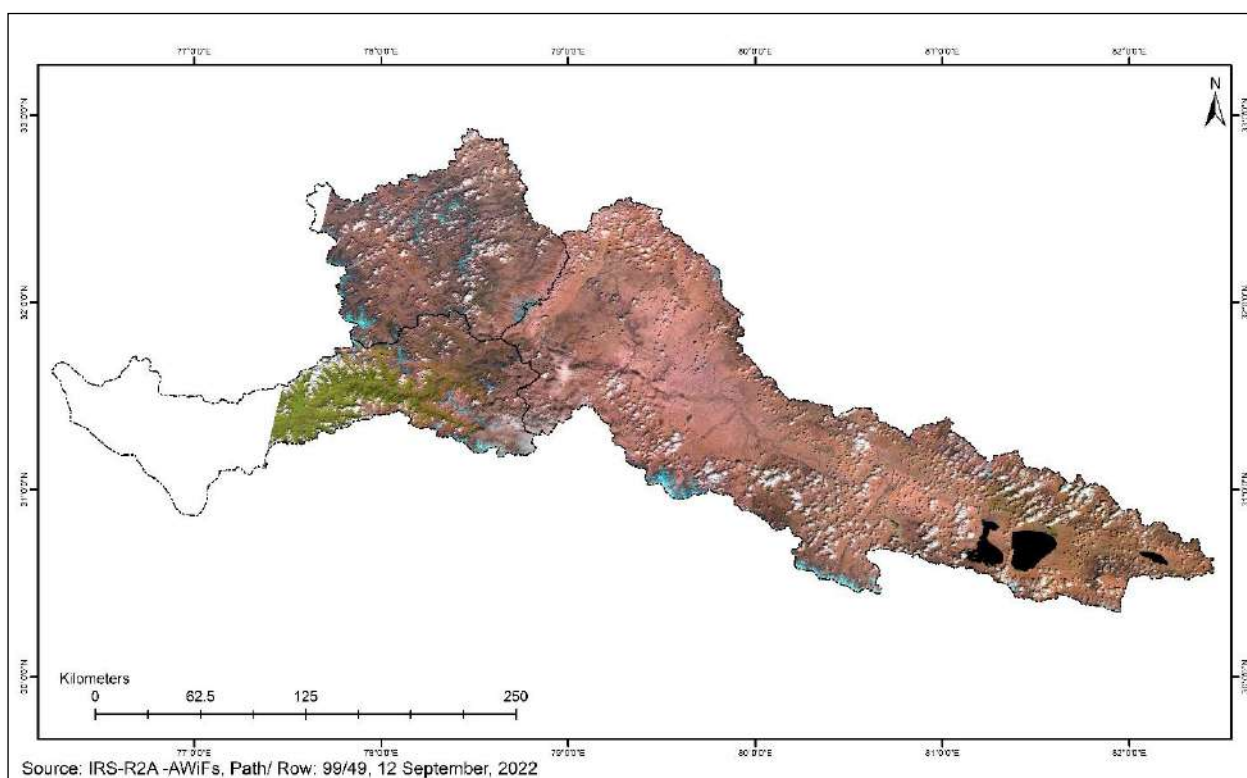


Fig.7.6 (c): IRS, R2, AWiFS, 99/49, 12th September 2022.

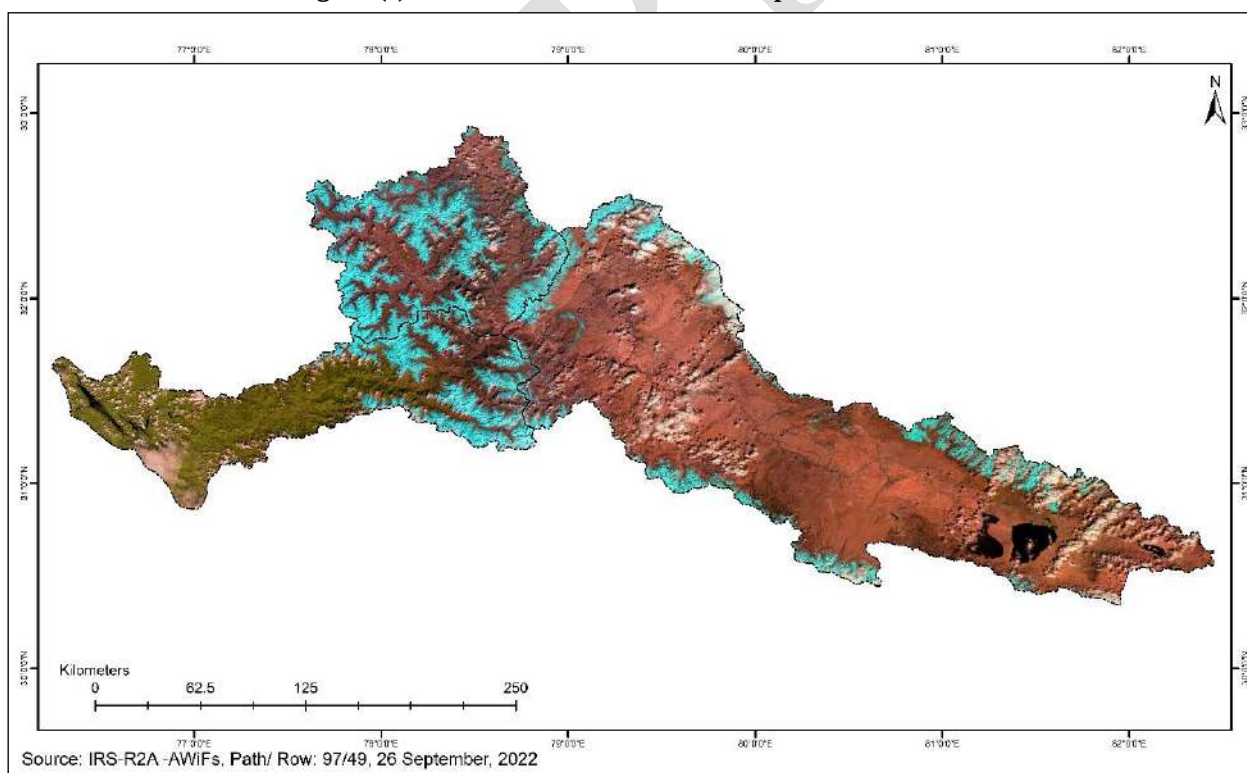


Fig.7.6 (d): IRS, R2, AWiFS, 97/49, 26th September 2022.

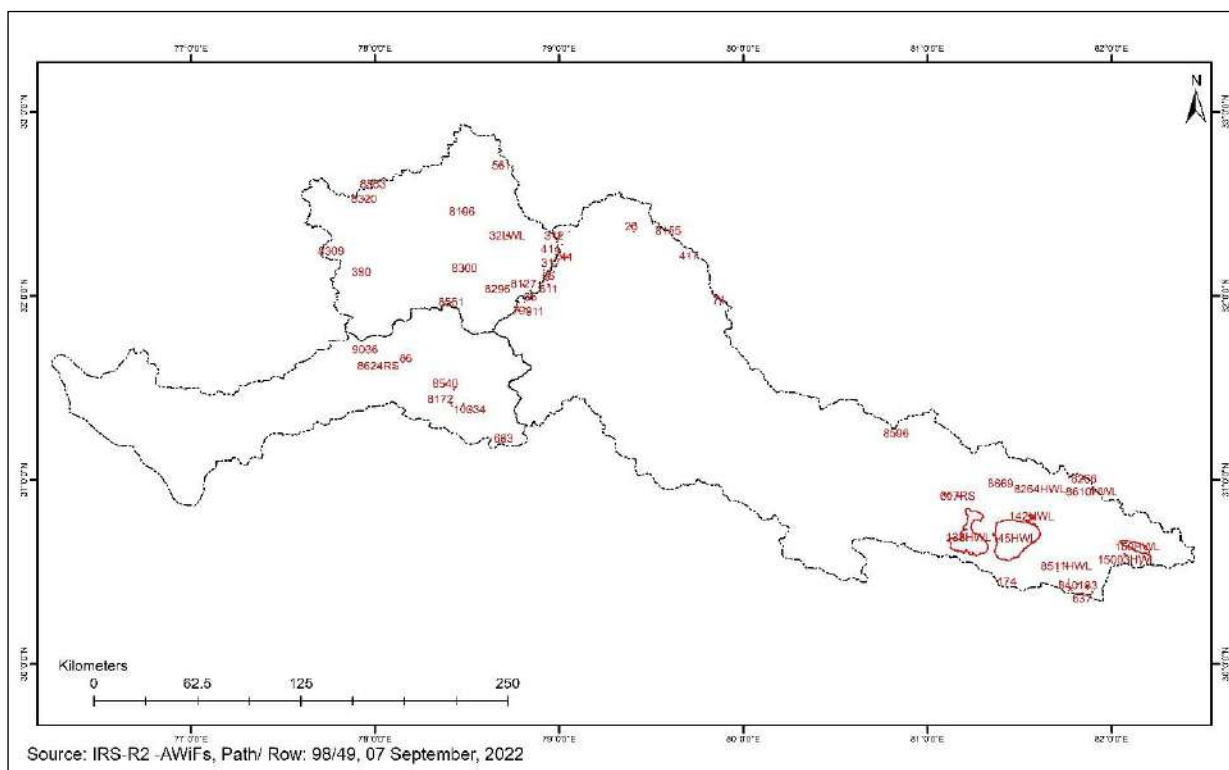


Fig.7.6 (e): IRS- R2, AWiFS, 98/49, 07th September 2022, Interpreted Layer

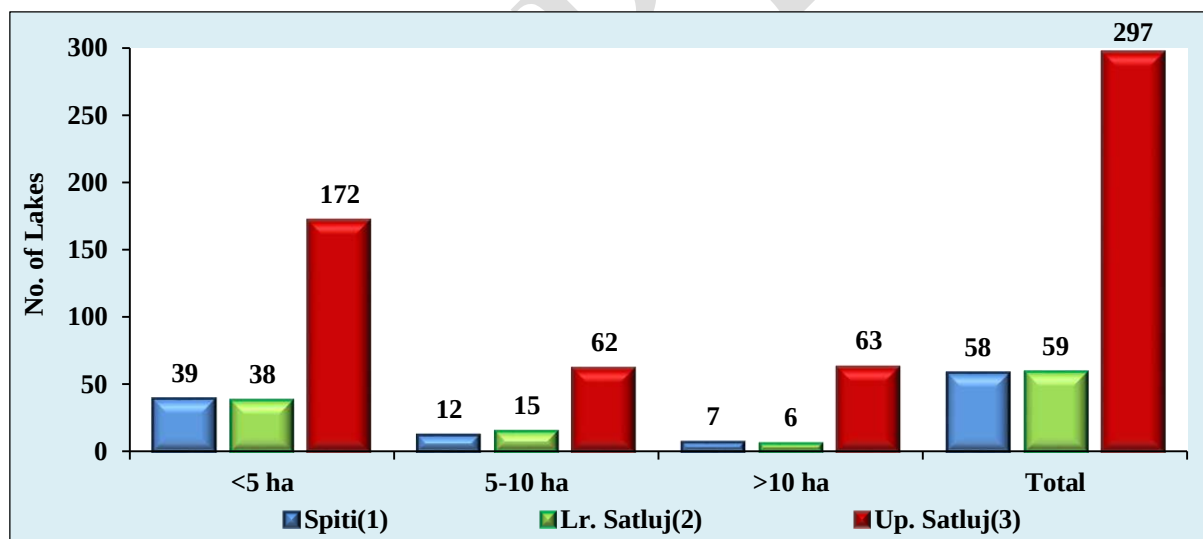


Fig. 7.6 (f): No. of Lakes based on IRS- R2, AWiFS, 98-49, 07th September 2022

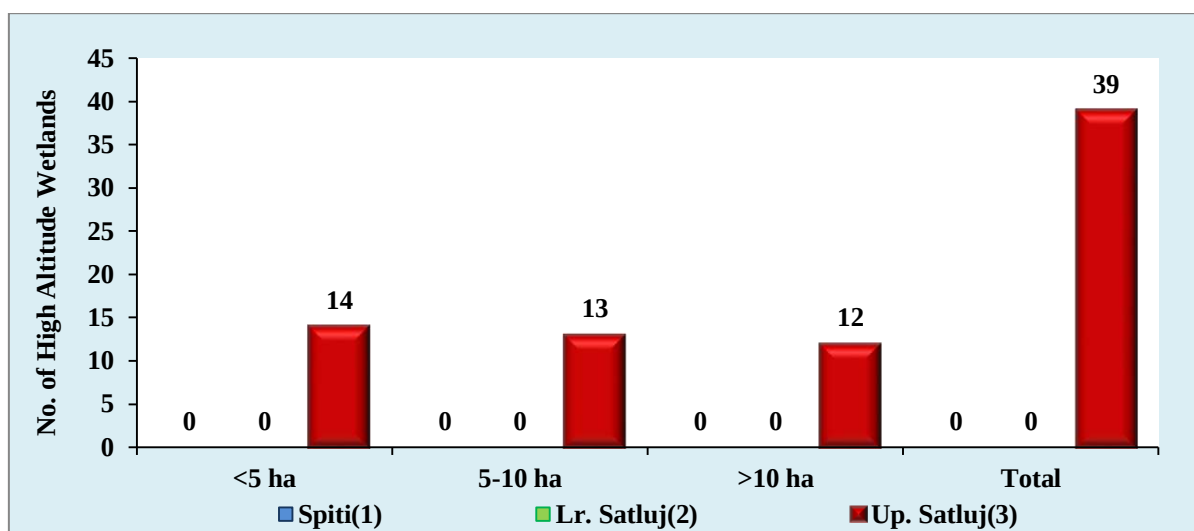


Fig. 7.6 (g): No. High altitude wetland lakes based on IRS- R2, AWiFS, 98-49, 07th September 2022

Table: 7.6 Aerial Extent of lakes as on 16 September, 2022

Sr. No.	Lake Id.	Basin Number	Longitude	Latitude	Aerial Extent on August 2021 (ha.)	Aerial Extent on September 2022 (ha.)	Change in Area w.r.t. August 2021 (ha.)
1	23	3	79.4170	32.3893	10.48	13.65	(+)3.17
2	25	3	79.3925	32.3774	25.28	36.04	(+)10.75
3	28	3	79.0515	32.3468	5.76	7.89	(+)2.13
4	31	3	79.0024	32.3349	11.63	10.17	(-)1.46
5	39	3	79.0268	32.2241	6.09	9.36	(+)3.27
6	41	3	79.0435	32.2104	24.84	31.23	(+)6.39
7	51	3	78.9429	32.1225	7.88	7.23	(-)0.65
8	54	3	78.9326	32.1075	10.92	12.81	(+)1.89
9	55	3	78.9418	32.1073	11.43	12.05	(+)0.62
10	60	3	78.8721	32.0318	6.27	9.68	(+)3.41
11	61	1	78.8448	32.0299	27.05	23.61	(-)3.44
12	62	3	78.8751	32.0168	11.50	13.89	(+)2.39
13	63	3	78.8759	32.0204	4.68	3.90	(-)0.78
14	65	3	78.8437	31.9924	22.99	33.21	(+)10.22
15	71	3	79.8715	31.9776	9.29	13.20	(+)3.91
16	74	3	79.8809	31.9698	5.19	5.67	(+)0.47
17	79	3	78.7828	31.9190	22.70	23.52	(+)0.82
18	85	1	78.1675	31.6606	40.86	47.64	(+)6.78
19	106	3	81.1014	31.2439	5.83	6.29	(+)0.46
20	107	3	81.0832	31.2397	8.03	6.56	(-)1.47
21	112	3	81.1477	31.1999	14.69	17.43	(+)2.74
22	113	3	81.1932	31.1819	53.32	53.61	(+)0.29
23	114	3	81.1513	31.1777	24.34	30.50	(+)6.16
24	118	3	81.2788	31.1373	13.54	19.62	(+)6.09

25	119	3	81.2272	31.1297	6.22	7.90	(+)1.68
26	122	3	81.4339	31.1143	7.32	4.41	(-)2.91
27	166	3	81.4291	30.4718	7.36	6.03	(-)1.32
28	173	3	81.6760	30.4471	8.36	7.98	(-)0.38
29	178	3	81.4313	30.4315	210.76	229.97	(+)19.22
30	179	3	81.7127	30.4293	28.01	23.75	(-)4.26
31	183	3	81.8707	30.4266	26.06	24.78	(-)1.27
32	184	3	81.7213	30.4207	21.52	14.75	(-)6.76
33	196	3	81.8942	30.3904	16.29	12.86	(-)3.44
34	312	3	78.9740	32.3251	6.68	11.87	(+)5.19
35	313	3	78.9797	32.3194	10.92	12.65	(+)1.73
36	315	1	78.9725	32.1906	4.92	6.80	(+)1.88
37	317	3	78.9772	32.1612	11.89	11.30	(-)0.58
38	319	3	78.8369	31.9803	13.69	18.56	(+)4.87
39	330	1	77.9246	32.1289	1.87	3.57	(+)1.70
40	343	3	79.8637	31.9264	32.41	36.62	(+)4.21
41	399	3	79.7305	31.0285	12.67	16.33	(+)3.66
42	402	2	78.1240	31.7395	5.25	3.47	(-)1.77
43	413	3	79.0064	32.2246	1.83	4.10	(+)2.27
44	414	1	78.9784	32.2580	3.66	3.33	(-)0.33
45	415	3	79.0025	32.3282	2.49	3.04	(+)0.54
46	416	3	79.1868	32.4518	4.21	4.21	-----
47	422	3	81.0685	31.2333	2.67	4.10	(+)1.43
48	423	3	81.1598	31.2171	9.16	11.77	(+)2.61
49	426	3	81.5035	31.0944	8.20	7.67	(-)0.53
50	427	3	81.3824	31.1392	7.10	9.49	(+)2.39
51	431	3	81.5018	31.1129	8.94	9.54	(+)0.60
52	432	3	81.5184	31.0825	3.88	3.53	(-)0.35
53	438	3	81.7398	30.4019	5.62	4.66	(-)0.96
54	439	3	81.7214	30.4286	3.64	4.61	(+)0.96
55	561	1	78.6890	32.7082	8.23	7.43	(-)0.80
56	562	3	79.0181	32.2763	3.65	3.37	(-)0.28
57	563	1	78.9838	32.2258	2.75	3.10	(+)0.34
58	570	3	79.1303	32.4460	6.39	6.05	(-)0.35
59	592	3	79.8042	32.1165	1.91	4.59	(+)2.68
60	607	3	81.1325	31.2453	3.13	5.32	(+)2.18
61	611	3	78.9418	32.0606	5.75	10.04	(+)4.29
62	616	1	78.7037	31.9123	4.85	9.23	(+)4.38
63	621	3	81.9285	30.3812	79.76	92.63	(+)12.87
64	622	3	81.0838	31.2721	2.56	3.30	(+)0.74
65	632	3	79.3658	31.1435	6.10	6.66	(+)0.55
66	634	3	81.1421	31.2459	8.73	9.77	(+)1.05
67	635	2	78.2531	31.3408	15.10	25.13	(+)10.03
68	636	3	81.1087	31.2698	4.72	4.39	(-)0.33

69	637	3	81.8398	30.3851	19.43	10.62	(-)8.82
70	638	3	81.8297	30.3812	2.48	1.97	(-)0.51
71	638	3	81.8378	30.3909	5.10	2.53	(-)2.56
72	641	3	79.8935	31.9589	4.33	3.81	(-)0.52
73	645	3	81.0887	31.2662	7.90	8.05	(+)0.16
74	646	3	81.1157	31.2635	2.09	1.72	(-)0.37
75	647	3	81.1163	31.2598	4.90	3.64	(-)1.25
76	648	3	81.1240	31.2377	2.15	4.19	(+)2.04
77	649	3	81.1299	31.2441	3.02	2.49	(-)0.54
78	651	3	81.4018	31.1275	6.72	7.97	(+)1.24
79	652	3	81.4237	31.1372	6.91	7.12	(+)0.21
80	655	3	81.5130	31.0988	5.54	7.22	(+)1.69
81	656	3	81.5310	31.0947	1.61	3.19	(+)1.58
82	657	3	81.5460	31.1032	6.66	5.84	(-)0.82
83	658	3	81.5414	31.1172	9.40	11.17	(+)1.77
84	663	3	79.3417	31.1534	6.14	6.14	-----
85	683	2	78.6996	31.2241	10.70	13.27	(+)2.57
86	688	3	81.8198	30.4073	10.78	10.39	(-)0.39
87	811	3	78.8399	31.9146	29.59	13.90	(-)15.68
88	825	3	81.1129	31.2500	2.19	2.01	(-)0.18
89	827	3	81.1373	31.1943	9.27	10.60	(+)1.32
90	828	3	81.1536	31.2080	2.47	2.00	(-)0.46
91	840	3	81.7919	30.3962	4.44	3.69	(-)0.74
92	865	3	81.7739	30.3994	4.44	3.63	(-)0.81
93	870	1	78.9279	32.1291	1.87	1.37	(-)0.50
94	885	3	79.8811	31.9327	2.45	2.45	-----
95	888	3	81.1473	31.2036	1.56	1.72	(+)0.16
96	895	3	81.8423	30.3794	5.19	2.47	(-)2.72
97	964	3	81.7654	30.4076	2.76	2.54	(-)0.22
98	1030	3	81.1777	31.1888	3.15	3.20	(+)0.05
99	1038	3	79.7966	32.1278	4.87	4.97	(+)0.10
100	1053	3	80.5923	30.4766	9.91	19.94	(+)10.03
101	1133	3	81.8683	30.4195	19.11	14.31	(-)4.80
102	1142	3	81.7731	30.4035	1.27	2.74	(+)1.47
103	1149	3	81.7688	30.3974	7.31	7.15	(-)0.15
104	1155	3	79.8362	31.9881	2.44	3.52	(+)1.08
105	1510	3	81.5604	31.0942	2.53	2.28	(-)0.25
106	1511	3	81.4250	31.0837	3.64	4.66	(+)1.02
107	1512	3	81.4242	31.0803	2.85	3.46	(+)0.62
108	1515	3	81.4162	31.1022	3.16	5.27	(+)2.11
109	1516	3	81.4073	31.1441	2.80	2.74	(-)0.06
110	1519	3	81.2153	31.1641	1.93	2.40	(+)0.47
111	1522	3	81.1152	31.1678	3.14	3.29	(+)0.15
112	1524	3	81.0328	31.2923	5.50	5.98	(+)0.48

113	1525	3	81.0314	31.2851	21.87	24.34	(+)2.47
114	1531	3	78.8700	31.9701	8.33	12.44	(+)4.11
115	1532	3	78.8680	31.9574	5.24	4.28	(-)0.96
116	1538	3	79.5695	31.0925	3.34	4.19	(+)0.85
117	1543	3	81.3926	30.4535	2.50	3.77	(+)1.26
118	1545	3	80.4030	30.5972	6.53	7.97	(+)1.43
119	1546	3	79.5126	31.1321	6.12	8.56	(+)2.43
120	1552	1	78.9922	32.2546	2.12	1.42	(-)0.70
121	1568	3	78.8451	32.0119	3.59	2.72	(-)0.87
122	1585	1	78.8650	32.0857	2.42	2.94	(+)0.52
123	1606	3	78.9991	32.2240	1.81	1.68	(-)0.13
124	6021	3	81.2623	31.1232	1.81	1.35	(-)0.46
125	6045	2	78.4312	31.5040	2.80	1.13	(-)1.67
126	6045	2	78.4327	31.5079	2.91	1.96	(-)0.96
127	6060	3	78.8175	31.9299	2.45	1.75	(-)0.70
128	6088	3	81.5140	31.0514	2.49	3.37	(+)0.88
129	7004	3	78.8185	31.9329	3.05	2.54	(-)0.51
130	8005	3	81.8305	30.3843	1.57	1.10	(-)0.47
131	8008	3	81.7767	30.3986	1.29	1.51	(+)0.22
132	8011	3	80.5690	30.4770	3.54	5.64	(+)2.10
133	8024	3	80.5083	30.5405	1.53	2.76	(+)1.23
134	8027 (1)	3	80.4708	30.5527	3.33	2.93	(-)0.40
135	8027(2)	3	80.4751	30.5562	10.55	15.60	(+)5.05
136	8028(1)	3	80.6170	30.5536	1.23	2.60	(+)1.38
137	8028(2)	3	78.9734	32.1701	2.80	8.31	(+)5.51
138	8029	3	80.6312	30.5535	1.78	3.95	(+)2.17
139	8031	3	80.2941	30.6066	16.01	23.21	(+)7.20
140	8037	3	79.4110	31.0606	4.94	6.65	(+)1.71
141	8038	3	79.4150	31.0599	7.72	7.84	(+)0.12
142	8047	3	79.4899	31.1317	1.83	4.16	(+)2.32
143	8048	3	81.2300	31.0598	3.70	6.79	(+)3.08
144	8052	3	81.5468	31.0787	2.17	4.03	(+)1.87
145	8053	3	81.5548	31.0907	1.18	2.63	(+)1.45
146	8054	3	81.5297	31.0921	3.80	3.68	(-)0.12
147	8056	3	81.4126	31.1042	1.85	2.58	(+)0.73
148	8057	3	81.2583	31.1163	5.37	5.27	(-)0.10
149	8058	3	81.4218	31.1136	3.97	2.03	(-)1.94
150	8062	3	81.1827	31.1368	4.10	4.36	(+)0.26
151	8063	3	81.2584	31.1390	3.40	2.84	(-)0.56
152	8065	3	81.2214	31.1481	11.55	14.08	(+)2.52
153	8067	3	81.1111	31.1598	4.03	4.12	(+)0.09
154	8071	2	78.8037	31.2947	4.60	2.71	(-)1.90
155	8074	3	81.1286	31.2188	3.72	5.77	(+)2.05
156	8076	3	81.1450	31.2308	3.31	1.15	(-)2.16

157	8077	2	78.6954	31.3257	2.47	4.91	(+)2.44
158	8079	3	81.1365	31.2353	11.00	12.54	(+)1.54
159	8083	3	81.0278	31.2760	3.05	2.43	(-)0.62
160	8086	3	81.0125	31.2946	4.43	4.82	(+)0.39
161	8087	2	78.4884	31.4013	6.16	7.96	(+)1.80
162	8088	3	80.9551	31.3183	2.18	2.98	(+)0.80
163	8096	1	78.7009	31.9219	0.90	1.68	(+)0.78
164	8101	1	78.6864	31.9335	2.46	1.33	(-)1.13
165	8107	3	79.8982	31.9646	4.82	2.19	(-)2.63
166	8117	1	78.7591	32.0420	3.39	2.71	(-)0.68
167	8118	1	78.7621	32.0409	2.19	1.83	(-)0.36
168	8121	3	79.8252	32.0181	4.50	13.96	(+)9.46
169	8123	3	78.8853	32.0721	4.47	2.99	(-)1.48
170	8125	3	79.8147	32.0274	2.99	2.62	(-)0.37
171	8127	1	78.8067	32.0585	12.26	11.07	(-)1.19
172	8131	3	78.9464	32.1199	3.28	4.20	(+)0.92
173	8136	3	79.8027	32.1063	1.22	3.97	(+)2.75
174	8137	1	78.9199	32.1415	4.08	4.43	(+)0.35
175	8138	3	78.9634	32.1496	1.82	3.14	(+)1.32
176	8139	3	79.7934	32.1213	6.08	8.10	(+)2.02
177	8141	1	78.9607	32.1850	2.73	2.96	(+)0.23
178	8142	3	79.0200	32.2079	3.34	3.77	(+)0.42
179	8143	3	79.0099	32.2152	3.98	2.05	(-)1.93
180	8146	3	78.9858	32.2997	15.54	18.62	(+)3.08
181	8153	3	79.1050	32.3529	5.09	3.68	(-)1.41
182	8154	3	79.4042	32.3505	2.75	2.75	-----
183	8159	3	79.5078	32.3924	1.18	1.18	-----
184	8170	2	78.4200	31.3995	3.37	3.16	(-)0.22
185	8171	2	78.4073	31.4122	3.08	2.69	(-)0.39
186	8172	2	78.4065	31.4387	3.44	3.00	(-)0.44
187	8173	2	78.3671	31.4592	1.24	3.43	(+)2.19
188	8194	1	78.2716	32.3633	14.13	13.97	(-)0.15
189	8196	1	78.4736	32.4569	11.11	6.60	(-)4.50
190	8236	3	79.7531	31.0401	5.48	7.07	(+)1.58
191	8249	3	81.8519	30.3981	18.60	25.98	(+)7.38
192	8251	3	81.8847	30.4020	2.54	4.80	(+)2.27
193	8252	3	81.4330	30.4709	1.26	1.92	(+)0.66
194	8262	3	81.9798	30.8408	2.46	4.15	(+)1.69
195	8265	3	79.4902	31.0984	3.37	4.06	(+)0.69
196	8266	3	81.8503	31.0049	30.68	28.57	(-)2.11
197	8272	3	81.2482	31.1158	1.85	3.22	(+)1.37
198	8277	2	78.0663	31.4201	3.72	3.01	(-)0.72
199	8280	2	78.0110	31.4066	7.71	10.30	(+)2.60
200	8281	2	78.0257	31.4087	2.37	5.35	(+)2.98

201	8281	2	78.0276	31.4121	5.99	6.53	(+)0.54
202	8282	3	80.9832	31.3128	1.91	1.78	(-)0.13
203	8286	3	78.9035	32.0432	1.53	2.68	(+)1.15
204	8287	2	78.1770	31.5850	2.78	1.94	(-)0.84
205	8288	2	78.1846	31.5857	8.82	10.46	(+)1.65
206	8289	1	78.7202	31.9005	2.73	3.84	(+)1.11
207	8292	3	79.9191	31.9341	1.60	1.60	-----
208	8293	3	79.8552	31.9503	1.77	1.77	-----
209	8295	1	78.6975	32.0372	2.40	2.40	-----
210	8296	3	79.8169	32.0209	2.48	4.86	(+)2.38
211	8299	3	78.9484	32.1222	1.49	1.84	(+)0.35
212	8304	1	78.4128	32.1762	12.82	10.20	(-)2.62
213	8307	1	78.4177	32.2043	5.83	5.68	(-)0.14
214	8309	1	77.7612	32.2425	3.64	4.77	(+)1.13
215	8320	1	77.9423	32.5252	6.65	6.88	(+)0.23
216	8503	3	81.8507	30.3911	1.65	1.65	-----
217	8506	3	81.7782	30.3908	0.94	1.78	(+)0.84
218	8507	3	81.7731	30.3956	1.26	1.16	(-)0.10
219	8508	3	81.7737	30.4010	1.23	2.09	(+)0.86
220	8509	3	81.7573	30.4006	1.32	1.18	(-)0.13
221	8514	3	81.4102	30.4562	1.58	2.76	(+)1.17
222	8517	3	80.5320	30.5111	5.48	11.76	(+)6.28
223	8518	3	80.5036	30.5323	2.52	3.59	(+)1.07
224	8520	3	79.6536	31.0732	2.13	2.00	(-)0.13
225	8521	3	79.6513	31.0717	2.42	2.66	(+)0.23
226	8522	3	79.6482	31.0776	2.17	1.84	(-)0.33
227	8523(1)	3	79.6079	31.0308	1.53	2.25	(+)0.72
228	8523(2)	3	79.4370	31.1120	1.20	2.96	(+)1.77
229	8524	3	79.3573	31.1508	2.16	2.82	(+)0.66
230	8525	3	79.3187	31.1540	1.81	1.25	(-)0.56
231	8529	3	78.8049	31.3179	0.85	0.85	-----
232	8530	3	78.7925	31.3125	0.94	0.94	-----
233	8531	2	78.7233	31.3627	4.59	4.59	-----
234	8532	2	78.7038	31.3602	3.61	2.45	(-)1.16
235	8535	2	78.4282	31.4321	1.51	1.70	(+)0.19
236	8537	2	78.4277	31.4950	1.17	1.87	(+)0.70
237	8538	2	78.4270	31.4918	1.86	4.84	(+)2.98
238	8539	2	78.3829	31.5165	4.55	5.17	(+)0.62
239	8540	2	78.3798	31.5232	6.74	9.86	(+)3.12
240	8541	2	78.1616	31.3722	2.75	2.89	(+)0.14
241	8543	2	78.1379	31.6706	1.24	4.00	(+)2.76
242	8545	2	78.1041	31.7783	3.05	3.56	(+)0.52
243	8546	2	78.1017	31.7774	4.89	4.04	(-)0.85
244	8549	1	78.3036	31.7898	2.77	4.01	(+)1.25

245	8550	1	78.2162	31.9450	3.56	3.46	(-)0.09
246	8551	1	78.4154	31.9644	9.19	9.97	(+)0.78
247	8552	1	77.9150	32.1370	2.40	4.25	(+)1.85
248	8553	1	77.9888	32.6069	5.77	5.77	-----
249	8554	1	78.0894	32.4264	-----	3.51	-----
250	8555	1	78.0829	32.4223	5.20	4.95	(-)0.25
251	8556	1	78.0713	32.4050	4.91	4.35	(-)0.56
252	8557	1	78.0689	32.4016	2.47	2.35	(-)0.12
253	8558	1	78.2196	32.4158	3.35	3.46	(+)0.11
254	8559	2	78.6013	31.5761	3.71	5.07	(+)1.37
255	8560	2	78.6087	31.5647	4.27	5.73	(+)1.45
256	8561	2	78.7166	31.5313	3.57	3.57	-----
257	8562	2	78.7341	31.5178	-----	6.74	-----
258	8563	2	78.7497	31.5540	5.58	5.58	-----
259	8564	1	78.7063	31.9099	1.23	1.63	(+)0.40
260	8565	1	78.7111	31.9996	1.86	1.86	-----
261	8566	3	78.8203	31.9305	1.28	1.14	(-)0.15
262	8567	3	78.8121	31.9652	8.88	6.11	(-)2.77
263	8568	3	78.7982	31.9716	1.24	1.37	(+)0.13
264	8569	3	78.8483	31.9947	1.77	2.16	(+)0.39
265	8570	1	78.8243	32.0137	1.89	2.42	(+)0.53
266	8571	1	78.7801	32.0332	1.85	1.45	(-)0.40
267	8572	1	78.7631	32.0444	2.99	3.24	(+)0.25
268	8573	1	78.8025	32.0813	1.24	1.86	(+)0.62
269	8574	1	78.8638	32.0702	1.23	1.29	(+)0.06
270	8575	3	78.9256	32.0148	1.52	2.38	(+)0.86
271	8576	3	78.9517	32.1196	1.87	2.45	(+)0.58
272	8577	1	78.9089	32.1437	1.25	1.91	(+)0.66
273	8578	1	78.9917	32.2757	9.60	8.08	(-)1.52
274	8580	3	78.9946	32.3160	2.44	4.40	(+)1.96
275	8581	1	78.8973	32.3249	1.20	3.24	(+)2.04
276	8584	1	78.8179	32.4183	11.66	11.73	(+)0.07
277	8588	3	79.5074	32.3829	2.78	2.85	(+)0.07
278	8589	3	79.5195	32.3770	1.17	1.62	(+)0.45
279	8590	3	79.8011	32.1257	3.33	4.96	(+)1.63
280	8591	3	79.7957	32.1188	1.23	1.23	-----
281	8592	3	79.8169	32.1146	1.24	1.24	-----
282	8596	3	80.8332	31.2518	4.44	6.37	(+)1.93
283	8598	3	81.0245	31.2810	1.88	1.49	(-)0.40
284	8599	3	81.0477	31.2863	1.79	2.34	(+)0.55
285	8600	3	81.1135	31.2406	1.25	2.42	(+)1.17
286	8601	3	81.1401	31.1691	2.50	1.44	(-)1.06
287	8602	3	81.3710	31.0930	1.83	2.97	(+)1.14
288	8603	3	81.4068	31.0552	3.10	3.89	(+)0.79

289	8604	3	81.4797	31.0808	3.81	3.71	(-)0.10
290	8605	3	81.4871	31.0067	1.23	1.58	(+)0.35
291	8606	3	81.4882	31.0063	2.49	3.04	(+)0.55
292	8607	3	81.5192	31.0312	2.22	1.82	(-)0.40
293	8608	3	81.5127	31.0351	3.08	4.97	(+)1.89
294	8609	3	81.5502	31.0932	2.49	2.51	(+)0.02
295	8614	3	79.5134	31.1044	3.36	1.77	(-)1.59
296	8616	2	78.7393	31.7096	3.66	4.14	(+)0.48
297	8654	2	77.8692	31.7182	-----	4.35	-----
298	9000	3	81.0853	31.2692	-----	1.39	-----
299	9001	3	81.0907	31.2412	-----	2.62	-----
300	9002	3	81.2489	31.1066	-----	1.62	-----
301	9003	3	81.3222	31.0736	-----	4.93	-----
302	9004	3	81.5054	31.0721	-----	1.83	-----
303	9005	3	81.5039	31.0644	-----	1.11	-----
304	9006	3	81.5246	31.1109	-----	3.85	-----
305	9007	3	81.5357	31.1176	-----	4.05	-----
306	9008	3	81.5057	31.0448	-----	4.01	-----
307	9009	3	81.5139	31.0381	-----	3.24	-----
308	9015	3	81.3765	30.4512	-----	8.24	-----
309	9016	3	81.4121	30.4593	-----	4.04	-----
310	9017	3	80.4503	30.5535	-----	4.37	-----
311	9018	2	78.7708	31.3613	-----	3.47	-----
312	9019	2	78.7572	31.3643	-----	1.23	-----
313	9020	2	78.7573	31.3538	-----	5.48	-----
314	9021	2	78.7330	31.3590	-----	4.03	-----
315	9022	2	78.7166	31.3398	-----	4.31	-----
316	9023	2	78.7168	31.3372	-----	1.85	-----
317	9024	2	78.6976	31.3313	-----	4.60	-----
318	9025	2	78.6642	31.3328	-----	3.02	-----
319	9026	2	78.6625	31.3303	-----	3.16	-----
320	9027	2	78.4646	31.2479	-----	10.79	-----
321	9028	2	78.3276	31.3139	-----	13.63	-----
322	9029	2	78.0718	31.4241	-----	3.85	-----
323	9030	2	78.5212	31.3777	-----	2.54	-----
324	9031	2	78.4777	31.4143	-----	3.93	-----
325	9032	2	78.4177	31.4041	-----	5.26	-----
326	9033	2	77.7081	31.6967	-----	5.96	-----
327	9034	2	77.8584	31.7455	-----	3.27	-----
328	9035	2	77.9025	31.7205	-----	7.54	-----
329	9036	2	77.9454	31.7077	-----	6.08	-----
330	9037	2	78.2910	31.7805	-----	3.88	-----
331	9038	1	77.8121	32.1097	-----	3.96	-----
332	9039	3	79.0255	32.2142	-----	4.81	-----

333	9040	1	78.9157	32.0932	-----	2.25	-----
334	9041	1	78.8714	32.0773	-----	4.19	-----
335	9042	3	78.9386	32.0264	-----	7.01	-----
336	9043	3	78.9270	32.0064	-----	3.91	-----
337	9044	1	78.8181	32.0329	-----	5.29	-----
338	9045	1	78.8493	32.0089	-----	1.98	-----
339	9046	3	78.8080	31.9527	-----	1.68	-----
340	9047	3	78.7820	31.9293	-----	7.89	-----
341	9048	3	78.7839	31.9268	-----	3.16	-----
342	9049	1	78.7161	31.8979	-----	0.74	-----
343	9050	1	78.7064	31.8866	-----	2.16	-----
344	9051	1	78.7094	31.8802	-----	1.40	-----
345	9052	2	78.7015	31.3272	-----	4.63	-----
346	9053	2	78.7949	31.2977	-----	4.49	-----
347	9055	1	78.4559	32.4632	-----	5.09	-----
348	9056	3	81.2248	31.1493	-----	3.40	-----
349	9057	3	81.5173	31.0549	-----	5.95	-----
350	9058	3	79.8750	31.9680	-----	8.48	-----
351	9059	3	79.8761	31.9558	-----	3.77	-----
352	9060	3	79.8786	31.9631	-----	4.15	-----
353	9061	3	79.8408	31.9664	-----	6.17	-----
354	9062	3	79.8452	31.9920	-----	6.17	-----
355	9063	3	79.7999	32.1217	-----	3.93	-----
356	9064	1	78.8810	32.0617	-----	9.52	-----
357	9066	3	79.8843	31.9538	-----	7.50	-----
358	13801	3	80.3993	30.5514	44.20	44.02	(-)0.18
359	18701	3	81.8474	30.3861	5.90	4.01	(-)1.89
360	185001	3	81.7457	30.4093	10.93	11.50	(+)0.57
361	187004	3	81.7832	30.4005	7.44	7.35	(-)0.09
362	1012HWL	3	81.5419	30.8186	2.51	2.13	(-)0.38
363	1022RS	3	81.1093	30.9236	2.49	2.39	(-)0.10
364	1101HWL	3	81.7483	30.4467	1.55	2.63	(+)1.07
365	1124HWL	3	81.8205	30.4373	4.32	3.54	(-)0.79
366	1136HWL	3	81.7768	30.4107	8.59	5.92	(-)2.67
367	138HWL	3	81.2230	30.6880	25770.35	25806.38	(+)36.03
368	142HWL	3	81.5703	30.8017	344.23	337.86	(-)6.37
369	145HWL	3	81.4659	30.7022	41523.84	41698.35	(+)174.51
370	148HWL	3	81.5775	30.7611	27.89	123.59	(+)95.69
371	15001HWL	3	82.0682	30.6075	2.51	9.01	(+)6.51
372	15002HWL	3	82.0716	30.5969	15.08	43.66	(+)28.58
373	15003HWL	3	82.0845	30.5928	16.17	5.30	(-)10.87
374	150HWL	3	8604	30.6361	5950.97	5974.58	(+)23.62
375	159HWL	3	81.7402	30.5485	14.52	15.60	(+)1.08
376	205HWL	3	81.5653	30.7877	2.21	5.56	(+)3.35

377	206HWL	3	81.5481	30.7842	-----	6.83	-----
378	210HWL	3	81.5543	30.7714	31.04	60.24	(+)29.20
379	211HWL	3	81.7002	30.5136	9.28	9.76	(+)0.48
380	211HWL	3	81.5654	30.7666		10.80	
381	32LWL	1	78.7184	32.3297	43.43	109.62	(+)66.19
382	385HWL	3	81.5377	30.7785	3.17	3.54	(+)0.37
383	440HWL	3	81.7200	30.4487	6.25	9.29	(+)3.03
384	441HWL	3	81.6976	30.4543	3.41	3.30	(-)0.11
385	607RS	3	81.1624	30.9137	32.05	76.41	(+)44.36
386	608RS	3	81.0929	30.9256	12.51	14.36	(+)1.84
387	608RS	3	81.0996	30.9256	6.73	4.44	(-)2.29
388	616RS	3	81.1173	30.9249	9.30	11.76	(+)2.45
389	8055SG	3	81.2228	31.1105	3.12	5.54	(+)2.42
390	824HWL	3	81.7628	30.4203	-----	4.83	-----
391	8258HWL	3	81.7111	30.5586	4.22	7.66	(+)3.44
392	8263RS	3	81.1057	30.9243	1.00	1.74	(+)0.74
393	8264HWL	3	81.6666	30.9488	5.22	3.09	(-)2.13
394	8500HWL	3	82.1241	30.5708	2.20	1.86	(-)0.33
395	8501HWL	3	82.1561	30.5431	4.85	4.85	-----
396	8502HWL	3	82.1798	30.5850	2.21	2.67	(+)0.45
397	8510RS	3	81.7699	30.4590	5.56	3.85	(-)1.71
398	8511HWL	3	81.7539	30.5311	21.14	13.64	(-)7.49
399	8515HWL	3	81.3615	30.7033	51.02	35.98	(-)15.04
400	8516RS	3	81.1337	30.9217	6.52	4.62	(-)1.90
401	8527RS	3	79.3065	31.2329	2.78	4.65	(+)1.87
402	8528RS	3	78.7966	31.3696	2.19	2.80	(+)0.60
403	8597RS	3	81.0199	31.3749	1.82	2.31	(+)0.50
404	8610HWL	3	81.8926	30.9534	4.87	6.66	(+)1.79
405	8611HWL	3	81.8938	30.9471	8.01	7.19	(-)0.81
406	9010HWL	3	81.5289	30.8309	-----	8.60	-----
407	9011HWL	3	81.5417	30.7877	-----	3.32	-----
408	9012HWL	3	81.5240	30.7757	-----	2.82	-----
409	9013HWL	3	82.1168	30.5843	-----	2.29	-----
410	9014HWL	3	81.7780	30.4066	-----	3.32	-----
411	9049RS	2	78.0251	31.6185	-----	5.18	-----
412	9052HWL	3	81.5452	30.7725	-----	6.06	-----
413	9065HWL	3	81.5549	30.7809	-----	9.52	-----
414	96HWL	3	79.5987	31.3055	43.44	59.81	(+)16.38

HWL- High Altitude Wetlands

RS- River Section

SG-Supra Glacial

7.7 Status of lakes as on October 2022

During the month of October 2022, a total of 05 data products could be procured for 06th, 15th, 25th, 27th and 30th October (Fig: 7. 7(a) – (e)). From the analysis of these five satellite data products for October 2022, a total of 174 lakes in comparison to 331(2021) in the entire catchment could be mapped comprising 51 from Spiti, 8 from Lower Satluj and 115 from Upper Satluj sub basin (Fig.7.7 (f)). On analyzing these 174 lakes further, it was found that 88 lakes were such which have the area less than 5ha comprising 33 from Spiti, 5 from Lower Satluj and 50 from Upper Satluj basin. Further 47 lakes were such which falls within the areal range of 5-10ha comprising 15 from Spiti, 3 from Lower Satluj and 29 from Upper Satluj basin. Similarly, 39 lakes were such which have the area more than 10ha and are considered big lakes comprising 3 from Spiti and 36 from Upper Satluj basin (Fig. 7.7 (g)). Besides this, when these 174 lakes were analyzed for their source, it was observed that 18 lakes were mainly the high altitude wetlands in Upper Satluj basin. Further out of 18 wetlands, 2 were mainly with area less than 5ha, 6 within the areal range of 5-10ha and 10 wetlands were the big one with area more than 10ha respectively (Fig. 7.7(h)). On analyzing these 174 lakes/wetlands for their temporal analysis with that of 2021, only 98 lakes/wetlands could be compared out of which 34 lakes/wetlands have shown a reducing trend in their water spread, whereas 64 lakes/wetlands shown an increasing trend in their water spread with reference to 2021 data (Table: 7.7). The remaining lakes/wetlands which could not be compared forms the base line data for their monitoring during the next ablation season, which may be due to the fact that either these lakes /wetlands were either not mapped during 2021 due to snow cover impacts or are the new one and thus mapped this year only. The 7 lakes with ids RS are mainly formed due to the accumulation of water along the main Satluj river course in the Upper Satluj sub basin on the extreme southeastern side downstream of the Mansarovar Lake and the Rakas Tal (i.e. lakes with ids 138 & 145) in the Tibetan Himalayan Region from where the Satluj originates.

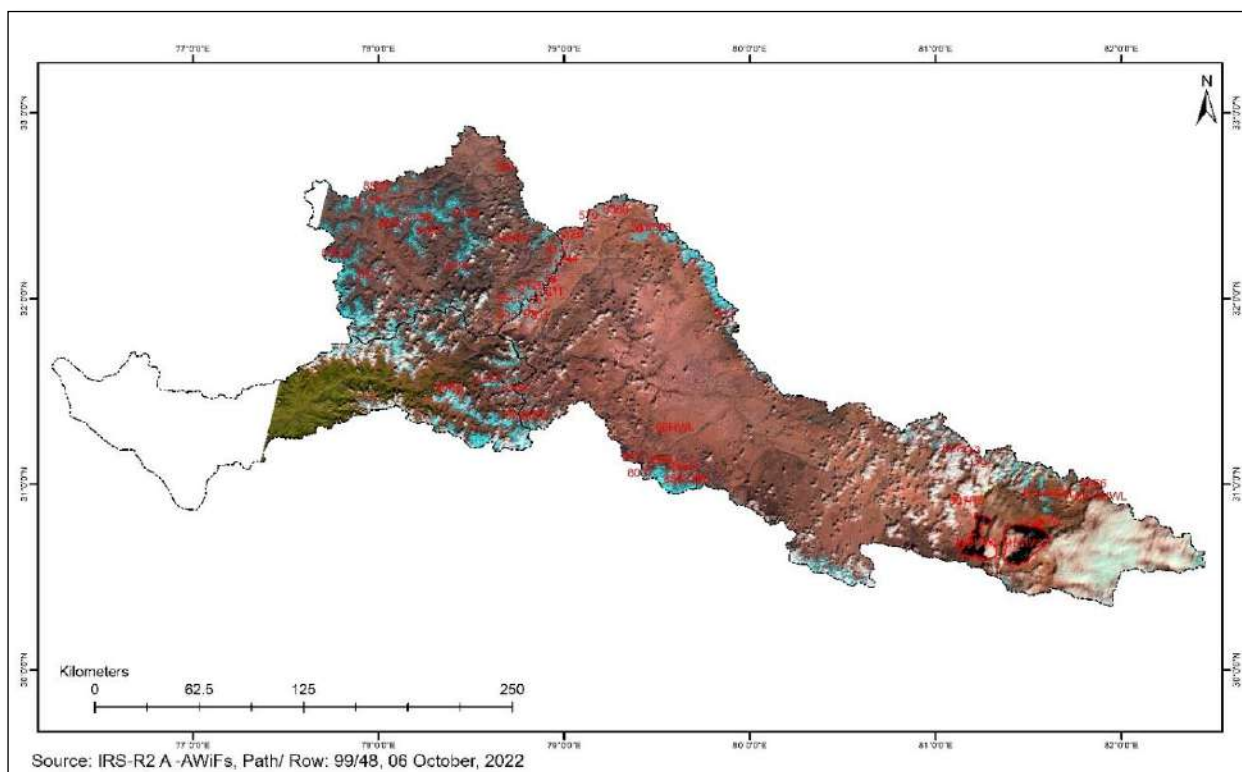


Fig.7.7 (a): IRS-R2, AWiFS, 99-48, 06th October, 2022.

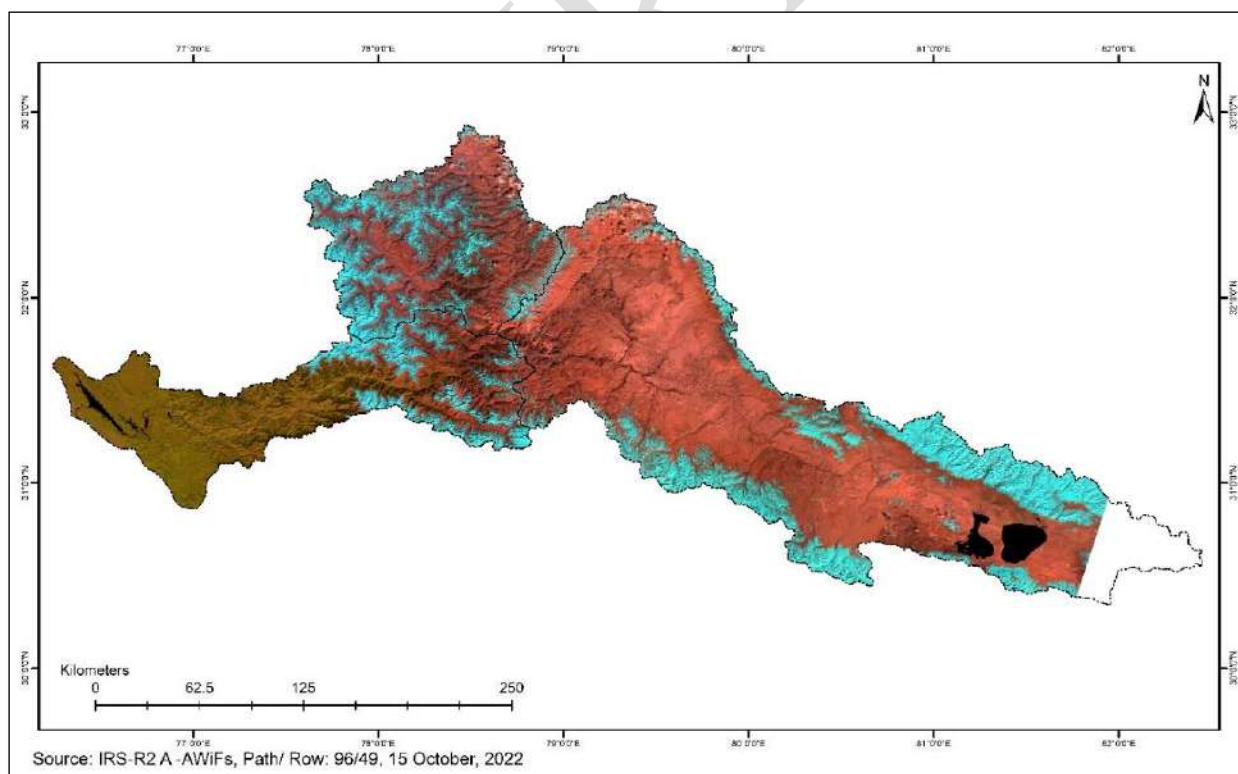


Fig.7.7 (b): IRS-R2, AWiFS, 96/49, 15th October, 2022.

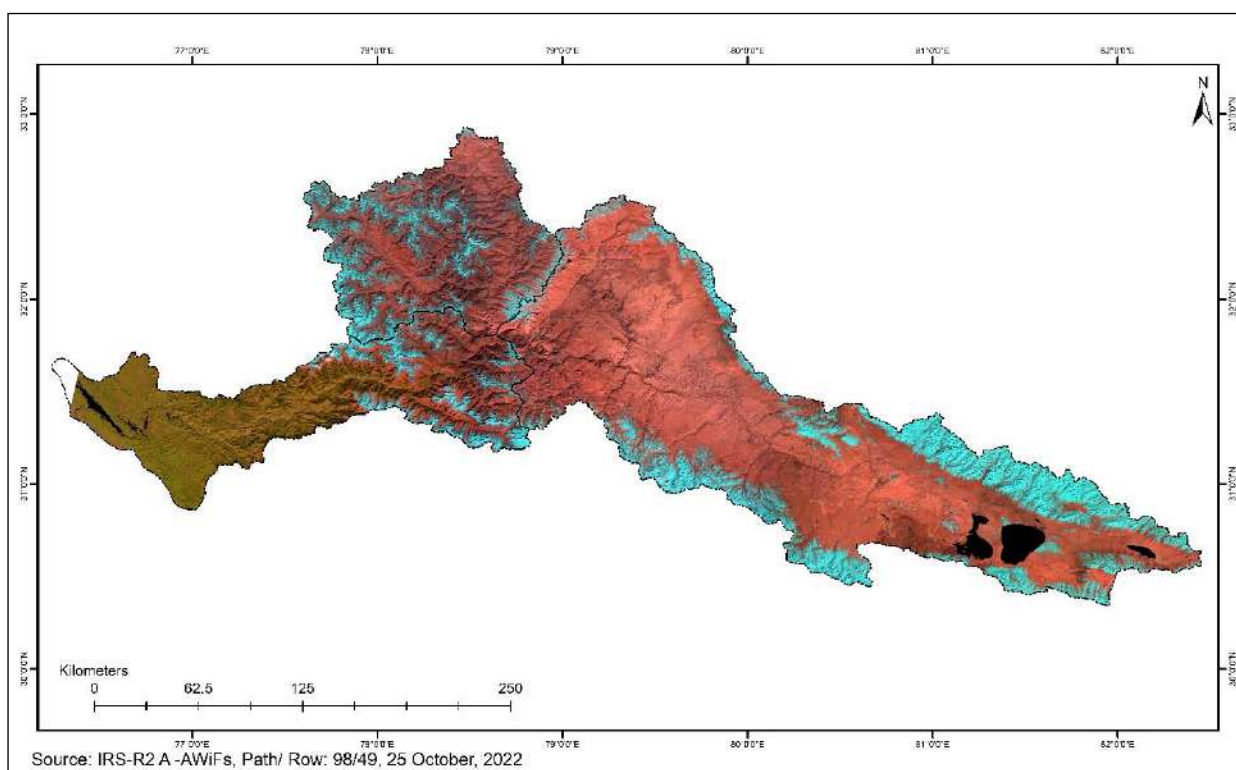


Fig.7.7 (c): IRS-R2, AWiFs, 97-48, 25th October, 2022.

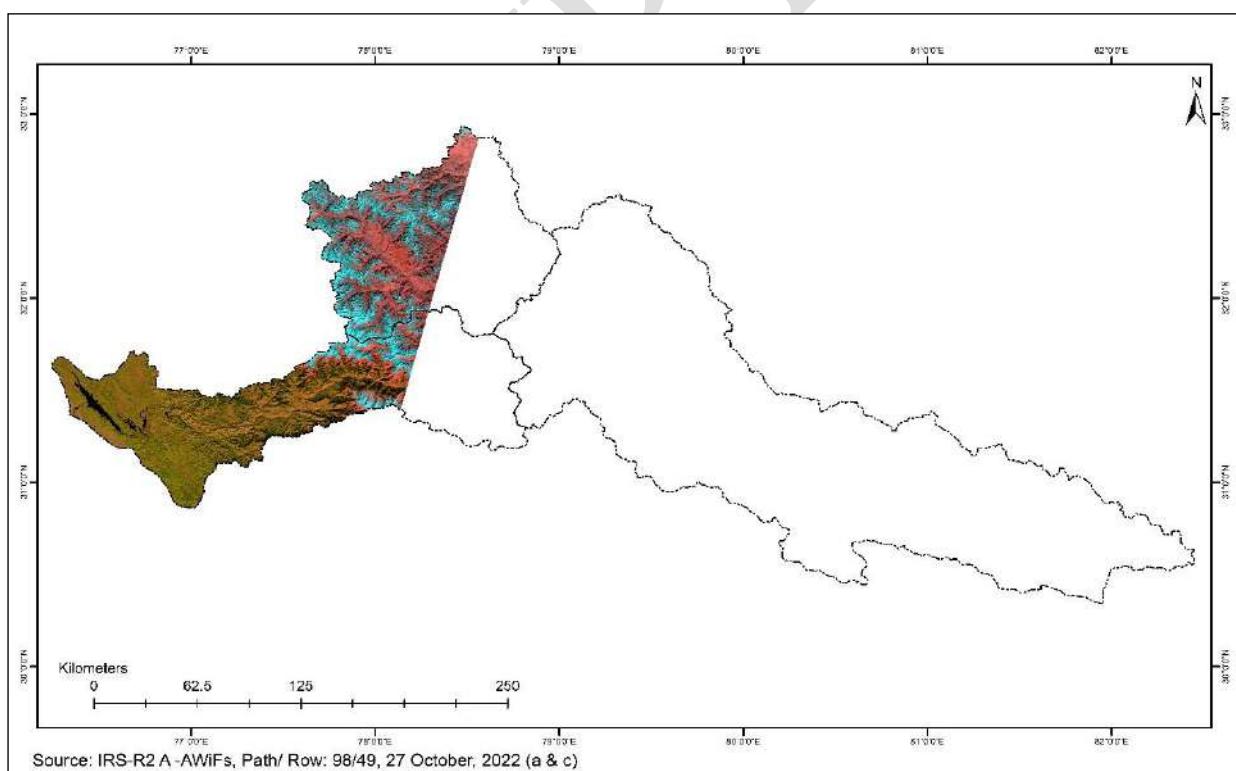


Fig.7.7 (d): IRS-R2, AWiFs, 98/49, 27th October, 2022.

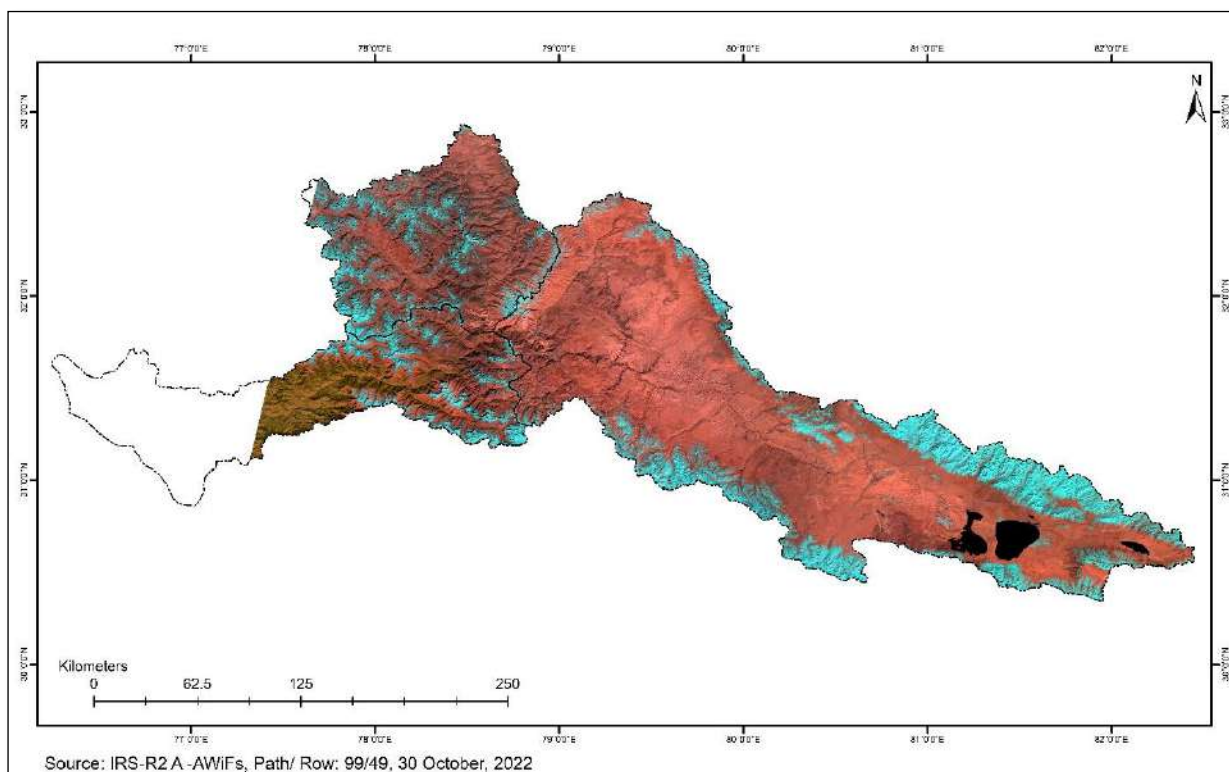


Fig.7.7 (e): IRS-R2, AWiFS, 99/49, 30th October, 2022.

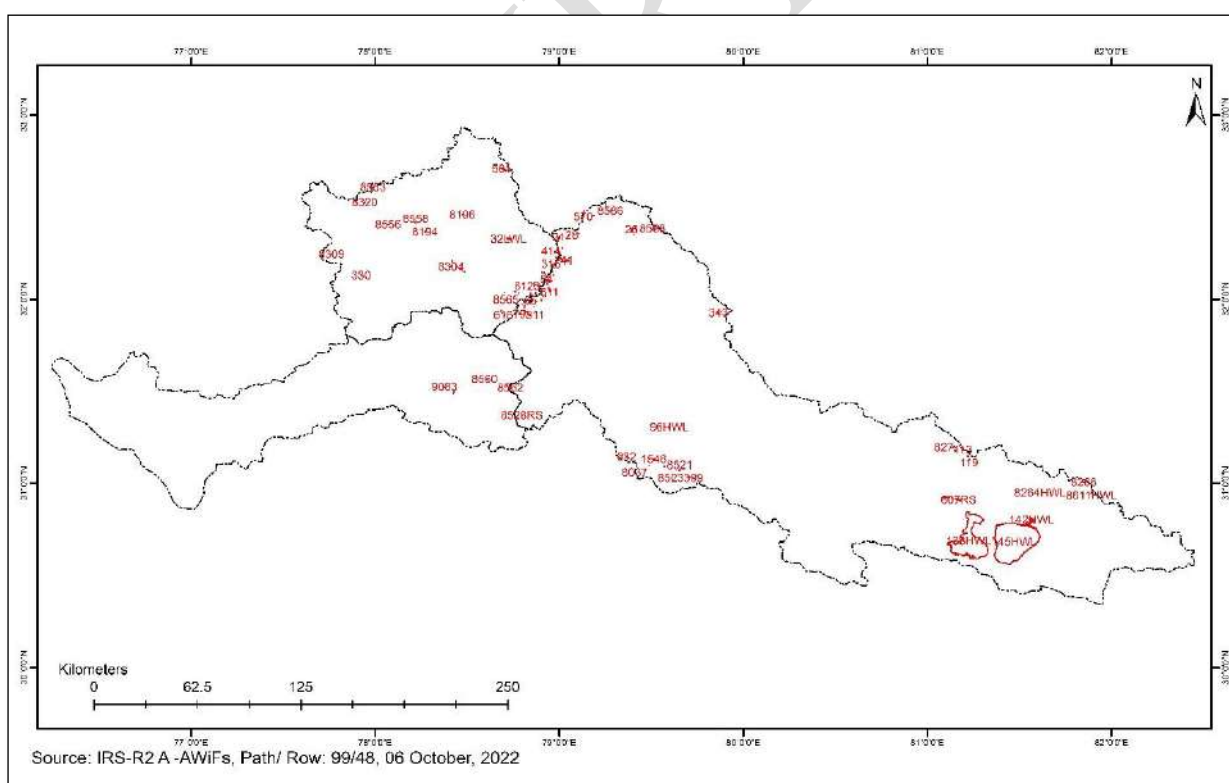


Fig.7.7 (f): IRS-R2, AWiFS, October, 2022, Interpreted Layer

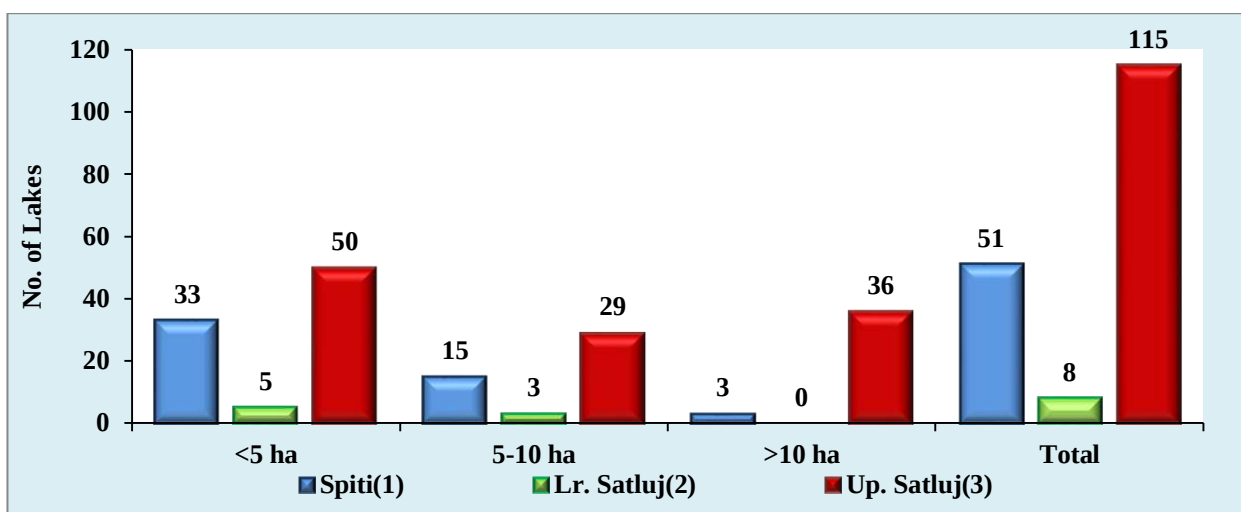


Fig. 7.7 (g): No. of Lakes based on IRS-R2, AWiFS, October, 2022.

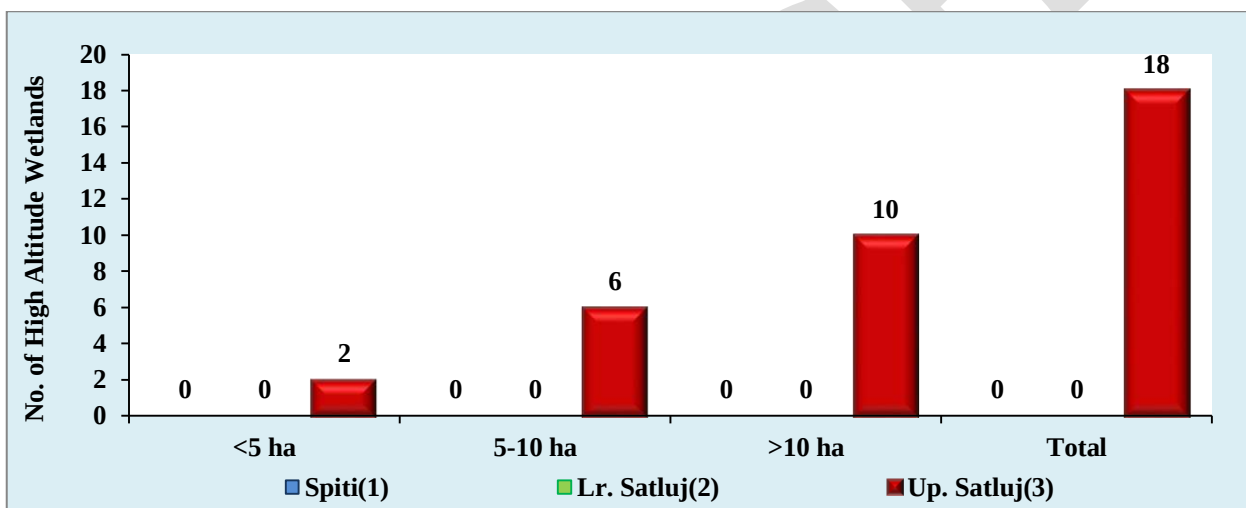


Fig. 7.7 (h): No. of High altitude wetland Lakes based on IRS-R2, AWiFS, and October, 2022.

Table: 7.7 Aerial Extent of lakes as on October 2022

Sr. No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on October 2021 (ha.)	Aerial Extent on October 2022 (ha.)	Change in Area w.r.t. October 2021 (ha.)
1	23	3	79.4155	32.3908	10.63	10.48	(-)0.15
2	25	3	79.3925	32.3774	25.03	25.29	(+)0.26
3	28	3	79.0515	32.3468	5.38	6.22	(+)0.84
4	31	3	78.9986	32.3362	-----	17.85	-----
5	39	3	79.0256	32.2253	6.81	6.09	(-)0.72
6	41	3	79.0435	32.2104	21.28	26.87	(+)5.59
7	51	3	78.9416	32.1222	2.85	4.61	(+)1.76
8	54	3	78.9303	32.1079	8.34	11.96	(+)3.62
9	55	3	78.9418	32.1073	12.25	10.71	(-)1.54

10	60	3	78.8721	32.0318	4.43	6.27	(+)1.84
11	61	1	78.8448	32.0299	20.55	23.21	(+)2.66
12	62	3	78.8741	32.0172	14.96	11.16	(-)3.80
13	63	3	78.876	32.02	4.06	3.75	(-)0.31
14	65	3	78.8437	31.9924	25.29	25.29	-----
15	79	3	78.7828	31.919	24.36	25.16	(+)0.80
16	112	3	81.1477	31.1999	17.78	14.69	(-)3.09
17	113	3	81.1932	31.1819	57.2	53.31	(-)3.89
18	114	3	81.1513	31.1777	33.04	24.34	(-)8.70
19	119	3	81.2272	31.1297	9.37	6.22	(-)3.15
20	312	3	78.9724	32.3252	6.91	7.44	(+)0.53
21	313	3	78.9776	32.3201	10.52	10.58	(+)0.06
22	315	1	78.9718	32.1905	3.81	6.55	(+)2.74
23	319	3	78.8369	31.9803	14.78	16.39	(+)1.61
24	330	1	77.9246	32.1289	2.65	2.14	(-)0.51
25	343	3	79.8637	31.9264	32.94	40.46	(+)7.52
26	399	3	79.7305	31.0285	12.54	13.32	(+)0.78
27	408	3	78.911	32.0178	4.16	7.97	(+)3.81
28	413	3	79.005	32.2247	3.22	3.5	(+)0.28
29	414	1	78.9765	32.2584	2.38	3.43	(+)1.05
30	415	3	79.0003	32.3291	2.38	3.08	(+)0.70
31	416	3	79.1868	32.4518	2.42	4.21	(+)1.79
32	559	1	78.7055	32.7068	-----	2.64	-----
33	561	1	78.689	32.7082	5.61	6.78	(+)1.17
34	562	3	79.0159	32.2771	1.18	2.65	(+)1.47
35	563	1	78.9823	32.2264	2.11	2.57	(+)0.46
36	570	3	79.1303	32.446	3.75	6.39	(+)2.64
37	571	3	79.1303	32.4631	2.97	3.86	(+)0.89
38	610	3	78.9462	32.0927	3.7	5.82	(+)2.12
39	611	3	78.9418	32.0606	7.7	9.89	(+)2.19
40	616	1	78.7017	31.9117	6.22	6.18	(-)0.04
41	632	3	79.3658	31.1435	4.26	8.36	(+)4.10
42	640	3	78.9698	32.1297	2.96	4.57	(+)1.61
43	663	3	79.3417	31.1534	4.15	4.64	(+)0.49
44	811	3	78.8399	31.9146	21.08	13.62	(-)7.46
45	827	3	81.1373	31.1943	9.69	9.27	(-)0.42
46	870	1	78.9264	32.1297	-----	1.87	-----
47	885	3	79.8811	31.9327	3.44	5.04	(+)1.60
48	1532	3	78.8659	31.9583	4.12	3.65	(-)0.47
49	1538	3	79.5695	31.0925	-----	6.18	-----
50	1546	3	79.5135	31.1312	6.11	6.62	(+)0.51
51	1568	3	78.8449	32.0116	-----	2.41	-----

52	1585	1	78.8645	32.0859	-----	1.7	-----
53	1604	3	78.9017	32.0044	-----	1.35	-----
54	1606	3	78.9976	32.2243	-----	1.38	-----
55	6001	3	78.8226	31.9328	-----	4.46	-----
56	6045	2	78.4306	31.504	-----	2.01	-----
57	7004 (1)	3	78.818	31.9317	-----	5.35	-----
58	7004(2)	3	78.8148	31.9333	8.12	3.18	(-)4.94
59	8028	3	78.9723	32.1705	2.44	3.89	(+)1.45
60	8037	3	79.411	31.0606	5.05	6.41	(+)1.36
61	8047	3	79.4906	31.1313	2.35	3.63	(+)1.28
62	8065	3	81.2214	31.1481	16.19	11.55	(-)4.64
63	8096	1	78.7011	31.9177	-----	1.35	-----
64	8101	1	78.6835	31.9341	-----	2.27	-----
65	8117	1	78.7572	32.0421	3.63	4.54	(+)0.91
66	8118	1	78.7621	32.0406	-----	2.01	-----
67	8123	3	78.8853	32.0721	-----	14.97	-----
68	8127	1	78.8067	32.0585	15.77	9.86	(-)5.91
69	8137	1	78.9184	32.1416	2.37	5.03	(+)2.66
70	8138	3	78.9622	32.1499	-----	3.11	-----
71	8141	1	78.9602	32.1851	2.09	6.02	(+)3.93
72	8142	3	79.0184	32.2085	1.76	3.34	(+)1.58
73	8143	3	79.0096	32.2151	1.81	4.31	(+)2.50
74	8146	3	78.9832	32.2994	-----	14.8	-----
75	8153	3	79.1033	32.3545	4.1	5.09	(+)0.99
76	8154	3	79.4042	32.3505	3.26	2.75	(-)0.51
77	8159	3	79.5078	32.3924	1.22	1.18	(-)0.04
78	8162	3	79.2537	32.5066	-----	5.94	-----
79	8194	1	78.2707	32.3634	15.76	14.13	(-)1.63
80	8196	1	78.4736	32.4569	9.12	5.47	(-)3.65
81	8236	3	79.7531	31.0401	8.41	8.41	-----
82	8265	3	79.4902	31.098	7.82	3.82	(-)4.00
83	8266	3	81.8503	31.0049	29.13	30.68	(+)1.55
84	8286	3	78.903	32.0434	-----	1.53	-----
85	8289	1	78.7181	31.9006	-----	1.49	-----
86	8295	1	78.7008	32.0363	2.38	1.18	(-)1.20
87	8299	3	78.9476	32.1225	1.52	1.59	(+)0.07
88	8300	1	78.4862	32.1496	8.03	6.67	(-)1.36
89	8302	1	78.4617	32.1616	-----	4.06	-----
90	8304	1	78.4123	32.1757	-----	9.62	-----
91	8307	1	78.4177	32.2043	-----	5.26	-----
92	8309	1	77.7624	32.2427	3.92	5.03	(+)1.11
93	8320	1	77.9434	32.525	4.46	4.83	(+)0.37

94	8323	1	78.7098	32.6953	3.33	3.93	(+)0.60
95	8324	1	78.719	32.698	-----	1.52	-----
96	8325	1	78.7329	32.6981	-----	3.22	-----
97	8326	1	78.6988	32.7046	-----	8.74	-----
98	8519	3	79.7072	31.0334	-----	2.51	-----
99	8520	3	79.6534	31.0746	-----	2.13	-----
100	8521	3	79.6503	31.0722	-----	2.42	-----
101	8523	3	79.6088	31.0307	-----	1.35	-----
102	8524	3	79.3573	31.1508	1.83	3.57	(+)1.74
103	8536	2	78.4279	31.4957	-----	1.17	-----
104	8537	2	78.4274	31.4942	-----	1.66	-----
105	8538	2	78.4267	31.4913	-----	3.43	-----
106	8552	1	77.915	32.137	5.29	2.61	(-)2.68
107	8553	1	77.9888	32.6069	-----	5.78	-----
108	8554	1	78.0894	32.4264	-----	3.86	-----
109	8555	1	78.0828	32.4231	-----	4.3	-----
110	8556	1	78.0713	32.405	-----	6.51	-----
111	8558	1	78.2196	32.4158	2.35	3.89	(+)1.54
112	8560	2	78.6079	31.5653	-----	5.07	-----
113	8561	2	78.7181	31.5313	-----	3.25	-----
114	8562	2	78.7349	31.5181	5.5	5.48	(-)0.02
115	8565	1	78.7115	31.9969	-----	2.7	-----
116	8566	3	78.8231	31.9298	1.18	1.1	(-)0.08
117	8567	3	78.8121	31.9652	5.97	5.34	(-)0.63
118	8568	3	78.7977	31.9715	1.77	1.75	(-)0.02
119	8569	3	78.847	31.9949	-----	1.76	-----
120	8570	1	78.8225	32.0139	-----	1.89	-----
121	8571	1	78.7803	32.0324	-----	2.39	-----
122	8573	1	78.8078	32.0795	-----	1.57	-----
123	8574	1	78.8633	32.0708	-----	1.23	-----
124	8575	3	78.9256	32.0148	2.29	3.69	(+)1.40
125	8576	3	78.9504	32.1201	-----	1.8	-----
126	8577	1	78.9054	32.1447	-----	3.28	-----
127	8580	3	78.9931	32.3161	-----	1.08	-----
128	8585	3	79.1209	32.4399	-----	2.68	-----
129	8586	3	79.2785	32.4796	-----	7.46	-----
130	8587	3	79.4162	32.3735	-----	3.39	-----
131	8588	3	79.5074	32.3829	-----	2.78	-----
132	8589	3	79.5195	32.377	-----	1.17	-----
133	9067	1	78.7011	32.7054	-----	4.6	-----
134	9068	1	78.7387	32.7064	-----	2.73	-----
135	9070	3	78.8247	31.9298	-----	1.09	-----

136	9071	3	78.8092	31.9523	-----	2.75	-----
137	9072	1	78.869	32.0787	-----	3.69	-----
138	9073	3	78.9014	31.9921	-----	3.25	-----
139	9075	3	78.9492	32.042	-----	12.96	-----
140	9076	3	78.9547	32.0457	-----	6.7	-----
141	9077	3	78.9357	32.0821	-----	10.66	-----
142	9078	3	78.9291	32.0929	-----	1.43	-----
143	9079	3	79.0075	32.2187	-----	2.28	-----
144	9079	1	78.8044	32.081	-----	1.98	-----
145	9080	1	78.8374	32.0539	-----	5.2	-----
146	9081	1	78.4156	32.1805	-----	4.05	-----
147	9083	2	78.377	31.5236	-----	7.98	-----
148	1012HWL	3	81.5422	30.8193	3.22	2.51	(-)0.71
149	138HWL	3	81.223	30.688	25755.26	25767.91	(+)12.65
150	142HWL	3	81.5703	30.8017	331.33	340.85	(+)9.52
151	145HWL	3	81.4659	30.7022	41501.52	41518.83	(+)17.31
152	148HWL	3	81.576	30.7623	57.26	61.08	(+)3.82
153	205HWL	3	81.5653	30.7877	4.03	10.76	(+)6.73
154	206HWL	3	81.5481	30.7842	3.05	7.66	(+)4.61
155	209hwl	3	81.5431	30.7723	10.5	33.2	(+)22.70
156	210HWL	3	81.5543	30.7714	58.11	73.07	(+)14.96
157	32LWL	1	78.7214	32.3276	29.39	133.78	(+)104.39
158	385HWL	3	81.5377	30.7785	3.95	5.65	(+)1.70
159	607RS	3	81.1624	30.9137	43.11	122.9	(+)79.79
160	608RS	3	81.0929	30.9256	2.98	18.44	(+)15.46
161	608RS	3	81.1001	30.9261	9.68	8.59	(-)1.09
162	616RS	3	81.1173	30.9249	13.44	10.43	(-)3.01
163	8156SG	3	79.3898	32.3683	4.83	3.92	(-)0.91
164	8263RS	3	81.105	30.9244	-----	2.21	-----
165	8264HWL	3	81.6675	30.9484	-----	5.22	-----
166	8515HWL	3	81.3615	30.7033	-----	48.86	-----
167	8516RS	3	81.1334	30.9217	-----	4.88	-----
168	8528RS	3	78.7973	31.3691	-----	3.24	-----
169	8610HWL	3	81.8926	30.9534	5.89	4.87	(-)1.02
170	8611HWL	3	81.8938	30.9471	1.79	8	(+)6.21
171	9069HWL	3	81.543	30.7886	-----	6.7	-----
172	9082HWL	3	81.5552	30.7813	-----	9.07	-----
173	9083HWL	3	81.5656	30.7664	-----	16.32	-----
174	96HWL	3	79.5987	31.3055	12.82	43.44	(+)30.62

HWL- High Altitude Wetlands

RS- River Section

7.8: Status of lakes as on November 2022.

During the month of November 2022, most of the catchment area as on 3rd, 13th, 22nd and 23rd November ((Fig: 7.8 (a)-(d))satellite images could be seen under the impact of fresh snow cover as a result of which only 93 lakes could be delineated (Fig: 7.8 (e)). Further analysis of the 93 lakes reveals that 71 lakes form part of the Upper Satluj basin i.e. sub basin number 3 comprising 30 lakes with area less than 5ha, 19 within the areal range of 5-10ha and 22 lakes with area more than 10ha respectively (Fig: 7.8 (f)). When these 93 lakes were analyzed based on their source, it was found that 28 lakes out of 93 were mainly the high altitude wetlands comprising 7 with area less than 5ha , 8 within the areal range of 5-10 ha and 13 with area more than 10ha lies in Upper Satluj sub basin(Fig: 7.8 (g)). Further analysis reveals that out of 93 lakes, 10 lakes were such that they have been formed along the river course by virtue of damming of the water due to one or the other reason (Table: 7.8) Further these 93 lakes /wetlands were seen temporally w.r.t 2021, it was found that only 13 lakes/wetlands could be compared of which 5 lakes/wetlands were characterized by reduction in their water spread, whereas 8 lakes/wetlands showed an increase in their water spread w.r.t 2021, and the remaining which could not be compared forms the base line data for the next ablation season.

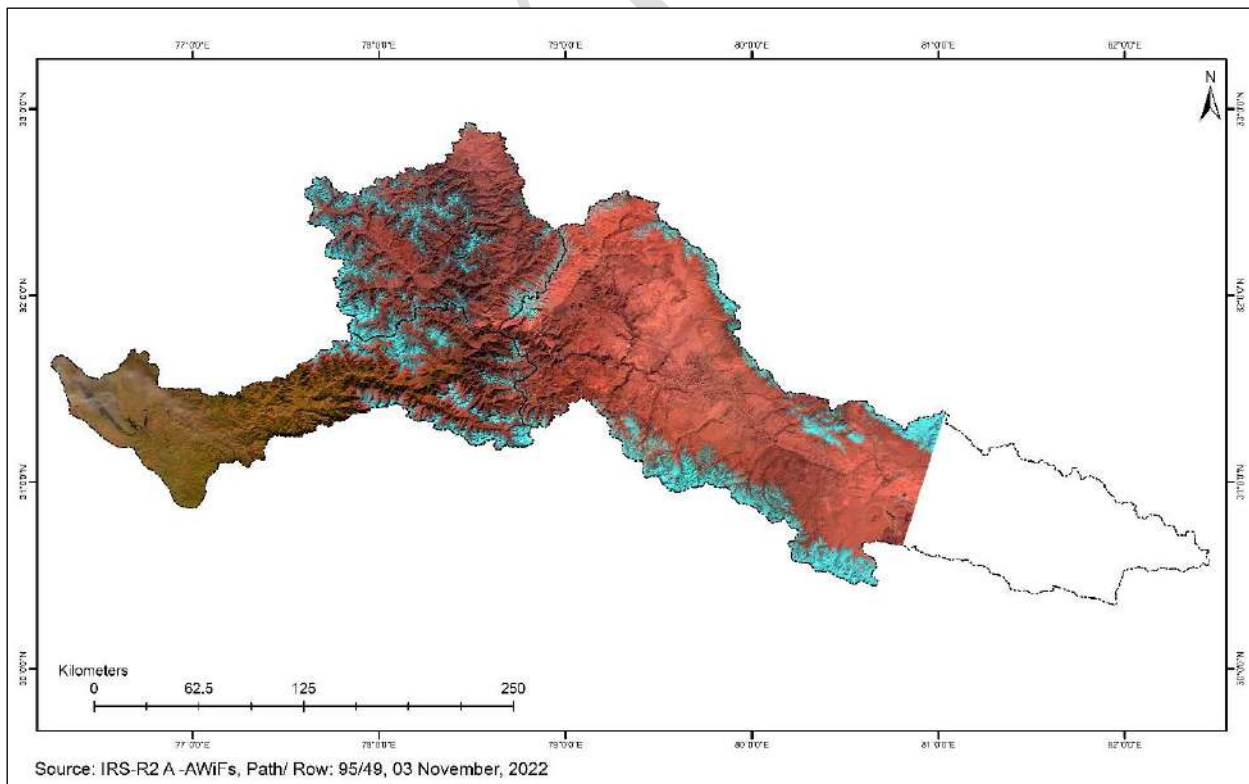


Fig.7.8 (a): IRS, R2, AWiFS, 95/49, 3rd November 2022.

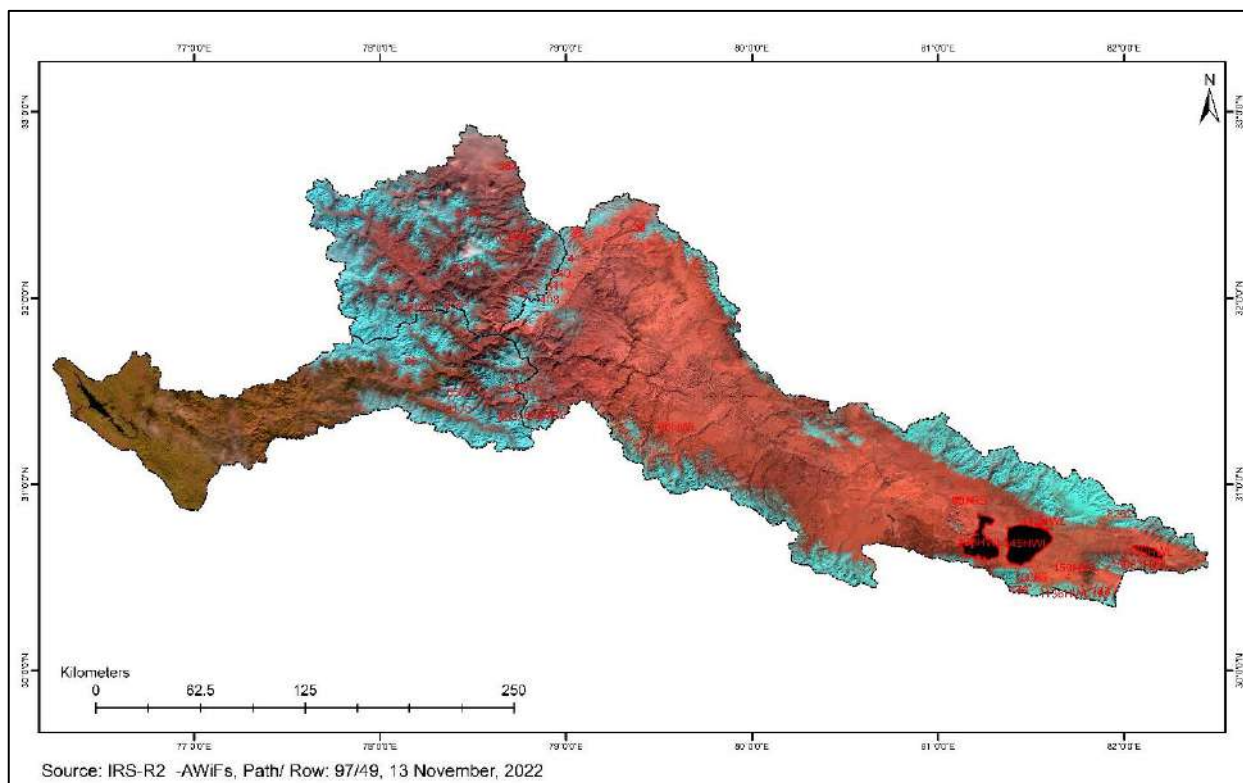


Fig.7.8 (b): IRS, R2, AWiFs, 97/49, 13th November 2022.

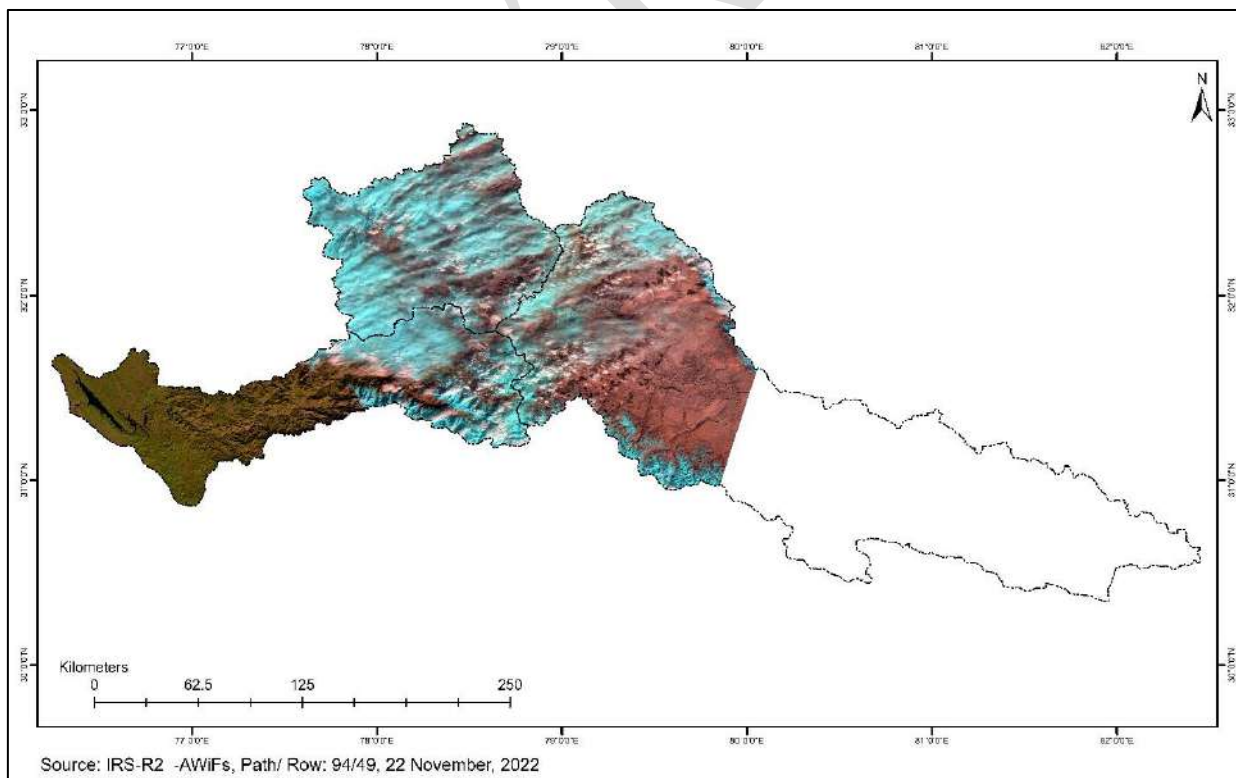


Fig.7.8 (c): IRS, R2, AWiFs, 94/49, 22nd November 2022.

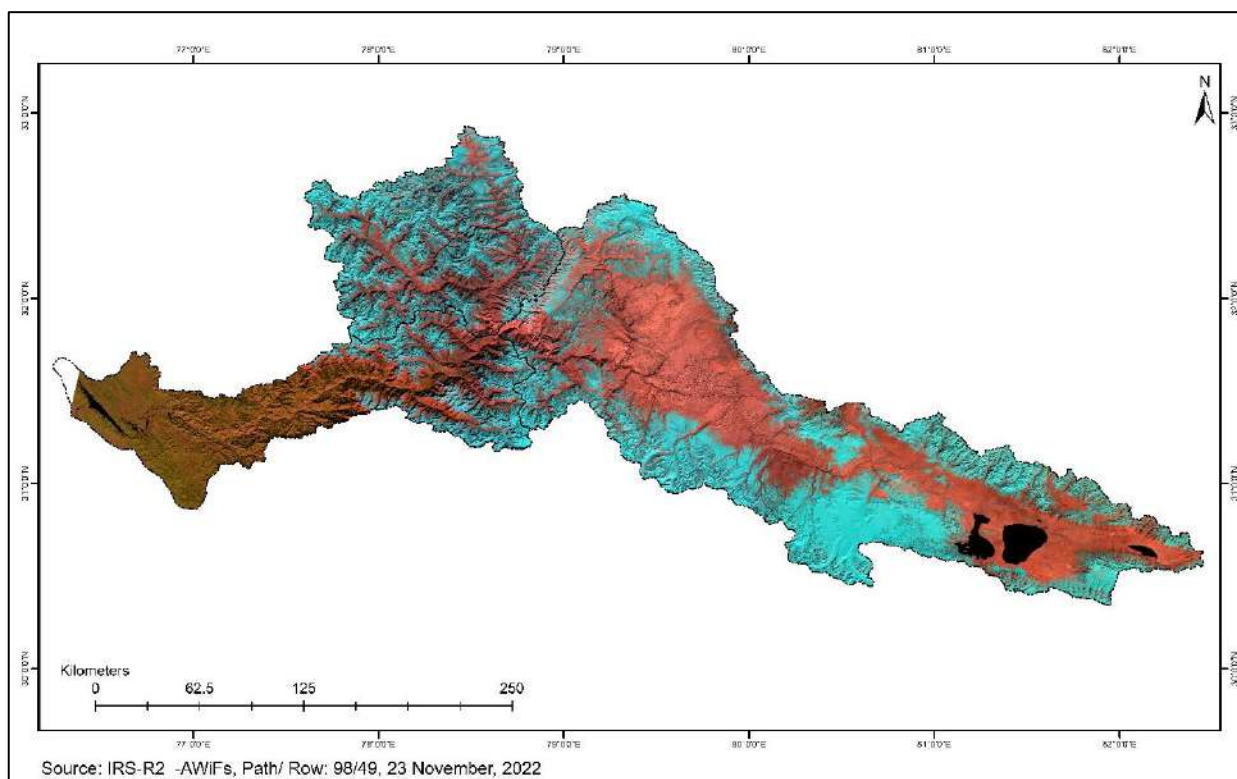


Fig.7.8 (d): IRS, R2, AWiFs, 98/49, 23rd November, 2022

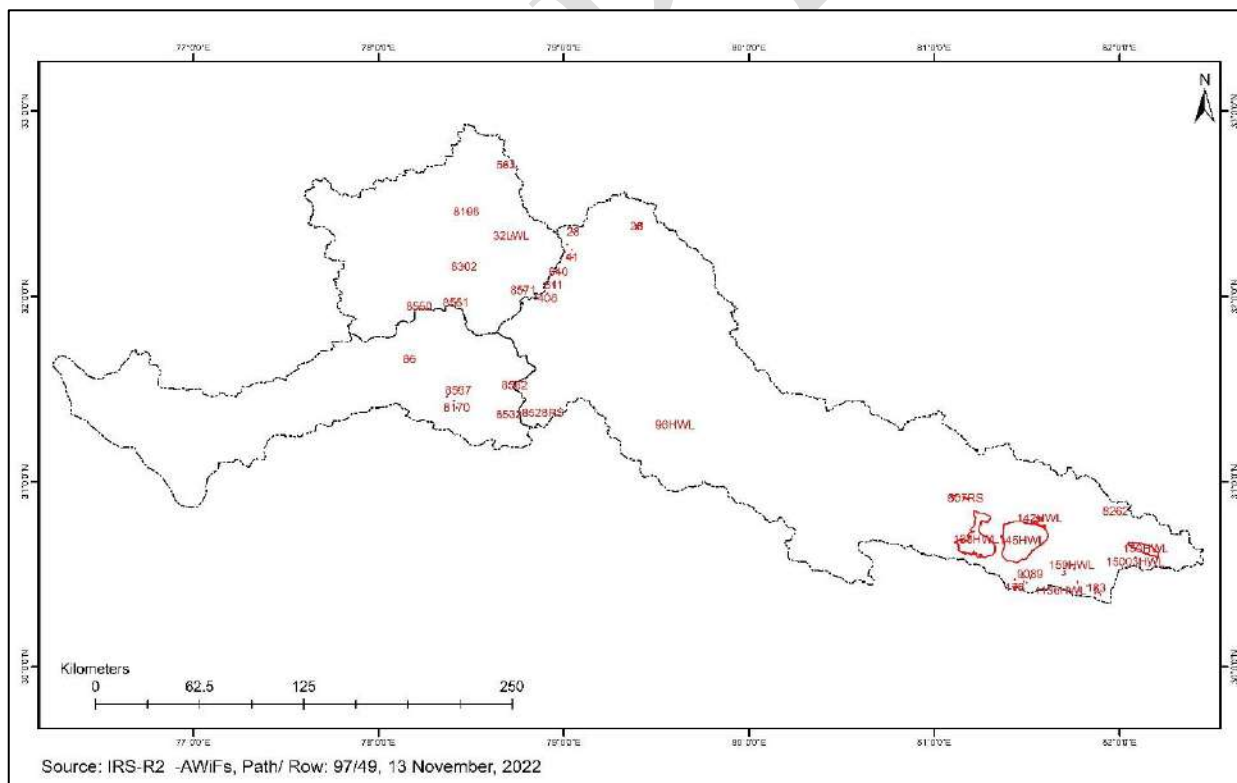


Fig.7.8 (e): IR, R2-AWiFs, 97/49, 13th November, 2022, Interpreted Layers.

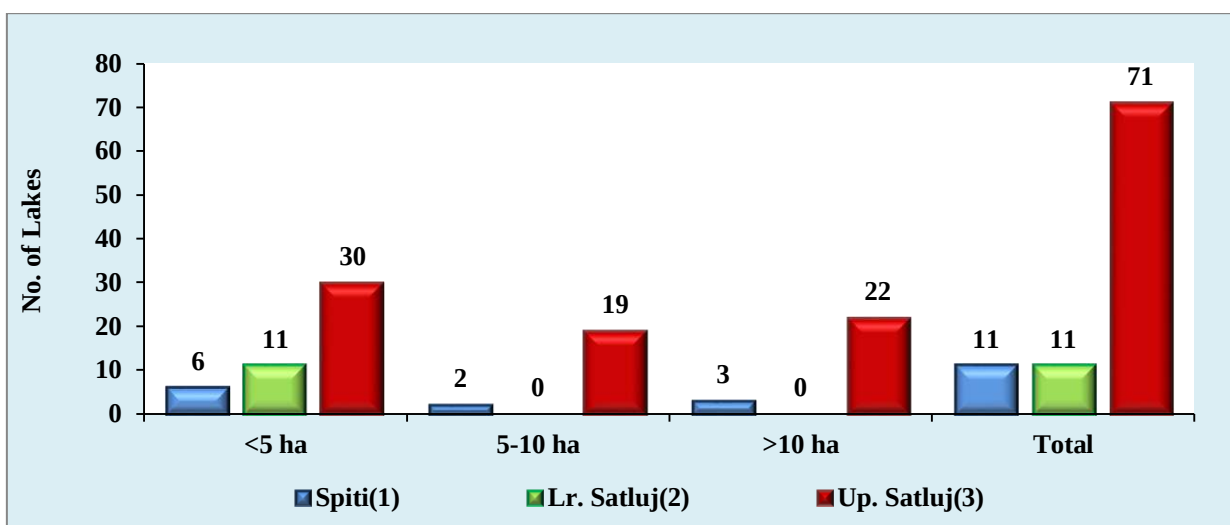


Fig.7.8 (f): No. of Lakes based on IRS, R2-AWiFS, November, 2022.

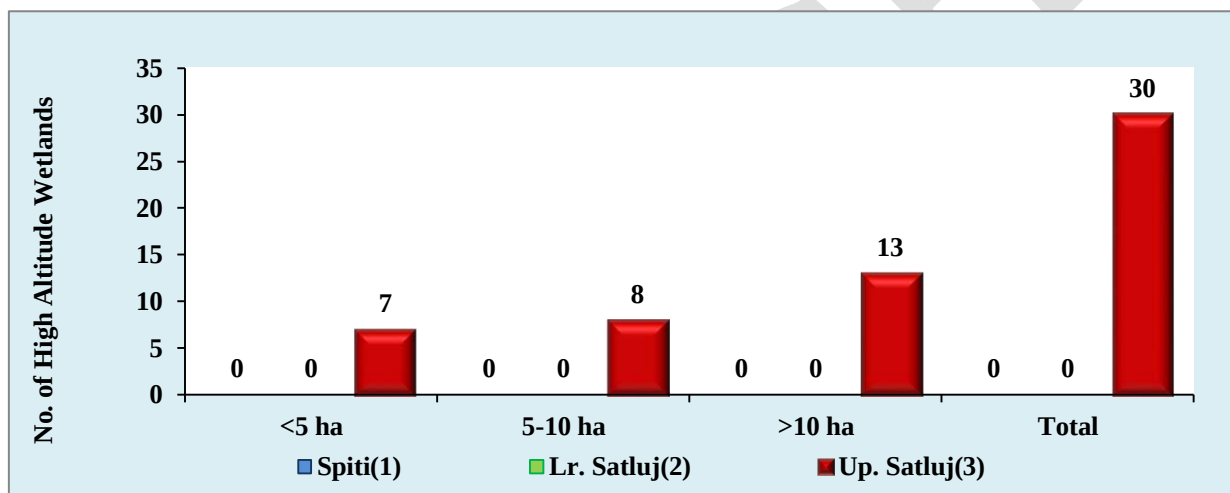


Fig.7.8 (g): No. of High Altitude Wetland Lakes based on IRS, R2-AWiFS, November, 2022.

Table: 7.8 Aerial Extent of lakes as on November 2022

Sr. No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on November 2021 (ha.)	Aerial Extent on November 2022 (ha.)	Change in Area w.r.t. November 2021 (ha.)
1	23	3	79.4186	32.391	-----	11.14	-----
2	25	3	79.3941	32.3779	-----	27.05	-----
3	28	3	79.0513	32.3492	-----	4.23	-----
4	39	3	79.027	32.2261	-----	6.47	-----
5	41	3	79.0443	32.2109	-----	22.52	-----
6	85	1	78.1675	31.6606	-----	37.34	-----
7	166	3	81.4334	30.4713	-----	6.45	-----
8	174	3	81.4348	30.4495	-----	6.73	-----
9	178	3	81.4313	30.4315	-----	179.22	-----
10	183	3	81.8707	30.4266	-----	27.32	-----

11	193	3	81.8678	30.4001	-----	9.03	-----
12	196	3	81.8961	30.3913	-----	8.18	-----
13	408	3	78.9119	32.0195	-----	4.12	-----
14	443	3	81.5161	30.477	-----	4.82	-----
15	445	3	81.485	30.4622	-----	3.27	-----
16	561	1	78.6889	32.7099	-----	4.57	-----
17	562	3	79.0174	32.2793	-----	3.3	-----
18	611	3	78.9436	32.0626	-----	6.24	-----
19	640	3	78.9717	32.1306	-----	1.78	-----
20	1005	3	81.478	30.427	-----	1.78	-----
21	1133	3	81.8683	30.4195	-----	14.4	-----
22	6045	2	78.4323	31.5074	-----	1.64	-----
23	8018	3	81.4957	30.4549	-----	1.48	-----
24	8142	3	79.0196	32.2079	-----	2.88	-----
25	8170	2	78.4213	31.4001	-----	2.42	-----
26	8172	2	78.4076	31.4383	-----	1.63	-----
27	8173	2	78.3674	31.4609	-----	2.21	-----
28	8196	1	78.4736	32.4569	-----	5.91	-----
29	8251	3	81.8861	30.403	-----	22.79	-----
30	8252	3	81.436	30.4717	-----	1.52	-----
31	8253	3	81.4784	30.4825	-----	2.23	-----
32	8262	3	81.9786	30.8409	-----	2.46	-----
33	8286	3	78.9045	32.0446	-----	1.79	-----
34	8302	1	78.4615	32.1612	-----	6.19	-----
35	8310	3	79.042	32.252	-----	2.09	-----
36	8323	1	78.7112	32.697	-----	2.35	-----
37	8324	1	78.7201	32.6989	-----	2.97	-----
38	8532	2	78.7033	31.3623	-----	2.82	-----
39	8536	2	78.4318	31.4958	-----	1.24	-----
40	8537	2	78.4308	31.4931	-----	3.62	-----
41	8550	1	78.2185	31.9465	-----	2.17	-----
42	8551	1	78.4175	31.9666	-----	10.55	-----
43	8562	2	78.7342	31.5202	-----	3.52	-----
44	8571	1	78.7815	32.0334	-----	1.63	-----
45	8572	1	78.7585	32.0448	-----	1.26	-----
46	8587	3	79.4199	32.3753	-----	3.95	-----
47	9084	2	78.3676	31.458	-----	1.23	-----
48	9085	2	78.3704	31.4606	-----	2.03	-----
49	9086	2	78.4044	31.4374	-----	2.33	-----
50	9087	3	79.0209	32.2101	-----	1.55	-----
51	9088	3	79.4002	32.3722	-----	2.84	-----
52	9089	3	81.5163	30.4818	-----	9.91	-----

53	10097	3	81.822	30.4387	-----	1.66	-----
54	1012HWL	3	81.5422	30.8193	-----	2.51	-----
55	1022RS	3	81.1101	30.9248	3.02	2.41	
56	1124HWL	3	81.822	30.4387	-----	3.15	-----
57	1136HWL	3	81.7793	30.4117	-----	6.7	-----
58	138HWL	3	81.223	30.688	25514.95	25820.06	(+)305.11
59	142HWL	3	81.5703	30.8017	336.8	328.72	(-)8.08
60	145HWL	3	81.4659	30.7022	41436.01	41563.09	(+)127.08
61	147HWL	3	81.5664	30.7691	8.99	13.09	(+)4.10
62	148HWL	3	81.584	30.7626	201.56	186.91	(-)14.65
63	15003HWL	3	82.0852	30.5929	-----	8.07	-----
64	150HWL	3	8604	30.6361	5935.08	5966.68	(+)31.60
65	159HWL	3	81.7411	30.5503	-----	28.67	-----
66	205HWL	3	81.5661	30.7891	8.36	6.36	(-)2.00
67	206HWL	3	81.5495	30.786	-----	5.78	-----
68	209HWL	3	81.5429	30.7736	2.28	28.46	(+)26.18
69	210HWL	3	81.5543	30.7714	62.12	56.44	(-)5.68
70	211HWL	3	81.7014	30.5155	-----	10.7	-----
71	32LWL	1	78.7184	32.3297	-----	16.07	-----
72	385HWL	3	81.539	30.7791	3.73	7.39	(+)3.66
73	437HWL	3	81.6936	30.4977	-----	6.01	-----
74	607RS	3	81.1624	30.9137	46.94	102.87	(+)55.93
75	608RS (1)	3	81.0929	30.9256	-----	14.59	-----
76	608RS(2)	3	81.1	30.9269	-----	7.89	-----
77	616RS	3	81.1166	30.9257	10.75	7.92	(-)2.83
78	677HWL	3	81.7072	30.5022	-----	2.62	-----
79	8156SG	3	79.3898	32.3683	-----	4.1	-----
80	8258HWL	3	81.7118	30.5607	-----	2.93	-----
81	8263RS	3	81.1065	30.9249	-----	2	-----
82	8501HWL	3	82.1588	30.5436	-----	4.06	-----
83	8502HWL	3	82.1804	30.5862	-----	1.09	-----
84	8510RS	3	81.7715	30.4603	-----	5.08	-----
85	8510RS	3	81.7718	30.4542	-----	2.6	-----
86	8511HWL	3	81.7552	30.5322	-----	15.44	-----
87	8515HWL	3	81.3615	30.7033	-----	46.22	-----
88	8516RS	3	81.1346	30.9228	-----	5.3	-----
89	8528RS	3	78.7951	31.3723	-----	1.41	-----
90	9011HWL	3	81.5438	30.7893	-----	5.05	-----
91	9012HWL	3	81.5246	30.7771	-----	3.22	-----
92	9065HWL	3	81.5563	30.7823	-----	7.18	-----
93	96HWL	3	79.6007	31.3069	-----	16.82	-----

8.0: Inventory of lakes based on LISS III satellite data for 2022:

IRS LISS-III Resourcesat 2 satellite data with a spatial resolution of 23.5 mts. were used to generate a more detailed inventory of glacial lakes/high altitude wetlands in the Satluj catchment, and the information was compared to that generated for the year 2021 due to technical reasons using LISS-III satellite data. The inventory based on LISS-III satellite data is more detailed one as this sensor has the better spatial resolution (23.5mt) than AWiFS (56mts) and thus gives more information about the terrain. Satellite data for the month of July to October 2022 was browsed and good quality cloud free data was selected for the mapping purpose as during this period the glacier surfaces are completely exposed and liable to give more detailed information about the glacier regions. During the year 2022, good quality data could not be obtained by virtue of the area under the impact of snow cover for a longer period and thereafter the cloud cover during the monsoon season. The study area is covered by LISS-III and Landsat 8 coverage mainly by seven numbers of scenes within 96/48, 96/49, 97/48, 98/48, 99/49, 100/49 and 145/38 path and rows and these data products were analyzed using visual interpretation techniques and the same methodology adopted for the AWiFS satellite data. As far as data availability is concerned, an attempt has been made to get the best quality data products during August/September, but still in parts the impacts of cloud cover or snow could be seen. The study area covered by path-row 96-48 and 96-49 covering mainly the basin 1 & 2 i.e. Spiti and Lower Satluj basins for the period 28th August 2022 (Fig: 8.2(a)) is a good quality data without any cloud cover and snow cover impacts leading to have maximum information of the catchment. Likewise under path row 97-48, 2nd September & 97-49, and Landsat, 145/38, 27th August, 2022, 97-48, 19 September & 97-49, 13 October 2022 (Fig: 8.3(a)) were also of comparatively good quality leading to have complete information. On the extreme eastern part of the study area which is covered by 99/49, 31 August & 100/49, 29 September, 2022 (Fig: 8.4(a)) were that of the good quality and thus have become possible to extract maximum information in 2022. Thus, based on the above LISS III and Landsat 8 satellite data products for the above-mentioned paths -rows, a total of 995 lakes and wetlands were delineated in 2022 in the study area, comprising 183 from Spiti basins, 173 from Lower Satluj basin, and 639 from Upper Satluj basin respectively in comparison to the total number of lakes delineated in 2021 (880), 2020 (993), 2019 (562), and 2018 (769) (Fig: 8.1). The difference in the total number of lakes varies mainly due to the non-availability of good-quality snow-free and cloud-free data coverage during that particular year.

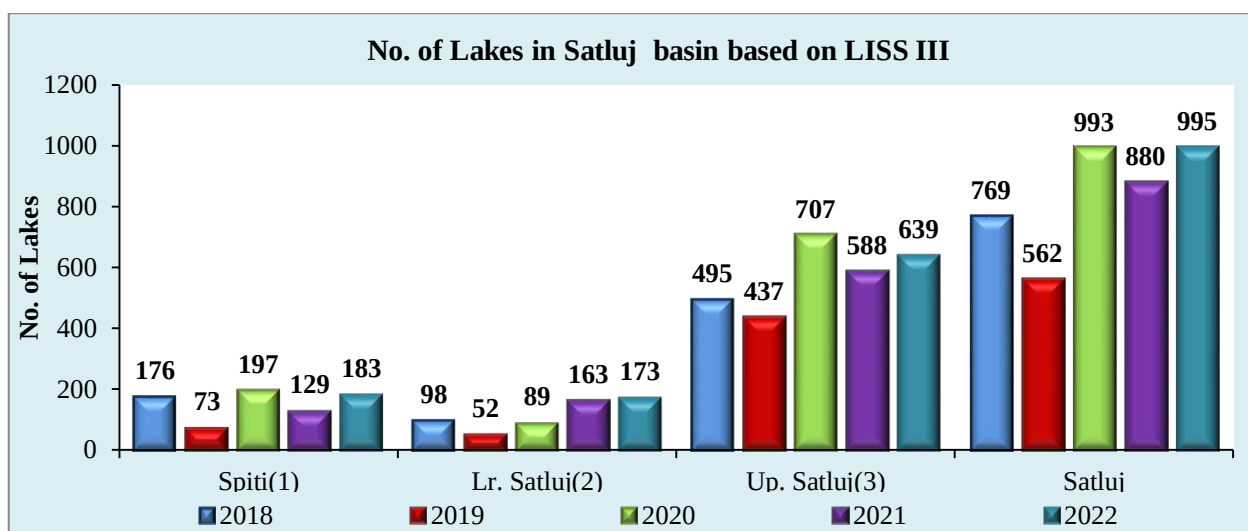


Fig. 8.1: No of lakes based in Satluj Basin based on LISS III

Further detailed analysis for 2022 using LISS III analysis found that in the area covered by path rows 96-48 and 96-49, a total of 478 lakes (Fig: 8.2(a) & (b)) predominantly from basins 1 and 2 could be delineated, out of which 4 lakes have been classified as high altitude wetlands in comparison to 384 lakes (2021), 362 lakes (2020), 153 lakes (2019), and 275 lakes (2018) respectively.

Further analysis reveals that out of 478 lakes, 183 lakes form part of the Spiti basin, i.e., basin 1, 173 form part of the Lower Satluj basin, i.e., basin 2, and 122 form part of the Upper Satluj basin, i.e., basin 3. Further analysis reveals the majority of the lakes (438) as small ones with an area less than 5 ha, out of which 168 form part of the Spiti sub basin, 166 from the Lower Satluj, and 104 from the Upper Satluj sub basin respectively. Likewise, 26 lakes are within the aerial range of 5–10 ha, out of which 8 lakes are in Spiti, 5 lakes are in the Lower Satluj, and 13 are in the Upper Satluj sub basin. Likewise 14 lakes are the big one with area greater than 10 ha, out of which 7 lakes are in Spiti, 2 lakes are in the Lower Satluj, and 5 lakes are in the Upper Satluj sub basin respectively (Fig. 8.2(c)). Further investigation based on their classification, only 4 lakes out of 438 are high-altitude wetland lakes, with 1 from the Spiti sub basin and 3 from the Lower Satluj basin having an aerial extent of less than 5 hectares (Fig. 8.2(d)).

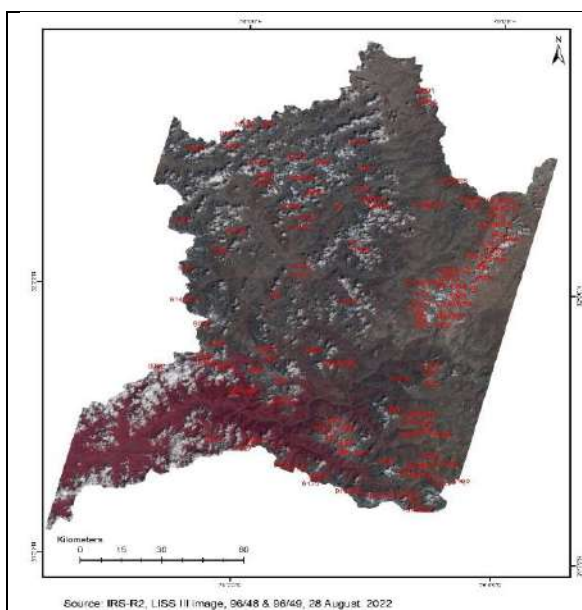


Fig.8.2 (a): IRS-R2, LISS III, 96/48 & 96/49, 28 August, 2022

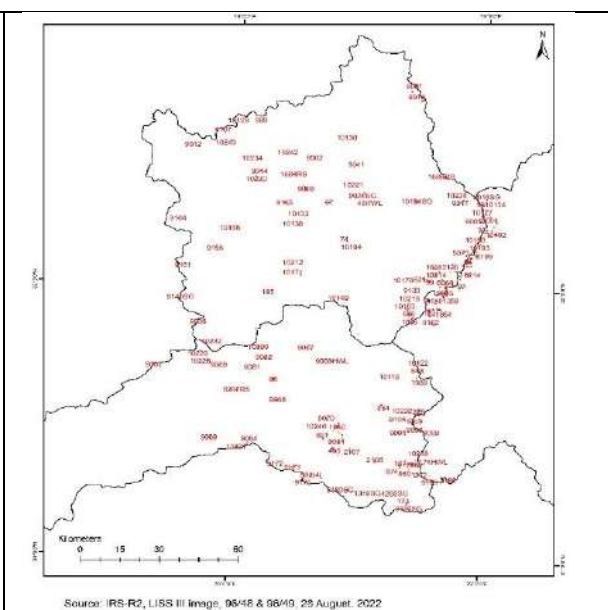


Fig.8.2 (b): IRS-R2, LISS III, 96/48 & 96/49, 28 August, 2022 & the Interpreted layer

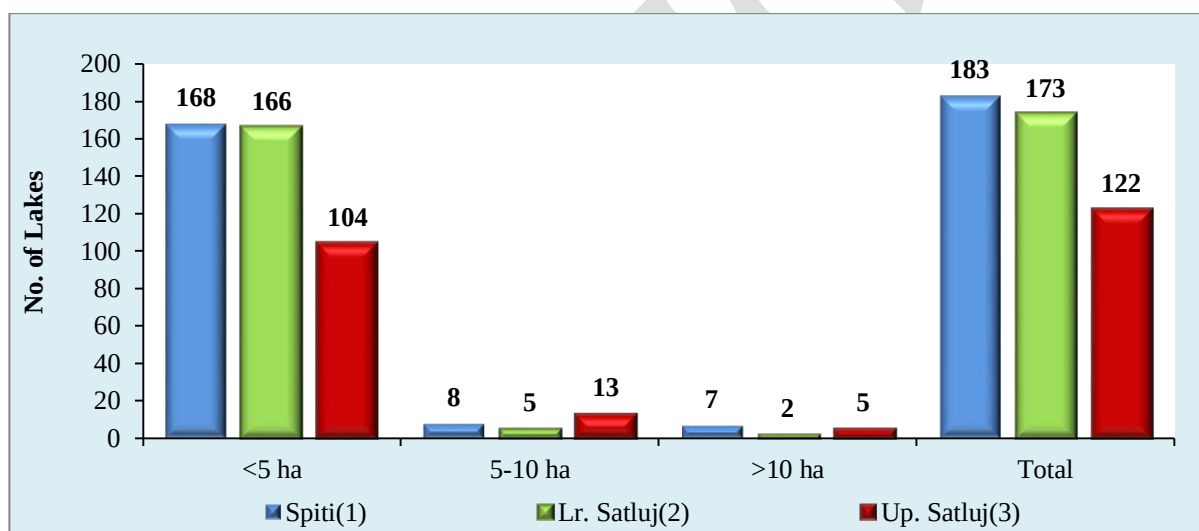


Fig.8.2 (c): No of lakes based on IRS-R2, LISS III, 96/48 and 96/49, 28 August, 2022

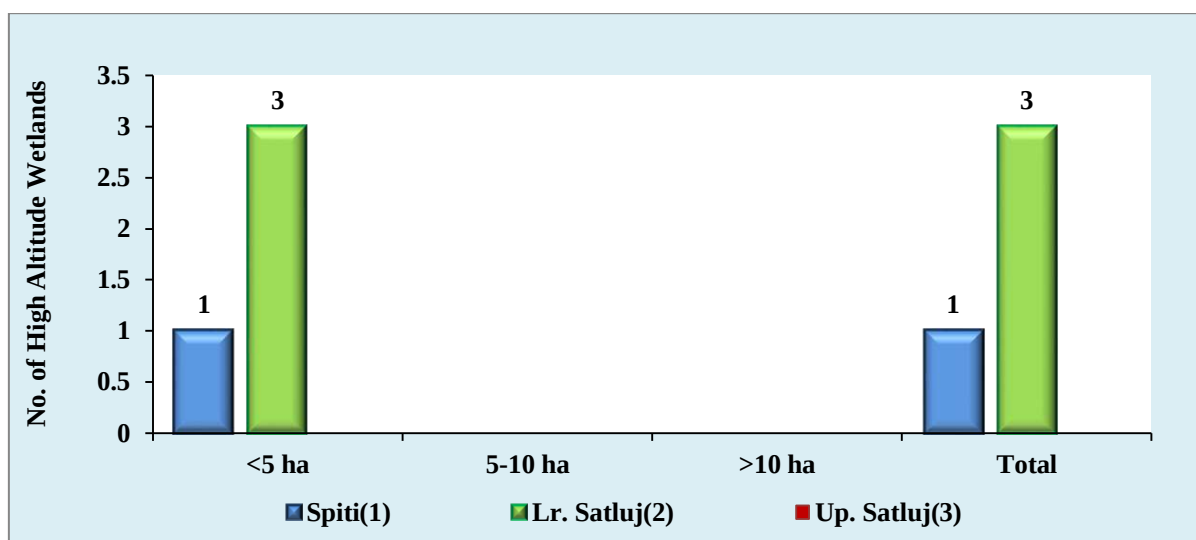


Fig.8.2 (d): No. of high altitude wetland Lakes based on IRS-R2, LISS III, 96/48 & 96/49, 28 August, 2022

Table 8.1: Distribution of Lakes as per satellite data interpretation for the year 2022 using LISS-III (96-48 & 96-49) sensor

Sr. No.	Lake Id.	Basin No.	Longitude	Latitude	Area extent (in ha) 2021	Area extent (in ha) 2022	Change in Area W.r.t 2021
1	38	1	78.7018	32.7072	3.49	0.28	(-)3.21
2	59	3	78.9789	32.3195	2.08	8.44	(+)6.36
3	61	3	78.9944	32.3167	8.51	0.5	(-)8.01
4	67	3	78.3673	32.3145	10.13	1.26	(-)8.87
5	68	3	78.9832	32.2207	8.02	0.79	(-)7.23
6	70	3	79.0197	32.2086	2.12	3.58	(+)1.46
7	71	3	78.9867	32.2205	2.84	0.45	(-)2.39
8	72	1	78.9977	32.2243	1.85	1.83	(-)0.02
9	74	1	78.4331	32.1811	5.38	1.34	(-)4.04
10	75	1	78.9832	32.1755	2.73	0.47	(-)2.26
11	76	3	78.963	32.1498	2.18	2.73	(+)0.55
12	80	1	78.9597	32.1374	3.72	0.52	(-)3.20
13	81	1	78.943	32.1227	1.04	6.41	(+)5.37
14	84	3	78.9329	32.1076	1.82	13.33	(+)11.51
15	85 (1)	3	78.9384	32.1046	0.83	0.51	(-)0.32
16	85 (2)	2	78.1661	31.6599	40.64	42.8	(+)2.16
17	94	3	78.8762	32.0199	6.74	3.1	(-)3.64
18	95	3	78.8517	32.0073	1.11	0.68	(-)0.43
19	96	3	78.7874	32.0308	3.04	0.19	(-)2.85
20	97	3	78.91074	32.01775	11.72	6.55	(-)5.17
21	99	1	78.77954	32.03289	21.38	0.95	(-)20.43
22	101	3	78.84817	31.99455	28.57	1.72	(-)26.85

23	103	3	78.81074	31.96034	5.06	0.29	(-)4.77
24	105	3	78.13248	31.97979	1.97	2.37	(+)0.40
25	106	3	78.84996	31.98203	5.85	0.66	(-)5.19
26	122	3	78.78318	31.91893	0.24	21.67	(+)21.43
27	131	1	78.70239	31.9177	0.87	0.91	(+)0.04
28	152	1	78.92664	32.12918	1.68	1.26	(-)0.42
29	167	2	78.70338	31.36005	1.13	0.91	(-)0.22
30	168	2	78.72359	31.36257	1.71	1.38	(-)0.33
31	173	2	78.6987	31.22415	4.89	3.93	(-)0.96
32	228	2	78.75101	31.55334	6.71	5.41	(-)1.30
33	405	2	78.42052	31.40324	3.23	2.45	(-)0.78
34	582(1)	2	78.32961	31.31498	-----	0.7	-----
35	582(4)	2	78.32923	31.31236	-----	2.85	-----
36	582(5)	2	78.32953	31.31054	-----	1.24	-----
37	586	1	78.70119	31.91219	6.78	5.47	(-)1.31
38	589	1	78.71849	31.90074	1.37	1.25	(-)0.12
39	811	1	78.90381	32.05417	12.08	0.71	(-)11.37
40	814	1	78.7445	32.04716	0.87	1.01	(+)0.14
41	816	1	78.74518	32.04574	0.44	0.36	(-)0.08
42	819	1	78.75468	32.04437	0.71	1.05	(+)0.34
43	820	1	78.75639	32.04449	0.68	0.74	(+)0.06
44	821	1	78.758	32.04166	2.77	2.47	(-)0.30
45	822	1	78.76144	32.04067	0.9	0.83	(-)0.07
46	825	1	78.76915	32.04027	0.43	0.46	(+)0.03
47	848	2	78.74094	31.70891	3.07	2.49	(-)0.58
48	854	2	78.60985	31.56423	1.76	3.83	(+)2.07
49	865	2	78.77069	31.36118	0.65	0.52	(-)0.13
50	866	2	78.73333	31.35863	3.11	2.5	(-)0.61
51	869	2	78.70189	31.32632	2.41	1.94	(-)0.47
52	870	2	78.69614	31.32565	2.22	1.79	(-)0.43
53	871	2	78.6636	31.33307	1.52	1.22	(-)0.30
54	891	2	78.36856	31.45823	1.73	1.69	(-)0.04
55	998	1	78.68172	32.70642	0.77	1.01	(+)0.24
56	999	1	78.08083	32.61064	1.33	0.45	(-)0.88
57	1013	3	78.9913	32.25444	2.51	2.02	(-)0.49
58	1022	1	78.77733	32.03588	1.5	0.27	(-)1.23
59	1033	3	78.78523	31.90577	0.18	0.21	(+)0.03
60	1035	1	78.70477	31.88719	1.31	1.87	(+)0.56
61	1039	2	78.75004	31.66128	0.7	0.97	(+)0.27
62	1048	2	78.72231	31.3665	0.5	0.4	(-)0.10
63	1049	3	78.73463	31.51831	3.87	3.12	(-)0.75
64	1209	2	78.73625	31.54213	1.59	1.28	(-)0.31

65	1213	3	78.73187	31.5075	1.3	1.05	(-)0.25
66	1218	2	78.42893	31.49374	0.26	0.33	(+)0.07
67	1220	2	78.43375	31.50708	0.5	0.46	(-)0.04
68	1230	3	78.77804	32.03393	5.52	0.6	(-)4.92
69	1231	1	78.75865	32.03916	0.48	0.38	(-)0.10
70	1232	1	78.8724	32.03151	0.97	4.96	(+)3.99
71	1234	3	78.69469	31.93018	1.73	0.6	(-)1.13
72	1237	3	78.82671	31.92987	0.25	0.58	(+)0.33
73	1238	3	78.79569	31.93361	0.83	0.32	(-)0.51
74	1259	3	78.86867	31.96945	6.89	8.94	(+)2.05
75	1269	2	78.71671	31.33963	0.91	0.73	(-)0.18
76	1270	2	78.75776	31.3642	1.06	0.85	(-)0.21
77	1272	2	78.7597	31.32203	1.71	1.38	(-)0.33
78	1273	2	78.75809	31.32216	1.18	0.95	(-)0.23
79	1274	2	78.75673	31.32168	1.19	0.96	(-)0.23
80	1275	2	78.75546	31.32396	1.18	0.95	(-)0.23
81	1619	2	78.37473	31.4485	0.24	0.6	(+)0.36
82	1623	2	78.41012	31.41136	0.93	1.73	(+)0.80
83	1625	2	78.42519	31.40337	0.76	0.72	(-)0.04
84	1626	2	78.4221	31.39865	0.93	1.75	(+)0.82
85	1628	2	78.43117	31.43132	1.55	1.7	(+)0.15
86	1640	2	78.4287	31.49101	2.46	2.85	(+)0.39
87	1647	3	78.79356	31.88007	0.57	0.61	(+)0.04
88	1648	3	78.79362	31.88197	1.08	1.1	(+)0.02
89	1652	3	78.81992	31.93055	0.77	0.31	(-)0.46
90	1653	3	78.81652	31.93265	2.25	2.52	(+)0.27
91	1654	3	78.84011	31.91401	24.36	8.45	(-)15.91
92	1656	1	78.75193	32.04258	0.87	0.83	(-)0.04
93	1658	1	78.77954	32.03495	0.73	0.19	(-)0.54
94	1660	1	78.76249	32.03028	0.32	1.21	(+)0.89
95	1668	1	78.80309	32.08076	1.81	1.37	(-)0.44
96	1692	1	78.73672	32.69971	0.45	0.65	(+)0.20
97	1693	1	78.73045	32.69495	0.35	0.4	(+)0.05
98	1714	2	78.32587	31.31065	0.5	0.41	(-)0.09
99	2100	2	78.71732	31.53103	0.94	0.76	(-)0.18
100	2101	2	78.74461	31.37547	0.43	0.35	(-)0.08
101	2102	2	78.74401	31.37447	1.13	0.91	(-)0.22
102	2103	2	78.7305	31.35124	0.38	0.31	(-)0.07
103	2104	2	78.66777	31.35953	0.37	0.3	(-)0.07
104	2106	2	78.58121	31.37284	1.83	1.48	(-)0.35
105	2107	2	78.4893	31.40055	2.14	4.32	(+)2.18
106	2113	3	78.822	31.93284	4.06	1.49	(-)2.57

107	2114	3	78.81161	31.94124	2.59	0.3	(-)2.29
108	2115	3	78.81991	31.93237	0.39	2.16	(+)1.77
109	2117 (1)	1	79.01702	32.20334	-----	0.87	-----
110	2117 (2)	3	78.7838	31.93098	0.25	0.37	(+)0.12
111	2118 (1)	1	78.20145	32.30218	3.93	0.55	(-)3.38
112	2118 (2)	3	78.78104	31.92924	0.36	7.4	(+)7.04
113	2119	1	78.26151	32.04547	2.04	0.99	(-)1.05
114	2120	1	78.86384	32.08567	2.14	1.89	(-)0.25
115	5045	1	78.97307	32.32515	3.3	8.45	(+)5.15
116	5048	3	78.18443	32.31334	0.64	0.85	(+)0.21
117	5056	1	79.00932	32.21486	0.62	1.8	(+)1.18
118	5058	3	79.00104	32.21637	1.24	0.76	(-)0.48
119	5068	3	78.94705	32.12025	1.66	5.02	(+)3.36
120	5073	1	78.91853	32.14156	1.54	3.01	(+)1.47
121	5074	1	78.91444	32.09392	0.67	2.34	(+)1.67
122	5077	1	78.8004	32.08061	0.7	0.47	(-)0.23
123	5079	1	78.8848	32.07195	0.55	4.07	(+)3.52
124	5081	1	78.92751	32.06355	0.56	1.78	(+)1.22
125	5095	3	78.8447	31.99235	0.47	23.26	(+)22.79
126	6004	1	78.71259	31.89455	0.25	0.71	(+)0.46
127	6013	3	78.83646	31.97847	2.18	2.15	(-)0.03
128	6014	3	78.83739	31.98038	0.8	6.28	(+)5.48
129	6016	1	78.70841	32.71013	0.48	6.56	(+)6.08
130	6017	1	78.70277	32.70721	0.48	0.66	(+)0.18
131	6019	1	78.70639	32.70684	0.86	1.46	(+)0.60
132	6035	1	78.75506	32.0424	0.37	0.3	(-)0.07
133	6036	1	78.84438	32.02906	0.69	18.72	(+)18.03
134	9000	1	78.30544	32.47496	4.19	0.77	(-)3.42
135	9001 (1)	1	78.69568	32.75559	0.37	0.46	(+)0.09
136	9001 (2)	1	78.69617	32.75488	-----	1.06	-----
137	9001(3)	1	78.69798	32.74947	-----	1.25	-----
138	9001 (4)	1	78.69656	32.74957	-----	0.55	-----
139	9002	1	78.30254	32.47646	3.74	3.03	(-)0.71
140	9004	1	79.01701	32.27647	0.73	3.34	(+)2.61
141	9005	1	78.97743	32.25812	0.68	2.66	(+)1.98
142	9006	1	79.02596	32.22409	0.94	6.47	(+)5.53
143	9007	1	79.00576	32.22425	0.94	3.14	(+)2.20
144	9008	1	78.98657	32.2529	0.37	0.74	(+)0.37
145	9009	1	78.50005	32.34629	17.12	0.2	(-)16.92
146	9011	1	78.47309	32.45694	0.18	6.45	(+)6.27
147	9012	1	77.81002	32.51419	2.15	2.23	(+)0.08
148	9014	1	78.08231	32.42252	7.58	3.98	(-)3.60

149	9016	1	78.2725	32.36293	1.13	18.38	(+)17.25
150	9017	1	78.50882	32.35525	1.42	0.76	(-)0.66
151	9021	1	78.98994	32.31522	1.99	0.6	(-)1.39
152	9027	1	78.97257	32.17039	1.25	2.01	(+)0.76
153	9028	1	78.9763	32.172	0.36	0.26	(-)0.10
154	9030	1	78.90671	32.14424	1.62	1.69	(+)0.07
155	9033	1	78.8742	31.96549	8.19	0.4	(-)7.79
156	9036	1	77.85632	31.86357	0.89	0.77	(-)0.12
157	9037	1	78.80455	31.95465	1.34	0.66	(-)0.68
158	9038	1	78.946	32.1221	2.23	0.61	(-)1.62
159	9040	1	78.98314	32.22556	2.26	2.59	(+)0.33
160	9052	2	77.68592	31.70132	1.72	2.08	(+)0.36
161	9055	2	77.88113	31.71156	0.72	0.63	(-)0.09
162	9056	2	77.90037	31.72032	1.79	2.46	(+)0.67
163	9057	2	77.9029	31.72121	1.76	2.31	(+)0.55
164	9059	2	77.94516	31.70727	3.04	2.56	(-)0.48
165	9060	2	78.06764	31.68581	0.31	0.83	(+)0.52
166	9061	2	78.07899	31.7019	1.8	1.56	(-)0.24
167	9062	2	78.12443	31.7394	3.92	3.18	(-)0.74
168	9063	2	78.12613	31.73703	0.5	0.4	(-)0.10
169	9064	2	78.15959	31.66198	0.5	0.58	(+)0.08
170	9065	2	78.17793	31.58418	1.07	1.08	(+)0.01
171	9066	2	78.18556	31.58491	8.62	7.41	(-)1.21
172	9067	2	78.2926	31.77945	1.85	2.99	(+)1.14
173	9068	2	78.30542	31.78939	2.58	2.5	(-)0.08
174	9070	2	78.3828	31.52207	7.7	7.2	(-)0.50
175	9071	2	78.38567	31.5154	3.55	3.91	(+)0.36
176	9074	2	78.44443	31.48698	0.37	0.42	(+)0.05
177	9077	2	78.48047	31.41365	1.62	1.86	(+)0.24
178	9080	2	78.41255	31.41786	0.39	0.85	(+)0.46
179	9081	2	78.40965	31.43736	2.55	2.01	(-)0.54
180	9082	2	78.40646	31.43663	0.24	0.5	(+)0.26
181	9084	2	78.07706	31.42762	0.75	0.61	(-)0.14
182	9085	2	78.06896	31.42228	1.08	1.33	(+)0.25
183	9086	2	78.06866	31.41893	1.74	2.6	(+)0.86
184	9089	2	77.91615	31.44032	0.68	1.59	(+)0.91
185	9091	2	78.60018	31.57358	0.56	0.57	(+)0.01
186	9092	2	78.6005	31.57507	0.63	0.66	(+)0.03
187	9093	2	78.60251	31.57492	0.51	0.46	(-)0.05
188	9095	2	78.67152	31.47455	0.58	0.69	(+)0.11
189	9096	2	78.6732	31.47618	0.19	0.33	(+)0.14
190	9097	2	78.67531	31.47348	0.5	0.51	(+)0.01

191	9098	2	78.73201	31.48624	0.46	0.37	(-)0.09
192	9099	2	78.77626	31.47627	0.46	0.37	(-)0.09
193	9100	2	78.69287	31.52477	0.46	0.37	(-)0.09
194	9101	2	78.69398	31.52576	0.36	0.29	(-)0.07
195	9102	2	78.75201	31.55673	0.38	0.3	(-)0.08
196	9103 (1)	2	78.75204	31.5603	0.51	0.41	(-)0.10
197	9103 (2)	2	78.75291	31.55861	0.59	0.47	(-)0.12
198	9104	2	78.75497	31.56148	0.44	0.35	(-)0.09
199	9105	2	78.7373	31.67551	0.53	0.49	(-)0.04
200	9106	1	78.6998	31.88931	0.37	0.42	(+)0.05
201	9113	1	78.68584	31.9347	1.28	0.47	(-)0.81
202	9115	1	78.73668	32.04891	0.37	0.33	(-)0.04
203	9116	1	78.74464	32.04481	0.62	0.61	(-)0.01
204	9117	1	78.75553	32.04367	0.24	0.21	(-)0.03
205	9118	1	78.75918	32.04035	0.36	0.35	(-)0.01
206	9119	1	78.75783	32.03965	0.59	0.65	(+)0.06
207	9120	1	78.75971	32.03969	0.3	0.26	(-)0.04
208	9122	1	78.83428	32.03606	0.24	0.73	(+)0.49
209	9123	1	78.78085	32.0319	0.58	0.42	(-)0.16
210	9124	1	78.78236	32.05282	1.05	1.48	(+)0.43
211	9125	1	78.83117	32.04305	0.96	0.78	(-)0.18
212	9126	3	78.82309	32.01361	2.11	1.71	(-)0.40
213	9127	3	78.84512	32.01143	0.26	2.39	(+)2.13
214	9128	3	78.84726	32.01105	1.12	0.4	(-)0.72
215	9129	3	78.85089	32.00788	0.63	0.2	(-)0.43
216	9130	3	78.71068	31.99925	2.21	0.42	(-)1.79
217	9131	3	77.7877	32.07072	1.6	0.4	(-)1.20
218	9132	1	78.82034	32.07095	3.11	0.41	(-)2.70
219	9135	3	78.87492	32.01704	1.9	7.28	(+)5.38
220	9136	3	78.79746	31.97117	7.87	0.77	(-)7.10
221	9137	3	78.84032	31.97625	0.25	0.32	(+)0.07
222	9138	3	78.83646	31.97537	1.41	0.55	(-)0.86
223	9142	3	78.80986	31.95068	0.48	0.33	(-)0.15
224	9143	3	78.82604	31.93225	0.3	0.25	(-)0.05
225	9144	3	78.82275	31.93066	0.26	0.21	(-)0.05
226	9145	3	78.82565	31.93135	0.19	0.19	-----
227	9146	3	78.81682	31.93165	0.24	0.45	(+)0.21
228	9147	3	78.81249	31.93283	0.21	0.19	(-)0.02
229	9148	3	78.80191	31.90836	-----	1.33	-----
230	9149	3	78.785	31.90698	0.55	0.34	(-)0.21
231	9150	3	78.78596	31.90619	0.27	0.59	(+)0.32
232	9151	3	78.7862	31.90502	0.68	0.35	(-)0.33

233	9152	3	78.79013	31.88298	0.34	1.11	(+)0.77
234	9156	1	77.91428	32.1365	0.32	2.1	(+)1.78
235	9157	1	78.43503	32.18244	-----	0.2	-----
236	9158	1	79.01073	32.21463	0.62	0.62	-----
237	9162	1	79.0444	32.2516	2.44	1.41	(-)1.03
238	9163	3	78.24751	32.23039	1.75	0.76	(-)0.99
239	9164	3	77.76094	32.24218	0.3	3.48	(+)3.18
240	9165	3	78.18712	32.30951	0.56	1.11	(+)0.55
241	9166	1	78.99318	32.31594	1.58	1.29	(-)0.29
242	9167	1	77.92985	32.57075	2.91	0.99	(-)1.92
243	9170	1	78.73343	32.69765	0.8	2.21	(+)1.41
244	9171	1	78.68921	32.73024	0.27	1.07	(+)0.80
245	9172	2	78.18481	31.3502	0.77	0.62	(-)0.15
246	9173	2	78.25372	31.33934	20.23	16.35	(-)3.88
247	9174	2	78.26031	31.33182	0.38	0.31	(-)0.07
248	9175	2	78.29839	31.2937	0.63	0.51	(-)0.12
249	9176	2	78.32622	31.3062	0.57	0.46	(-)0.11
250	9181	2	78.70141	31.22241	0.71	0.57	(-)0.14
251	9188	2	78.89032	31.29544	0.62	0.5	(-)0.12
252	9189	2	78.88137	31.30432	0.25	0.2	(-)0.05
253	9190	2	78.87752	31.30569	2.31	1.86	(-)0.45
254	9191	2	78.8755	31.30779	0.53	0.43	(-)0.10
255	9192	2	78.8456	31.31741	0.26	0.21	(-)0.05
256	9193	2	78.80385	31.29462	0.75	2.41	(+)1.66
257	9194	2	78.80235	31.31977	0.19	0.15	(-)0.04
258	9195	2	78.7929	31.3124	0.37	0.29	(-)0.08
259	9196	2	78.75198	31.3281	0.25	0.2	(-)0.05
260	9203	2	78.67017	31.36923	0.39	0.32	(-)0.07
261	9204	2	78.66254	31.33085	1.75	1.41	(-)0.34
262	9209	2	78.8354	31.98013	1.5	0.97	(-)0.53
263	9210	2	78.43257	31.5027	1.79	2.28	(+)0.49
264	9212	1	78.9481	32.13848	0.32	1.17	(+)0.85
265	9213	3	78.97564	32.20664	0.25	0.36	(+)0.11
266	9215	1	78.70667	32.70771	1.25	0.9	(-)0.35
267	9217	1	78.89621	32.32493	-----	1.62	-----
268	9218	1	78.29117	32.36209	-----	1.43	-----
269	10098	1	78.82088	32.06781	-----	0.61	-----
270	10099	1	78.10137	31.77738	-----	3.06	-----
271	10100	1	78.10354	31.77806	-----	2.93	-----
272	10101	2	77.91579	31.44223	-----	1	-----
273	10102	2	78.36566	31.45621	-----	0.28	-----
274	10103	2	78.37116	31.44622	-----	0.34	-----

275	10104	2	78.40951	31.41313	-----	0.2	-----
276	10105	2	78.41136	31.40863	-----	0.31	-----
277	10106	2	78.42314	31.40085	-----	1.46	-----
278	10110	2	78.43401	31.43427	-----	0.27	-----
279	10111	2	78.43466	31.47001	-----	1.01	-----
280	10112	2	78.43052	31.49463	-----	0.57	-----
281	10113	2	78.42964	31.49481	-----	0.91	-----
282	10114	2	78.43234	31.49741	-----	0.46	-----
283	10115	2	78.42655	31.49234	-----	0.43	-----
284	10116	2	78.42524	31.48981	-----	1.93	-----
285	10117	2	78.60119	31.57632	-----	0.63	-----
286	10118	2	78.62958	31.68014	-----	0.81	-----
287	10120	2	78.74691	31.65677	-----	0.58	-----
288	10121	2	78.74158	31.67845	-----	0.21	-----
289	10122	2	78.74429	31.73284	-----	5.6	-----
290	10127	1	78.98517	32.29991	-----	14.17	-----
291	10128	1	78.99503	32.27797	-----	0.57	-----
292	10129	1	77.98924	32.60685	-----	6.06	-----
293	10130	1	78.43072	32.55494	-----	2.78	-----
294	10131	1	78.50099	32.34216	-----	0.6	-----
295	10132	1	78.24467	32.26997	-----	0.36	-----
296	10133	3	78.36858	32.31435	-----	1.02	-----
297	10134	3	79.00166	32.32859	-----	2.18	-----
298	10135	3	79.04856	32.25554	-----	0.24	-----
299	10136	1	78.22237	32.23292	-----	1.21	-----
300	10137	1	79.03433	32.2384	-----	1.45	-----
301	10138	1	77.97045	32.21202	-----	7.67	-----
302	10139	3	78.98511	32.22182	-----	0.66	-----
303	10140	1	78.96761	32.13398	-----	0.4	-----
304	10141	3	78.87206	32.10103	-----	0.51	-----
305	10142	1	78.86317	32.07064	-----	2.27	-----
306	10143	1	78.75877	32.03668	-----	0.79	-----
307	10144	3	78.84887	32.00853	-----	1.23	-----
308	10145	3	78.83768	31.97711	-----	2.06	-----
309	10146	3	78.8393	31.9768	-----	0.58	-----
310	10147	3	78.84354	31.98761	-----	0.35	-----
311	10148	3	78.81183	31.96391	-----	5.86	-----
312	10149	3	78.41563	31.96463	-----	8.32	-----
313	10150	3	78.78233	31.9565	-----	1.04	-----
314	10151	3	78.82133	31.93175	-----	0.29	-----
315	10152	3	78.82427	31.92935	-----	0.2	-----
316	10153	3	78.6927	31.93131	-----	0.2	-----

317	10154	3	78.84249	31.91691	-----	0.3	-----
318	10155	3	78.79475	31.88028	-----	0.25	-----
319	10156	3	78.79548	31.87937	-----	0.2	-----
320	10157	3	78.78346	31.90708	-----	0.31	-----
321	10158	3	78.78354	31.91115	-----	0.48	-----
322	10159	3	78.69315	31.9305	-----	0.5	-----
323	10160	3	78.82449	31.93131	-----	0.2	-----
324	10161	3	78.78338	31.92676	-----	1.24	-----
325	10162	3	78.79672	31.93329	-----	0.61	-----
326	10163	3	78.68476	31.93386	-----	1.1	-----
327	10164	3	78.70339	31.95758	-----	0.51	-----
328	10165	1	78.88647	32.07369	-----	0.31	-----
329	10166	1	78.8063	32.08007	-----	0.72	-----
330	10167	1	78.80499	32.08057	-----	0.57	-----
331	10168	1	78.81805	32.07024	-----	1.02	-----
332	10169	1	78.9323	32.06223	-----	1.28	-----
333	10170	1	78.92571	32.01466	-----	1.35	-----
334	10171	1	78.22904	32.05453	-----	2.44	-----
335	10172	1	78.77845	32.03559	-----	0.23	-----
336	10173	1	78.7021	32.03553	-----	2.03	-----
337	10174	1	78.77585	32.03843	-----	0.19	-----
338	10175	1	78.758	32.03852	-----	0.36	-----
339	10176	1	78.78294	32.03076	-----	0.62	-----
340	10177	1	78.75293	32.04277	-----	0.22	-----
341	10178	1	78.75205	32.04455	-----	0.43	-----
342	10179	1	78.81334	31.93383	-----	3.9	-----
343	10180	1	78.82829	31.93079	-----	0.42	-----
344	10181	1	78.69566	31.92913	-----	0.53	-----
345	10182	1	78.71754	31.89983	-----	0.78	-----
346	10183	1	78.71415	31.89798	-----	1.17	-----
347	10184	1	78.72208	31.89212	-----	0.38	-----
348	10185	1	78.31557	32.4775	-----	0.31	-----
349	10186	2	77.68304	31.70189	-----	0.46	-----
350	10187	2	78.63425	31.51998	-----	0.35	-----
351	10188	2	78.68996	31.47612	-----	0.53	-----
352	10189	3	79.00754	32.2263	-----	0.39	-----
353	10190	3	78.97267	32.19066	-----	5.27	-----
354	10191	3	78.96033	32.18491	-----	3.15	-----
355	10192	1	79.04333	32.20994	-----	29.26	-----
356	10193	1	78.97788	32.16112	-----	10.22	-----
357	10194	1	78.46181	32.16088	-----	1.34	-----
358	10195	1	78.96815	32.1451	-----	0.28	-----

359	10196	1	78.9641	32.14364	-----	1.29	-----
360	10197	1	78.94563	32.14017	-----	0.59	-----
361	10198	1	78.92036	32.14344	-----	0.25	-----
362	10199	3	78.97047	32.12975	-----	4.56	-----
363	10200	3	78.94786	32.12285	-----	2.11	-----
364	10201	3	77.92518	32.12849	-----	2.05	-----
365	10202	3	78.95083	32.11935	-----	1.29	-----
366	10203	3	78.94137	32.11896	-----	0.76	-----
367	10204	3	78.94182	32.10775	-----	12.49	-----
368	10205	3	78.94718	32.10659	-----	1.14	-----
369	10206	3	78.92489	32.10467	-----	1	-----
370	10207 (1)	3	78.94732	32.10443	-----	0.3	-----
371	10207 (2)	3	78.88095	32.10337	-----	1.01	-----
372	10208	3	78.93683	32.08773	-----	0.7	-----
373	10209	3	78.94709	32.09296	-----	6.53	-----
374	10210	3	78.92982	32.0926	-----	1.44	-----
375	10211	3	78.79959	32.0816	-----	0.17	-----
376	10212	3	78.22797	32.09068	-----	1.38	-----
377	10213	3	78.7982	32.05583	-----	0.52	-----
378	10214 (1)	3	78.94301	32.06041	-----	7.77	-----
379	10214(2)	3	78.80669	32.05826	-----	10.47	-----
380	10215	3	78.90327	32.04374	-----	2.95	-----
381	10216	3	78.89172	32.04337	-----	2.79	-----
382	10217	1	78.86666	31.95715	-----	4.06	-----
383	10218	1	78.70191	31.95797	-----	0.61	-----
384	10219	1	78.06709	32.40197	-----	1.73	-----
385	10220	1	78.06941	32.40453	-----	1.75	-----
386	10221	1	78.46169	32.38101	-----	1.21	-----
387	10222	2	78.711	31.55593	-----	1.27	-----
388	10223	2	78.75758	31.35331	-----	3.86	-----
389	10224	2	78.73314	31.36148	-----	0.37	-----
390	10225	2	78.79479	31.29759	-----	2.17	-----
391	10226	2	78.80605	31.28996	-----	0.72	-----
392	10227	2	78.02737	31.40924	-----	8.77	-----
393	10228	2	77.87135	31.71791	-----	4.74	-----
394	10229	2	77.85952	31.74462	-----	3.08	-----
395	10230	2	77.87083	31.75707	-----	1	-----
396	10231	2	77.86633	31.75916	-----	0.45	-----
397	10232	2	77.91262	31.79375	-----	1	-----
398	10233	1	78.08823	32.426	-----	2.41	-----
399	10234	1	78.05021	32.4683	-----	1.01	-----
400	10235	1	78.06496	32.39028	-----	1.31	-----

401	10236	1	78.88052	32.35204	-----	1.3	-----
402	10237	1	78.50232	32.34527	-----	0.56	-----
403	10238	1	78.0922	32.43058	-----	0.61	-----
404	10239	1	78.08982	32.42757	-----	1.19	-----
405	10240	1	77.91015	32.5452	-----	1.2	-----
406	10241	1	77.96593	32.53319	-----	1.26	-----
407	10242	1	78.19399	32.49438	-----	1.82	-----
408	10243	1	77.94238	32.52445	-----	4.7	-----
409	10244	1	78.90795	32.09822	-----	1.34	-----
410	10245	1	78.92635	32.0943	-----	0.66	-----
411	10246	2	78.34324	31.49118	-----	0.74	-----
412	10247	2	78.34511	31.4906	-----	0.47	-----
413	10248	2	78.75415	31.39996	-----	1.34	-----
414	10107SG	2	78.4483	31.45148	-----	0.53	-----
415	10108SG	2	78.44933	31.46182	-----	0.46	-----
416	10109SG	2	78.44765	31.46138	-----	0.43	-----
417	10119SG	2	78.62903	31.67633	-----	0.26	-----
418	10123SG	1	78.49557	32.34149	-----	0.51	-----
419	10124SG	1	78.71956	32.32713	-----	118.91	-----
420	10125SG	1	78.90862	32.33398	-----	2.94	-----
421	10126SG	1	78.90665	32.33207	-----	2.12	-----
422	1216SG	2	78.58084	31.36543	-----	0.71	-----
423	1264SG	2	78.61367	31.24933	-----	0.2	-----
424	1265SG	2	78.61549	31.24864	-----	0.54	-----
425	1310SG	2	78.55659	31.24988	-----	0.71	-----
426	1649SG	1	78.70055	31.89685	-----	0.26	-----
427	1682RS	1	78.82794	32.42176	0.38	2.05	(+)1.67
428	1683RS	1	78.81656	32.41939	1.47	11.82	(+)10.35
429	1684RS	1	78.22027	32.41537	2.61	3.81	(+)1.20
430	1685RS	1	78.82759	32.41429	4.96	2.37	(-)2.59
431	1686RS	1	78.4606	32.38095	1.58	0.43	(-)1.15
432	1687RS	1	78.48079	32.37593	1.3	1.19	(-)0.11
433	171HWL	2	78.79531	31.36956	1.75	1.41	(-)0.34
434	49HWL	1	78.52984	32.32449	19.4	1.61	(-)17.79
435	9003RS	1	78.26149	32.37548	0.9	1.59	(+)0.69
436	9018SG	1	79.00212	32.3381	-----	3.13	-----
437	9019SG	1	78.49918	32.34084	-----	0.21	-----
438	9020SG	1	78.50192	32.3435	-----	2.87	-----
439	9058RS	2	77.89693	31.72476	0.51	0.41	(-)0.10
440	9068HWL	2	78.39914	31.73163	3	2.91	(-)0.09
441	9069HWL	2	78.40061	31.72969	0.74	1.02	(+)0.28

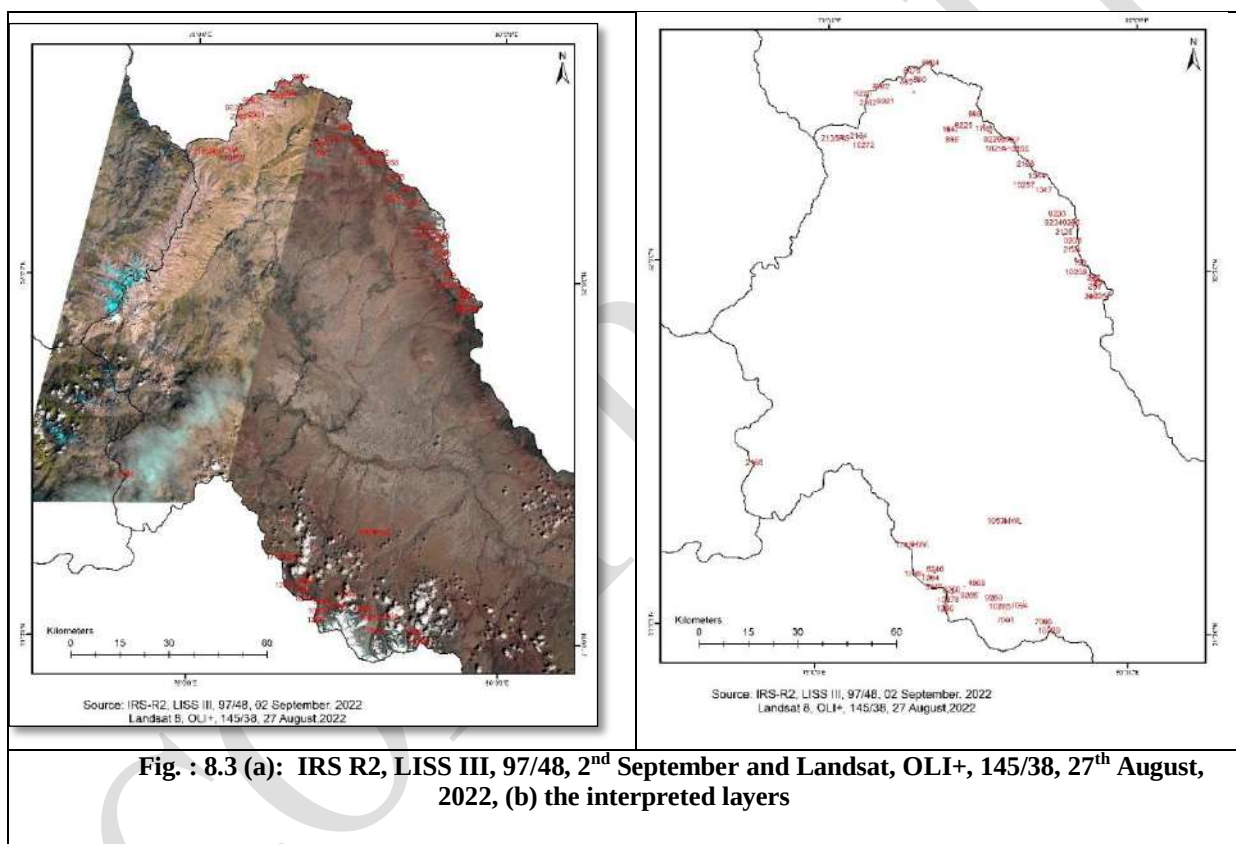
442	9072SG	2	78.41324	31.47619	-----	0.62	-----
443	9073SG	2	78.41904	31.48378	-----	0.41	-----
444	9075SG(1)	2	78.45054	31.4401	-----	0.58	-----
445	9075SG (2)	2	78.44624	31.43503	-----	0.4	-----
446	9078SG	2	78.43346	31.3907	-----	0.75	-----
447	9083SG	2	78.38893	31.46041	-----	0.53	-----
448	9107SG	1	78.7086	31.90639	0.93	0.73	(-)0.20
449	9108SG	1	78.69798	31.92733	0.5	0.61	(+)0.11
450	9109SG	1	78.82314	31.92999	0.26	0.35	(+)0.09
451	9110SG (1)	1	78.81859	31.92946	-----	1.79	-----
452	9110SG (2)	1	78.69358	31.92999	0.47	0.21	(-)0.26
453	9111SG	1	78.82163	31.93024	0.31	0.89	(+)0.58
454	9112SG	1	78.6912	31.92905	0.36	0.76	(+)0.40
455	9114SG	1	78.90195	32.00396	0.75	2.15	(+)1.40
456	9139SG	3	78.80402	31.95602	0.45	0.28	(-)0.17
457	9140SG	3	77.7819	31.95306	0.63	1.32	(+)0.69
458	9141SG	3	78.80828	31.95198	0.44	1.08	(+)0.64
459	9153SG	3	78.80048	31.87529	0.46	0.72	(+)0.26
460	9154SG	3	78.80251	31.87323	0.42	0.56	(+)0.14
461	9177SG	2	78.37206	31.30271	0.5	0.4	(-)0.10
462	9178SG	2	78.47883	31.27313	0.51	0.41	(-)0.10
463	9179SG	2	78.47621	31.26244	0.49	0.4	(-)0.09
464	9180SG	2	78.47784	31.2609	0.62	0.5	(-)0.12
465	9182SG	2	78.71145	31.21284	0.62	0.5	(-)0.12
466	9183SG	2	78.71446	31.21313	0.24	0.19	(-)0.05
467	9184SG	2	78.71229	31.21137	0.25	0.2	(-)0.05
468	9185SG	2	78.71603	31.21052	0.45	0.36	(-)0.09
469	9186SG	2	78.72279	31.20461	1.04	0.83	(-)0.21
470	9187SG	2	78.74159	31.19998	0.44	0.35	(-)0.09
471	9198SG	2	78.6801	31.34764	0.69	0.56	(-)0.13
472	9199SG	2	78.68111	31.35141	0.18	0.14	(-)0.04
473	9200SG	2	78.67698	31.35461	0.44	0.36	(-)0.08
474	9201SG	2	78.67889	31.36018	0.25	0.2	(-)0.05
475	9202SG	2	78.67824	31.36443	0.37	0.3	(-)0.07
476	9205SG	2	78.61117	31.38389	0.49	0.4	(-)0.09
477	9206SG	2	78.58029	31.37481	1.21	0.98	(-)0.23
478	9207RS	2	78.02092	31.61887	5.51	4.55	(-)0.96

HWL= High Altitude Wetland

RS= River Section

SG= Supra Glacier lakes

A total of 155 lakes could be identified based on the interpretation of satellite data for path rows 97/48 and 145/38 (Fig. 8.3(b)), as compared to 119 lakes in 2021, 208 lakes in 2020, 86 lakes in 2019 and 72 lakes in 2018 all forming part of the Upper Satluj basin i.e. the basin 3. Further analysis of 155 lakes reveals that 131 lakes have an area less than 5 ha, 18 lakes have an aerial range of 5 to 10 ha and 6 lakes have an area larger than 10 ha; all of these falls are in the Upper Satluj sub basin (Fig. 8.3(c)). Out of 155 lakes, 5 have been identified as high altitude wetlands forming part of the Upper Satluj basin, with 3 wetlands having an area of less than 5 ha, 1 having an area between 5 and 10 ha, and 1 having an aerial extent greater than 10 ha (Fig. 8.3(d)).



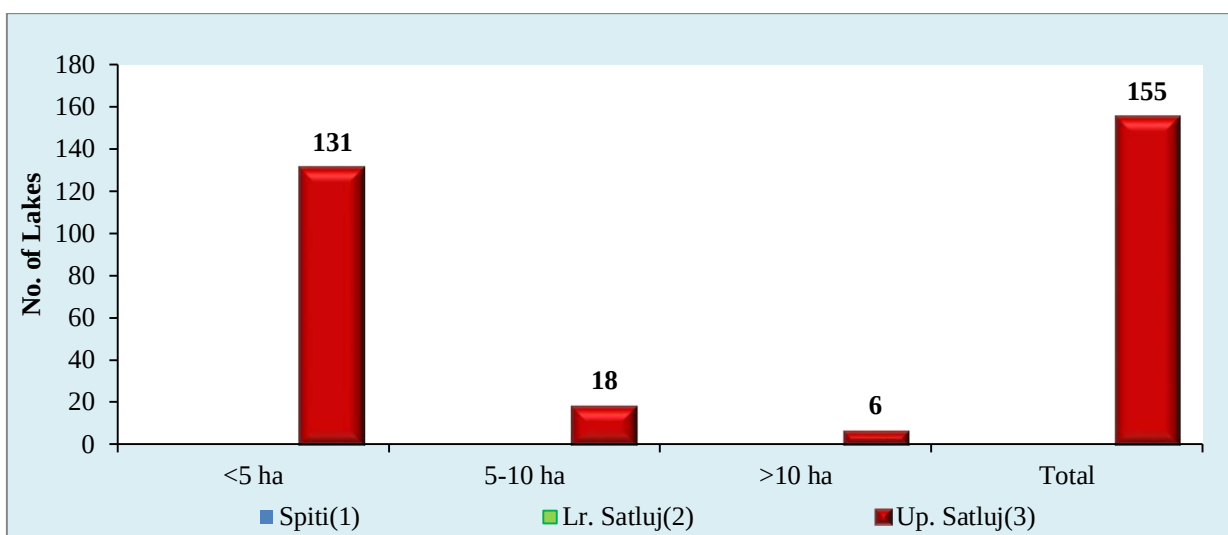


Fig. 8.3(c): No. of lakes based on IRS R-2, LISS III, 97-48, 2nd Sept. and Landsat, OLI+, 145/38, 27th August, 2022,

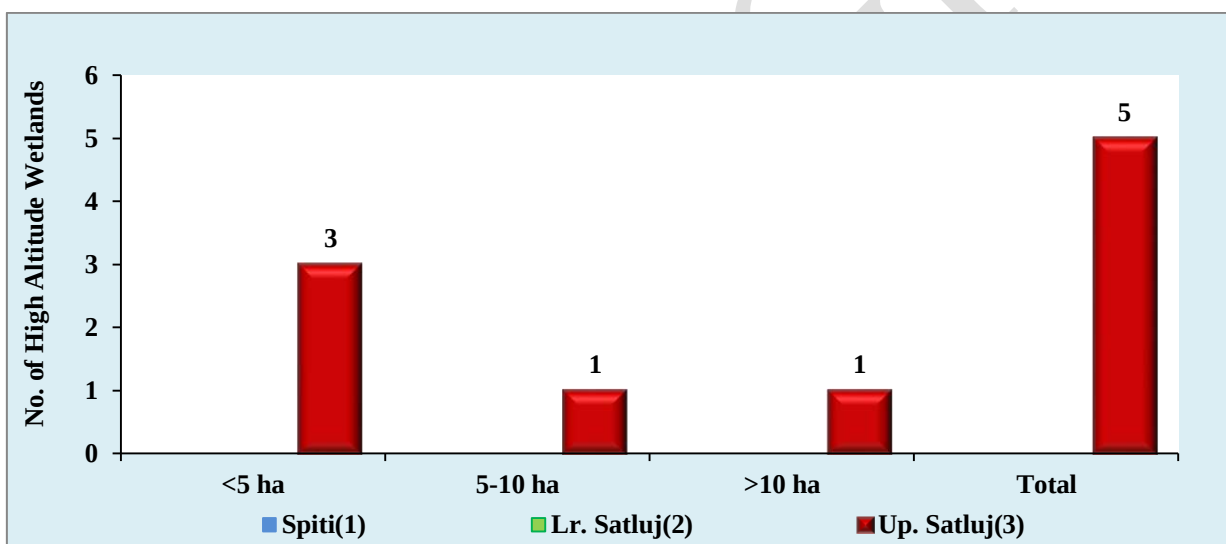


Fig.8.3 (d): No. of high altitude wetland Lakes based on IRS R-2, LISS III, 97-48, 2nd Sept. and Landsat, OLI+, 145/38, 27th August, 2022

Table 8.2: Distribution of Lakes as per satellite data interpretation for the year 2022 using LISS-III (97-48) & Landsat 8 (145/38) sensor

Sr. No.	Lake Id.	Basin No.	Longitude	Latitude	Area extent (in ha) 2021	Area extent (in ha) 2022	Change in Area W.r.t 2021
1	11	3	79.27944	32.4775	-----	3.87	-----
2	17	3	79.47736	32.4185	-----	1.47	-----
3	27	3	79.53357	32.3705	-----	1.94	-----
4	40	3	79.61978	32.3329	-----	1.73	-----
5	184	3	79.39309	32.3777	24.96	29.7	(+)4.74
6	198	3	79.8177	32.0211	0.69	0.69	-----

7	199	3	79.82626	32.0178	3.66	3.66	-----
8	200	3	79.83644	31.9887	2.981	2.84	(-)0.14
9	202	3	79.87186	31.9775	9	10.6	(+)1.60
10	203	3	79.8819	31.9701	3.88	5.11	(+)1.23
11	204	3	79.87579	31.9683	4.14	5.16	(+)1.02
12	207	3	79.87737	31.9562	5.04	6.02	(+)0.98
13	208	3	79.85625	31.9502	2.46	2.94	(+)0.48
14	209	3	79.86486	31.9251	34.07	34.77	(+)0.70
15	210	3	79.8821	31.9325	2.75	3.3	(+)0.55
16	211	3	79.90156	31.9273	1.45	2.34	(+)0.89
17	665	3	79.88951	31.9678	-----	4.71	-----
18	806	3	79.4777	32.4217	1.08	1.44	(+)0.36
19	885	3	79.25378	32.5067	4.45	6.58	(+)2.13
20	887	3	79.28806	32.52	0.41	1.35	(+)0.94
21	890	3	79.29184	32.513	2.59	3.17	(+)0.58
22	891	3	79.29784	32.5121	0.86	1.59	(+)0.73
23	895	3	79.40604	32.3502	3.19	5.12	(+)1.93
24	1008	3	79.47205	32.4181	0.45	0.76	(+)0.31
25	1014	3	79.6836	32.2543	5.24	8.25	(+)3.01
26	1017	3	79.70578	32.2159	2.12	3.79	(+)1.67
27	1023	3	79.81243	32.0296	2.2	2.2	-----
28	1029	3	79.91935	31.9342	1.84	1.73	(-)0.11
29	1066	3	79.51336	31.1317	4.82	7.48	(+)2.66
30	1290	3	79.31876	31.1542	0.55	2.15	(+)1.60
31	1291	3	79.3414	31.1531	3.58	6.56	(+)2.98
32	1292	3	79.35758	31.1506	1.44	2.73	(+)1.29
33	1293	3	79.36184	31.1498	0.35	0.89	(+)0.54
34	1294	3	79.36581	31.1435	4.46	7.97	(+)3.51
35	1295	3	79.41057	31.0604	4.17	4.73	(+)0.56
36	1296(1)	3	79.41584	31.0619	0.77	0.74	(-)0.03
37	1296	3	79.41402	31.06	4.01	5.49	(+)1.48
38	1728	3	79.50902	32.3827	2.72	4.37	(+)1.65
39	1729	3	79.52998	32.39	0.51	1.18	(+)0.67
40	1732	3	79.80099	32.1254	2.69	2.69	-----
41	1733	3	79.80376	32.1165	2.35	2.35	-----
42	1734	3	79.80213	32.1126	1.01	1.01	-----
43	1738	3	79.87916	31.9634	2.39	2.94	(+)0.55
44	1739	3	79.87445	31.9587	1.03	1.1	(+)0.07
45	2121	3	79.90662	31.9169	1.33	1.33	-----
46	2122	3	79.8665	31.9677	0.35	0.65	(+)0.30
47	2123	3	79.8149	32.0275	0.57	0.57	-----
48	2124	3	79.8	32.0591	1.19	1.19	-----

49	2126	3	79.7733	32.095	2.63	2.63	-----
50	2127	3	79.774	32.12	0.34	0.34	-----
51	2128	3	79.646	32.2877	1.88	3.32	(+)1.44
52	2132	3	79.1312	32.4466	4.801	6.43	(+)1.63
53	2134	3	79.1037	32.3542	2.6	4.18	(+)1.58
54	2136	3	78.7939	31.4499	7.41	9.91	(+)2.50
55	2140	3	79.7483	31.0137	0.71	1.29	(+)0.58
56	6075	3	79.2718	32.5284	1.43	2.8	(+)1.37
57	6076	3	79.5207	32.3767	0.69	0.97	(+)0.28
58	6080	3	79.7849	32.1065	0.35	0.35	-----
59	6083	3	79.8104	32.0282	0.57	0.57	-----
60	6086	3	79.8739	31.9596	0.17	0.68	(+)0.51
61	6089	3	79.9152	31.9257	0.89	0.94	(+)0.05
62	6090	3	79.8758	31.9403	0.92	0.84	(-)0.08
63	6092	3	79.4912	31.1313	2.12	2.09	(-)0.03
64	7091	3	79.608	31.031	1.72	2.19	(+)0.47
65	7092	3	79.6187	31.0352	0.34	0.47	(+)0.13
66	7094	3	79.6518	31.0722	1.3	1.95	(+)0.65
67	7096	3	79.7295	31.0285	9.35	11.74	(+)2.39
68	9220	3	79.1304	32.4628	2.97	2.97	-----
69	9221	3	79.1874	32.4516	3.16	3.16	-----
70	9222	3	79.1719	32.4915	2.04	4.85	(+)2.81
71	9223	3	79.3321	32.5541	1.61	2.75	(+)1.14
72	9224	3	79.3316	32.5601	2.95	4.14	(+)1.19
73	9225	3	79.4174	32.39	9.07	10.96	(+)1.89
74	9226	3	79.4183	32.3737	2.82	3.11	(+)0.29
75	9227	3	79.5087	32.3924	1.45	3.59	(+)2.14
76	9229	3	79.5631	32.3536	0.46	1.17	(+)0.71
77	9230	3	79.5818	32.3262	1.22	1.46	(+)0.24
78	9231	3	79.5899	32.3534	1.49	4.58	(+)3.09
79	9232	3	79.5945	32.3527	5.04	7.26	(+)2.22
80	9233	3	79.7515	32.1448	1.21	2.71	(+)1.50
81	9234	3	79.763	32.134	0.4	0.4	-----
82	9235	3	79.7967	32.1276	3.26	3.26	-----
83	9236	3	79.8024	32.0782	4.09	4.09	-----
84	9237	3	79.8024	32.0613	0.46	0.46	-----
85	9238	3	79.8306	32.0169	0.29	0.29	-----
86	9239	3	79.8273	32.0115	0.58	0.58	-----
87	9240	3	79.882	31.9662	0.34	0.92	(+)0.58
88	9241	3	79.8808	31.9521	0.7	1.23	(+)0.53
89	9242	3	79.889	31.9336	0.58	0.51	(-)0.07
90	9243	3	79.9076	31.9313	0.41	0.51	(+)0.10

91	9244	3	79.9268	31.9405	0.47	1.15	(+)0.68
92	9245	3	79.3695	31.1461	0.2	0.44	(+)0.24
93	9246	3	79.3804	31.1589	0.44	2.78	(+)2.34
94	9247	3	79.392	31.1251	0.34	1.37	(+)1.03
95	9248	3	79.3951	31.1253	0.51	0.79	(+)0.28
96	9249	3	79.4377	31.1147	0.87	1.04	(+)0.17
97	9250	3	79.4366	31.1119	1.28	2.13	(+)0.85
98	9251	3	79.4358	31.1107	0.29	0.47	(+)0.18
99	9252	3	79.4389	31.1082	0.58	0.7	(+)0.12
100	9253	3	79.4378	31.1039	0.24	0.3	(+)0.06
101	9255	3	79.4906	31.0975	3.52	5.86	(+)2.34
102	9256	3	79.507	31.1017	2.23	2.89	(+)0.66
103	9258	3	79.5161	31.1047	0.5	0.72	(+)0.22
104	9259	3	79.5691	31.0927	3.61	3.71	(+)0.10
105	9260	3	79.5679	31.0884	0.3	0.56	(+)0.26
106	9261	3	79.5625	31.0951	0.23	0.53	(+)0.30
107	9262	3	79.568	31.067	0.36	0.36	-----
108	9265	3	79.6631	31.0851	0.75	0.81	(+)0.06
109	9266	3	79.767	30.9979	1.09	1.44	(+)0.35
110	10249	3	79.0473	32.3483	-----	0.42	-----
111	10250	3	79.1211	32.4398	-----	0.41	-----
112	10251	3	79.2865	32.5165	-----	1.35	-----
113	10253	3	79.5265	32.372	-----	2.84	-----
114	10254	3	79.5732	32.332	-----	2.87	-----
115	10255	3	79.6207	32.327	-----	3.26	-----
116	10256	3	79.6727	32.2604	-----	0.58	-----
117	10257	3	79.6535	32.235	-----	3.39	-----
118	10258	3	79.8456	31.9926	-----	5.12	-----
119	10259	3	79.8985	31.9647	-----	6.42	-----
120	10260	3	79.8926	31.9604	-----	1.16	-----
121	10261	3	79.8947	31.9589	-----	4.17	-----
122	10262	3	79.8907	31.9558	-----	1.09	-----
123	10263	3	79.9021	31.9311	-----	0.21	-----
124	10264	3	79.9216	31.9362	-----	0.61	-----
125	10265	3	79.9141	31.9237	-----	0.78	-----
126	10266	3	79.9058	31.9179	-----	0.62	-----
127	10267	3	79.9048	31.9178	-----	0.6	-----
128	10269	3	79.3952	32.3536	-----	0.84	-----
129	10270	3	79.4266	32.3562	-----	1.9	-----
130	10272	3	79.1197	32.3343	-----	1.13	-----
131	10273	3	79.1175	32.3468	-----	0.49	-----
132	10275	3	79.4158	31.0631	-----	0.52	-----

133	10276	3	79.4199	31.0709	-----	0.74	-----
134	10277	3	79.4216	31.0765	-----	0.39	-----
135	10278	3	79.4241	31.0817	-----	2.8	-----
136	10279	3	79.4247	31.085	-----	1.02	-----
137	10280	3	79.4352	31.114	-----	0.65	-----
138	10281	3	79.4362	31.1028	-----	0.57	-----
139	10282	3	79.4356	31.1016	-----	0.77	-----
140	10283	3	79.4745	31.1205	-----	2.43	-----
141	10284	3	79.5205	31.1072	-----	0.77	-----
142	10285	3	79.5879	31.0695	-----	0.55	-----
143	10286	3	79.5885	31.061	-----	0.55	-----
144	10289	3	79.7469	31.015	-----	4.33	-----
145	10267SG	3	79.3941	32.352	-----	0.84	-----
146	10274HWL	3	79.5756	31.3077	-----	0.64	-----
147	10287SG	3	79.6053	31.0528	-----	0.45	-----
148	10288SG	3	79.6102	31.0614	-----	0.39	-----
149	10290HWL	3	79.6063	31.3011	-----	2.28	-----
150	10291SG	3	79.5676	31.0871	-----	0.48	-----
151	1063HWL	3	79.5991	31.3045	14.16	56.17	(+)42.01
152	1743HWL	3	79.3062	31.2331	4.81	5.94	(+)1.13
153	2135RS	3	79.052	32.3469	-----	6.44	-----
154	6091HWL	3	79.3017	31.24	0.66	0.76	(+)0.10
155	9254SG	3	79.4234	31.079	0.4	0.56	(+)0.16

HWL= High Altitude Wetland

RS= River Section

SG= Supra Glacier lakes

Area covered under path row 99/49 and 100/49 mainly falls in Upper Satluj sub basin and based on interpretation in 99/49 and 100/49 (Fig. 8.4(b)), a total of 362 lakes could be delineated in 2022 in comparison to 311 (2021), 348 (2020) and 275 (2019) forming part of the Upper Satluj basin. Further, out of 362 lakes 281 lakes have been classified as the small one with area less than 5ha against 249(2021) reflecting an enhancement of about 13 % in case of small lakes in the Upper Satluj basin .Likewise 39 lakes have been classified with area with 5-10 ha against 28 lakes (2021) indicating an increase of 39% in 2022 and 42 lakes have been classified as the big one with area more than 10ha against the 34 lakes (2021) indicating an increase of about 24% in the category of bigger lakes (Fig: 8.4(c)). Further 62 lakes have been classified as high altitude in 2022 out of 362 mapped from 99/49 and 100/49 path rows LISS III images comprising 43 wetlands with area less than 5ha, 5 within the areal range of 5-10 ha and 14 the big one with area more than 10ha (Fig: 8.4(d)) against 42 (2021), 51 (2020) and 45 (2019) respectively.

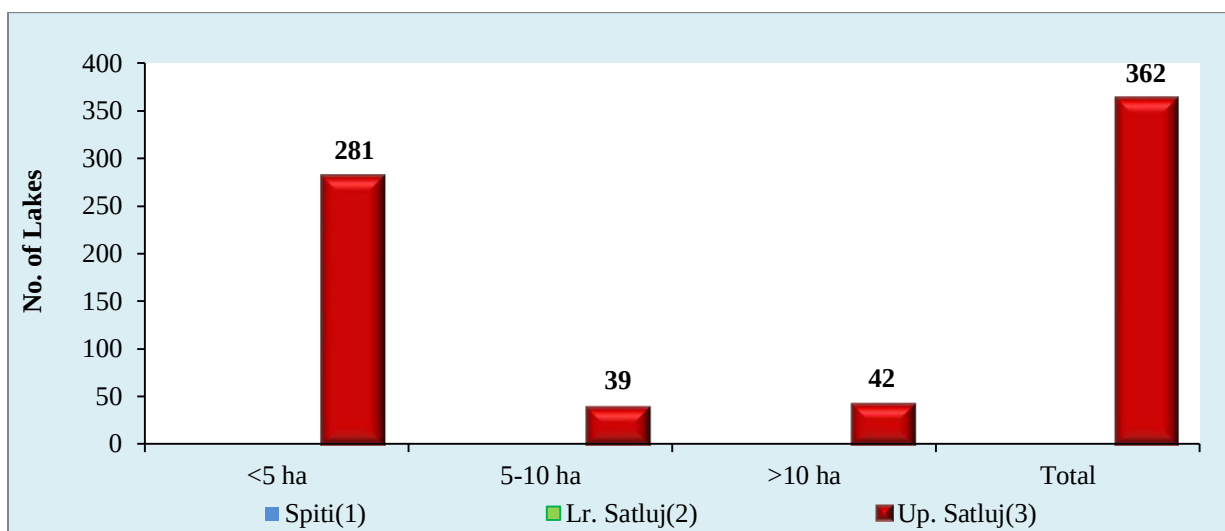


Fig. 8.4 (c): No. of lakes based on IRS-R2, LISS III, 99/49 & 100/49, 29 September,

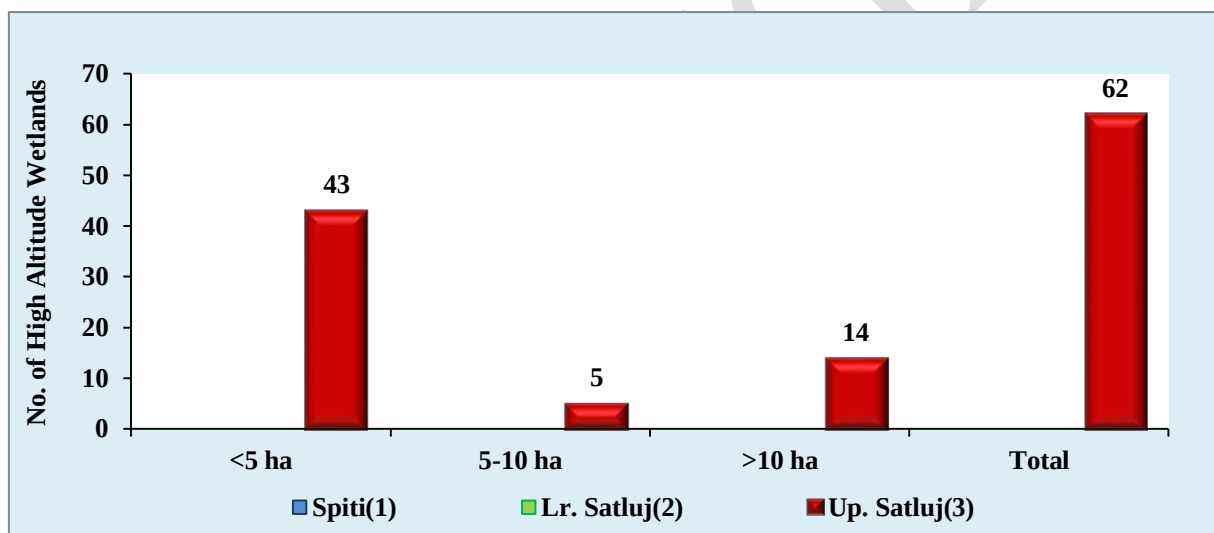


Fig. 8.4 (d): No. of High Altitude Wetland lakes based on IRS-R2, LISS III 99/49 & 100/49, 29 September,

Table 8.3: Distribution of Lakes as per satellite data interpretation for the year 2022 using LISS-III (99-49 & 100-49) sensor

Sr. No.	Lake Id.	Basin No.	Longitude	Latitude	Area extent (in ha) 2021	Area extent (in ha) 2022	Change in Area W.r.t 2021
1	26	3	81.1319	31.2603	-----	15.65	-----
2	98	3	81.4045	30.4659	0.57	0.54	(-)0.03
3	155	3	81.5342	31.0259	-----	4.3	-----
4	166	3	81.4291	30.4714	6.66	6.96	(+)0.30
5	171	3	81.1423	30.9193	-----	1.66	-----
6	172	3	81.7197	30.4482	6.17	7.87	(+)1.70

7	173	3	81.6749	30.4477	8.33	9.51	(+)1.18
8	174	3	81.4323	30.4486	9.02	9.64	(+)0.62
9	178	3	81.4324	30.4305	208.01	204.39	(-)3.62
10	179	3	81.7127	30.4294	25.48	25.88	(+)0.40
11	181 (1)	3	81.2312	30.8877	-----	0.73	-----
12	181 (2)	3	81.4617	30.4296	17.55	18.31	(+)0.76
13	182	3	81.2286	30.8856	-----	3.51	-----
14	184	3	81.7207	30.421	20.88	23.51	(+)2.63
15	185	3	81.7452	30.4091	9.79	10.71	(+)0.92
16	193	3	81.5114	30.7942	-----	0.14	-----
17	216	3	81.2125	30.7619	-----	0.38	-----
18	222	3	82.2155	30.5932	-----	7.12	-----
19	236	3	81.7345	30.5535	-----	2.3	-----
20	273	3	81.8158	30.4577	-----	1.2	-----
21	282	3	81.7212	30.4278	2.82	3.66	(+)0.84
22	284	3	81.7481	30.4471	-----	2.32	-----
23	964	3	81.7653	30.4079	1.09	1.88	(+)0.79
24	966	3	81.74	30.4019	4.32	5.78	(+)1.46
25	968	3	81.6977	30.4544	2.85	3.26	(+)0.41
26	969	3	81.6967	30.4306	4.13	5.68	(+)1.55
27	970	3	81.5128	30.4809	7.44	9.15	(+)1.71
28	971	3	81.5132	30.4766	3.12	3.92	(+)0.80
29	972	3	81.492	30.4546	1.91	2.5	(+)0.59
30	973	3	81.4964	30.4538	0.17	0.2	(+)0.03
31	975	3	81.4826	30.4963	0.86	0.35	(-)0.51
32	976	3	81.475	30.4871	0.82	0.58	(-)0.24
33	977	3	81.4745	30.482	2.71	1.58	(-)1.13
34	978	3	81.4563	30.4377	3.62	4.29	(+)0.67
35	983	3	81.3925	30.4537	2.13	2.41	(+)0.28
36	989	3	81.4754	30.4264	1.91	1.91	-----
37	990	3	81.479	30.4275	3.27	3.98	(+)0.71
38	996	3	81.4982	30.459	2.16	2.5	(+)0.34
39	1102	3	81.4859	30.4791	0.33	0.43	(+)0.10
40	1128	3	81.8701	30.4267	24.96	24.18	(-)0.78
41	1133	3	81.8669	30.4188	17	16.59	(-)0.41
42	1137	3	81.8191	30.4082	7.71	7.71	-----
43	1141	3	81.8838	30.4025	5.7	5.83	(+)0.13
44	1142	3	81.7733	30.4032	0.64	0.94	(+)0.30
45	1143	3	81.8526	30.4025	0.73	0.51	(-)0.22
46	1144	3	81.7832	30.4005	5.99	7.29	(+)1.30
47	1145	3	81.7738	30.4008	1.18	1.35	(+)0.17
48	1146	3	81.8652	30.3988	9.66	10.85	(+)1.19

49	1147	3	81.774	30.3987	3.25	4.44	(+)1.19
50	1148	3	81.7766	30.3982	0.81	1.33	(+)0.52
51	1149	3	81.7681	30.3965	5.42	6.99	(+)1.57
52	1150	3	81.7916	30.3963	4	4.87	(+)0.87
53	1151	3	81.7841	30.3947	0.52	0.51	(-)0.01
54	1152	3	81.7735	30.3945	1.27	0.74	(-)0.53
55	1153	3	81.9292	30.3838	74.71	76.46	(+)1.75
56	1154	3	81.7947	30.3921	0.88	0.71	(-)0.17
57	1155	3	81.8177	30.3901	16.3	17.13	(+)0.83
58	1156	3	81.8937	30.3902	11.9	11.44	(-)0.46
59	1157	3	81.8374	30.3913	2.16	2.85	(+)0.69
60	1158	3	81.8025	30.391	3.1	2.45	(-)0.65
61	1159	3	81.8137	30.3911	0.45	0.64	(+)0.19
62	1161	3	81.9142	30.3884	2.64	1.08	(-)1.56
63	1162	3	81.8476	30.3881	0.35	0.6	(+)0.25
64	1163	3	81.8434	30.3877	0.58	0.6	(+)0.02
65	1164	3	81.8399	30.3847	4.19	15.32	(+)11.13
66	1165	3	81.8469	30.3864	14.68	4.6	(-)10.08
67	1166	3	81.83	30.3845	0.18	0.72	(+)0.54
68	1167	3	81.8242	30.3827	0.71	0.9	(+)0.19
69	1168	3	81.8295	30.3805	3.29	4.19	(+)0.90
70	1395	3	81.4126	30.4601	1.53	2.06	(+)0.53
71	1443	3	81.7613	30.9887	1.55	2.73	(+)1.18
72	1445	3	81.722	31.0702	8.19	9.13	(+)0.94
73	1446	3	81.724	31.0563	0.48	0.79	(+)0.31
74	1447	3	81.7271	31.0518	0.87	1	(+)0.13
75	1453	3	81.5417	31.1169	10.21	10.42	(+)0.21
76	1454	3	81.545	31.1029	4.73	5.35	(+)0.62
77	1455	3	81.5502	31.094	0.87	1.57	(+)0.70
78	1456	3	81.554	31.0909	0.97	1.27	(+)0.30
79	1457	3	81.5604	31.0942	1.74	1.89	(+)0.15
80	1458	3	81.5467	31.0791	1.22	2.19	(+)0.97
81	1460	3	81.5302	31.092	1.32	1.13	(-)0.19
82	1462	3	81.5185	31.0827	2.17	2.6	(+)0.43
83	1463	3	81.5137	31.0388	1.71	1.45	(-)0.26
84	1465	3	81.5183	31.0308	0.66	0.78	(+)0.12
85	1467	3	81.4888	31.0062	0.92	1.05	(+)0.13
86	1468	3	81.5035	31.0637	0.98	1.27	(+)0.29
87	1469	3	81.5048	31.0718	0.51	1.16	(+)0.65
88	1470	3	81.5022	31.1122	7.95	8.44	(+)0.49
89	1471	3	81.5127	31.0992	-----	4.49	-----
90	1472	3	81.5034	31.0941	5.65	7.15	(+)1.50

91	1473	3	81.4805	31.0804	2.64	2.27	(-)0.37
92	1475	3	81.425	31.0843	1.67	2.88	(+)1.21
93	1476	3	81.4242	31.08	0.76	1.56	(+)0.80
94	1479	3	81.4161	31.1025	2.8	2.6	(-)0.20
95	1480	3	81.412	31.1042	1.49	1.47	(-)0.02
96	1481	3	81.4222	31.114	1.62	2.53	(+)0.91
97	1482	3	81.4342	31.1145	4.59	5.21	(+)0.62
98	1483	3	81.4238	31.1369	6.04	5.79	(-)0.25
99	1484	3	81.4069	31.1445	1.35	2.18	(+)0.83
100	1485	3	81.4128	31.1341	1.83	1.55	(-)0.28
101	1486	3	81.4065	31.125	1.27	1.27	-----
102	1487	3	81.4009	31.1275	5.35	5.5	(+)0.15
103	1488	3	81.3827	31.1382	8.91	9.62	(+)0.71
104	1493	3	81.2631	31.1245	0.22	0.57	(+)0.35
105	1495 (1)	3	81.2303	31.06	5.58	3.9	(-)1.68
106	1495 (2)	3	81.5545	30.7807	4.41	8.03	(+)3.62
107	1496	3	81.2065	31.0736	1.28	1.28	-----
108	1497	3	81.1958	31.0954	0.54	0.71	(+)0.17
109	1499	3	81.2271	31.1289	5.96	6.49	(+)0.53
110	1501	3	81.2313	31.1429	0.67	0.67	-----
111	1502	3	81.2323	31.1454	0.52	0.63	(+)0.11
112	1503	3	81.2348	31.1481	0.52	0.44	(-)0.08
113	1505	3	81.2246	31.1494	2.01	2.74	(+)0.73
114	1508	3	81.2152	31.1638	2.23	2.76	(+)0.53
115	1509	3	81.1996	31.1652	0.83	1.01	(+)0.18
116	1510	3	81.1937	31.1816	53.14	54.97	(+)1.83
117	1511	3	81.1779	31.1893	1.79	2.29	(+)0.50
118	1512	3	81.1509	31.1785	23.25	23.17	(-)0.08
119	1513	3	81.1399	31.1692	0.59	1.09	(+)0.50
120	1516	3	81.1297	31.1931	0.75	1.09	(+)0.34
121	1518	3	81.1471	31.1986	12.69	14.98	(+)2.29
122	1519	3	81.1472	31.2035	0.5	1.6	(+)1.10
123	1520	3	81.1532	31.2082	1.55	1.19	(-)0.36
124	1524	3	81.1338	31.2207	0.35	0.72	(+)0.37
125	1525	3	81.1284	31.2193	1.84	1.82	(-)0.02
126	1526	3	81.1447	31.2308	2.15	2.15	-----
127	1527	3	81.1368	31.234	11.37	12.34	(+)0.97
128	1528	3	81.1408	31.246	9.66	10.62	(+)0.96
129	1529	3	81.1297	31.244	3.47	3.21	(-)0.26
130	1530	3	81.124	31.2374	3.83	4.22	(+)0.39
131	1531	3	81.1255	31.2577	0.42	0.73	(+)0.31
132	1532	3	81.1163	31.26	4.8	4.87	(+)0.07

133	1533	3	81.1158	31.2636	2.45	2.36	(-)0.09
134	1534	3	81.1087	31.2692	4.25	3.88	(-)0.37
135	1535	3	81.0844	31.2721	1.77	2.11	(+)0.34
136	1537	3	81.0887	31.2658	6.15	7.99	(+)1.84
137	1538	3	81.1128	31.2498	1.83	2.15	(+)0.32
138	1539	3	81.1019	31.2433	4.28	4.14	(-)0.14
139	1542	3	81.0824	31.2399	4.73	6.23	(+)1.50
140	1545	3	81.0486	31.2904	0.29	0.71	(+)0.42
141	1546	3	81.0473	31.2866	0.85	0.53	(-)0.32
142	1547	3	81.0324	31.2925	4.58	6.65	(+)2.07
143	1548	3	81.0315	31.2847	15.45	17.21	(+)1.76
144	1549	3	81.0281	31.2769	1.44	3.31	(+)1.87
145	1550	3	81.0123	31.2945	2.82	3.05	(+)0.23
146	1551	3	81.0115	31.3316	0.36	1	(+)0.64
147	1552	3	81.1325	31.245	4.07	5.39	(+)1.32
148	1553	3	81.1352	31.2469	0.57	1.21	(+)0.64
149	1554	3	81.2623	31.1227	1.54	1.64	(+)0.10
150	1562	3	81.8216	30.3896	1.37	1.59	(+)0.22
151	1564	3	81.8417	30.379	-----	4.29	-----
152	1565	3	81.8516	30.3989	17.18	18.33	(+)1.15
153	1744	3	81.001	31.2867	0.48	0.86	(+)0.38
154	1745	3	81.02	31.3741	1.9	1.32	(-)0.58
155	1753	3	81.3213	31.1724	1.23	1.09	(-)0.14
156	1754 (1)	3	81.3218	31.16	0.17	0.34	(+)0.17
157	1754 (2)	3	81.4821	31.0393	0.41	0.48	(+)0.07
158	1755	3	81.326	31.1385	1.49	2.29	(+)0.80
159	1756	3	81.4574	31.0142	0.29	0.91	(+)0.62
160	1777	3	81.4649	30.4272	2.81	3.46	(+)0.65
161	1778	3	81.4667	30.4268	0.76	1.02	(+)0.26
162	1779	3	81.4689	30.4278	0.64	1.09	(+)0.45
163	1781	3	81.482	30.4615	2.8	2.99	(+)0.19
164	1809	3	81.9163	30.3909	0.49	0.67	(+)0.18
165	2172	3	81.1636	31.222	0.56	0.67	(+)0.11
166	2173	3	81.1378	31.1937	7.19	7.52	(+)0.33
167	2174	3	81.1725	31.209	1.14	1.44	(+)0.30
168	2175	3	81.3949	31.1679	4.33	8.9	(+)4.57
169	2176	3	81.4693	31.0364	-----	0.45	-----
170	2177	3	81.5181	31.111	0.86	1.28	(+)0.42
171	2179	3	81.6673	30.9493	2.34	4.29	(+)1.95
172	2180	3	81.85	31.0049	24.03	24.28	(+)0.25
173	2182	3	81.9128	30.3692	-----	1.63	-----
174	2184	3	81.8146	30.4011	0.2	0.36	(+)0.16

175	2185	3	81.7783	30.3912	0.34	0.34	-----
176	2187	3	81.7701	30.4588	2.93	4.1	(+)1.17
177	2190	3	80.9521	31.3416	0.41	0.64	(+)0.23
178	2191	3	80.9549	31.3184	1.91	1.07	(-)0.84
179	2193	3	81.085	31.2693	0.86	0.73	(-)0.13
180	2194	3	81.4804	31.109	0.52	0.52	-----
181	2195	3	81.4101	30.4565	1.92	2.33	(+)0.41
182	7029	3	81.4005	30.4765	0.47	0.31	(-)0.16
183	7035	3	81.4831	30.4647	0.3	0.64	(+)0.34
184	7037	3	81.4813	30.4627	0.42	0.61	(+)0.19
185	7040	3	81.698	30.4389	1.08	0.88	(-)0.20
186	7042	3	81.7482	30.4049	0.25	0.25	-----
187	7043	3	81.7569	30.4009	0.48	0.3	(-)0.18
188	7055	3	81.4865	31.0064	0.45	0.45	-----
189	7060	3	81.3666	31.1255	0.54	0.54	-----
190	7064	3	81.3124	31.1493	0.78	0.55	(-)0.23
191	7066	3	81.2973	31.1807	1.8	1.8	-----
192	7067	3	81.248	31.1068	0.61	0.46	(-)0.15
193	7071	3	81.2058	31.1553	0.3	0.69	(+)0.39
194	7074	3	81.1138	31.2401	0.83	1.25	(+)0.42
195	7075	3	81.0904	31.2416	0.52	0.47	(-)0.05
196	7076	3	81.0904	31.2407	0.43	0.37	(-)0.06
197	7079	3	81.0731	31.2593	0.46	0.64	(+)0.18
198	7080	3	81.0718	31.273	0.18	0.5	(+)0.32
199	7081	3	81.0687	31.276	0.4	0.69	(+)0.29
200	7089	3	81.8035	30.4076	0.19	0.19	-----
201	7090	3	81.8455	30.4099	0.73	0.8	(+)0.07
202	9324	3	80.8225	31.2644	0.89	1.23	(+)0.34
203	9326	3	80.8324	31.2518	2.99	3.88	(+)0.89
204	9327	3	80.9705	31.3374	0.52	0.71	(+)0.19
205	9329	3	81.1288	31.2176	0.72	1.41	(+)0.69
206	9330	3	81.1589	31.2181	10.13	5.65	(-)4.48
207	9331	3	81.1562	31.2178	0.28	0.28	-----
208	9333	3	81.1361	31.1616	0.35	0.34	(-)0.01
209	9334	3	81.1902	31.1777	0.21	0.5	(+)0.29
210	9335	3	81.1927	31.1779	0.73	0.95	(+)0.22
211	9336	3	81.1818	31.1375	3.12	2	(-)1.12
212	9337	3	81.2247	31.1604	1.19	1.57	(+)0.38
213	9338	3	81.2209	31.148	9.09	10.92	(+)1.83
214	9339	3	81.2319	31.1484	0.39	0.66	(+)0.27
215	9340	3	81.2349	31.1471	0.34	0.21	(-)0.13
216	9341	3	81.2221	31.1101	2.2	2.2	-----

217	9342	3	81.2581	31.1391	1.13	1.37	(+)0.24
218	9343	3	81.2797	31.1377	10.41	9.3	(-)1.11
219	9344	3	81.2579	31.1168	4.31	4.94	(+)0.63
220	9346	3	81.3167	31.084	0.57	0.48	(-)0.09
221	9348	3	81.3475	31.0589	0.34	0.46	(+)0.12
222	9349	3	81.371	31.0928	1.07	1.17	(+)0.10
223	9351	3	81.444	31.0884	0.3	0.53	(+)0.23
224	9354	3	81.5126	31.0351	4.34	3.63	(-)0.71
225	9355	3	81.5184	31.0317	0.79	0.72	(-)0.07
226	9356	3	81.5144	31.0515	1.07	1.22	(+)0.15
227	9357	3	81.8926	30.9532	4.68	4.7	(+)0.02
228	9358	3	81.8923	30.9462	6.45	5.59	(-)0.86
229	9359	3	81.9003	30.9465	0.8	0.48	(-)0.32
230	9361	3	81.4328	30.4708	1.45	1.95	(+)0.50
231	9362	3	81.4668	30.4228	0.7	0.7	-----
232	9363	3	81.4621	30.4338	0.33	0.33	-----
233	9364	3	81.4699	30.4278	0.48	0.61	(+)0.13
234	9365	3	81.484	30.4655	0.24	0.51	(+)0.27
235	9366	3	81.4647	30.5033	1.15	1.15	-----
236	9368	3	81.7509	30.3916	0.29	0.3	(+)0.01
237	9369	3	81.8228	30.3817	0.66	0.56	(-)0.10
238	9370	3	81.9902	30.5459	3.84	3.84	-----
239	9371	3	81.1665	31.2083	0.4	0.47	(+)0.07
240	9372	3	81.1745	31.2101	0.53	1.07	(+)0.54
241	9374	3	81.5312	31.0938	0.34	0.25	(-)0.09
242	9375	3	81.4955	30.4536	0.29	0.61	(+)0.32
243	10294	3	82.1558	30.5423	-----	5.74	-----
244	10295	3	82.1187	30.5449	-----	1.41	-----
245	10296	3	82.0577	30.57	-----	1.47	-----
246	10297	3	82.0624	30.5693	-----	0.46	-----
247	10298	3	82.0515	30.5747	-----	0.26	-----
248	10299	3	82.0388	30.5726	-----	0.27	-----
249	10300	3	82.0351	30.5732	-----	0.86	-----
250	10301	3	82.0342	30.5569	-----	0.78	-----
251	10302	3	82.0347	30.5561	-----	0.25	-----
252	10303	3	82.0145	30.5468	-----	1.39	-----
253	10304	3	81.9277	30.3879	-----	0.42	-----
254	10305	3	81.9273	30.3858	-----	0.88	-----
255	10307	3	81.8656	30.3909	-----	1.07	-----
256	10308	3	81.8623	30.3937	-----	0.31	-----
257	10310	3	81.8305	30.3879	-----	0.33	-----
258	10311	3	81.8136	30.3881	-----	0.36	-----

259	10312	3	81.8128	30.386	-----	0.21	-----
260	10313	3	81.7751	30.3907	-----	1.06	-----
261	10314	3	81.7848	30.4615	-----	0.57	-----
262	10315	3	81.7894	30.4611	-----	0.38	-----
263	10316	3	81.74	30.4282	-----	1.19	-----
264	10317	3	81.7122	30.441	-----	0.69	-----
265	10318	3	81.712	30.4402	-----	0.3	-----
266	10319	3	81.7025	30.4538	-----	0.44	-----
267	10320	3	81.6949	30.5065	-----	0.73	-----
268	10321	3	81.4429	30.4675	-----	0.42	-----
269	10322	3	81.488	30.4706	-----	0.25	-----
270	10323	3	81.4857	30.4649	-----	0.33	-----
271	10328	3	81.0734	31.2773	-----	0.89	-----
272	10329	3	81.2047	31.1585	-----	0.57	-----
273	10330	3	81.3225	31.1607	-----	0.41	-----
274	10331	3	81.0668	31.2625	-----	0.64	-----
275	10332	3	81.14	31.2322	-----	1.11	-----
276	10333	3	81.1533	31.1439	-----	3.92	-----
277	10334	3	81.2497	31.1056	-----	0.63	-----
278	10335	3	81.2498	31.1086	-----	1.26	-----
279	10336	3	81.2516	31.116	-----	1.65	-----
280	10337	3	81.3673	31.139	-----	4.68	-----
281	10338	3	81.3648	31.1408	-----	1.44	-----
282	10339	3	81.3625	31.1465	-----	0.67	-----
283	10340	3	81.3611	31.1472	-----	0.76	-----
284	10341	3	81.3588	31.1022	-----	1.72	-----
285	10342	3	81.4006	31.1901	-----	14	-----
286	10343	3	81.5241	31.111	-----	3.36	-----
287	10344	3	81.5316	31.0128	-----	8.48	-----
288	10345	3	81.5484	31.0508	-----	4.29	-----
289	10346	3	81.6969	31.0501	-----	2.53	-----
290	10347	3	81.0163	31.2817	-----	16.52	-----
291	10348	3	81.0086	31.3481	-----	4.6	-----
292	10349	3	81.2969	31.1622	-----	3.99	-----
293	10350	3	81.9792	30.8412	-----	4.26	-----
294	10292HWL	3	82.028	30.6619	-----	0.93	-----
295	10293HWL	3	82.1793	30.5846	-----	2.34	-----
296	1031HWL	3	81.5239	30.7761	1.72	1.97	(+)0.25
297	10325HWL	3	81.5397	30.7798	-----	0.29	-----
298	10326RS	3	81.1824	30.9001	-----	13.47	-----
299	10327HWL	3	81.2153	30.8737	-----	2.38	-----
300	1039HWL	3	81.7005	30.5143	9.33	10.34	(+)1.01

301	1074HWL	3	81.2293	30.8915	1.18	1.63	(+)0.45
302	1075HWL	3	81.2318	30.8907	1.29	2.68	(+)1.39
303	1088HWL	3	81.542	30.8183	-----	2.73	-----
304	1090HWL	3	81.5405	30.7779	0.93	1.57	(+)0.64
305	1092HWL	3	81.5648	30.7667	4.14	12.85	(+)8.71
306	1093HWL	3	82.1344	30.6369	5992.44	5966.5	(-)25.94
307	1094HWL	3	82.0709	30.5961	14.85	14.37	(-)0.48
308	1095HWL	3	82.0826	30.5913	17.22	15.69	(-)1.53
309	1122HWL	3	81.816	30.4387	0.68	0.53	(-)0.15
310	1123HWL	3	81.8178	30.4389	0.45	0.56	(+)0.11
311	1124HWL	3	81.82	30.4376	4.45	5.17	(+)0.72
312	1136HWL	3	81.7766	30.4105	7.34	8.87	(+)1.53
313	1139HWL	3	81.7969	30.4232	0.86	3.22	(+)2.36
314	1349HWL	3	81.5662	30.8011	338.39	323.66	(-)14.73
315	1355HWL	3	81.5485	30.781	1.84	1.44	(-)0.40
316	1358HWL	3	81.5529	30.7782	0.84	1.47	(+)0.63
317	1359HWL	3	81.5422	30.788	-----	4.5	-----
318	1363HWL	3	81.5407	30.7727	25.57	25.57	-----
319	1375HWL	3	81.3611	30.7022	76.23	27.39	(-)48.84
320	1376HWL	3	81.2373	30.8907	1.17	1.33	(+)0.16
321	1377HWL	3	81.2377	30.8922	0.28	0.31	(+)0.03
322	1383HWL	3	81.2105	30.8934	1.41	1.72	(+)0.31
323	138HWL	3	81.2336	30.6881	25718.1	25710.72	(-)7.38
324	145HWL	3	81.4709	30.6842	41484.74	41517.06	(+)32.32
325	1557RS	3	81.167	30.911	116.29	71.15	(-)45.14
326	1566HWL	3	82.0327	30.6619	10.76	5.26	(-)5.50
327	1771RS	3	81.0922	30.9253	13.73	13.73	-----
328	1772RS	3	81.1	30.9256	4.89	4.89	-----
329	1773RS	3	81.1091	30.9237	2.36	2.45	(+)0.09
330	1775RS	3	81.1332	30.9217	5.57	5.57	-----
331	1782HWL	3	81.7376	30.5477	28.08	30.34	(+)2.26
332	1784HWL	3	81.7104	30.5595	2.38	3.28	(+)0.90
333	1786HWL	3	81.7495	30.5416	0.72	0.53	(-)0.19
334	1787HWL	3	82.115	30.5846	2.53	1.75	(-)0.78
335	1788HWL	3	82.1225	30.5712	-----	2	-----
336	205HWL	3	81.5652	30.7877	3.58	6.2	(+)2.62
337	207HWL	3	81.5485	30.7843	5.86	5.86	-----
338	208HWL	3	81.5529	30.7833	1.75	2.4	(+)0.65
339	210HWL	3	81.5535	30.7713	57.41	57.41	-----
340	211HWL	3	81.7062	30.5017	1.7	1.73	(+)0.03
341	2157HWL	3	81.5206	30.7923	0.41	0.25	(-)0.16
342	2158HWL	3	81.5123	30.7957	0.77	0.6	(-)0.17

343	2159HWL	3	81.5118	30.7931	0.25	0.3	(+)0.05
344	2160HWL	3	81.5106	30.7954	0.3	0.46	(+)0.16
345	2161HWL	3	81.5041	30.7983	1.32	0.92	(-)0.40
346	2162HWL	3	81.5033	30.79775	0.51	0.41	(-)0.10
347	2163HWL	3	81.5024	30.7979	0.2	0.32	(+)0.12
348	2165HWL	3	81.5507	30.7814	0.36	0.5	(+)0.14
349	2166HWL	3	81.5493	30.78	0.34	0.24	(-)0.10
350	2167HWL	3	81.5832	30.7617	89.11	99.15	(+)10.04
351	2169HWL	3	81.1879	30.8922	0.78	11.29	(+)10.51
352	2170RS	3	81.1051	30.9239	2.36	2.32	(_)0.04
353	2196HWL	3	81.521	30.7758	0.23	0.31	(+)0.08
354	257HWL	3	81.5687	30.789	1.54	1.96	(+)0.42
355	385HWL	3	81.5376	30.7781	3.88	3.88	-----
356	7047HWL	3	81.6901	30.554	0.7	0.7	-----
357	7088HWL	3	81.7622	30.4202	4.27	4.39	(+)0.12
358	9360hwl	3	81.237	30.8895	0.29	0.57	(+)0.28
359	9367hwl	3	81.6868	30.4992	0.29	0.32	(+)0.03
360	960HWL	3	81.6913	30.4963	3.05	3.44	(+)0.39
361	961HWL	3	81.6939	30.4972	1.79	2.3	(+)0.51
362	962HWL	3	81.7001	30.4942	1.54	0.82	(-)0.72

HWL= High Altitude Wetland

RS= River Section

SG= Supra Glacier lakes

Based on the further analysis of LISS III satellite data, it has been found that total number of lakes that could be mapped in Upper Satluj basin varies from 495 (2018) to 437 (2019) to 707 (2020) to 588 (2021) to 639 (2022) thus by indicating an increase of 144 lakes w.r.t. 2018, 202 lakes w.r.t 2019 , reduction of 68 lakes w.r.t 2020 data and increase of 51 lakes w.r.t 2021 or in other words we can say that the increase is of the order of about 29%, 46%, with reference to 2018 & 2019 and about 10% decrease with reference to 2020 and again an increase by 9% in comparison to 2021 data is observed respectively (Fig: 8.5) and this small variation could be due to non-availability of the good quality snow free and cloud free data coverage based on LISS III satellite data in 2022.

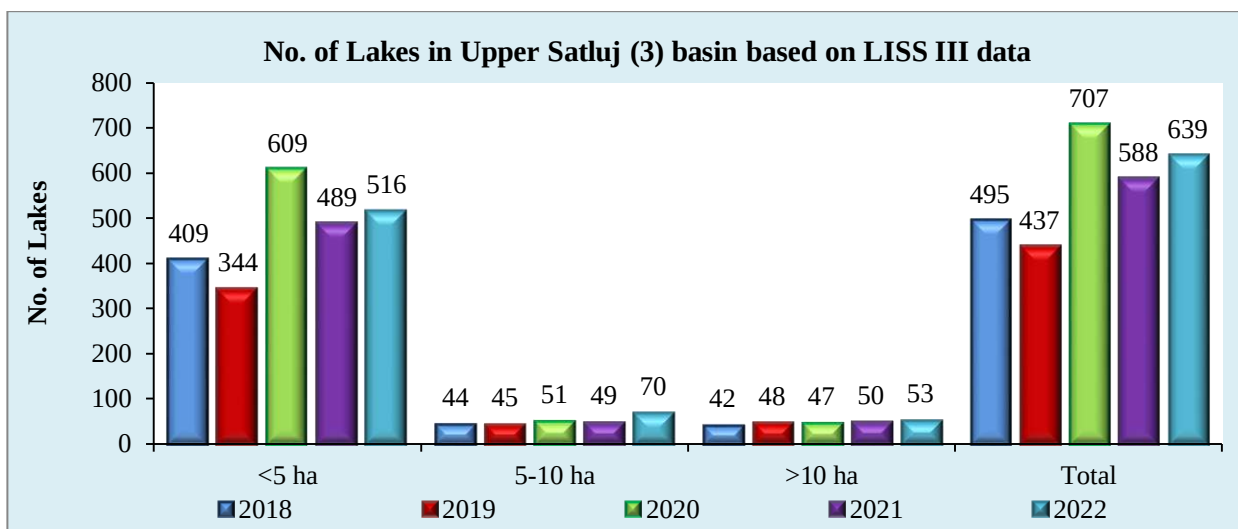


Fig. 8.5: No. of Lakes in Upper Satluj (3) basin based on LISS III data

Likewise in Lower Satluj basin, total number of lakes mapped varies from 98 (2018) to 52 (2019) to 89 (2020) to 163 (2021) to 173 (2022) thus by indicating an increase of about 75 lakes (about 77%) w.r.t 2018, 121 lakes (232%) w.r.t 2019, 84 lakes (about 94%) w.r.t 2020 and 10 Lakes (about 6%) w.r.t. to 2021 could be observed (Fig: 8.6).

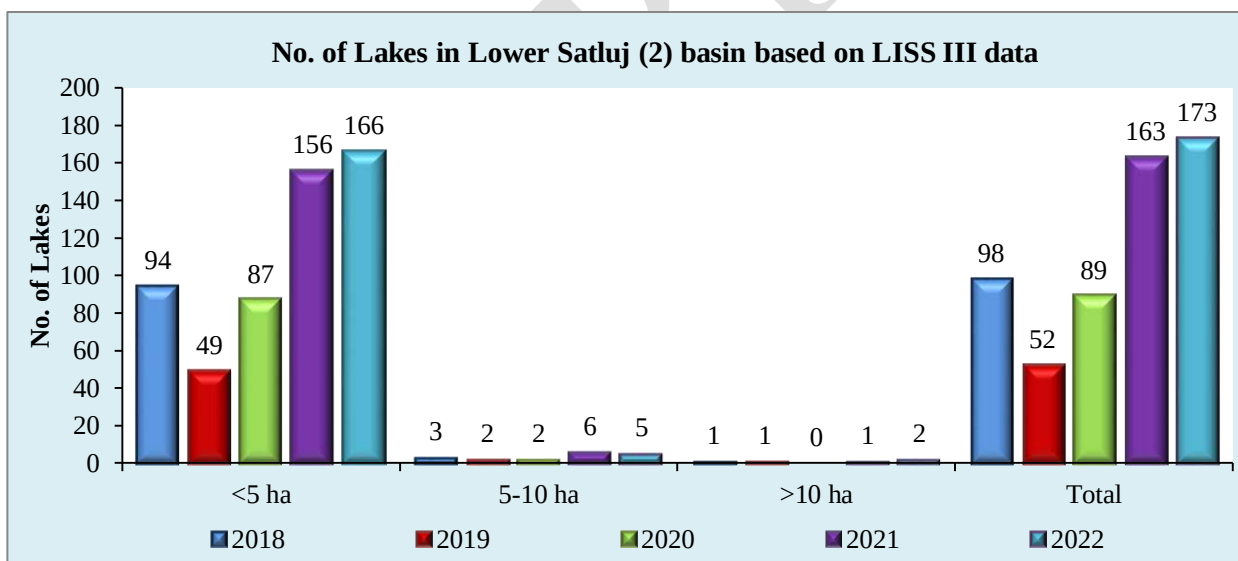


Fig. 8.6: No. of Lakes in Lower Satluj (2) basin based on LISS III data

Similarly in Spiti basin, the variation in the total number of lakes is from 176 (2018) to 73 (2019) to 197 (2020) to 129 (2021) to 183 (2022) thus by indicating an increase of about 4% (7 lakes) w.r.t. 2018, about 150 % increase (110 lakes) w.r.t to 2019, decrease of about 7% (14 lakes) w.r.t. to 2020 and further of about 42% (54 Lakes) w.r.t. to 2021 respectively (Fig: 8.7)

and the difference is mainly due to the data quality which is either due to snow cover or cloud cover impacts.

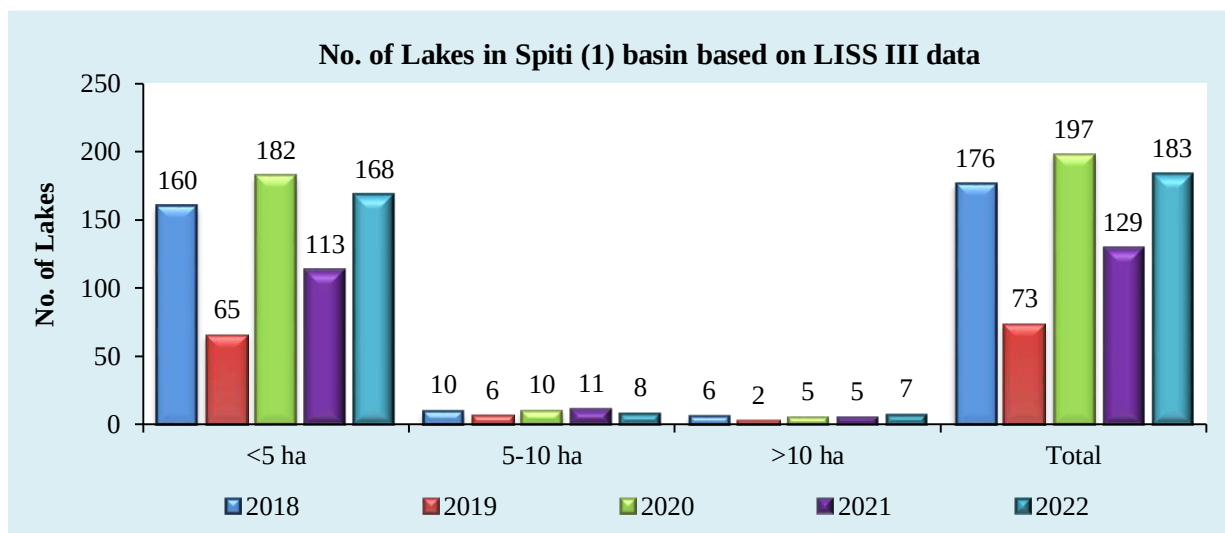


Fig. 8.7:No. of Lakes in Spiti (1) basin based on LISS III data

Further analysis of these 995 lakes mapped in the entire Satluj basin using LISS-III satellite data in 2022 reveals that total number of lakes with area more than 10 ha varies from 49 (2018) to 51 (2019) to 49 (2020) to 56 (2021) and 62 (2022). Likewise, the analysis for 2022 based on LISS-III products, the total number of lakes with area less than 5ha varies from 850 (2022) to 758 (2021) to 878 (2020) to 458 (2019) and 663 (2018) indicating an enhancement of 92 lakes w.r.t 2021 and decrease of 28 lakes w.r.t.2020, further enhancement of 392 lakes w.r.t 2019 and 187 lakes w.r.t 2018 respectively. Likewise the lakes within the aerial range of 5-10 ha shows an increase of 17 lakes w.r.t. 2021 (66), 20 lakes w.r.t 2020(63), 22 lakes w.r.t 2019 (61) and 26 lakes in comparison to 2018(57) respectively in comparison to 83 lakes in 2022. Also, the analysis for 2022 based on LISS-III products, the total number of lakes with area more than 10ha shows an increase of 6 lakes w.r.t. 2021 (56), and increase of 11 lake w.r.t 2019 (51) and 13 lakes 2018(49) in comparison to 62 lakes in 2022 respectively. The large variation in the number of lakes with reference to the preceding years is mainly due to the non-availability of cloud free satellite data covering the entire catchment. Hence these small dimensional lakes/water bodies can be future vulnerable sites and thus needs proper monitoring using higher resolution satellite data for better management. The lakes with ids RS are the lakes formed along the small river section due to debris coverer along the river course on the left bank of Spiti River are the vulnerable locations formed due to temporary damming along the stream course and thus needs monitoring.

9.0: Basin wise comparative Analysis

Based on the analysis of satellite data for AWiFS and LISS III sensors during 2022 and the comparative analysis on the basis of result obtained with that of results obtained from 2021, the total number of lakes and the lakes with area more than 10ha in each basin i.e. Spiti basin (Basin 1), Lower Satluj basin (Basin 2) and Upper Satluj Basin (Basin 3) has been seen temporally for each basin. Based on the AWiFS satellite data analysis from April to November 2022 (Fig. 9.1) suggest that maximum number of lakes/wetlands that could be delineated in 2022 using AWiFS satellite data having spatial resolution of 56 mts were 414 during the month of September, 2022 in comparison to 414 of August 2021 indicating no change in the total number of lakes during 2021 and 2022 using AWiFS data product. However on analyzing the total lakes based on the aerial extent, the total lakes with are amore than 10ha has increase from 66 (2021) to 76 (2022) whereas the lakes with aerial range 5-10 ha are 89 in 2022 and <5ha are 249 (2022).

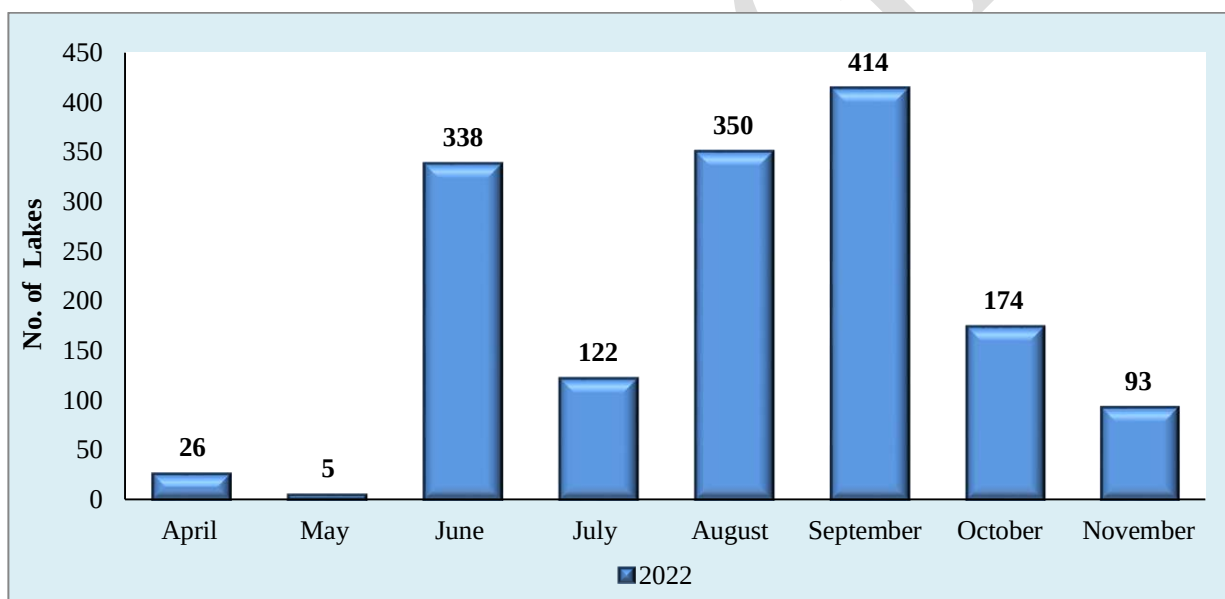


Fig. 9.1: Total No. of Lakes based on AWiFS satellite data, 2022

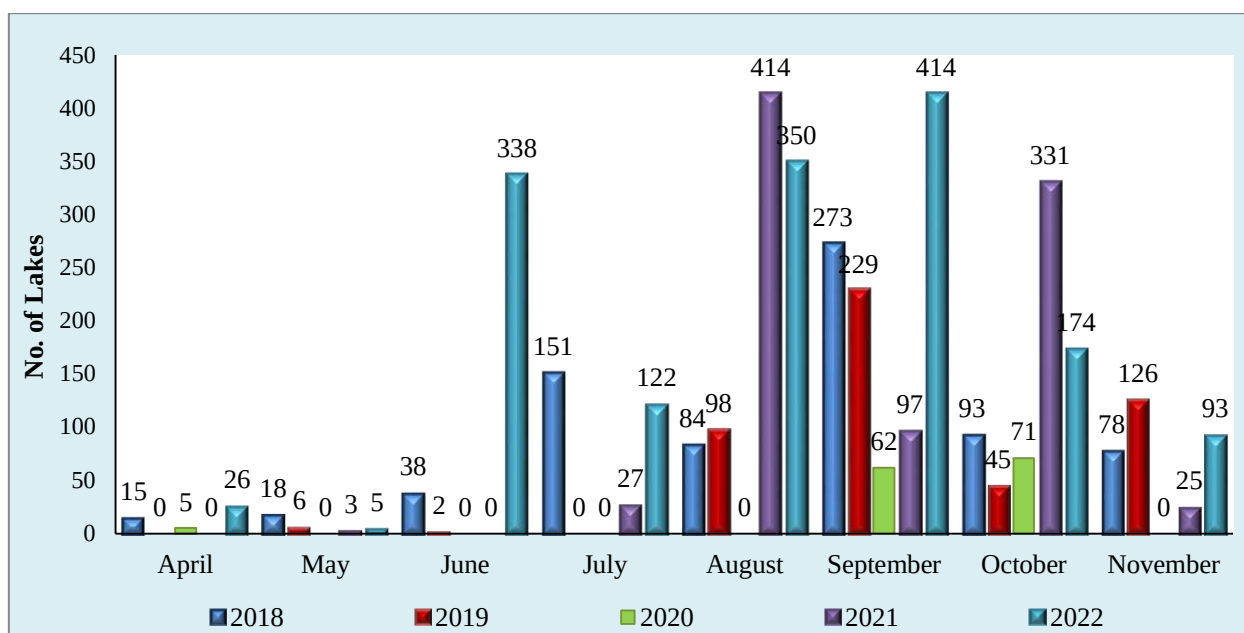


Fig. 9.2: Total No. of Lakes based on AWiFS satellite data, 2018, 2019, 2020, 2021 and 2022

The basin wise comparative analysis based on LISS-III satellite data reveals that total number of lakes mapped in Spiti basin varies from 176 (2018) to 73(2019) to 197 (2020) to 129 (2021) to 183 (2022) indicating an increase of 42% w.r.t 2021, decrease of 7% w.r.t 2020 an further an increase of about 150% with that of 2019 and 4% w.r.t 2018. The large variation between 2019 and 2022 is mainly due to the data gap in procuring good quality satellite data during 2019 with the result the complete information about the catchment could not be retrieved. Likewise in the Lower Satluj basin the total number of lakes varies from 98 (2018) to 52 (2019) to 89 (2020) to 163 (2021) and 173 (2022) reflecting an overall increase of 77% with that 2018, 232% with that of 2019, 94% w.r.t 2020 and 6% increase w.r.t 2021 respectively. In Upper Satluj basin, the increase is of the order of 29% w.r.t.2018 (495), 46% with that of 2019 (437), and a reduction of 10% w.r.t. 2020 (707) and further an increase of 9% w.r.t 2021 (639) respectively.

Further basin wise comparative analysis reveals that, the Spiti basin shows an increase 54 lakes w.r.t. 2021, decrease of 14 lakes w.r.t 2020, increase of 110 lakes (2019) and 7 (2018) comprising 168 lakes with area less 5ha, 8lakes with area between 5-10ha and 7 lakes with more than 10ha. Likewise in Lower Satluj basin, total number of lakes mapped varies from 98 (2018) to 52 (2019) to 89 (2020) to 163 (2021) to 173 (2022) thus by indicating an increase of about 75 lakes (about 77%) w.r.t 2018, 121 lakes (232%) w.r.t 2019, 84 lakes (about 94%) w.r.t 2020 and 10 Lakes (about 6%) w.r.t. to 2021.

In Upper Satluj basin varies from 495 (2018) to 437 (2019) to 707 (2020) to 588(2021) to 639 (2022) thus by indicating an increase of 144 lakes w.r.t. 2018, 202 lakes w.r.t 2019 , reduction of 68 lakes w.r.t 2020 data and increase of 51 lakes w.r.t 2021 or in other words we can say that the increase is of the order of about 29%, 46%, with reference to 2018 & 2019 and about 10% decrease with reference to 2020 and again an increase by 9% in comparison to 2021 data is observed respectively and this small variation could be due to non-availability of the good quality snow free and cloud free data coverage based on LISS III satellite data in 2022.

Further comparative analysis of the bigger lakes with area >10ha based on AWiFS data does not show any change during 2021& 2022 and total number of lakes falling in this category varies 31(2019) to 62 (2020) to 66 (2021) to 76(2022) out of which 12 are the high-altitude wetlands forming part of the Upper Satluj basin. Further it is found that the Spiti basin the number of lakes with area >10ha that could be mapped varies from 1 (2019) to 7 (2020) to 7 (2021) to 7(2022), in Lower Satluj basin the number of such lakes varies from 0 (2019) to 2 (2020) to 6 (2021) to 6(2022), whereas in Upper Satluj basin the number varies from 30 (2019) to 53 (2020) to 53 (2021) to 63(2022).

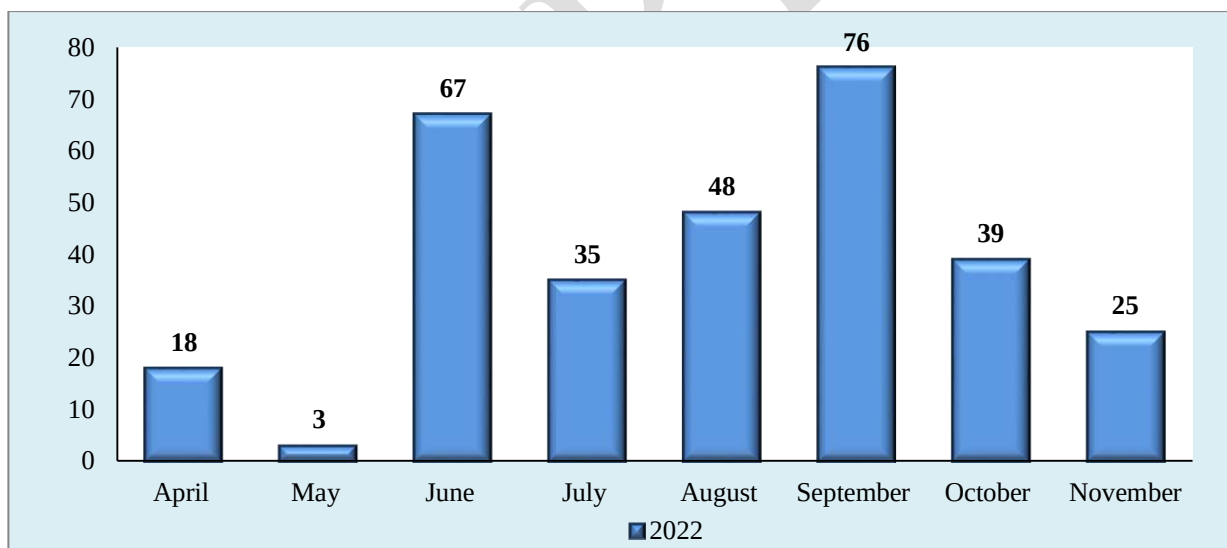


Fig. 9.3: Total No. of Lakes > 10ha based on AWiFS satellite data, 2022

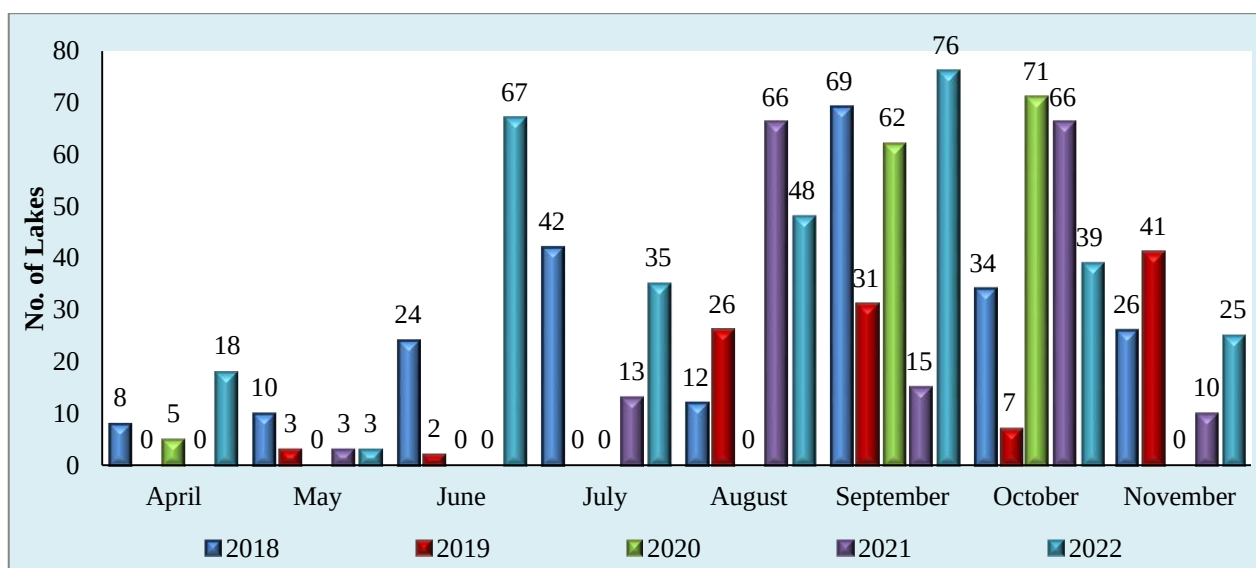


Fig. 9.4: Total No. of Lakes > 10ha based on AWiFS satellite data (2018- 2022)

When the total number of lakes based on AWiFS data are seen w.r.t. 2007 (196) as the base line data , a gradual increase in their number could be seen with some abnormalities in the beginning, whereas a gradual increasing trend could be seen from 2012 onwards and the number varies from 214 (2011) to 128 (2012) to 130 (2013) to 192 (2014) to 241 (2015) to 280 (2016) to 280 (2017) to 273 (2018) to 229 (2019) to 361 (2020) to 414 (2021) to 414 (2022) (Fig: 9.5) indicating a slight variation in 2018 and 2019. Further out of 414 lakes mapped in 2022, 39 are the high altitude wetlands that too from the Upper Satluj basin out of which 12 are with more than 10ha, 13 are having area between 5 -10 ha and 14 are smaller one with area less than 5ha respectively.



Fig. 9.5: Total Number of Lakes based on AWiFS Data (2011-2022)

Based on the LISS-III satellite data analysis (96-48, 97-48, 97-49, 98-48, 98-49, 99-49 and 100-49) a total of 995 lakes mapped in 2022 comprises of 850 lakes as the small one with area less 5ha, 83 lakes with area 5-10 ha and 62 lakes with area more than 10ha (Fig: 8.2-8.4). In view of the data gaps in 2022 for LISS III sensor, maximum number of lakes mapped in 2022 from LISS III and Landsat 8 data forms part of the path-row 96-48 & 96-49 (478) (Fig: 8.2) and 99-49 & 100-49 (362) (Fig: 8.4). The maximum number of forms part of the sub basin 3 i.e. Upper Satluj basin (639) followed by 173 from the Lower Satluj and 183 from the Spiti basins i.e. sub basin 1 (Table 9.1).

Table 9.1: Basin wise distribution of total number of lakes in Satluj Catchment during the year 2022 based on LISS III and Landsat 8 Satellite data interpretation.

Date of Pass	No. of lakes in Basin 1	No. of lakes in Basin 2	No. of lakes in Basin 3	Total No. of lakes (2022)	Total No. of lakes with area >10 ha
Number of Lakes based on LISS III satellite Data during 2022					
96-48 & 96-49 (28 August 2022)	183	173	122	478	14
97-48 & 98-48 (02 Sept 2022)	0	0	155	155	6
99-49 & 100-49 (12 sept 2022)	0	0	362	362	42

Further out of 995 lakes mapped, 71 are mainly the high-altitude wetlands comprising 1 from Spiti basin, 3 from Lower Satluj basin and 67 from Upper Satluj basin respectively. The comparative analysis based on LISS-III satellite data reveals that total number of lakes varies from 769 (2018) to 562 (2019) to 993 (2020) to 880 (2021) and 995 (2022) (Fig:9.7) indicating an overall enhancement about 29% (2018), 77% (2019) , 0.2% (2020) and 21% (2021) respectively as compared to 2022. As far as the big lakes with area more than 10ha are concerned, total number of big lakes varies from 49 (2018) to 51 (2019) to 49 (2020) to 56 (2021) to 62(2022) (Fig: 9.9) indicating a fluctuating trend in the lakes/wetlands with area >10ha based on LISS III data analysis. The total variation in the number of lakes mapped in Upper Satluj basin based on LISS III data varies from 495 (2018) to 437 (2019) to 707 (2020) to 588 (2021) to 639(2022) (Fig 8.3), in Lower Satluj basin the number varies from 98 (2018) to 52 (2019) to 89 (2020) to 163(2021) to (173)2022 (Fig 8.2) and in case of Spiti sub basin it varies from 176 (2018) to 73 (2019) to 197 (2020) to 129(2021) to 183 (2022)(Fig.8.1) indicating an reduction of about 11% (2018-19) and further enhancement by about 61% (2019-20) , about 16% reduction (2020-21) and again rise by 9% (2021-22) in case of Upper Satluj basin, a reduction of about 46% (2018-19), enhancement by

71% (2019-20) and further enhancement by 83% (2020-21) and 6% (2021-22) in case of Lower Satluj and reduction of about 58% (2018-19) and enhancement by about 116% (2019-20) and reduction of about 34% in 2020-21 and further enhancement of about 41% in 2021-22 in case of Spiti basin could be seen. Further in Spiti basin the lakes with ids 1682RS (2.05ha), 1683RS (11.82ha), 1684RS (3.81ha), 1685RS (2.37ha), 1686RS (0.43ha), 1687RS (1.19ha), 9003RS (1.59ha), 9004RS (0.55ha), in Lower Satluj basin lakes with ids 9207RS (4.55ha), 9058RS (0.41ha), and in Upper Satluj basin, the lakes with ids 1557RS (71.15ha), 1771RS (13.73ha), 1772RS (4.89ha), 1775RS (5.57ha) 2170RS (2.32ha) and 10326RS (13.47) are some of the water bodies which have been developed along the nala sections in the different sub basins. All these water bodies are although small but needs monitoring to be (Fig.9.11a and 9.11b). Thus from the above analysis for the period 2022, it is clear that although the maximum number of lakes (about 64%) are being formed in the Upper Satluj basin, about 17% in the Lower Satluj basin and about 18% in the Spiti basin of the study area and majority of the lakes delineated in the entire study area during 2022 are small one with area less than 5ha (about 86%), about 9% are within 5-10 ha and about 5% with area more than 10ha reflects that the Upper Satluj basin is more susceptible for undergoing climate induced changes resulting to have higher number of such lakes than the Lower Satluj and Spiti basin.

Thus to summaries based on the results obtained by using AWiFS and LISS III data products, the results obtained using AWiFS reflecting no change in the total number of lakes. Reduction of about 13% in Spiti basin, 48% increase in Lower Satluj and again decreased by 4% in the Upper Satluj basin could be seen in 2022 from AWiFS data analysis in comparison to 2021 and the maximum lakes (72%) of the total 414 lakes have been mapped from Upper Satluj, 14% and 14% from Lower Satluj and Spiti sub-basins respectively. In case of the bigger lakes with area >10ha, about 15% increase could be seen in 2022 (76) in comparison to 2021 (66) majority of the lakes (63) forming part of the Upper Satluj basin, 6 from the Lower Satluj basin and 7 from the Spiti basin. Out of 414 lakes, 39 are the high altitude wetlands and the remaining lakes were from the glacial origin. Besides this on during August 2022, wherein a total of 350 lakes were also mapped, out of which 48 lakes were with area more than 10ha comprising 2 lakes were as the high altitude wetlands and the remaining 348 were the lakes from glacial origin as a whole in the entire study area. Likewise, LISS-III data indicates enhancement of about 13% in terms of the total number of lakes and as far as lakes with area more than 10ha are concerned from LISS III data, an

increase of 11% could be seen. The comparative analysis based on LISS-III satellite data reveals that total number of lakes varies from 769 (2018) to 562 (2019) to 993 (2020) to 880 (2021) to 995 (2022) indicating an reduction of about 26% between 2018-19, enhancement of about 76% between 2019-20, further reduction of about 11% between 2020-21 and enhancement of about 13% between 2021-22 respectively. Thus, the data base based on AWiFS data product is reflects a complete inventory of lakes 414 lakes in the Satluj catchment with a coarse resolution (56mts) as the data product used covers the complete study area and also free from the impact of clouds as in September 2022, whereas the LISS-III data products reflect a more detailed inventory of the 995 lakes of with a set of fine resolution (23.5mts) reflecting more detailed information about the lakes with small dimensions.

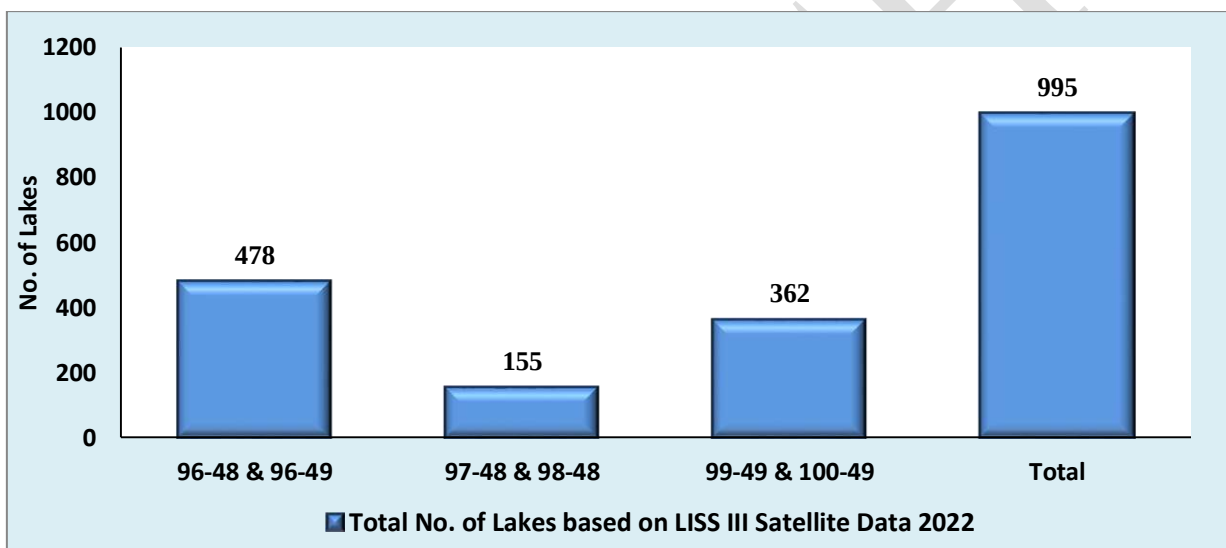


Fig. 9.6: Total No. of Lakes based on LISS III Satellite Data, 2022

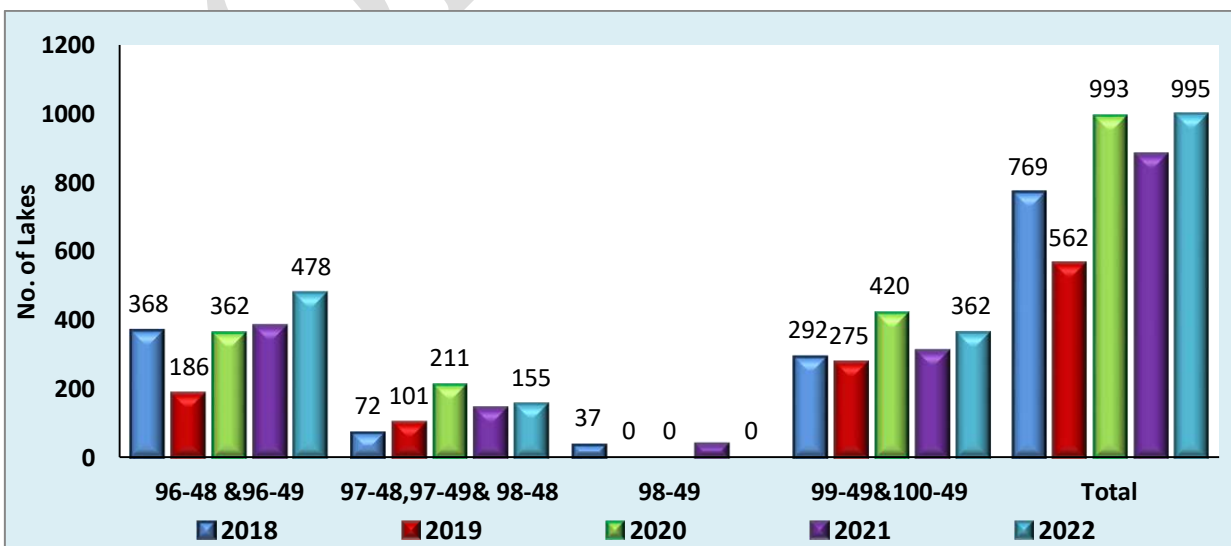


Fig. 9.7: Total No. of Lakes based on LISS III Satellite Data (2018- 2022)

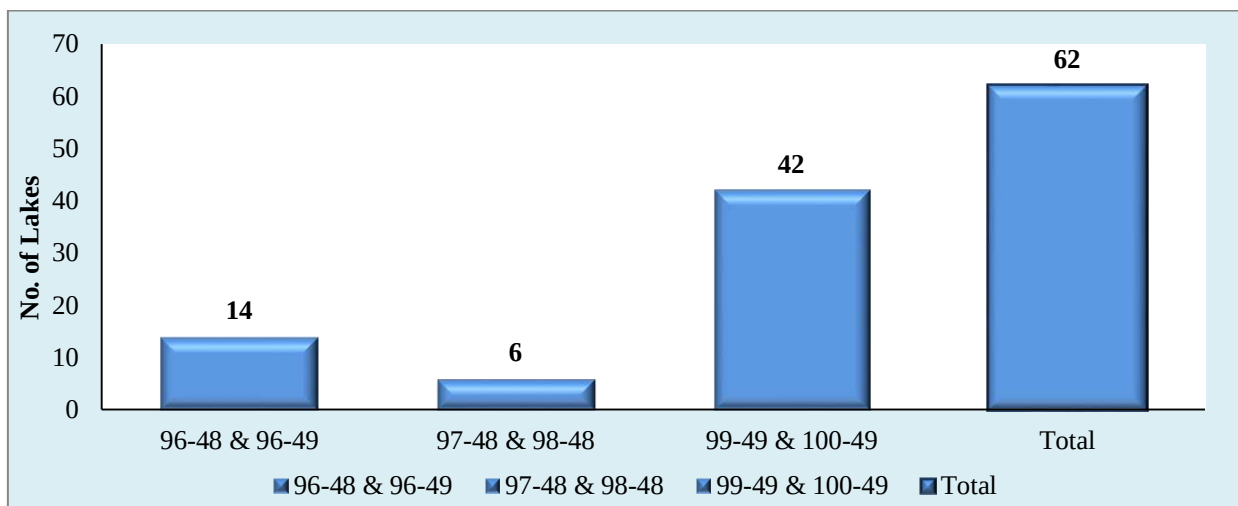


Fig. 9.8: Total No. of Lakes > 10ha based on LISS III Satellite Data 2022

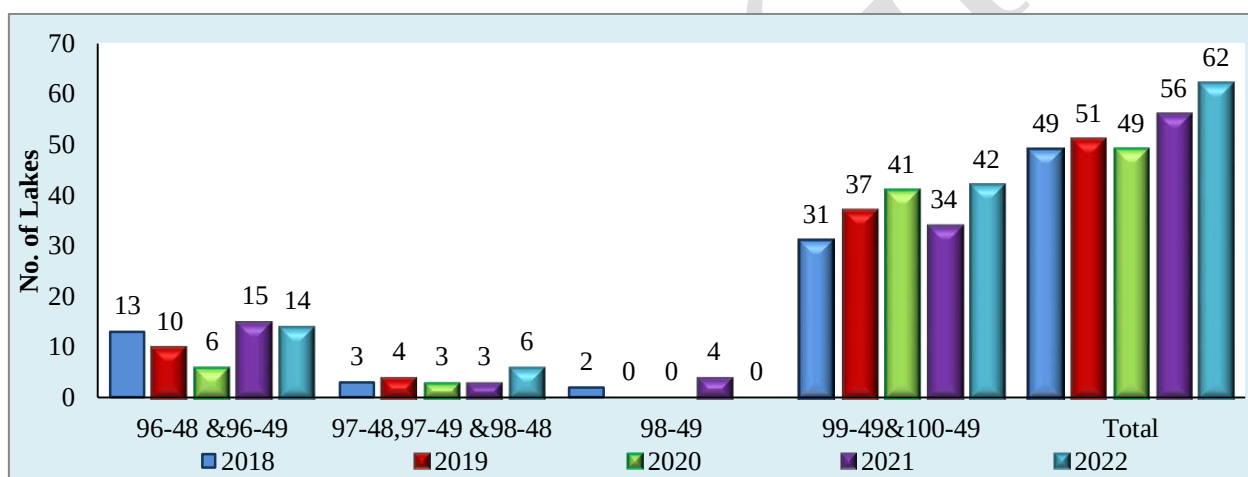


Fig. 9.9: Total No. of Lakes >10ha based on LISS III Satellite Data 2018, 2019, 2020, 2021 and 2022

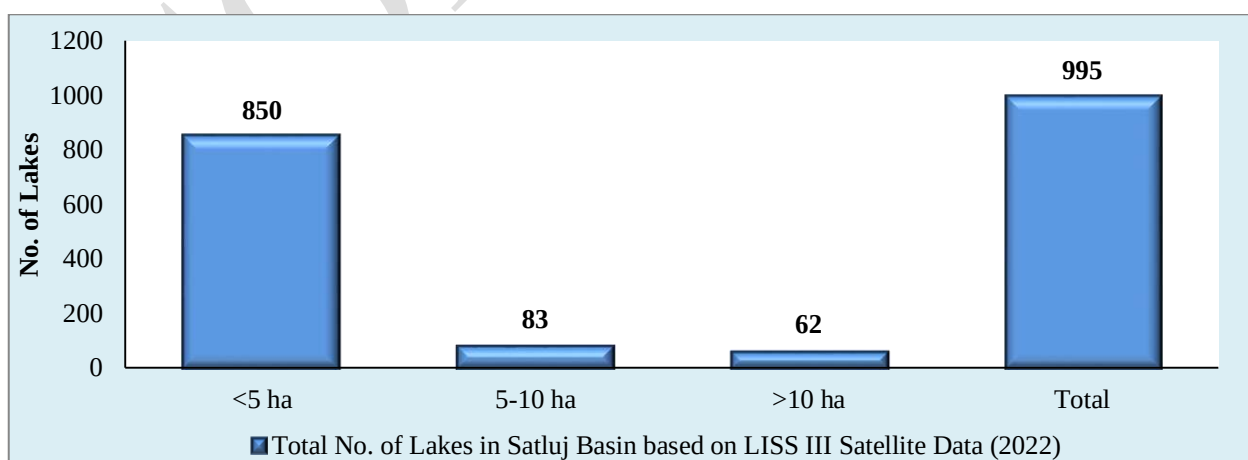


Fig. 9.10: Total No. of Lakes in Satluj Basin based on LISS III Satellite Data (2022)

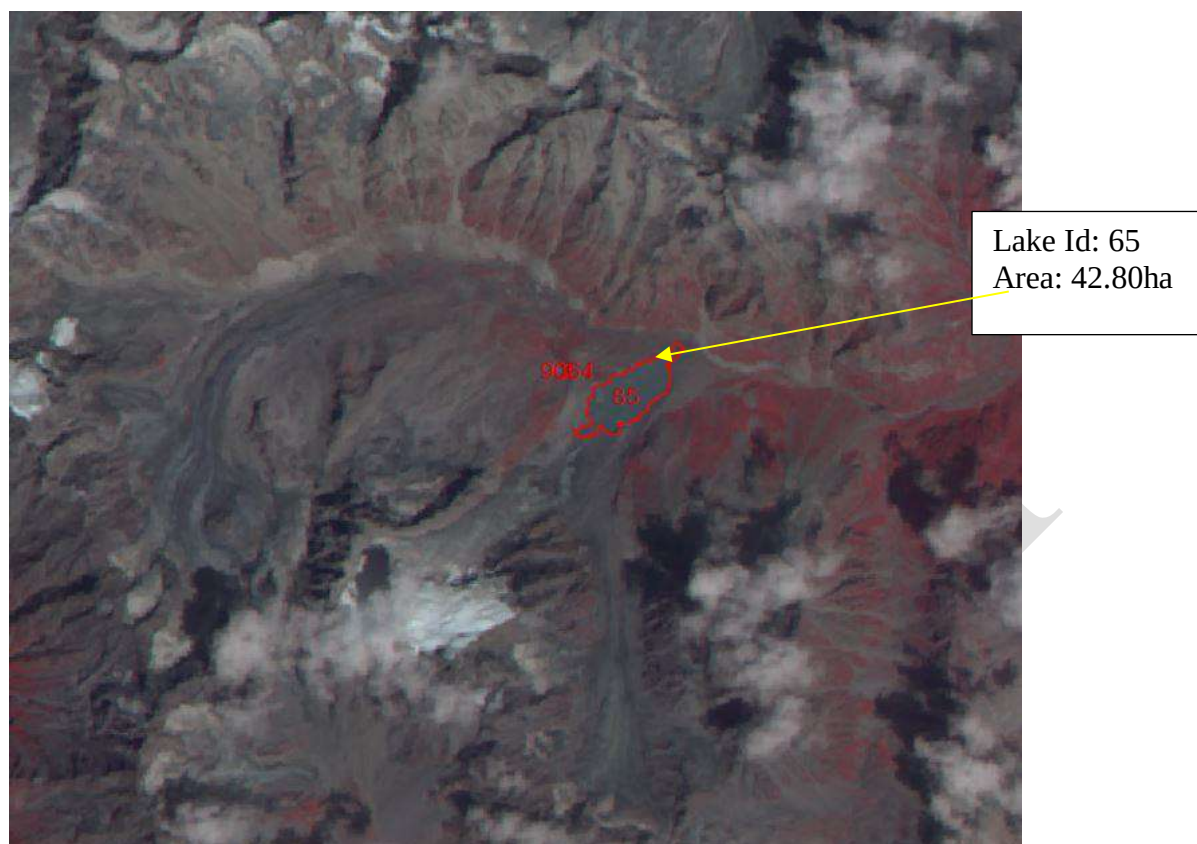


Fig. 9.11 (a): Satellite view, LISS III of water bodies in Spiti basin



Fig. 9.11 (b): Satellite view, LISS III of water bodies along the River Section in Spiti basin

10.0: Inventory of lakes based on LISS -IV satellite data for 2022

Besides the two datasets generated during 2022 using AWiFS (56mts) and LISS-III (23.5mts), from 2020 onwards very high resolution inventory using LISS IV with spatial resolution of 5.8 mts was also initiated that gives a very precise information of the catchment and by virtue of which it has become possible to map all those lakes/water bodies of size less than 23.5 mts. Although the data procurement of the LISS-IV sensor is always a challenge due to its very fine resolution and the less swath in comparison to the LISS III and AWiFS sensors, however an attempt has been made in 2022 to procure whatever data which is cloud free and snow free was browsed, acquired and analyzed. The data which was available mainly falls within 96-48a, 96-48c, 97-48a, 97-48c, 97-49b, 98-49a, 98-48c, 98-49c, 100-49c and sentinel data to fill the gap (**Fig.10.1a-m**) & (**Table 10.1- 10.6**).

10.1 Interpreted layer of LISS-IV data in Satluj Basin in 2022

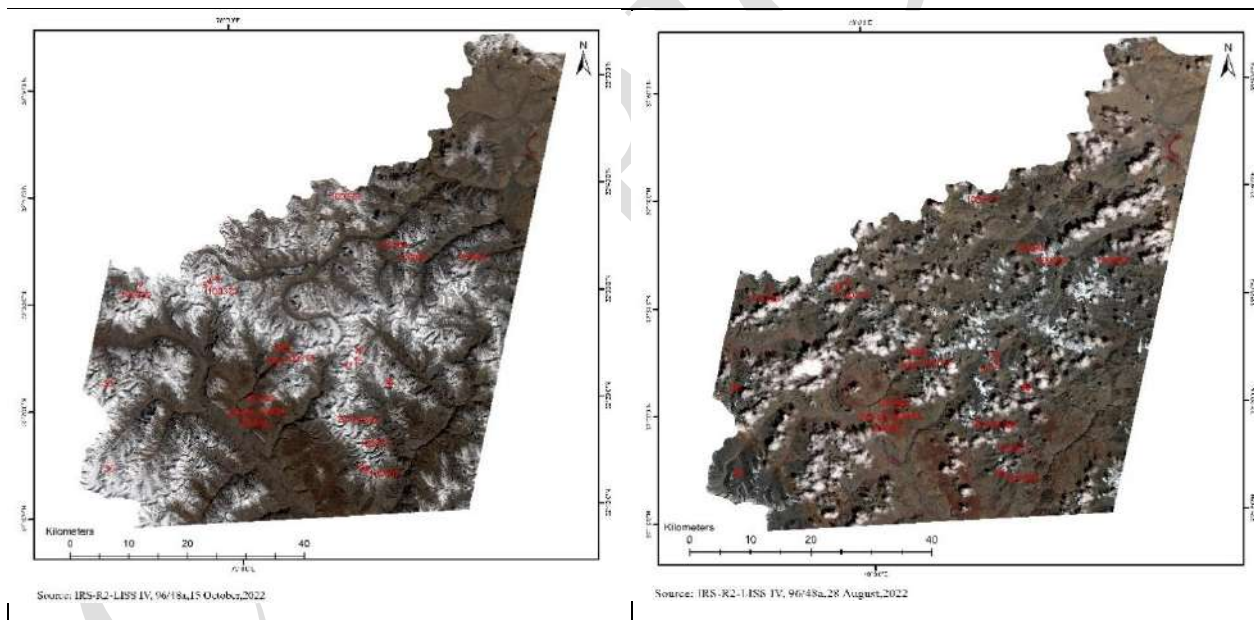


Fig10.1 (a) & (b): IRS R2, LISS IV, 96/48 a, 15 October, 2022 and 28 August, 2022

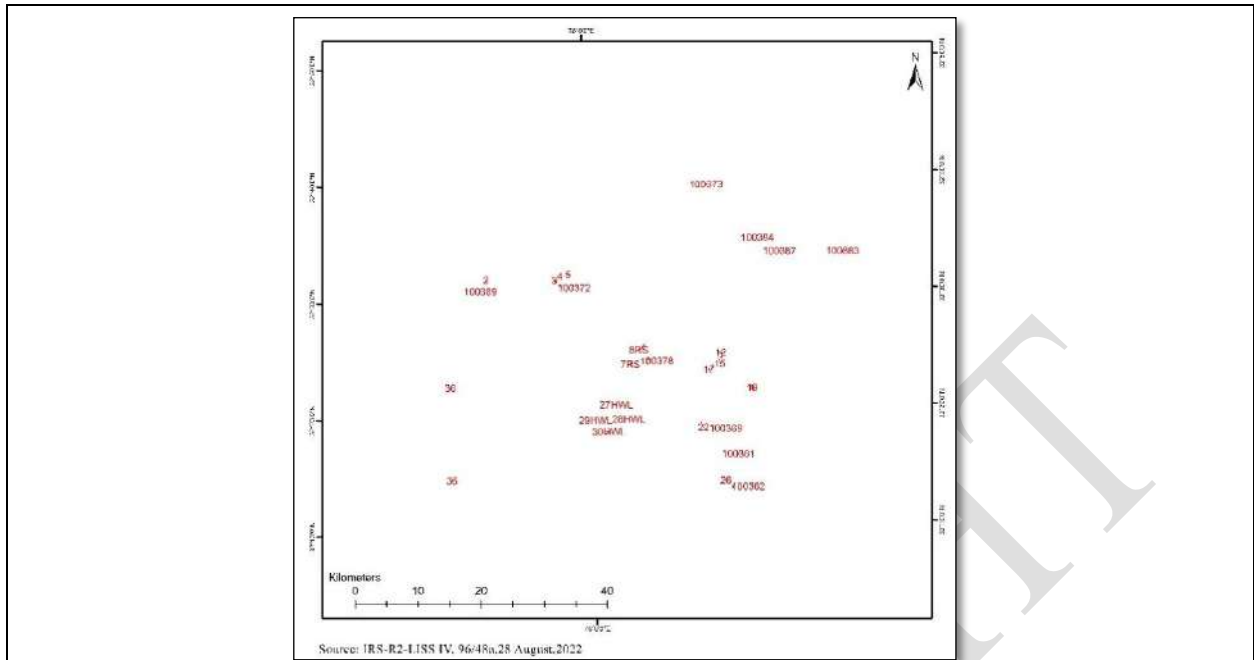


Fig10.1 (c): Interpreted layers, IRS R2, LISS IV, 96/48 a, 15 October, 2022 and 28 August, 2022

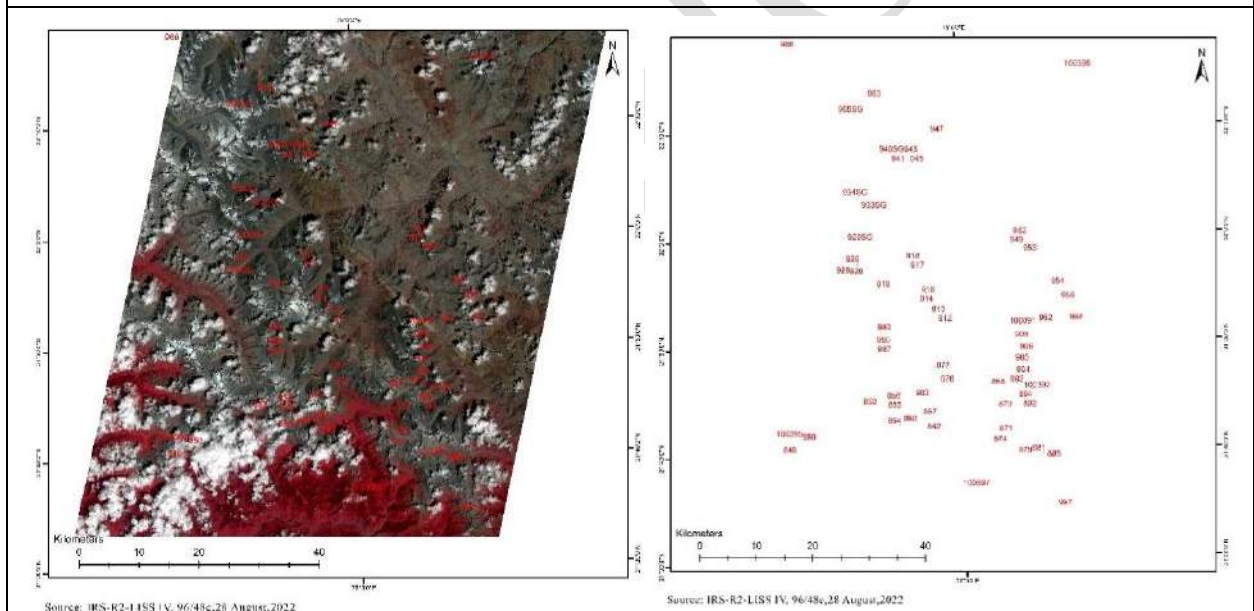


Fig10.1 (d)& (e): IRS R2, LISS IV, 96/48 c, 28 August, 2022 and Interpreted layers

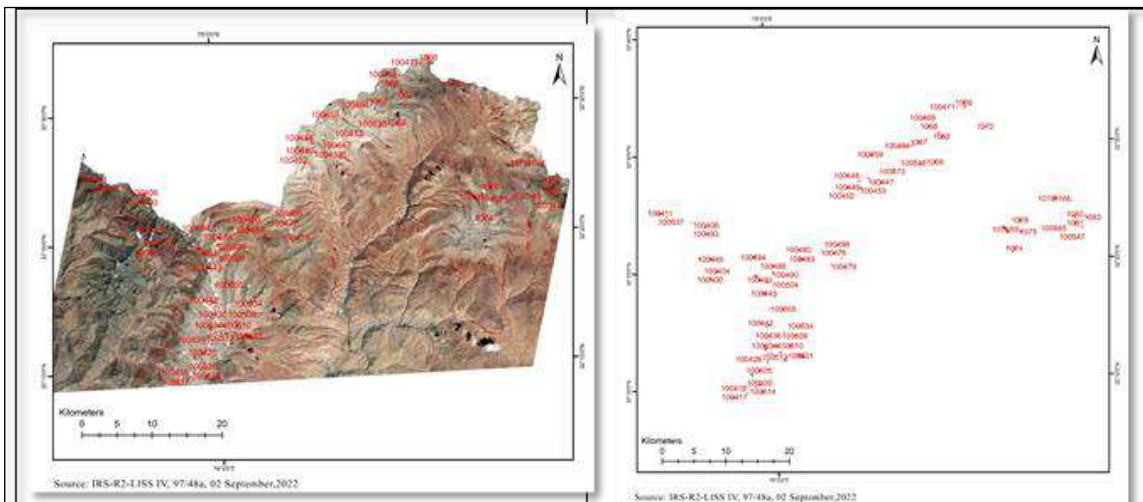


Fig10.1 (f)& (g): IRS R2, LISS IV, 97/48 a, 2 September, 2022 and Interpreted layers

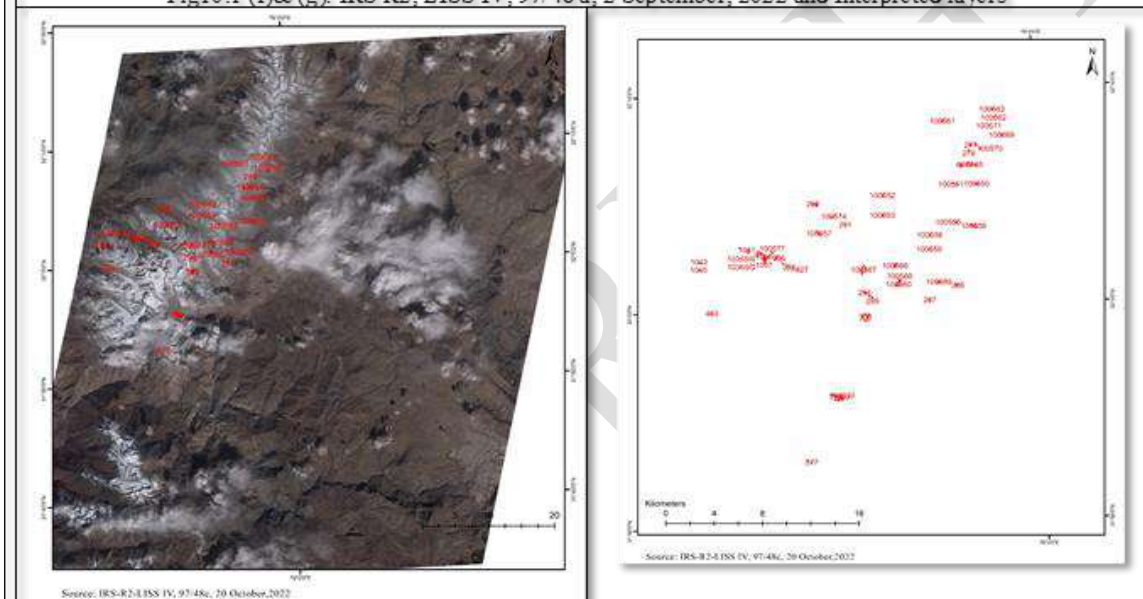


Fig10.1 (h)& (i): IRS R2, LISS IV, 97/48 c, 20 October, 2022 and Interpreted layers

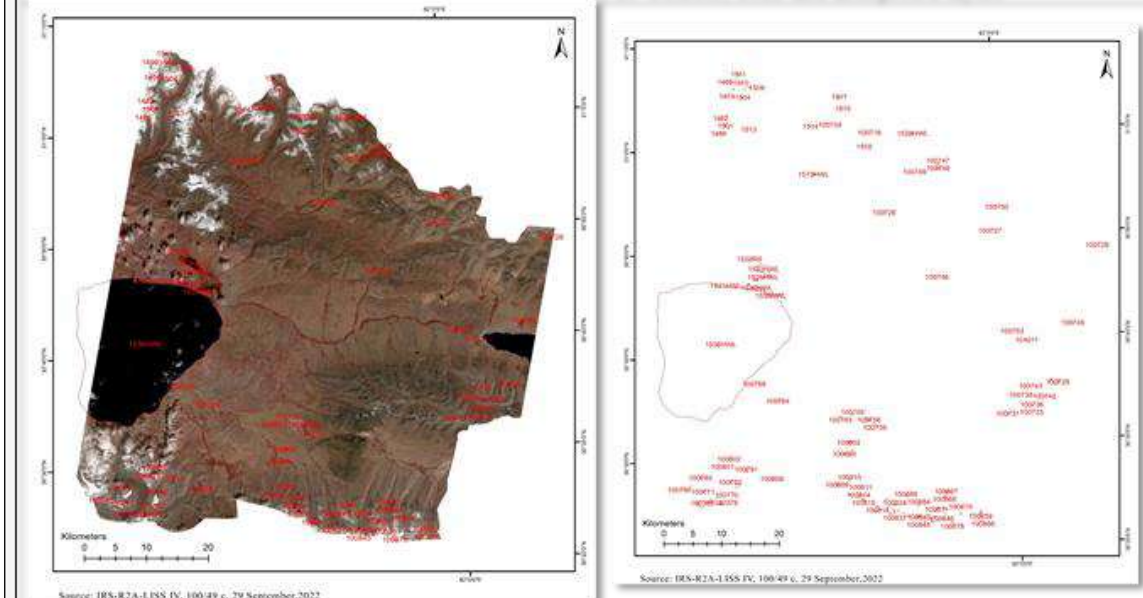


Fig10.1 (j)& (k): IRS R2, LISS IV, 100/49 c, 29 September, 2022 and Interpreted layers

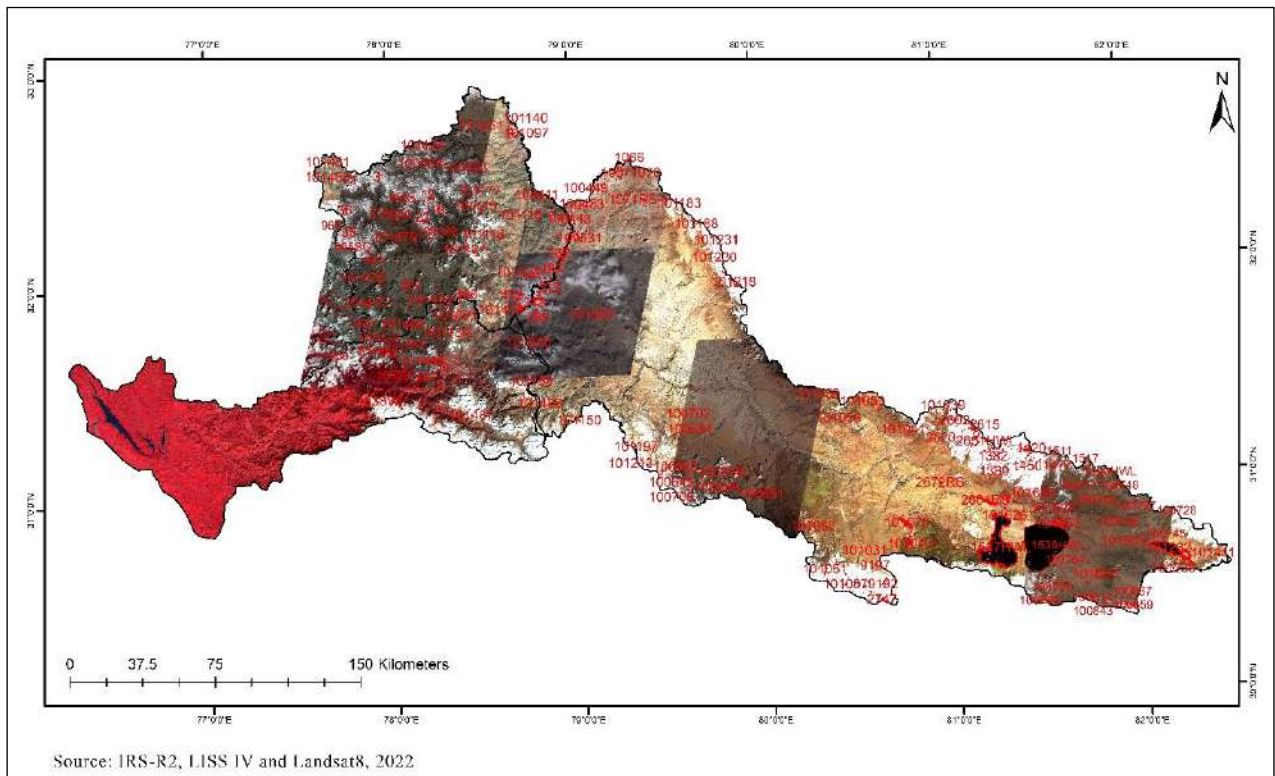


Fig. 10.2: LISS-IV data and Sentinel Data in Satluj Basin in 2022

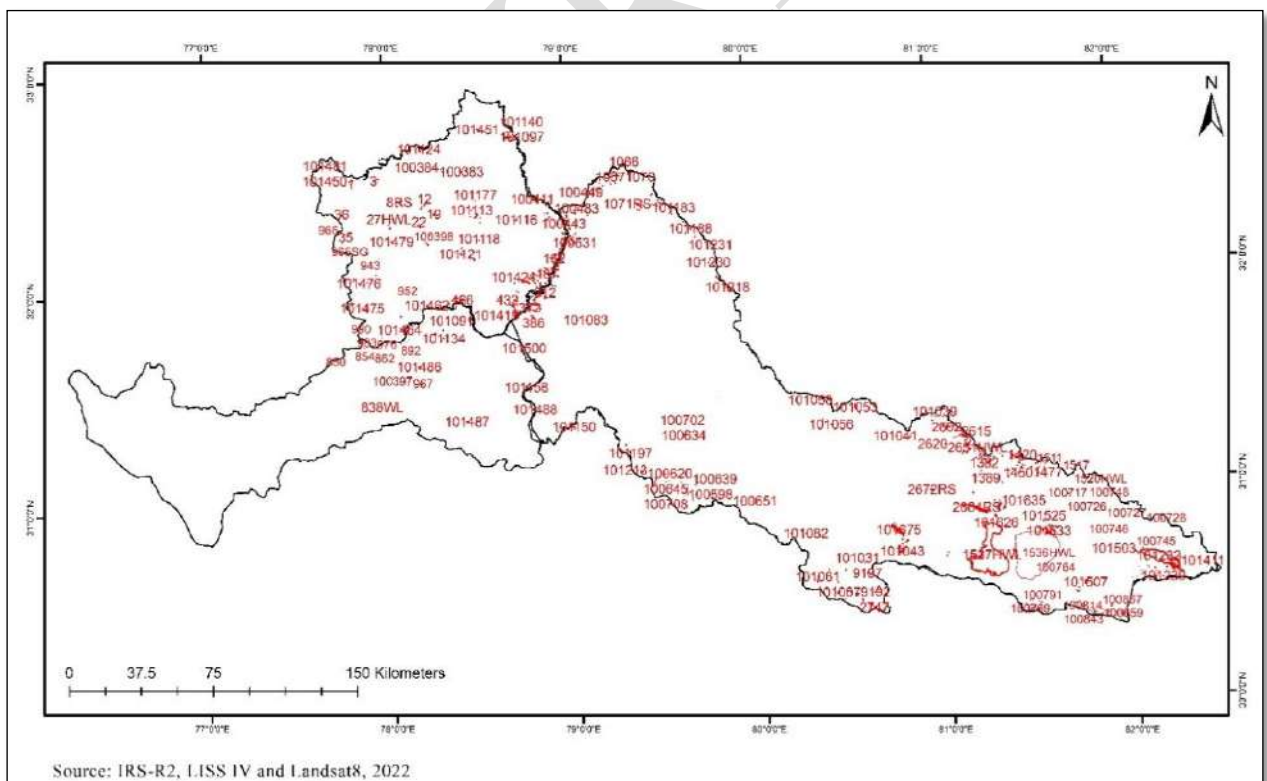


Fig. 10.3: Interpreted layer of LISS-IV and Sentinel data in Satluj Basin in 2022

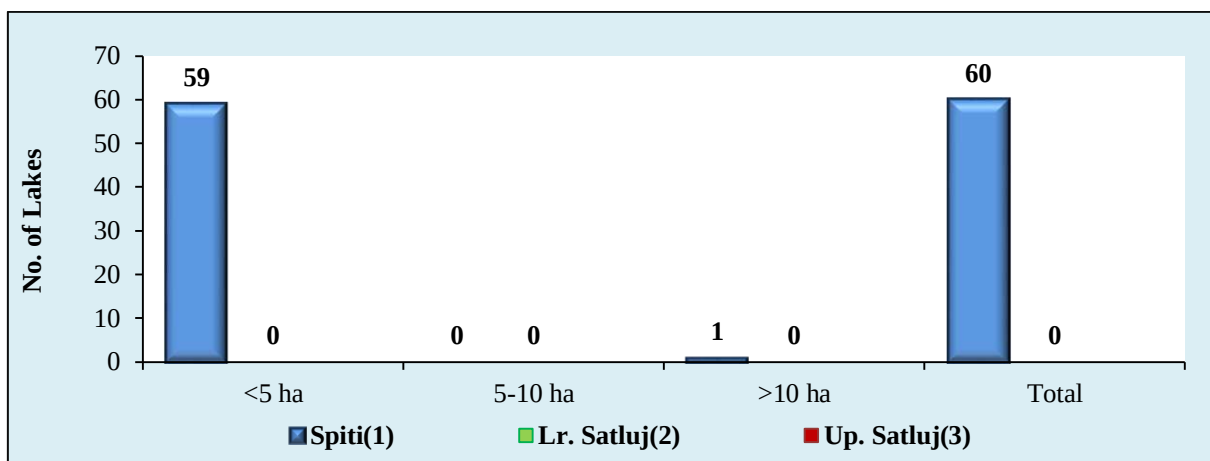


Fig. 10.4: No of lakes based on LISS-IV image 96/48a, 2022

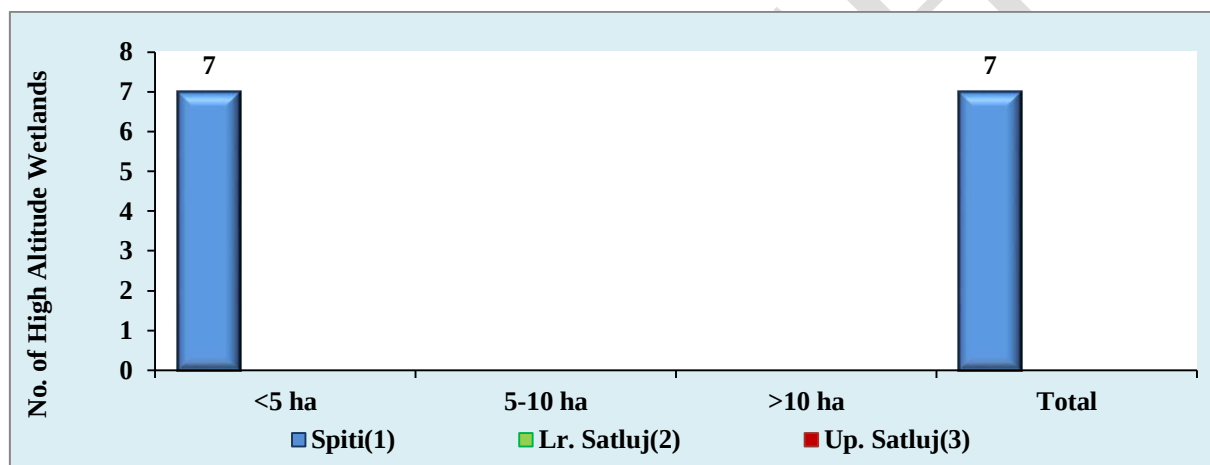


Fig. 10.5: No. of high altitude wetland Lakes based on LISS-IV image 96/48a, 2022

Table: 10.1 Distribution of Lakes as per satellite data interpretation for 96/48a, 2022 using LISS-IV sensor

Sr.No.	Lake Id.	Basin No.	Longitude	Latitude	Aerial Extent on 2022
1	2	1	77.8284	32.528	0.36
2	3	1	77.9435	32.525	2.06
3	4	1	77.9495	32.5305	0.10
4	5	1	77.9668	32.5333	0.80
5	6	1	77.9662	32.5297	0.18
6	12	1	78.2204	32.4155	1.70
7	13	1	78.2219	32.4145	0.06
8	14	1	78.2212	32.4089	0.12
9	15	1	78.2177	32.4055	0.17
10	16	1	78.2062	32.3988	0.16
11	17	1	78.1995	32.3917	0.23
12	18	1	78.2706	32.3675	0.19
13	19	1	78.2721	32.3638	12.18

14	22	1	78.1877	32.3097	0.35
15	23	1	78.1943	32.3055	0.03
16	26	1	78.2229	32.2331	0.44
17	35	1	77.7624	32.2425	1.76
18	36	1	77.7632	32.375	0.16
19	100361	1	78.245	32.2703	0.21
20	100362	1	78.2345	32.2239	0.05
21	100363	1	78.2339	32.2234	0.04
22	100364	1	78.2341	32.2222	0.04
23	100365	1	78.2334	32.225	0.02
24	100366	1	77.9438	32.5236	0.77
25	100367	1	78.1834	32.3173	0.27
26	100368	1	78.1841	32.318	0.11
27	100369	1	78.2031	32.3076	0.13
28	100370	1	78.2068	32.308	0.01
29	100371	1	77.9475	32.5253	0.05
30	100372	1	77.9548	32.5165	0.14
31	100373	1	78.2043	32.6564	0.23
32	100374	1	78.2037	32.6573	0.16
33	100375	1	78.204	32.6575	0.01
34	100376	1	78.1989	32.6601	0.03
35	100377	1	78.0699	32.4048	1.27
36	100378	1	78.1004	32.4081	0.07
37	100379	1	78.0998	32.4086	0.04
38	100380	1	78.0987	32.4097	0.02
39	100381	1	78.4314	32.5552	0.35
40	100382	1	78.4313	32.5546	0.14
41	100383	1	78.431	32.5555	1.34
42	100384	1	78.2877	32.5784	0.09
43	100385	1	78.288	32.5794	0.02
44	100386	1	78.4337	32.5571	0.09
45	100387	1	78.3243	32.5583	0.48
46	100388	1	78.3234	32.5588	0.02
47	100389	1	77.8181	32.5121	0.13
48	100390	1	78.2869	32.5815	0.05
49	27HWL	1	78.0419	32.3453	0.44
50	28HWL	1	78.0625	32.324	0.09
51	29HWL	1	78.018	32.3197	0.03
52	30HWL	1	78.0283	32.3071	0.15
53	31HWL	1	78.0269	32.3064	0.09
54	32HWL	1	78.024	32.3047	0.07
55	33HWL	1	78.0245	32.3042	0.04
56	7RS	1	78.0676	32.4023	1.12
57	8RS	1	78.0823	32.4228	3.04

58	9RS	1	78.0887	32.4264	1.82
59	10RS	1	78.0903	32.4279	0.91
60	11RS	1	78.0928	32.431	0.30

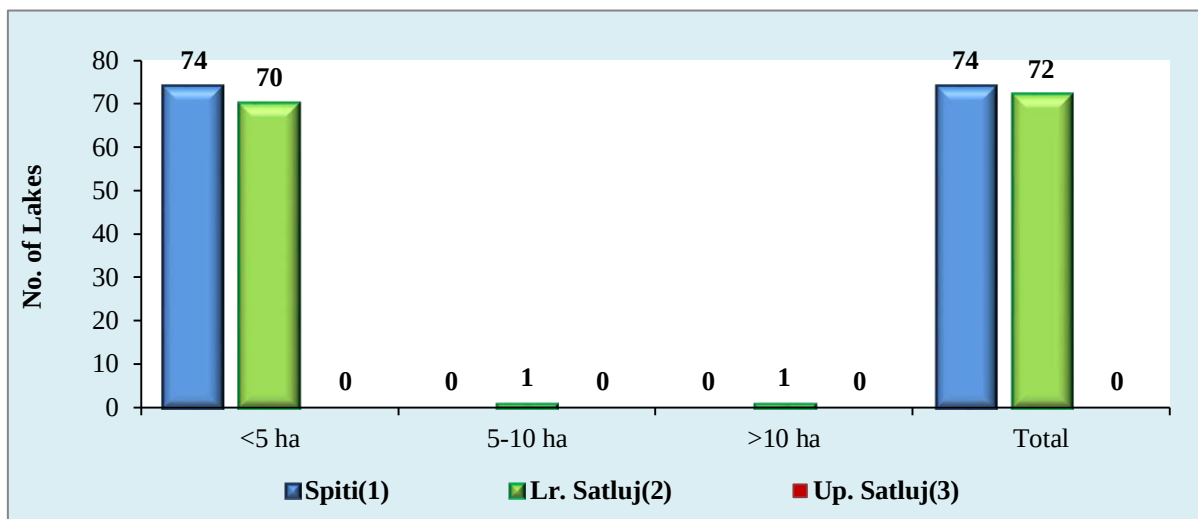


Fig. 10.6: No of lakes based on LISS-IV image 96/48c, 2022

Table: 10.2 Distribution of Lakes as per satellite data interpretation for 96/48c, 2022 using LISS-IV sensor

Sr. No.	Lake Id.	Basin No.	Longitude	Latitude	Aerial Extent on 2022
1	840	2	77.6649	31.6755	0.33
2	841	2	77.667	31.6741	0.21
3	845	2	77.6722	31.6792	0.37
4	846	2	77.6744	31.6771	0.95
5	850	2	77.7111	31.6962	2.70
6	851	2	77.825	31.7487	0.14
7	852	2	77.8264	31.7487	0.33
8	853	2	77.8812	31.7119	0.42
9	854	2	77.8714	31.7183	1.59
10	855	2	77.8723	31.7448	0.15
11	856	2	77.8709	31.7571	0.21
12	857	2	77.8663	31.7592	0.19
13	858	2	77.8964	31.7251	0.28
14	860	2	77.9006	31.7209	1.36
15	861	2	77.903	31.7218	0.73
16	862	2	77.9452	31.7079	1.48
17	864	2	77.9456	31.7068	0.02
18	865	2	77.9458	31.7065	0.17
19	866	2	77.9475	31.706	0.04

20	867	2	77.9374	31.7307	0.61
21	868	2	78.0666	31.775	0.52
22	869	2	78.0664	31.7739	0.28
23	870	2	78.0787	31.7396	0.09
24	871	2	78.079	31.7019	0.81
25	872	2	78.0805	31.6877	0.02
26	873	2	78.0696	31.6809	0.12
27	874	2	78.0675	31.686	0.18
28	875	2	78.0636	31.685	0.03
29	876	2	78.0633	31.6851	0.07
30	877	2	78.0636	31.6855	0.09
31	878	2	78.0616	31.6866	0.11
32	879	2	78.1247	31.6673	0.09
33	880	2	78.1386	31.6695	0.04
34	881	2	78.1391	31.6704	0.43
35	882	2	78.1487	31.6623	0.12
36	883	2	78.1596	31.662	0.34
37	884	2	78.1671	31.6628	0.24
38	885	2	78.1668	31.6606	30.17
39	886	2	78.1623	31.6582	0.51
40	887	2	78.163	31.6576	0.04
41	888	2	78.1627	31.6574	0.03
42	889	2	78.1627	31.6572	0.01
43	890	2	78.1622	31.6566	0.13
44	891	2	78.1261	31.7371	0.26
45	892	2	78.1244	31.7396	2.82
46	893	2	78.115	31.7402	0.04
47	894	2	78.117	31.7486	0.34
48	895	2	78.1254	31.7536	0.18
49	896	2	78.1254	31.7596	0.22
50	897	2	78.1269	31.7615	0.23
51	898	2	78.1277	31.7617	0.03
52	899	2	78.1284	31.7618	0.06
53	901	2	78.1012	31.7774	0.06
54	902	2	78.1018	31.778	0.53
55	903	2	78.1037	31.7782	0.34
56	904	2	78.1139	31.7911	0.17
57	905	2	78.113	31.8107	0.21
58	906	1	78.1212	31.8276	0.11
59	907	1	78.1082	31.8461	0.05
60	908	1	78.1131	31.8466	0.07
61	909	1	78.1086	31.8624	0.03
62	910	1	78.1019	31.8641	0.04
63	911	1	77.9713	31.8801	0.02

64	912	1	77.9709	31.8799	0.04
65	913	1	77.9581	31.889	0.09
66	914	1	77.937	31.9108	0.02
67	915	1	77.9366	31.9147	0.07
68	916	1	77.9401	31.9194	0.10
69	917	1	77.9216	31.962	0.03
70	918	1	77.9134	31.9722	0.06
71	919	1	77.8567	31.9298	0.07
72	920	1	77.7975	31.9509	0.15
73	921	1	77.7972	31.9516	0.15
74	922	1	77.8091	31.9597	0.07
75	923	1	77.8081	31.9605	0.03
76	924	1	77.8087	31.9609	0.01
77	925	1	77.8106	31.9619	0.17
78	926	1	77.8	31.9699	0.21
79	927	1	77.7876	31.9632	0.17
80	928	1	77.782	31.9529	0.74
81	941	1	77.8906	32.1246	0.04
82	943	1	77.9144	32.1367	1.66
83	944	1	77.9154	32.137	0.04
84	945	1	77.9252	32.1286	1.42
85	946	1	77.9643	32.1663	0.07
86	947	1	77.9644	32.1672	0.56
87	948	1	77.964	32.1681	0.05
88	949	1	78.1151	31.9977	0.15
89	950	1	78.1188	31.9985	0.03
90	951	1	78.114	32.0058	0.05
91	952	1	78.1149	32.0069	0.44
92	953	1	78.1324	31.9798	1.90
93	954	1	78.1826	31.9272	0.21
94	955	1	78.1805	31.934	0.09
95	956	2	78.2009	31.9051	0.19
96	957	2	78.2133	31.8698	0.04
97	958	2	78.2155	31.8709	0.28
98	959	2	78.214	31.8687	0.12
99	960	2	78.2085	31.8661	0.04
100	961	1	78.158	31.8707	0.02
101	962	1	78.1586	31.8712	0.13
102	963	1	77.8484	32.2245	0.12
103	966	1	77.6871	32.304	0.10
104	967	2	78.1855	31.5851	5.28
105	968	2	78.1808	31.5873	0.14
106	969	2	78.1778	31.5845	0.59
107	976	2	77.972	31.7809	0.12

108	977	1	77.9649	31.8025	0.29
109	978	1	77.9657	31.8024	0.02
110	979	1	77.9674	31.803	0.06
111	980	1	77.9656	31.8037	0.28
112	981	1	77.9648	31.8037	0.05
113	982	1	77.9649	31.8056	0.23
114	983	1	77.9245	31.76	0.56
115	984	1	77.9243	31.7668	0.12
116	985	1	77.8496	31.825	0.09
117	986	1	77.8553	31.8305	0.03
118	987	1	77.8554	31.831	0.10
119	988	1	77.8506	31.8416	0.01
120	989	1	77.8512	31.8422	0.04
121	990	1	77.8543	31.8432	0.42
122	991	1	77.8514	31.8612	0.04
123	992	1	77.8522	31.8618	0.07
124	993	1	77.8564	31.8636	0.41
125	100391	1	78.1158	31.8674	1.91
126	100392	2	78.1313	31.7624	0.04
127	100393	2	77.8727	31.7453	0.02
128	100394	2	77.8719	31.7169	0.05
129	100395	2	77.6862	31.7017	1.78
130	100396	2	77.6833	31.7021	0.21
131	100397	2	78.0209	31.6189	4.30
132	100398	1	78.2308	32.2624	0.05
133	929SG	1	77.8153	32.0032	0.03
134	930SG	1	77.8336	32.0456	0.04
135	932SG	1	77.8424	32.0506	0.03
136	933SG	1	77.8428	32.0525	0.19
137	934SG	1	77.8079	32.0732	0.11
138	935SG	1	77.8154	32.0747	0.03
139	936SG	1	77.8159	32.0771	0.07
140	937SG	1	77.8229	32.0782	0.06
141	938SG	1	77.8824	32.1344	0.03
142	939SG	1	77.8844	32.1375	0.01
143	940SG	1	77.887	32.1378	0.08
144	942SG	1	77.9111	32.13	0.04
145	964SG	1	77.8033	32.2054	0.15
146	965SG	1	77.8036	32.2016	0.37

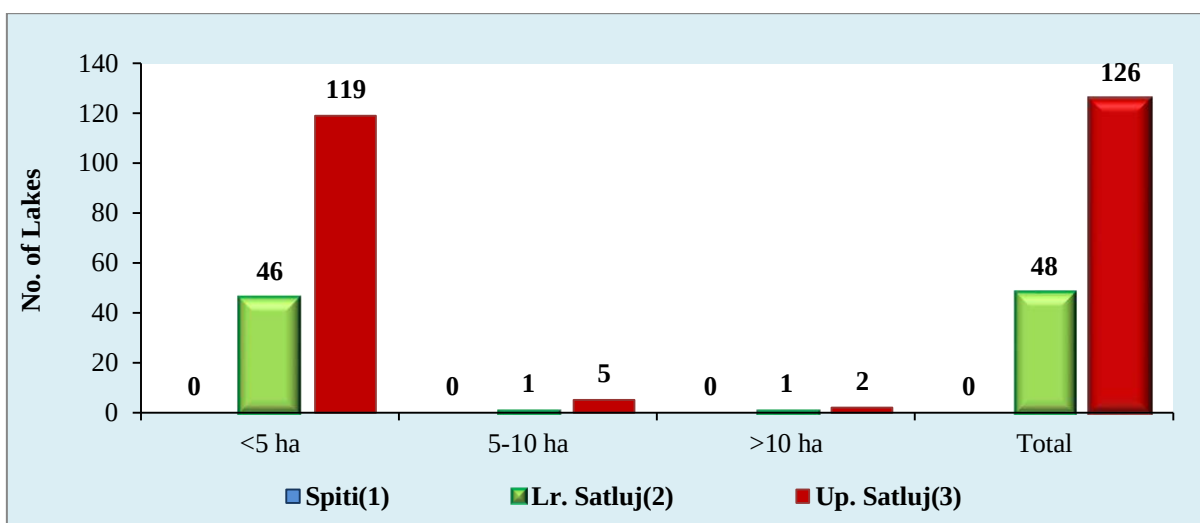


Fig. 10.7: No of lakes based on LISS-IV image 97/48a, 2022

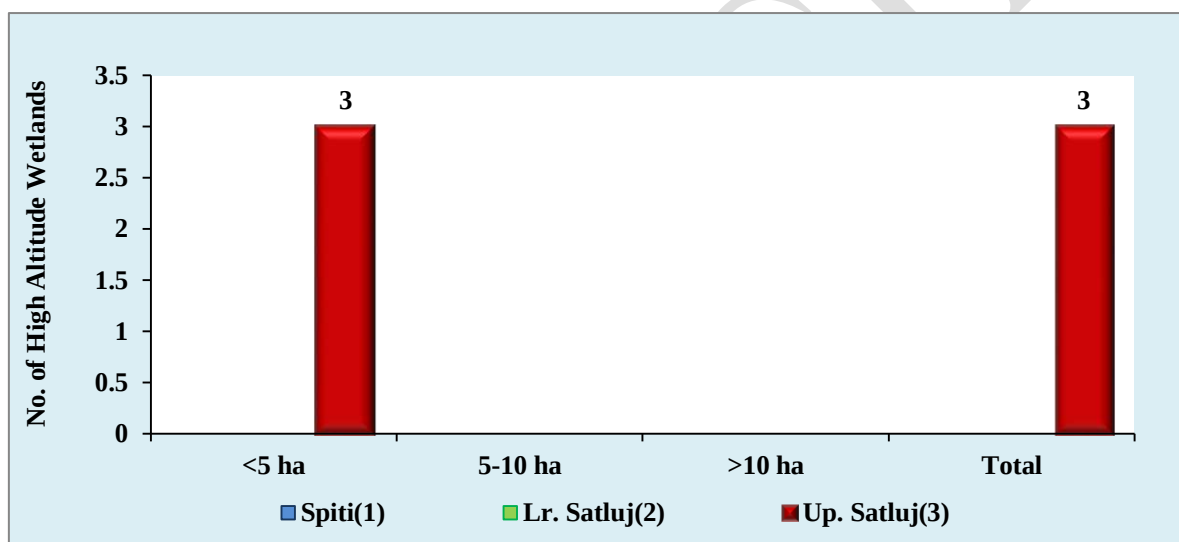


Fig. 10.8: No. of high altitude wetlands based on LISS-IV image 97/48a, 2022

Table: 10.3 Distribution of Lakes as per satellite data interpretation for 97/48a, 2022 using LISS-IV sensor

Sr.No.	Lake Id.	Basin No.	Longitude	Latitude	Aerial Extent on 2022
1	1057	3	79.2539	32.5064	4.44
2	1058	3	79.2717	32.5282	1.76
3	1059	3	79.2793	32.4773	2.53
4	1060	3	79.2881	32.5197	0.73
5	1061	3	79.2864	32.5161	0.64
6	1062	3	79.2919	32.5128	1.99
7	1063	3	79.2979	32.5119	1.06
8	1064	3	79.2733	32.527	0.02
9	1065	3	79.3201	32.5537	0.40

10	1066	3	79.3316	32.56	2.76
11	1067	3	79.3319	32.5539	1.43
12	1068	3	79.333	32.5539	0.17
13	1070	3	79.3653	32.5249	0.68
14	1072	3	79.394	32.3518	0.37
15	1073	3	79.4035	32.3461	0.16
16	1074	3	79.4058	32.35	3.88
17	1075	3	79.4181	32.3734	2.24
18	1076	3	79.4172	32.3898	9.72
19	1080	3	79.5083	32.3922	1.89
20	1081	3	79.5086	32.3826	2.40
21	1082	3	79.5205	32.3766	0.74
22	1083	3	79.5297	32.39	0.59
23	100399	2	78.9076	32.3321	1.59
24	100400	2	78.897	32.3249	1.26
25	100401	2	78.8981	32.3228	0.04
26	100402	2	79.3336	32.5537	0.05
27	100403	2	79.2864	32.5153	0.10
28	100404	2	78.9091	32.3339	2.13
29	100405	2	78.8923	32.3968	0.05
30	100406	2	78.8934	32.3963	0.50
31	100407	2	78.8691	32.4043	0.05
32	100408	2	78.8691	32.404	0.03
33	100409	2	78.8422	32.4049	0.14
34	100410	2	78.8412	32.4051	0.03
35	100411	2	78.8174	32.4188	6.74
36	100412	2	78.8287	32.4211	0.75
37	100413	2	78.8279	32.4134	0.30
38	100414	2	78.9538	32.1587	0.16
39	100415	2	78.9525	32.1604	0.02
40	100416	2	78.9425	32.1618	0.05
41	100417	2	78.9305	32.1542	0.22
42	100418	2	78.9281	32.1542	0.03
43	100419	2	78.9305	32.1536	0.02
44	100420	2	78.9265	32.1548	0.02
45	100421	2	78.9542	32.1669	0.02
46	100422	2	78.9555	32.1724	0.02
47	100423	2	78.9537	32.1695	0.11
48	100424	2	78.9609	32.1848	2.96
49	100425	2	78.9731	32.1905	4.28
50	100426	2	78.9761	32.2064	0.30
51	100427	2	78.9837	32.2207	0.51
52	100428	2	78.9857	32.2217	0.38
53	100429	2	78.9873	32.2203	0.29

54	100430	2	78.9855	32.2198	0.02
55	100431	2	78.9862	32.2196	0.02
56	100432	2	78.9881	32.221	0.02
57	100433	2	78.987	32.223	0.01
58	100434	2	78.9837	32.2255	1.81
59	100435	2	78.9879	32.2348	0.14
60	100436	2	78.9908	32.2396	0.28
61	100437	2	78.9955	32.2391	0.01
62	100438	2	78.9896	32.2388	0.02
63	100439	2	78.9919	32.2546	0.88
64	100440	2	78.9873	32.2527	0.32
65	100441	2	78.9897	32.2511	0.02
66	100442	2	78.9779	32.258	2.13
67	100443	2	78.9858	32.2998	12.36
68	100444	2	78.8811	32.352	0.90
69	100445	2	78.8991	32.3514	2.24
70	100446	2	78.8988	32.3522	0.06
71	100447	3	79.1879	32.4516	2.90
72	100448	3	79.1312	32.4627	3.12
73	100449	3	79.1314	32.4462	4.06
74	100450	3	79.153	32.4545	0.68
75	100451	3	79.1498	32.4552	0.15
76	100452	3	79.1214	32.4393	0.30
77	100453	3	79.1549	32.4442	0.18
78	100454	3	79.1546	32.4439	0.07
79	100455	3	79.1542	32.4438	0.04
80	100456	3	79.1538	32.4442	0.03
81	100457	3	79.1543	32.4443	0.10
82	100458	3	79.1562	32.4451	0.01
83	100459	3	79.172	32.4916	2.37
84	100460	3	79.1727	32.4901	0.38
85	100461	3	79.1659	32.4889	0.24
86	100462	3	79.2098	32.5054	0.05
87	100463	3	79.2314	32.5025	0.07
88	100464	3	79.2313	32.5019	0.15
89	100465	3	79.2416	32.502	0.11
90	100466	3	79.2441	32.5021	0.08
91	100467	3	79.2422	32.5027	0.02
92	100468	3	79.2477	32.5046	0.27
93	100469	3	79.2617	32.5404	0.24
94	100470	3	79.2646	32.5422	0.10
95	100472	3	79.1897	32.4793	0.10
96	100473	3	79.2073	32.4691	0.13
97	100474	3	79.208	32.4681	0.01

98	100475	3	79.2102	32.4705	0.02
99	100476	3	79.104	32.3538	3.08
100	100477	3	79.1178	32.3463	0.34
101	100478	3	79.1131	32.3516	0.11
102	100479	3	79.1199	32.3338	0.54
103	100480	3	79.0462	32.3601	0.09
104	100481	3	79.0466	32.3602	0.03
105	100482	3	79.0477	32.3604	0.09
106	100483	3	79.052	32.3466	4.69
107	100484	3	79.0473	32.3478	0.20
108	100485	3	79.0481	32.3481	0.08
109	100486	3	79.0477	32.3446	0.10
110	100487	3	79.0509	32.3449	0.09
111	100488	3	79.0027	32.3381	2.84
112	100489	3	79.004	32.3391	0.03
113	100490	3	79.0022	32.3286	2.01
114	100491	3	78.9795	32.3194	7.16
115	100492	3	78.9736	32.3251	6.38
116	100493	3	78.8928	32.3874	1.38
117	100494	3	78.9702	32.3515	0.54
118	100495	3	78.9715	32.3534	0.08
119	100496	3	79.1105	32.363	0.03
120	100497	3	78.9906	32.3151	0.52
121	100498	3	78.9942	32.3162	1.42
122	100499	3	78.9978	32.3175	0.17
123	100500	3	78.9988	32.3176	0.09
124	100501	3	79.005	32.2961	0.24
125	100502	3	79.0029	32.2934	0.09
126	100503	3	79.0005	32.3087	0.14
127	100504	3	79.0073	32.3114	0.02
128	100505	3	79.0175	32.2766	2.29
129	100506	3	78.9957	32.278	0.45
130	100507	3	79.0171	32.2436	0.22
131	100508	3	79.033	32.239	0.11
132	100509	3	79.0346	32.2377	1.00
133	100510	3	79.0266	32.2239	6.61
134	100511	3	79.0102	32.2147	1.93
135	100512	3	79.0197	32.208	2.59
136	100513	3	79.0174	32.2027	0.56
137	100514	3	78.9781	32.1604	8.70
138	100515	3	78.9671	32.168	0.12
139	100516	3	78.9679	32.1683	0.10
140	100517	3	78.9767	32.1711	0.06
141	100518	3	78.9753	32.1699	0.07

142	100519	3	78.974	32.1693	0.02
143	100520	3	78.9731	32.1701	1.52
144	100521	3	78.988	32.2012	0.87
145	100522	3	78.9863	32.2044	0.04
146	100523	3	78.9997	32.2109	0.11
147	100524	3	78.9947	32.2116	0.02
148	100525	3	78.9909	32.2146	0.11
149	100526	3	78.9911	32.2151	0.01
150	100527	3	78.9952	32.2154	0.13
151	100528	3	78.994	32.2157	0.06
152	100529	3	78.9982	32.2241	1.00
153	100530	3	79.0062	32.2243	2.79
154	100531	3	79.0438	32.2093	23.58
155	100532	3	79.0474	32.2106	0.14
156	100533	3	79.0467	32.2094	0.02
157	100534	3	79.0448	32.2515	1.11
158	100535	3	79.049	32.2555	0.21
159	100536	3	78.9735	32.3547	0.10
160	100537	3	78.8356	32.4078	0.17
161	100538	3	79.2545	32.4767	0.15
162	100539	3	79.252	32.4747	0.01
163	100540	3	79.2543	32.4762	0.10
164	100541	3	79.2543	32.4754	0.02
165	100542	3	79.2841	32.5293	0.12
166	100543	3	79.1772	32.4517	0.20
167	100544	3	79.1675	32.4586	0.86
168	100545	3	79.4758	32.3764	0.23
169	100546	3	79.499	32.3668	0.04
170	100547	3	79.5024	32.3656	0.05
171	1071RS	3	79.3928	32.3776	23.40
172	1077HWL	3	79.4718	32.4179	0.37
173	1078HWL	3	79.4772	32.4184	0.93
174	1079HWL	3	79.4776	32.4216	0.92

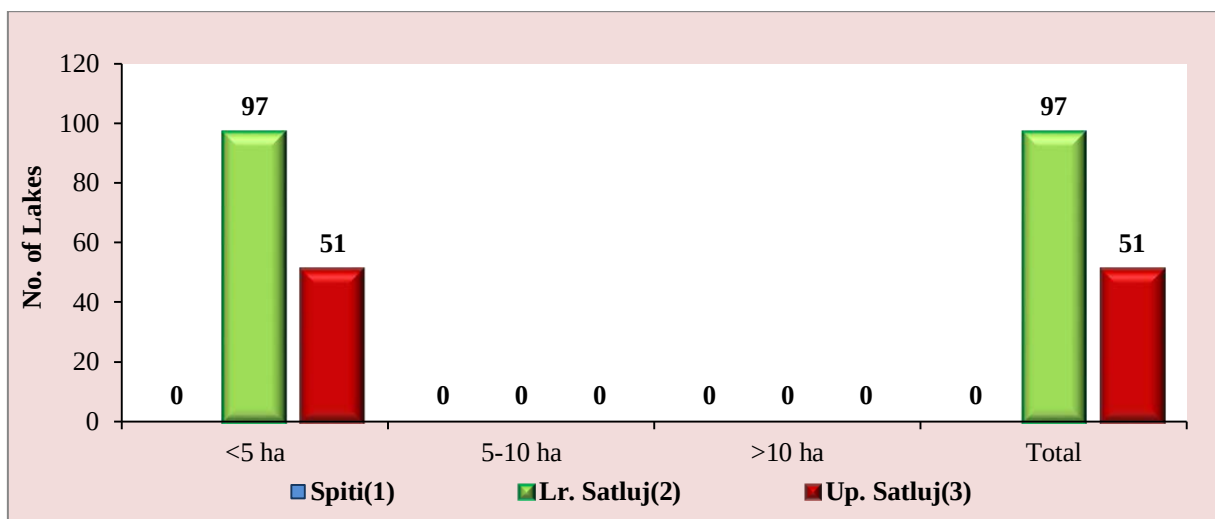


Fig. 10.9: No of lakes based on LISS-IV image 97/48c 2022

Table: 10.4 Distribution of Lakes as per satellite data interpretation for 97/48c, 2022 using LISS-IV sensor

Sr.No.	Lake Id.	Basin No.	Longitude	Latitude	Aerial Extent on 2022
1	277	3	78.9439	32.1221	2.27
2	279	3	78.9423	32.1184	0.32
3	286	3	78.927	32.0146	1.36
4	287	3	78.9033	32.004	0.76
5	288	2	78.8039	32.081	0.62
6	289	2	78.8076	32.0801	0.43
7	291	2	78.8318	32.0641	0.06
8	294	2	78.8467	32.0113	1.28
9	295	2	78.8489	32.011	0.10
10	296	2	78.8482	32.011	0.05
11	297	2	78.8506	32.0086	0.82
12	298	2	78.8524	32.008	0.06
13	299	2	78.8533	32.0073	0.31
14	305	2	78.8463	31.9922	20.95
15	306	2	78.8497	31.9943	1.43
16	323	2	78.7846	32.0306	0.19
17	324	2	78.7851	32.0325	0.03
18	325	2	78.7838	32.0315	0.02
19	326	2	78.7814	32.0328	0.59
20	327	2	78.7799	32.0338	0.35
21	328	2	78.7566	32.0422	0.16
22	329	2	78.7562	32.0444	0.72
23	335	3	78.818	31.9327	2.32
24	335	3	78.8147	31.9339	2.18
25	336	3	78.8137	31.9329	0.06

26	337	3	78.8183	31.9317	0.28
27	338	3	78.8214	31.9322	1.49
28	339	3	78.8226	31.9316	0.18
29	340	3	78.8238	31.9327	0.99
30	341	3	78.8261	31.9323	0.16
31	342	3	78.8259	31.9312	0.06
32	344	3	78.8295	31.9309	0.18
33	345	3	78.8289	31.9302	0.16
34	346	3	78.828	31.9299	0.25
35	347	3	78.8256	31.9293	0.05
36	348	3	78.8241	31.9307	0.09
37	349	3	78.8243	31.9299	0.21
38	350	3	78.8241	31.9292	0.03
39	351	3	78.8229	31.9302	0.71
40	352	3	78.8234	31.9291	0.03
41	353	3	78.8217	31.9297	0.07
42	354	3	78.8211	31.9298	0.03
43	355	3	78.8212	31.9304	0.23
44	356	3	78.8201	31.9303	0.05
45	357	3	78.8199	31.9293	1.39
46	358	3	78.8187	31.9292	0.13
47	359	3	78.818	31.93	0.02
48	360	3	78.8173	31.9301	0.03
49	361	3	78.8167	31.9296	0.04
50	374	3	78.7913	31.8832	0.31
51	377	3	78.7951	31.8819	0.66
52	463	2	78.7126	31.9992	0.34
53	542	2	78.7477	31.5587	0.44
54	827	2	78.7891	32.0307	0.10
55	828	2	78.7812	32.0347	0.09
56	829	2	78.7789	32.0359	0.09
57	830	2	78.7776	32.0385	0.06
58	994	2	78.7765	32.0353	0.08
59	995	2	78.7759	32.0356	0.11
60	996	2	78.7707	32.0401	0.42
61	997	2	78.7711	32.0413	0.03
62	998	2	78.7702	32.0412	0.04
63	999	2	78.7693	32.0395	0.09
64	1000	2	78.7634	32.0428	0.06
65	1001	2	78.763	32.0406	0.65
66	1003	2	78.7616	32.0412	0.07
67	1004	2	78.7617	32.0388	0.10
68	1005	2	78.7614	32.0396	0.14
69	1006	2	78.761	32.0379	0.02

70	1007	2	78.7605	32.0365	0.21
71	1008	2	78.76	32.0369	0.14
72	1009	2	78.76	32.0375	0.09
73	1010	2	78.7601	32.0382	0.05
74	1011	2	78.7595	32.0384	0.06
75	1012	2	78.7603	32.039	0.42
76	1013	2	78.7597	32.0392	0.09
77	1014	2	78.7595	32.0398	0.23
78	1015	2	78.7592	32.0393	0.04
79	1016	2	78.7596	32.0415	1.86
80	1017	2	78.7585	32.0413	0.03
81	1018	2	78.7596	32.0433	0.04
82	1019	2	78.76	32.0438	0.02
83	1020	2	78.7579	32.0432	0.02
84	1021	2	78.757	32.0436	0.10
85	1022	2	78.7577	32.0445	0.50
86	1023	2	78.7555	32.0452	0.07
87	1024	2	78.7557	32.0455	0.02
88	1025	2	78.7546	32.0458	0.05
89	1026	2	78.7547	32.0451	0.06
90	1027	2	78.7537	32.0445	0.27
91	1028	2	78.7546	32.0428	0.22
92	1029	2	78.7534	32.0425	0.64
93	1030	2	78.7522	32.0427	0.08
94	1031	2	78.746	32.0471	0.78
95	1032	2	78.7467	32.0458	0.25
96	1033	2	78.7461	32.0448	0.22
97	1034	2	78.7449	32.045	0.01
98	1040	2	78.7021	32.0328	0.08
99	1041	2	78.7032	32.034	0.01
100	1043	2	78.7025	32.0382	0.05
101	100548	3	78.9272	32.0938	0.12
102	100549	3	78.9279	32.0935	0.02
103	100550	3	78.948	32.0923	3.07
104	100551	3	78.9307	32.0923	0.35
105	100552	2	78.8652	32.0857	1.15
106	100553	2	78.8647	32.0703	0.99
107	100554	2	78.8196	32.0703	0.30
108	100555	3	78.9287	32.0631	0.96
109	100556	3	78.9439	32.0599	6.20
110	100557	2	78.8083	32.0581	5.85
111	100558	3	78.9052	32.0541	0.72
112	100559	3	78.9042	32.0431	0.40
113	100560	2	78.7619	32.0414	0.02

114	100560	2	78.8761	32.0168	7.76
115	100561	2	78.7607	32.0403	0.10
116	100561	2	78.9199	32.1414	2.39
117	100562	2	78.7606	32.0401	0.06
118	100562	3	78.965	32.1431	0.45
119	100563	2	78.761	32.0399	0.04
120	100563	3	78.9639	32.1492	1.54
121	100564	2	78.7613	32.0392	0.09
122	100564	2	78.9218	32.1433	0.19
123	100565	2	78.7616	32.0392	0.02
124	100565	3	78.9427	32.1071	9.72
125	100566	2	78.8741	32.0313	4.03
126	100566	3	78.9488	32.1222	1.32
127	100567	2	78.846	32.0291	16.36
128	100567	3	78.9483	32.1066	0.38
129	100568	2	78.8775	32.0199	1.83
130	100568	3	78.9337	32.107	8.90
131	100569	3	78.9117	32.0177	4.64
132	100569	3	78.9714	32.1291	2.64
133	100570	3	78.952	32.1192	1.11
134	100571	3	78.9606	32.1368	0.19
135	100572	2	78.8176	32.0718	0.02
136	100573	2	78.8062	32.0807	0.23
137	100574	2	78.8218	32.0708	0.34
138	100575	2	78.7698	32.042	0.07
139	100576	2	78.7719	32.0421	0.24
140	100577	2	78.7669	32.0447	1.21
141	100578	2	78.7044	32.038	0.07
142	100579	2	78.7756	32.0363	0.10
143	100580	2	78.7746	32.0376	0.01
144	1035SG	2	78.7489	32.0402	0.03
145	1036SG	2	78.748	32.0364	0.03
146	1037SG	2	78.7507	32.0361	0.03
147	1038SG	2	78.7383	32.0488	0.17
148	1039SG	2	78.7389	32.0483	0.01

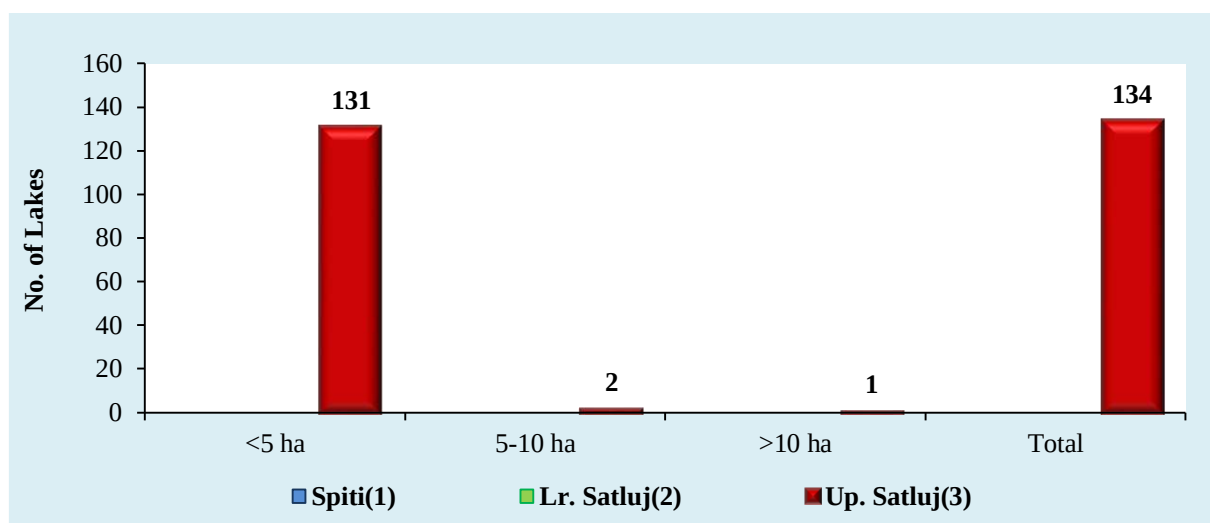


Fig. 10.10: No of lakes based on LISS-IV image 98-49 a& c, 2022

Table: 10.5 Distribution of Lakes as per satellite data interpretation for 98-49 a& c, 2022 using LISS-IV

Sr. No.	Lake Id.	Basin No.	Longitude	Latitude	Aerial Extent on 2022
1	100581	3	79.551	31.0673	0.11
2	100582	3	79.5543	31.0666	0.12
3	100583	3	79.5466	31.0653	0.05
4	100584	3	79.5903	31.0634	0.10
5	100585	3	79.5433	31.0632	0.07
6	100586	3	79.5898	31.062	0.08
7	100587	3	79.5899	31.0609	0.17
8	100588	3	79.6124	31.0514	0.06
9	100589	3	79.6101	31.0431	0.14
10	100590	3	79.7545	31.04	4.33
11	100591	3	79.5992	31.0371	0.02
12	100592	3	79.6023	31.0364	0.02
13	100593	3	79.6017	31.0359	0.01
14	100594	3	79.5929	31.0351	0.07
15	100595	3	79.609	31.0309	1.31
16	100596	3	79.7299	31.0309	0.02
17	100597	3	79.73	31.0303	0.14
18	100598	3	79.7308	31.0282	6.98
19	100599	3	79.6498	31.0293	0.02
20	100600	3	79.58	31.0238	0.06
21	100601	3	79.5833	31.0213	0.07
22	100602	3	79.7716	31.0105	0.10
23	100603	3	79.7758	31.0098	0.04
24	100604	3	79.7383	31.0099	0.02

25	100605	3	79.7717	31.0093	0.20
26	100606	3	79.7386	31.0081	0.14
27	100607	3	79.6332	31.0083	0.05
28	100608	3	79.6353	31.002	0.04
29	100609	3	79.7785	31.0026	0.22
30	100610	3	79.6351	31.0015	0.03
31	100611	3	79.6359	30.9989	0.03
32	100612	3	79.768	30.9978	0.85
33	100613	3	79.7687	30.9946	0.12
34	100614	3	79.598	31.0362	0.02
35	100615	3	79.6498	31.0293	0.02
36	100616	3	79.58	31.0238	0.06
37	100617	3	79.5833	31.0213	0.07
38	100618	3	79.7717	31.0093	0.20
39	100619	3	79.5764	31.3077	0.28
40	100620	3	79.5149	31.1314	5.28
41	100621	3	79.5704	31.0925	2.32
42	100622	3	79.5712	31.0898	0.10
43	100623	3	79.5726	31.0893	0.04
44	100624	3	79.5701	31.0882	0.03
45	100625	3	79.6108	31.0633	0.04
46	100626	3	79.6123	31.0631	0.14
47	100627	3	79.6113	31.0613	0.09
48	100628	3	79.599	31.0369	0.02
49	100629	3	79.5795	31.0238	0.06
50	100630	3	79.6516	31.0215	0.06
51	100631	3	79.5828	31.0213	0.07
52	100632	3	79.5763	31.1031	0.04
53	100633	3	79.5748	31.1003	0.02
54	100634	3	79.5998	31.3044	51.46
55	100635	3	79.5088	31.1014	1.81
56	100636	3	79.6755	31.0849	0.12
57	100637	3	79.6647	31.0846	0.23
58	100638	3	79.5629	31.0796	0.04
59	100639	3	79.6503	31.0771	0.76
60	100640	3	79.6116	31.0759	0.06
61	100641	3	79.6503	31.0756	0.04
62	100642	3	79.6121	31.075	0.08
63	100643	3	79.6562	31.0737	0.74
64	100644	3	79.5893	31.0694	0.20
65	100645	3	79.5899	31.0682	0.25
66	100646	3	79.5874	31.0717	0.06
67	100647	3	79.588	31.0709	0.04
68	100648	3	79.5874	31.0713	0.06

69	100649	3	79.9028	30.9901	0.56
70	100650	3	79.9035	30.9907	0.48
71	100651	3	79.9465	30.9893	0.79
72	100652	3	79.9395	30.9943	0.10
73	100653	3	79.9403	30.9933	0.11
74	100654	3	79.9032	30.9903	0.05
75	100655	3	79.9056	30.9896	0.03
76	100656	3	79.8216	30.9939	0.21
77	100657	3	79.7793	31.0069	0.33
78	100658	3	79.7778	31.0091	0.08
79	100659	3	79.7762	31.0097	0.04
80	100660	3	79.7726	31.0097	0.03
81	100661	3	79.7477	31.0135	0.10
82	100662	3	79.7482	31.014	0.07
83	100663	3	79.7469	31.0133	0.01
84	100664	3	79.7436	31.0189	0.03
85	100665	3	79.7362	31.0213	0.06
86	100666	3	79.7305	31.0303	0.02
87	100667	3	79.6532	31.0719	1.35
88	100668	3	79.6064	31.0527	0.19
89	100669	3	79.6138	31.0534	0.06
90	100670	3	79.6124	31.0742	0.02
91	100671	3	79.6113	31.0778	0.03
92	100672	3	79.612	31.079	0.04
93	100673	3	79.6114	31.0789	0.01
94	100674	3	79.5905	31.0653	0.04
95	100675	3	79.5895	31.0658	0.02
96	100676	3	79.5907	31.0638	0.01
97	100678	3	79.5892	31.0611	0.03
98	100679	3	79.5886	31.0605	0.01
99	100680	3	79.581	31.0752	0.01
100	100681	3	79.5725	31.0706	0.03
101	100682	3	79.5696	31.0668	0.13
102	100683	3	79.5657	31.0621	0.01
103	100684	3	79.5637	31.0618	0.01
104	100685	3	79.5565	31.0626	0.04
105	100686	3	79.5561	31.0623	0.01
106	100687	3	79.5534	31.0665	0.01
107	100688	3	79.5486	31.0657	0.01
108	100689	3	79.5178	31.1029	0.03
109	100690	3	79.5176	31.1045	0.01
110	100691	3	79.5184	31.1044	0.01
111	100692	3	79.5109	31.1066	0.03
112	100693	3	79.553	31.0689	0.13

113	100694	3	79.528	31.0799	0.06
114	100695	3	79.5303	31.0793	0.03
115	100696	3	79.529	31.0797	0.01
116	100697	3	79.5291	31.077	0.01
117	100698	3	79.5292	31.0776	0.02
118	100699	3	79.5693	31.3308	0.03
119	100700	3	79.6188	31.3296	0.37
120	100701	3	79.6158	31.3303	0.26
121	100702	3	79.5943	31.3539	0.26
122	100703	3	79.4927	31.0972	2.86
123	100704	3	79.5684	31.0335	0.07
124	100705	3	79.5708	31.0332	0.05
125	100706	3	79.5705	31.0332	0.02
126	100707	3	79.5703	31.0333	0.02
127	100708	3	79.5378	31.0162	0.04
128	100709	3	79.5424	31.0254	0.01
129	100710	3	79.5428	31.024	0.02
130	100711	3	79.6091	31.0391	0.08
131	100712	3	79.6085	31.0382	0.02
132	100713	3	79.604	31.0352	0.04
133	100714	3	79.8229	30.9954	0.33
134	100715	3	79.9142	30.9729	0.05

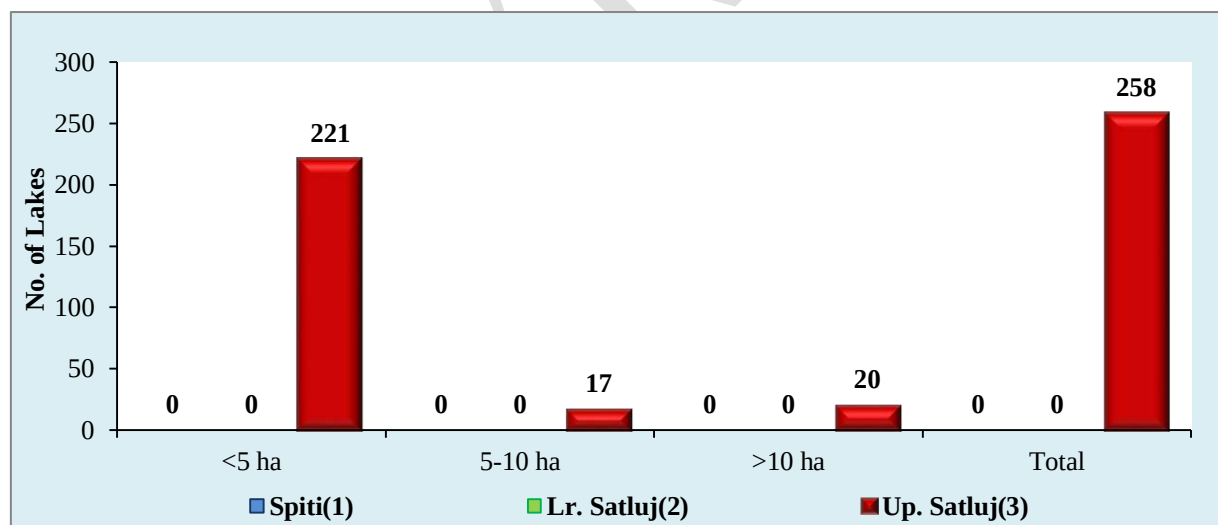


Fig. 10.11: No of lakes based on LISS-IV image 100/49 C, 2022

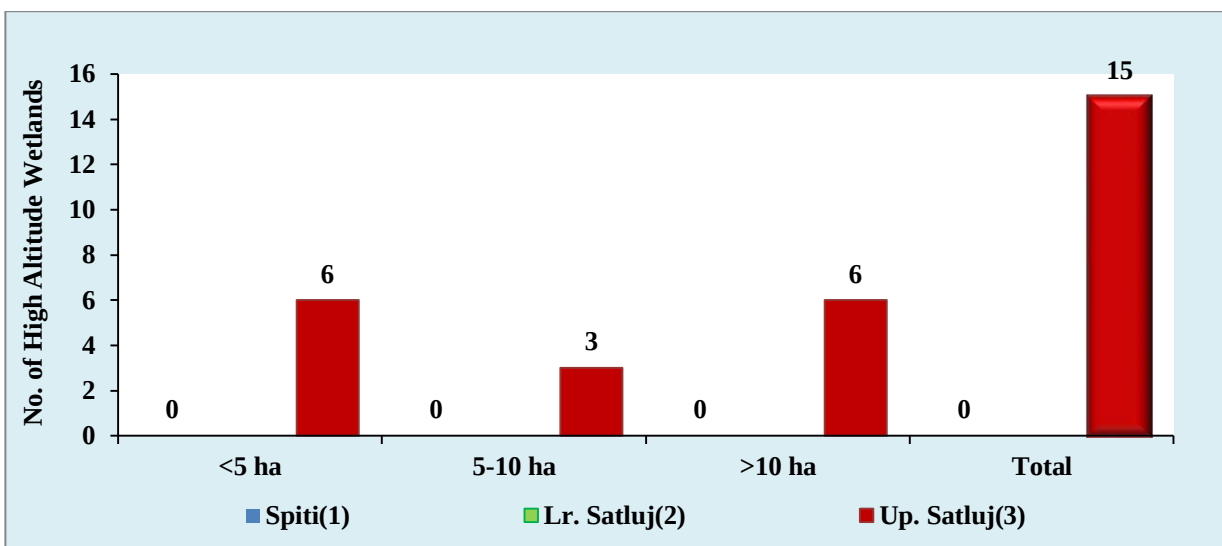


Fig. 10.12: No of High Altitude wetlands lakes based on LISS-IV image 100/49 C, 2022

Table: 10.6 Distribution of Lakes as per satellite data interpretation for 100/49 c, 2022 using LISS-IV sensor.

Sr. No.	Lake Id.	Basin No.	Longitude	Latitude	Aerial Extent on 2022 in Ha
1	1469	3	81.525	31.1054	0.39
2	1470	3	81.5315	31.0949	1.41
3	1471	3	81.5318	31.0939	0.31
4	1472	3	81.5305	31.0921	1.51
5	1473	3	81.5323	31.0913	0.04
6	1474	3	81.5195	31.0823	1.72
7	1475	3	81.5216	31.0754	0.17
8	1478	3	81.5154	31.051	0.83
9	1479	3	81.5165	31.0518	0.02
10	1480	3	81.5167	31.0521	0.06
11	1481	3	81.5191	31.0507	0.03
12	1482	3	81.5054	31.0442	2.01
13	1484	3	81.4993	31.0357	0.37
14	1488	3	81.5004	31.0257	0.05
15	1498	3	81.5185	31.0287	0.26
16	1499	3	81.5193	31.0304	0.38
17	1500	3	81.5194	31.0315	0.56
18	1501	3	81.5135	31.0348	2.82
19	1502	3	81.5148	31.0384	1.27
20	1503	3	81.5453	31.0757	0.17
21	1504	3	81.5478	31.0788	1.92
22	1505	3	81.5414	31.0895	0.05

23	1506	3	81.5479	31.0915	0.24
24	1507	3	81.551	31.0936	1.04
25	1508	3	81.5549	31.0906	1.05
26	1509	3	81.5612	31.0938	1.63
27	1510	3	81.5459	31.1024	3.92
28	1511	3	81.5426	31.1165	9.37
29	1512	3	81.5556	31.0288	0.06
30	1513	3	81.5552	31.0267	0.17
31	1514	3	81.667	31.0262	2.09
32	1515	3	81.7275	31.0515	0.66
33	1516	3	81.7243	31.0567	0.45
34	1517	3	81.7223	31.0705	7.77
35	1518	3	81.7616	30.9885	1.81
36	1519	3	81.8394	31.0112	0.33
37	100716	3	81.7728	31.0106	0.43
38	100717	3	81.6672	30.9503	0.17
39	100718	3	81.6708	30.9518	0.07
40	100719	3	81.6709	30.948	0.03
41	100720	3	81.6702	30.9477	0.02
42	100721	3	81.6708	30.9476	0.02
43	100722	3	81.6676	30.9465	0.03
44	100723	3	81.6843	31.0273	0.32
45	100724	3	81.6853	31.028	0.5
46	100725	3	81.696	31.0315	0.27
47	100726	3	81.7904	30.8807	0.81
48	100727	3	81.9791	30.8414	3.02
49	100728	3	82.1703	30.8082	1.86
50	100729	3	82.0828	30.5919	14.02
51	100730	3	82.071	30.5965	12.69
52	100731	3	81.9902	30.5463	3.08
53	100732	3	81.9887	30.5487	0.23
54	100733	3	82.0146	30.547	0.81
55	100734	3	82.0157	30.5484	0.06
56	100735	3	82.0155	30.5479	0.06
57	100736	3	82.0343	30.5575	0.55
58	100737	3	82.0348	30.5566	0.27
59	100738	3	82.0352	30.5736	0.37
60	100739	3	82.0391	30.5729	0.22
61	100740	3	82.0516	30.5753	0.15
62	100741	3	82.0627	30.5698	0.42
63	100742	3	82.0578	30.5705	1.05
64	100743	3	82.0342	30.5881	0.11

65	100744	3	82.0296	30.5945	0.08
66	100745	3	82.1173	30.686	1.67
67	100746	3	81.8782	30.7722	0.65
68	100747	3	81.8927	30.9537	4.44
69	100748	3	81.8924	30.9469	5.62
70	100749	3	81.8652	30.9426	0.07
71	100750	3	81.9939	30.879	0.56
72	100751	3	81.9928	30.8795	0.51
73	100752	3	81.9919	30.8802	0.23
74	100753	3	82.007	30.6783	0.76
75	100754	3	82.0085	30.6748	0.19
76	100755	3	81.7106	30.5598	2.4
77	100756	3	81.7401	30.5491	15.05
78	100757	3	81.738	30.5511	0.67
79	100758	3	81.7496	30.5419	0.71
80	100759	3	81.7495	30.5389	0.1
81	100760	3	81.7508	30.5369	0.08
82	100761	3	81.7346	30.5537	2.23
83	100762	3	81.69	30.5544	0.38
84	100763	3	81.6883	30.5572	2.32
85	100764	3	81.5779	30.5878	0.38
86	100765	3	81.5807	30.5887	0.36
87	100766	3	81.5793	30.5893	0.17
88	100767	3	81.5786	30.5894	0.07
89	100768	3	81.5371	30.6173	0.17
90	100769	3	81.4331	30.4303	192.41
91	100770	3	81.4574	30.4376	3.24
92	100771	3	81.4336	30.4484	7.99
93	100772	3	81.481	30.428	0.26
94	100773	3	81.4799	30.4273	2.34
95	100774	3	81.4761	30.4262	1.43
96	100775	3	81.4745	30.4263	0.13
97	100776	3	81.4676	30.4266	0.54
98	100777	3	81.4659	30.4271	2.3
99	100778	3	81.4627	30.4336	0.11
100	100779	3	81.4628	30.4297	15.65
101	100780	3	81.3941	30.4535	1.39
102	100781	3	81.4114	30.4564	1.14
103	100782	3	81.4139	30.46	1.02
104	100783	3	81.4303	30.4713	5.54
105	100784	3	81.434	30.4708	1.25
106	100785	3	81.4309	30.4736	0.03

107	100786	3	81.4474	30.4695	0.09
108	100787	3	81.4468	30.47	0.05
109	100788	3	81.4392	30.4501	0.09
110	100789	3	81.4888	30.4389	0.12
111	100790	3	81.5139	30.4767	3.22
112	100791	3	81.5135	30.481	7.49
113	100792	3	81.4831	30.4615	2.49
114	100793	3	81.4824	30.4627	0.25
115	100794	3	81.482	30.4637	0.04
116	100795	3	81.4828	30.4653	0.04
117	100796	3	81.4841	30.4646	0.23
118	100797	3	81.4868	30.4649	0.08
119	100798	3	81.4851	30.4654	0.18
120	100799	3	81.4798	30.4711	0.09
121	100800	3	81.487	30.4791	0.32
122	100801	3	81.4762	30.4869	0.59
123	100802	3	81.4834	30.4964	0.28
124	100803	3	81.4928	30.4542	1.66
125	100804	3	81.4965	30.4534	0.41
126	100805	3	81.4972	30.4537	0.2
127	100806	3	81.4981	30.454	0.07
128	100807	3	81.4989	30.459	2.26
129	100808	3	81.5586	30.4634	1.21
130	100809	3	81.6753	30.4478	8.49
131	100810	3	81.6979	30.4545	2.29
132	100811	3	81.6984	30.4389	0.78
133	100812	3	81.697	30.4308	4.76
134	100813	3	81.7214	30.4279	3.2
135	100814	3	81.713	30.4295	24.6
136	100815	3	81.7209	30.4211	21.23
137	100816	3	81.7624	30.4202	3.72
138	100817	3	81.757	30.416	0.95
139	100818	3	81.7453	30.4092	9.5
140	100819	3	81.7402	30.4021	4.92
141	100820	3	81.7484	30.4048	0.21
142	100821	3	81.7466	30.4057	0.04
143	100822	3	81.7573	30.4009	0.3
144	100823	3	81.7657	30.408	1.44
145	100824	3	81.7768	30.4106	7.24
146	100825	3	81.7683	30.3966	6.15
147	100826	3	81.7737	30.395	0.33
148	100827	3	81.7769	30.3984	0.68

149	100828	3	81.7743	30.3989	2.93
150	100829	3	81.7741	30.401	1.08
151	100830	3	81.7734	30.4033	0.65
152	100831	3	81.7834	30.4005	6.05
153	100832	3	81.7787	30.402	0.04
154	100833	3	81.7811	30.4004	0.04
155	100834	3	81.7782	30.3909	0.23
156	100835	3	81.7843	30.3949	0.31
157	100836	3	81.7918	30.3964	4.2
158	100837	3	81.7949	30.3922	0.76
159	100838	3	81.8026	30.3912	1.64
160	100839	3	81.8035	30.3903	0.29
161	100840	3	81.8179	30.3902	15.45
162	100841	3	81.8219	30.3897	1.1
163	100842	3	81.814	30.3914	0.36
164	100843	3	81.8131	30.3859	0.22
165	100844	3	81.8245	30.3829	0.51
166	100845	3	81.8298	30.3807	3.3
167	100846	3	81.8401	30.3847	13.23
168	100847	3	81.8472	30.3864	3.77
169	100848	3	81.8478	30.3882	0.32
170	100849	3	81.8461	30.3894	0.05
171	100850	3	81.8437	30.3878	0.36
172	100851	3	81.845	30.3899	0.1
173	100852	3	81.8377	30.3913	1.69
174	100853	3	81.842	30.3791	2.98
175	100854	3	81.8404	30.3788	0.06
176	100855	3	81.8415	30.3812	0.13
177	100856	3	81.8411	30.3815	0.02
178	100857	3	81.841	30.3807	0.14
179	100858	3	81.8606	30.3837	0.24
180	100859	3	81.9294	30.384	70.18
181	100860	3	81.9317	30.3898	0.75
182	100861	3	81.928	30.3873	0.06
183	100862	3	81.9276	30.3862	0.35
184	100863	3	81.9275	30.384	0.1
185	100864	3	81.9276	30.3844	0.11
186	100865	3	81.928	30.3882	0.45
187	100866	3	81.9328	30.3764	0.09
188	100867	3	81.8704	30.4269	22.39
189	100868	3	81.8672	30.4189	14.58
190	100869	3	81.8676	30.4153	0.18

191	100870	3	81.8847	30.4034	1.79
192	100871	3	81.8519	30.3989	16.15
193	100872	3	81.8655	30.3989	8.66
194	100873	3	81.8659	30.391	0.81
195	100874	3	81.8625	30.3937	0.19
196	100875	3	81.8632	30.3927	0.02
197	100876	3	81.8644	30.3945	0.02
198	100877	3	81.8529	30.4026	0.43
199	100878	3	81.8779	30.3761	1.73
200	100879	3	81.8808	30.3769	0.26
201	100880	3	81.894	30.3904	10.38
202	100881	3	81.9144	30.3887	0.62
203	100882	3	81.9165	30.3911	0.31
204	100883	3	81.9122	30.387	0.07
205	100884	3	81.8193	30.4082	7.05
206	100885	3	81.8035	30.4074	0.09
207	100886	3	81.8015	30.4199	0.07
208	100887	3	81.801	30.4197	0.04
209	100888	3	81.797	30.4233	1.96
210	100890	3	81.8148	30.4012	0.13
211	100891	3	81.6861	30.4477	0.15
212	100892	3	81.6863	30.4487	0.06
213	100893	3	81.6861	30.4482	0.03
214	100894	3	81.6804	30.4512	0.01
215	100895	3	81.6918	30.4966	2.06
216	100896	3	81.6904	30.4963	0.35
217	100897	3	81.6939	30.4974	1.77
218	100898	3	81.6868	30.4994	0.32
219	100899	3	81.6904	30.499	0.09
220	100900	3	81.7063	30.502	1.67
221	100901	3	81.6951	30.5067	0.63
222	100902	3	81.7006	30.5146	9.03
223	100903	3	81.7002	30.4944	0.63
224	100904	3	81.6987	30.4958	0.02
225	100905	3	81.6974	30.5003	0.03
226	100906	3	81.7009	30.499	0.02
227	100907	3	81.6961	30.4984	0.02
228	100908	3	81.6937	30.4995	0.02
229	100909	3	81.6808	30.5039	0.21
230	101000	3	81.6799	30.5039	0.05
231	101001	3	81.7031	30.514	0.05
232	101002	3	81.7025	30.514	0.02

233	101003	3	81.7016	30.5137	0.03
234	101004	3	81.7038	30.5148	0.02
235	101005	3	81.7041	30.5142	0.02
236	101006	3	81.7051	30.5159	0.04
237	101007	3	81.7076	30.5177	0.07
238	101008	3	81.7071	30.5175	0.03
239	101009	3	81.7115	30.5175	0.03
240	101010	3	81.7025	30.5091	0.14
241	101011	3	82.0328	30.6625	4.01
242	101012	3	82.0282	30.6627	0.55
243	1520HWL	3	81.85	31.0054	24.23
244	1523HWL	3	81.5667	30.8008	292.59
245	1524HWL	3	81.5689	30.7892	1.68
246	1525HWL	3	81.5653	30.7879	5.54
247	1526HWL	3	81.5528	30.7841	2.13
248	1527HWL	3	81.5485	30.7844	4.67
249	1528HWL	3	81.541	30.7781	6.33
250	1530HWL	3	81.5326	30.7763	0.33
251	1531HWL	3	81.524	30.7763	1.52
252	1532HWL	3	81.5448	30.7726	5.35
253	1533HWL	3	81.5533	30.7713	62.54
254	1534HWL	3	81.5649	30.7672	13.49
255	1535HWL	3	81.5786	30.7607	51.74
256	1536HWL	3	81.471	30.6845	41730.5
257	1572HWL	3	81.6674	30.9489	2.76
258	1522RS	3	81.5422	30.8185	1.27

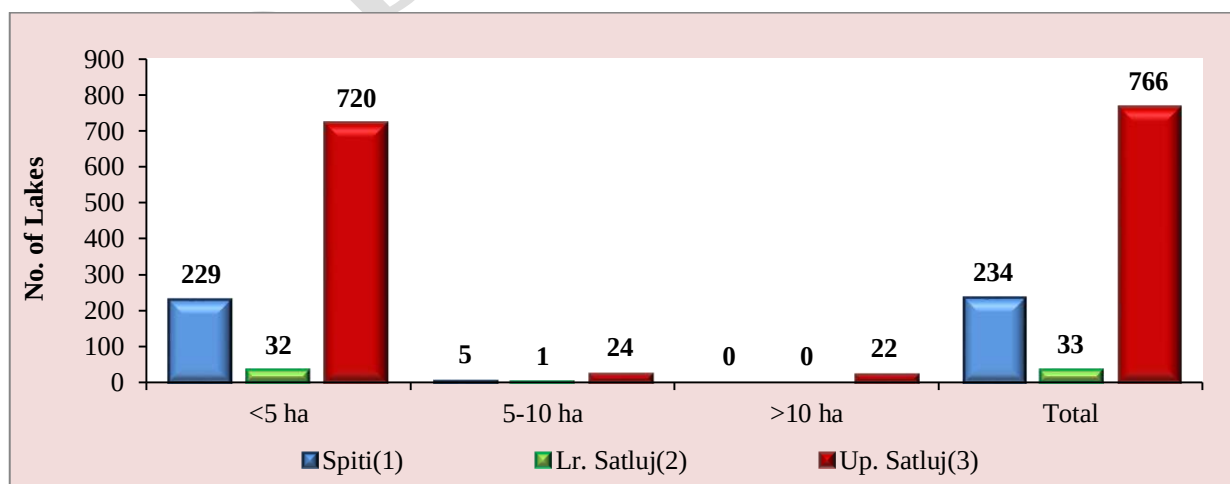


Fig. 10.13: No of lakes based on Sentinel Data, 2022

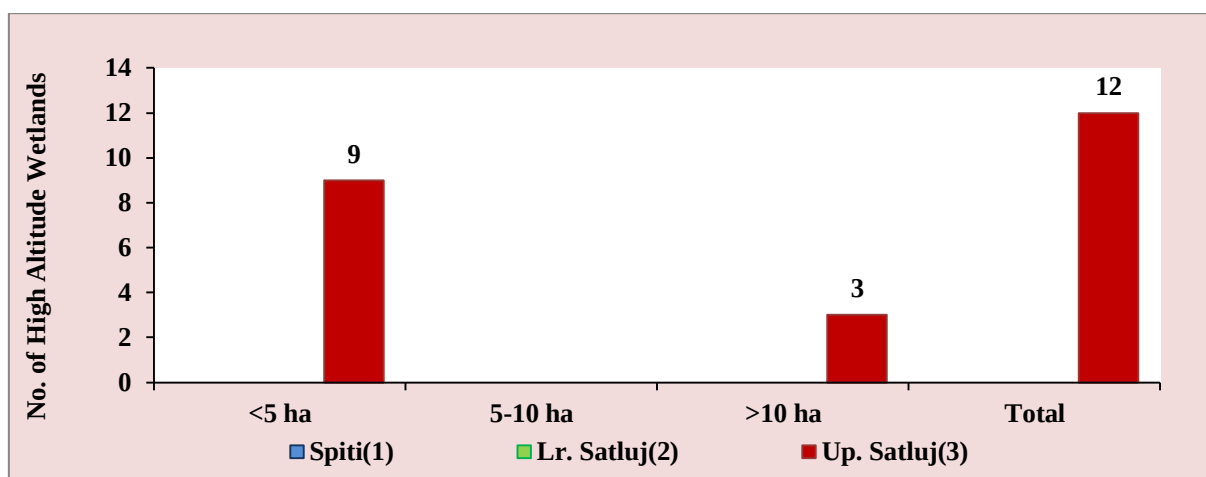


Fig. 10.14: No of High Altitude Wetland lakes based on Sentinel Data, 2022

Table: 10.7 Distribution of Lakes as per satellite data interpretation for Sentinel Data, 2022.

Sr. No.	Lake Id.	Basin No.	Longitude	Latitude	Aerial Extent on 2022 in Ha
1	1	1	77.8169	32.5123	0.14
2	157	1	78.948	32.1446	0.07
3	158	1	78.9468	32.1431	0.06
4	159	1	78.9464	32.1437	0.02
5	162	1	78.9266	32.1294	0.81
6	163	1	78.9253	32.1261	0.11
7	163	1	78.9253	32.1261	0.11
8	164	1	78.9243	32.1286	0.09
9	176	1	78.9102	32.0961	0.09
10	177	1	78.908	32.0987	0.83
11	180	1	78.9059	32.0765	0.15
12	183	1	78.9008	32.064	0.05
13	184	1	78.8949	32.0695	0.1
14	185	1	78.8948	32.0648	0.16
15	186	1	78.8859	32.0743	0.05
16	188	1	78.8833	32.0729	0.36
17	191	1	78.8825	32.0973	0.19
18	192	1	78.872	32.101	0.19
19	215	1	78.407	31.9664	0.33
20	292	1	78.8315	32.0433	0.76
21	300	1	78.8163	32.0329	2.41
22	301	1	78.8141	32.0328	0.25
23	302	1	78.8133	32.0324	0.08
24	303	1	78.815	32.0326	0.16

25	307	3	78.8437	31.9879	0.26
26	308	3	78.8372	31.9811	5.71
27	309	3	78.8358	31.9804	0.53
28	310	3	78.8365	31.9788	1.69
29	311	3	78.838	31.9774	1.61
30	312	3	78.8688	31.9696	7.88
31	313	3	78.8668	31.9575	3.88
32	314	3	78.7975	31.9715	0.53
33	315	3	78.812	31.9642	3.88
34	316	3	78.8109	31.9606	0.05
35	319	3	78.8085	31.9523	0.4
36	321	3	78.8097	31.953	0.09
37	333	3	78.7958	31.9338	0.12
38	334	3	78.7969	31.9336	0.46
39	366	3	78.8398	31.9139	8.79
40	367	3	78.802	31.9086	0.63
41	368	3	78.7862	31.9052	0.48
42	369	3	78.786	31.9062	0.33
43	370	3	78.7852	31.906	0.12
44	371	3	78.785	31.9071	0.14
45	372	3	78.7832	31.9191	18.73
46	375	3	78.7904	31.8826	0.21
47	378	3	78.7937	31.8805	0.25
48	379	3	78.7949	31.8804	0.07
49	381	3	78.7955	31.8795	0.07
50	383	3	78.8008	31.8755	0.36
51	384	3	78.8016	31.8733	0.08
52	385	3	78.8017	31.8729	0.06
53	386	3	78.8025	31.8735	0.54
54	387	3	78.8034	31.8726	0.08
55	388	3	78.8047	31.8729	0.06
56	389	1	78.7048	31.8875	1.07
57	391	1	78.7042	31.8891	0.09
58	392	1	78.6998	31.8896	0.46
59	414	1	78.7185	31.9009	1.03
60	415	1	78.7175	31.9002	0.5
61	416	1	78.7141	31.8983	0.8
62	421	1	78.698	31.9275	0.41
63	422	1	78.6955	31.929	0.01
64	423	1	78.6957	31.9293	0.3
65	424	1	78.6946	31.9302	0.2
66	425	1	78.6936	31.9303	0.34

67	426	1	78.6931	31.9308	0.24
68	427	1	78.6925	31.9308	0.06
69	428	1	78.6927	31.9316	0.1
70	429	1	78.6934	31.9279	0.19
71	430	1	78.692	31.9287	0.08
72	431	1	78.6911	31.9294	0.4
73	432	1	78.6849	31.934	0.88
74	433	1	78.6858	31.9347	0.04
75	434	1	78.6859	31.9349	0.07
76	435	1	78.6767	31.9357	0.21
77	436	1	78.6755	31.9373	0.05
78	437	1	78.6713	31.9377	0.07
79	466	1	78.4157	31.9649	6.43
80	1369	3	81.2017	31.145	0.11
81	1370	3	81.2058	31.1497	0.71
82	1371	3	81.2152	31.1642	2.16
83	1372	3	81.2248	31.1609	1.15
84	1372	3	81.2311	31.1449	1.16
85	1373	3	81.2131	31.1399	0.06
86	1374	3	81.2118	31.1397	0.36
87	1375	3	81.2208	31.148	8.32
88	1376	3	81.2246	31.1493	1.88
89	1377	3	81.232	31.149	0.55
90	1378	3	81.2347	31.1486	0.28
91	1379	3	81.2348	31.1475	0.09
92	1380	3	81.2322	31.1458	0.5
93	1381	3	81.2311	31.1431	0.38
94	1382	3	81.2272	31.1293	4.49
95	1383	3	81.2221	31.1104	1.97
96	1384	3	81.1959	31.0954	0.36
97	1385	3	81.2063	31.0739	0.5
98	1389	3	81.2303	31.06	2.67
99	1390	3	81.2478	31.107	0.28
100	1392	3	81.2516	31.116	0.97
101	1393	3	81.2578	31.1169	3.71
102	1394	3	81.2622	31.1233	1.36
103	1396	3	81.2631	31.1245	0.38
104	1397	3	81.2581	31.1394	0.95
105	1398	3	81.2796	31.1378	6.77
106	1402	3	81.2971	31.1811	1.51
107	1406	3	81.3122	31.1497	0.36
108	1411	3	81.3212	31.1728	1.01

109	1414	3	81.4236	31.1374	5.42
110	1416	3	81.4063	31.1253	0.97
111	1417	3	81.4008	31.1276	4.13
112	1420	3	81.3827	31.1383	8.05
113	1421	3	81.3664	31.1258	0.44
114	1424	3	81.4019	31.0896	0.04
115	1425	3	81.378	31.0778	0.11
116	1426	3	81.3771	31.0776	0.85
117	1427	3	81.3562	31.0699	0.08
118	1428	3	81.3537	31.0437	0.3
119	1429	3	81.3514	31.0412	0.07
120	1430	3	81.3176	31.017	0.19
121	1433	3	81.412	31.1042	1.22
122	1435	3	81.4161	31.1024	2.43
123	1436	3	81.4221	31.1139	1.27
124	1437	3	81.434	31.1145	4.05
125	1441	3	81.4744	31.1185	0.51
126	1443	3	81.444	31.0884	0.29
127	1444	3	81.4324	31.0922	0.2
128	1445	3	81.425	31.0843	2.15
129	1447	3	81.4259	31.0796	0.08
130	1448	3	81.4243	31.0801	1.17
131	1450	3	81.4067	31.0555	2.88
132	1461	3	81.4801	31.0807	2.37
133	1462	3	81.5032	31.0946	4.57
134	1463	3	81.5127	31.0992	3.22
135	1468	3	81.5022	31.1123	7.45
136	1476	3	81.5034	31.0642	0.71
137	1477	3	81.5108	31.0531	0.83
138	2032	1	78.9464	32.1408	0.03
139	2033	1	78.9457	32.1404	0.19
140	2034	1	78.9451	32.1396	0.05
141	2037	1	78.9435	32.1377	0.05
142	2038	1	78.9432	32.1379	0.04
143	2039	1	78.9432	32.1386	0.19
144	2042	1	78.9106	32.0957	0.02
145	2043	1	78.9101	32.0957	0.02
146	2044	1	78.9097	32.0956	0.04
147	2101	1	78.9246	32.1043	0.72
148	2141	1	78.8865	32.0739	0.34
149	2142	1	78.887	32.075	0.03
150	2151	1	78.4113	31.9594	0.04

151	2153	1	78.8143	32.0324	0.03
152	2154	1	78.8139	32.0324	0.03
153	2155	1	78.814	32.032	0.06
154	2201	1	78.6879	31.9346	0.04
155	2202	1	78.6865	31.9326	0.04
156	2203	1	78.6852	31.9295	0.03
157	2204	1	78.6914	31.9321	0.01
158	2205	1	78.6905	31.9301	0.01
159	2228	3	78.8026	31.9367	0.07
160	2239	3	78.8115	31.9414	0.24
161	2241	3	78.8352	31.9803	0.1
162	2250	3	78.8505	31.9803	0.16
163	2253	3	78.8742	31.9657	0.24
164	2254	3	78.8796	31.9629	0.3
165	2599	3	81.0124	31.2951	2.34
166	2601	3	81.0322	31.2925	4.22
167	2602	3	81.0314	31.2847	14.48
168	2603	3	81.0278	31.2769	1.2
169	2604	3	81.0486	31.2903	0.44
170	2605	3	81.0468	31.2866	0.85
171	2606	3	81.0844	31.275	0.03
172	2607	3	81.0843	31.2725	1.49
173	2608	3	81.0886	31.2662	5.26
174	2609	3	81.085	31.2697	0.5
175	2610	3	81.1086	31.2696	3.16
176	2611	3	81.1157	31.2635	1.71
177	2612	3	81.1163	31.2601	4.25
178	2613	3	81.1128	31.2501	1.28
179	2614	3	81.1254	31.2577	0.26
180	2615	3	81.1318	31.2602	13.6
181	2616	3	81.1137	31.2406	0.65
182	2617	3	81.1018	31.2437	3.74
183	2618	3	81.0824	31.2399	4.31
184	2619	3	81.0682	31.234	1.41
185	2620	3	81.0183	31.2066	2.28
186	2621	3	81.1206	31.2346	0.09
187	2622	3	81.1241	31.2374	3.34
188	2623	3	81.1297	31.2441	2.92
189	2624	3	81.1325	31.245	3.91
190	2625	3	81.14	31.2462	9.86
191	2627	3	81.1367	31.234	10.1
192	2628	3	81.1445	31.2311	2.01

193	2629	3	81.1337	31.221	0.31
194	2630	3	81.1283	31.2193	1.1
195	2631	3	81.1112	31.1599	1.73
196	2632	3	81.1151	31.168	1.77
197	2633	3	81.1297	31.1931	0.35
198	2634	3	81.1345	31.1995	0.16
199	2635	3	81.1371	31.1984	0.1
200	2636	3	81.1377	31.1943	6.49
201	2637	3	81.1471	31.1991	10.98
202	2638	3	81.1473	31.2041	0.77
203	2639	3	81.1533	31.2084	1.56
204	2640	3	81.156	31.218	0.14
205	2641	3	81.1595	31.2173	9.06
206	2642	3	81.1778	31.1891	1.57
207	2643	3	81.1548	31.1813	0.05
208	2644	3	81.1511	31.1785	20.99
209	2645	3	81.1399	31.1692	0.59
210	2646	3	81.1366	31.1617	0.6
211	2647	3	81.1357	31.1619	0.15
212	2652	3	81.1955	31.1914	0.88
213	2654	3	81.1995	31.1657	0.7
214	2655	3	81.2134	31.1661	0.03
215	2656	3	81.2056	31.1557	0.22
216	2669	3	81.1902	31.1782	0.61
217	2670	3	81.1928	31.1783	0.73
218	2676	3	80.5325	30.5125	0.98
219	2689	3	80.5038	30.5398	0.08
220	2695	3	80.5989	30.5474	0.12
221	2703	3	80.6158	30.5426	0.42
222	2709	3	80.6151	30.5416	0.29
223	2714	3	80.5042	30.5385	0.01
224	2715	3	80.505	30.5383	0.09
225	2716	3	80.5044	30.5383	0.03
226	2718	3	80.5013	30.5372	0.23
227	2719	3	80.5043	30.537	0.06
228	2722	3	80.5035	30.5326	1.57
229	2727	3	80.5043	30.5354	0.14
230	2738	3	80.534	30.5141	1.45
231	2740	3	80.5356	30.5141	0.09
232	2741	3	80.5349	30.514	0.04
233	2743	3	80.532	30.511	2.12
234	2747	3	80.5923	30.4765	14.27

235	6094	3	80.6311	30.5537	1.33
236	9166	3	80.5082	30.5412	0.69
237	9192	3	80.5978	30.5448	7.81
238	9193	3	80.6167	30.5543	0.94
239	9194	3	80.6166	30.5555	1.31
240	9195	3	80.6203	30.5725	0.21
241	9197	3	80.563	30.6327	4.41
242	9240	3	80.5286	30.5151	0.36
243	101013	3	80.6115	30.5645	0.07
244	101014	3	80.6266	30.545	0.15
245	101015	3	80.5686	30.4923	0.09
246	101016	3	80.5695	30.4912	0.42
247	101017	3	80.5714	30.4876	0.13
248	101018	3	80.5688	30.4771	3.5
249	101019	3	80.5686	30.4923	0.09
250	101020	3	80.5695	30.4912	0.42
251	101021	3	80.5714	30.4876	0.13
252	101022	3	81.0282	31.2866	0.19
253	101023	3	81.073	31.2932	0.21
254	101024	3	81.1287	31.2176	0.81
255	101025	3	81.3218	31.1605	0.24
256	101026	3	81.3225	31.1613	0.09
257	101027	3	81.1478	30.9186	1.98
258	101028	3	81.1434	30.9182	0.6
259	101029	3	80.6399	30.4626	0.73
260	101030	3	80.6401	30.4599	0.35
261	101031	3	80.5518	30.683	0.2
262	101032	3	81.5048	31.0723	0.63
263	101033	3	81.3259	31.1385	1.76
264	101034	3	81.4128	31.1342	1.29
265	101035	3	81.407	31.1445	1.64
266	101036	3	81.4004	31.145	0.14
267	101037	3	81.1818	31.1376	1.45
268	101038	3	80.9545	31.3187	1.93
269	101039	3	80.9703	31.3379	0.29
270	101040	3	81.0115	31.3318	0.29
271	101041	3	80.8323	31.2519	3.29
272	101042	3	80.838	31.2643	0.17
273	101043	3	80.756	30.7255	168.79
274	101044	3	80.77	30.7338	2.87
275	101045	3	80.7461	30.7512	0.25
276	101046	3	80.7401	30.751	0.43

277	101047	3	80.7397	30.7496	0.71
278	101048	3	80.742	30.7482	0.32
279	101049	3	80.7468	30.7491	0.06
280	101050	3	80.7456	30.7442	1.76
281	101051	3	80.9978	30.696	4.5
282	101052	3	81.0066	30.712	1.05
283	101053	3	80.5405	31.3977	47.91
284	101054	3	80.5394	31.4103	15.61
285	101055	3	80.561	31.3686	0.41
286	101056	3	80.4061	31.324	0.28
287	101057	3	80.3606	31.349	0.14
288	101058	3	80.379	31.437	0.51
289	101059	3	80.3562	30.6595	1.01
290	101060	3	80.2943	30.6083	1.6
291	101060	3	80.2936	30.606	0.2
292	101060	3	80.2936	30.6054	0.16
293	101060	3	80.2879	30.614	0.05
294	101060	3	80.2889	30.6011	0.07
295	101060	3	80.29	30.6027	0.43
296	101061	3	80.2916	30.6047	9.51
297	101062	3	80.2928	30.6074	0.23
298	101063	3	80.4033	30.5973	3.7
299	101064	3	80.45	30.5538	1.91
300	101065	3	80.3949	30.5471	2.22
301	101066	3	80.3945	30.5487	0.34
302	101067	3	80.3997	30.5521	27.18
303	101068	3	80.4062	30.5533	2
304	101069	3	80.4003	30.5545	0.1
305	101070	3	80.472	30.553	7.96
306	101071	3	80.4754	30.5556	0.44
307	101072	3	80.4751	30.5563	0.08
308	101073	3	80.446	30.6498	0.28
309	101074	3	80.4472	30.6505	0.19
310	101075	3	80.4476	30.6492	0.19
311	101076	3	80.4476	30.6537	0.67
312	101077	3	80.4476	30.655	0.1
313	101078	3	80.4481	30.6555	0.09
314	101079	3	80.3385	30.572	0.94
315	101080	3	80.3821	30.5348	0.81
316	101081	3	80.436	30.5201	0.43
317	101082	3	80.2405	30.8291	0.29
318	101083	3	79.0884	31.8539	0.13

319	101084	1	78.3741	31.9759	0.12
320	101085	2	78.3719	31.9263	0.21
321	101086	2	78.4625	31.9081	0.03
322	101087	2	78.4491	31.8778	0.05
323	101088	2	78.4496	31.8723	0.04
324	101089	2	78.4496	31.872	0.03
325	101090	2	78.4478	31.8698	0.05
326	101091	2	78.448	31.8681	0.1
327	101092	2	78.4515	31.8651	0.05
328	101093	1	78.7083	32.7108	2.84
329	101094	1	78.7097	32.7099	0.1
330	101095	1	78.7124	32.7099	0.01
331	101096	1	78.7116	32.7095	0.04
332	101097	1	78.6885	32.7079	5
333	101098	1	78.7068	32.708	0.52
334	101099	1	78.703	32.7077	0.34
335	101100	1	78.702	32.7077	0.27
336	101101	1	78.706	32.7073	0.59
337	101102	1	78.7042	32.7074	0.04
338	101103	1	78.6818	32.7068	0.74
339	101104	1	78.6986	32.7066	0.11
340	101105	1	78.7035	32.7063	0.35
341	101106	1	78.6982	32.7046	3.86
342	101107	1	78.7012	32.7055	1.22
343	101108	1	78.7389	32.705	0.22
344	101109	1	78.7194	32.6981	0.83
345	101110	1	78.7335	32.6981	1.96
346	101111	1	78.7111	32.6952	2.7
347	101112	1	78.7306	32.6954	0.26
348	101113	1	78.4807	32.3761	0.89
349	101114	1	78.4703	32.3475	0.12
350	101115	1	78.5265	32.3404	0.13
351	101116	1	78.7247	32.3261	4.21
352	101117	1	78.7174	32.3241	1.08
353	101118	1	78.5154	32.2377	0.31
354	101119	1	78.435	32.1828	0.07
355	101120	1	78.4331	32.1814	0.78
356	101121	1	78.4137	32.1759	9.76
357	101122	1	78.418	32.2046	3.5
358	101123	1	78.4183	32.1735	0.07
359	101124	1	78.1991	32.665	0.34
360	101125	1	78.4567	32.1634	0.04

361	101126	1	78.4619	32.161	0.82
362	101127	1	78.4877	32.149	5.68
363	101128	1	78.3406	31.9496	0.19
364	101129	2	78.3038	31.8291	0.05
365	101130	2	78.2573	31.8166	0.02
366	101131	2	78.2621	31.8139	0.04
367	101132	2	78.2622	31.8135	0.05
368	101133	2	78.3046	31.7907	0.05
369	101134	2	78.3054	31.7895	1.6
370	101135	2	78.2931	31.7797	1.2
371	101136	1	78.7121	32.7089	0.05
372	101137	1	78.6912	32.7079	0.29
373	101138	1	78.6892	32.7307	0.67
374	101139	1	78.6969	32.7278	0.07
375	101140	1	78.698	32.7499	1
376	101141	1	78.6965	32.7501	0.41
377	101142	1	78.6957	32.7561	0.14
378	101143	1	78.6962	32.7552	0.45
379	101144	1	78.6884	32.7563	0.29
380	101145	1	78.7737	31.9149	0.29
381	101146	1	78.9863	31.3768	0.26
382	101147	3	78.9904	31.38	0.1
383	101148	3	78.9665	31.3626	0.15
384	101149	3	78.9637	31.3622	0.06
385	101150	3	79.0047	31.364	0.37
386	101151	3	79.0004	31.3625	0.04
387	101152	3	78.997	31.3646	0.13
388	101153	3	79.0067	31.3586	0.27
389	101154	3	79.0055	31.36	0.05
390	101155	3	79.0037	31.3679	0.18
391	101156	3	78.9156	31.3465	0.13
392	101157	2	78.7346	31.5184	1.89
393	101158	2	78.751	31.5535	4.54
394	101159	1	78.5054	32.3491	0.04
395	101160	1	78.5036	32.3457	0.03
396	101161	1	78.5077	32.3565	0.08
397	101162	1	78.5014	32.3485	0.04
398	101163	1	78.5087	32.3628	0.05
399	101164	1	78.5056	32.3486	0.06
400	101165	1	78.5088	32.3557	0.19
401	101166	1	78.5027	32.3439	0.75
402	101167	1	78.5025	32.3457	0.31

403	101168	1	78.5033	32.3449	0.09
404	101169	1	78.4984	32.3439	0.05
405	101170	1	78.499	32.3438	0.04
406	101171	1	78.5	32.3467	0.03
407	101172	1	78.5051	32.3464	0.04
408	101173	1	78.5006	32.3427	0.06
409	101174	1	78.4993	32.3412	0.04
410	101175	1	78.4955	32.3417	0.25
411	101176	1	78.5243	32.3193	0.1
412	101177	1	78.502	32.4207	0.78
413	101178	3	79.5445	32.3767	0.16
414	101179	3	79.5436	32.3759	0.1
415	101180	3	79.5436	32.3754	0.03
416	101181	3	79.5335	32.3706	2.17
417	101182	3	79.5899	32.3537	1.52
418	101183	3	79.5941	32.3527	5.29
419	101184	3	79.5728	32.3318	1.39
420	101185	3	79.5816	32.3261	1.02
421	101186	3	79.6458	32.2876	0.99
422	101187	3	79.6521	32.2697	0.27
423	101188	3	79.683	32.2542	5.84
424	101189	3	79.6684	32.2543	0.12
425	101190	3	79.6535	32.2353	0.92
426	101191	3	79.7054	32.2156	2.78
427	101192	3	79.3022	31.242	0.19
428	101193	3	79.3063	31.2329	4.23
429	101194	3	79.4378	31.1147	0.33
430	101195	3	79.425	31.0959	0.04
431	101196	3	79.4286	31.0946	0.03
432	101197	3	79.3063	31.2329	4.23
433	101198	3	79.3016	31.2401	0.3
434	101199	3	79.3573	31.1504	1.09
435	101200	3	79.3618	31.1498	0.31
436	101201	3	79.4351	31.1141	0.15
437	101202	3	79.4389	31.108	0.08
438	101203	3	79.4361	31.1026	0.1
439	101204	3	79.4372	31.0866	0.03
440	101205	3	79.4259	31.0862	0.07
441	101206	3	79.4234	31.079	0.25
442	101207	3	79.4105	31.0605	3.6
443	101208	3	79.4139	31.06	3.71
444	101209	3	79.4912	31.1312	1.56

445	101210	3	79.3658	31.1437	3.72
446	101211	3	79.3695	31.1462	0.08
447	101212	3	79.3796	31.1594	0.41
448	101213	3	79.3414	31.1534	3.77
449	101214	3	79.3187	31.1545	0.42
450	101215	3	79.3202	31.152	0.04
451	101216	3	79.2836	31.2732	0.14
452	101217	3	79.2785	31.2718	0.08
453	101218	3	79.8717	31.9772	8.9
454	101219	3	79.8754	31.968	3.23
455	101220	3	79.8895	31.9675	2.72
456	101221	3	79.8102	32.0283	0.75
457	101222	3	79.8124	32.0295	2.13
458	101223	3	79.8136	32.029	0.13
459	101224	3	79.8149	32.0277	0.97
460	101225	3	79.8145	32.027	0.36
461	101226	3	79.8176	32.021	0.32
462	101227	3	79.8263	32.0179	2.95
463	101228	3	79.8273	32.0117	0.24
464	101229	3	79.8024	32.0785	3.66
465	101230	3	79.7733	32.0947	4.95
466	101231	3	79.7891	32.1752	0.75
467	101232	3	82.1345	30.6373	5975.96
468	101233	3	82.1153	30.5852	1.6
469	101234	3	82.1796	30.5848	2.31
470	101235	3	82.2178	30.5974	1.02
471	101236	3	82.2185	30.5956	0.52
472	101237	3	82.2152	30.5916	0.24
473	101238	3	82.2146	30.5935	6.62
474	101239	3	82.156	30.5427	5.7
475	101240	3	82.1191	30.5451	1.65
476	101241	3	82.1227	30.5714	1.78
477	101242	3	82.2082	30.6094	0.14
478	101243	3	82.2092	30.6089	0.13
479	101244	3	82.2064	30.6067	0.11
480	101245	3	82.2263	30.6236	0.94
481	101246	3	82.2269	30.6227	0.66
482	101247	3	82.2298	30.62	1.76
483	101248	3	82.2344	30.619	1.15
484	101249	3	82.2353	30.6168	0.19
485	101250	3	82.236	30.6173	0.29
486	101251	3	82.2067	30.5809	1.16

487	101252	3	82.2081	30.5796	0.59
488	101253	3	82.2148	30.5765	0.27
489	101254	3	82.2148	30.5772	0.07
490	101255	3	82.2143	30.5783	0.22
491	101256	3	82.2174	30.5742	0.27
492	101257	3	82.2193	30.5738	0.09
493	101258	3	82.221	30.5724	0.05
494	101259	3	82.2202	30.5752	0.17
495	101260	3	82.2353	30.5743	2.11
496	101261	3	82.237	30.5763	2.62
497	101262	3	82.2348	30.5784	1.59
498	101263	3	82.2457	30.5836	1.82
499	101264	3	82.2471	30.5801	1.52
500	101265	3	82.2415	30.589	0.8
501	101266	3	82.2447	30.5879	0.55
502	101267	3	82.2439	30.5916	0.68
503	101268	3	82.2458	30.5967	1.52
504	101269	3	82.2458	30.5974	0.47
505	101270	3	82.2446	30.599	2.59
506	101271	3	82.2426	30.6027	0.27
507	101272	3	82.2428	30.6021	0.28
508	101273	3	82.2505	30.5986	0.42
509	101274	3	82.2507	30.5996	0.2
510	101275	3	82.25	30.6007	0.07
511	101276	3	82.2459	30.6003	0.27
512	101277	3	82.2466	30.5989	0.46
513	101278	3	82.2467	30.5982	0.29
514	101279	3	82.2475	30.5983	0.22
515	101280	3	82.2466	30.5999	0.12
516	101281	3	82.2429	30.6006	0.15
517	101282	3	82.2472	30.6023	0.12
518	101283	3	82.2446	30.6013	0.22
519	101284	3	82.2364	30.6152	0.81
520	101285	3	82.2368	30.6161	0.23
521	101286	3	82.2359	30.6162	0.29
522	101287	3	82.2295	30.6235	0.16
523	101288	3	82.2292	30.6229	0.22
524	101289	3	82.2278	30.6232	0.15
525	101290	3	82.2273	30.624	0.36
526	101291	3	82.2092	30.6231	0.23
527	101292	3	82.2288	30.6244	0.11
528	101293	3	82.2292	30.6241	0.05

529	101294	3	82.2326	30.6203	0.2
530	101295	3	82.2333	30.6207	0.09
531	101296	3	82.2336	30.6202	0.12
532	101297	3	82.2352	30.6191	0.08
533	101298	3	82.2348	30.6198	0.26
534	101299	3	82.2353	30.6185	0.12
535	101300	3	82.2348	30.6176	0.03
536	101301	3	82.2353	30.6178	0.05
537	101302	3	82.2307	30.6174	0.37
538	101303	3	82.2322	30.6179	0.34
539	101304	3	82.2285	30.6188	0.26
540	101305	3	82.2284	30.6194	0.88
541	101306	3	82.2257	30.6199	0.09
542	101307	3	82.2276	30.6205	0.15
543	101308	3	82.2285	30.6238	0.13
544	101309	3	82.228	30.6222	0.03
545	101310	3	82.2311	30.6191	0.4
546	101311	3	82.2403	30.6101	0.45
547	101312	3	82.2406	30.6094	0.28
548	101313	3	82.2387	30.6108	0.09
549	101314	3	82.2372	30.6121	0.65
550	101315	3	82.2363	30.6116	0.28
551	101316	3	82.2406	30.6126	0.08
552	101317	3	82.227	30.6132	0.47
553	101318	3	82.226	30.6115	0.79
554	101319	3	82.2273	30.6121	0.91
555	101320	3	82.2362	30.5848	0.56
556	101321	3	82.2363	30.5833	0.08
557	101322	3	82.2357	30.5805	0.09
558	101323	3	82.2474	30.5766	0.25
559	101324	3	82.2504	30.5751	0.12
560	101325	3	82.2497	30.5742	0.22
561	101326	3	82.2507	30.5736	0.12
562	101327	3	82.2077	30.5838	0.3
563	101328	3	82.208	30.5821	0.18
564	101329	3	82.2088	30.5829	0.12
565	101330	3	82.2118	30.5814	0.15
566	101331	3	82.2181	30.5857	1.26
567	101332	3	82.2207	30.5846	0.19
568	101333	3	82.2246	30.5816	0.11
569	101334	3	82.2182	30.5824	0.15
570	101335	3	82.2166	30.5836	0.85

571	101336	3	82.212	30.589	0.55
572	101337	3	82.2147	30.5883	0.27
573	101338	3	82.2145	30.5871	0.2
574	101339	3	82.2122	30.5864	0.14
575	101340	3	82.2164	30.5867	0.43
576	101341	3	82.2099	30.5849	0.07
577	101342	3	82.2109	30.5827	0.07
578	101343	3	82.2108	30.5819	0.08
579	101344	3	82.2102	30.5824	0.08
580	101345	3	82.2108	30.5842	0.98
581	101346	3	82.2197	30.5811	0.12
582	101347	3	82.221	30.5812	0.06
583	101348	3	82.2254	30.5841	0.13
584	101349	3	82.2266	30.5835	0.53
585	101350	3	82.2284	30.5824	0.19
586	101351	3	82.2243	30.5885	0.82
587	101352	3	82.2259	30.5881	0.31
588	101353	3	82.2301	30.5869	0.57
589	101354	3	82.2525	30.5675	0.74
590	101355	3	82.2512	30.5665	0.69
591	101356	3	82.2565	30.5638	0.37
592	101357	3	82.2577	30.5632	0.32
593	101358	3	82.2592	30.5627	0.28
594	101359	3	82.2628	30.5619	2.43
595	101360	3	82.2668	30.561	2.83
596	101361	3	82.255	30.565	0.42
597	101362	3	82.2488	30.5655	0.07
598	101363	3	82.2464	30.5655	0.25
599	101364	3	82.2402	30.5662	0.26
600	101365	3	82.2434	30.5686	0.34
601	101366	3	82.2095	30.5784	0.12
602	101367	3	82.2089	30.5792	0.06
603	101368	3	82.2072	30.5796	0.04
604	101369	3	82.208	30.581	0.12
605	101370	3	82.2057	30.5819	0.09
606	101371	3	82.2063	30.5821	0.05
607	101372	3	82.2067	30.586	0.32
608	101373	3	82.2248	30.5937	0.16
609	101374	3	82.2054	30.6043	0.17
610	101375	3	82.2083	30.6006	0.12
611	101376	3	82.212	30.5943	0.46
612	101377	3	82.2051	30.5954	0.05

613	101378	3	82.0421	30.6644	0.47
614	101379	3	82.0417	30.6651	0.13
615	101380	3	82.2325	30.6168	0.37
616	101381	3	82.2301	30.6187	0.17
617	101382	3	82.2309	30.6199	0.12
618	101383	3	82.2318	30.6195	0.07
619	101384	3	82.2315	30.6198	0.06
620	101385	3	82.2321	30.6222	0.22
621	101386	3	82.2227	30.6207	0.12
622	101387	3	82.2247	30.619	0.1
623	101388	3	82.2235	30.6177	0.24
624	101389	3	82.2234	30.6225	0.07
625	101390	3	82.2207	30.6207	0.08
626	101391	3	82.2181	30.6172	0.11
627	101392	3	82.2145	30.616	0.06
628	101393	3	82.2038	30.6166	0.13
629	101394	3	82.2484	30.5872	0.33
630	101395	3	82.2474	30.5866	0.2
631	101396	3	82.2461	30.5862	0.08
632	101397	3	82.2469	30.584	0.05
633	101398	3	82.2495	30.582	0.23
634	101399	3	82.2465	30.5824	0.07
635	101400	3	82.2472	30.5949	0.45
636	101401	3	82.2478	30.6017	0.23
637	101402	3	82.2485	30.6017	0.1
638	101403	3	82.2463	30.6023	0.12
639	101404	3	82.2373	30.6032	0.19
640	101405	3	82.2357	30.6067	0.1
641	101406	3	82.24	30.6113	0.05
642	101407	3	82.2401	30.6108	0.04
643	101408	3	82.2413	30.6101	0.06
644	101409	3	82.2408	30.6112	0.61
645	101410	3	82.2557	30.6245	1.88
646	101411	3	82.2801	30.5984	0.13
647	101412	3	82.2804	30.5988	0.07
648	101413	3	82.2802	30.5992	0.03
649	101414	3	82.242	30.5844	0.23
650	101415	3	82.2428	30.5824	0.15
651	101416	3	82.2422	30.5813	0.74
652	101417	3	82.245	30.5784	0.27
653	101418	3	82.2378	30.5794	0.56
654	101419	1	78.7012	31.9124	4.17

655	101420	1	78.7086	31.9067	0.5
656	101421	1	78.7023	31.9178	0.54
657	101422	1	78.7104	31.9534	0.03
658	101423	1	78.711	31.952	0.07
659	101424	1	78.7824	32.0531	0.76
660	101425	1	78.7806	32.0581	0.08
661	101426	1	78.781	32.0585	0.09
662	101427	1	78.7983	32.0562	0.18
663	101428	1	78.7992	32.0558	0.07
664	101429	1	78.798	32.0554	0.04
665	101430	1	78.9482	32.1388	0.81
666	101431	3	81.3615	30.7024	52.71
667	101432	3	78.781	31.9294	5.76
668	101433	3	78.784	31.9311	0.31
669	101434	3	78.7835	31.9271	1.09
670	101435	3	78.7972	31.9323	0.06
671	101436	3	78.7988	31.8767	0.03
672	101437	1	78.8426	31.9172	0.05
673	101438	3	78.8045	31.9545	0.14
674	101439	3	78.8097	31.9512	0.09
675	101440	3	78.8159	31.9632	0.06
676	101441	3	78.8375	31.9757	0.09
677	101442	3	78.8366	31.9757	0.19
678	101443	3	78.839	31.9762	0.03
679	101444	3	78.8429	31.9747	1.66
680	101445	3	78.8405	31.9763	0.07
681	101446	3	78.8395	31.9769	0.13
682	101447	3	78.85	31.9823	0.45
683	101448	1	78.1985	32.6646	0.15
684	101449	1	78.199	32.6643	0.09
685	101450	1	77.7147	32.5345	0.02
686	101451	1	78.5248	32.7469	8.12
687	101452	1	78.53	32.7445	2.93
688	101453	1	78.5295	32.7427	0.37
689	101454	1	78.7368	32.7	0.51
690	101455	1	78.9067	32.1444	1.35
691	101456	1	78.8231	32.0137	1.56
692	101457	1	78.6279	31.8798	0.87
693	101458	1	78.628	31.8846	0.12
694	101459	1	78.3861	31.9772	0.05
695	101460	1	78.3856	31.9748	0.04
696	101461	1	78.3392	31.9596	0.09

697	101462	1	78.2173	31.945	1.71
698	101463	1	78.2391	31.9357	0.16
699	101464	1	78.0827	31.8353	0.33
700	101465	1	78.0702	31.8425	0.04
701	101466	1	78.0741	31.8985	0.12
702	101467	1	78.0723	31.8979	0.04
703	101468	1	77.8089	31.9614	0.08
704	101469	1	77.8093	31.9611	0.02
705	101470	1	77.8083	31.9594	0.03
706	101471	1	77.8074	31.9591	0.01
707	101472	1	77.8068	31.9589	0.02
708	101473	1	77.8157	31.9655	0.07
709	101474	1	77.863	31.943	0.06
710	101475	1	77.8629	31.9399	0.47
711	101476	1	77.8477	32.0549	0.38
712	101477	1	77.8926	32.0596	0.04
713	101478	1	77.9434	32.0913	0.08
714	101479	1	78.0331	32.2421	0.51
715	101480	1	78.0388	32.2427	0.08
716	101481	1	77.6781	32.599	2.66
717	101482	1	77.6759	32.6028	0.16
718	101483	1	77.6755	32.6023	0.02
719	101484	1	77.6611	32.6223	0.02
720	101485	1	77.662	32.6203	0.05
721	101486	2	78.1662	31.663	0.06
722	101487	2	78.4205	31.4037	1.42
723	101488	2	78.7934	31.4498	7.95
724	101489	2	78.7411	31.7093	2.12
725	101490	2	78.7631	31.6923	1.08
726	101491	0	78.7361	31.5424	1.43
727	101492	0	78.7381	31.5448	0.44
728	101493	0	78.7389	31.5457	0.16
729	101494	0	78.7526	31.5588	0.11
730	101495	0	78.7533	31.5601	0.03
731	101496	2	78.7712	31.5559	0.07
732	101497	2	78.7521	31.5569	0.41
733	101498	2	78.3755	31.928	0.13
734	101499	2	78.3788	31.9363	0.14
735	101500	2	78.7443	31.7335	3.16
736	101501	3	82.0549	30.6803	0.23
737	101502	3	82.0208	30.6655	2.22
738	101503	3	82.0081	30.6774	0.07

739	101504	3	81.74	30.5385	0.35
740	101505	3	81.7384	30.5326	0.67
741	101506	3	81.7372	30.5336	0.21
742	101507	3	81.7369	30.537	1.51
743	101510	3	81.7354	30.5411	0.72
744	101511	3	81.7369	30.54	0.79
745	101512	3	81.738	30.5416	0.09
746	101513	3	81.7412	30.5427	0.06
747	101514	3	81.7388	30.5441	1.35
748	101515	3	81.7378	30.5376	0.13
749	101516	3	81.7355	30.5329	0.25
750	101517	3	81.736	30.534	0.29
751	101518	3	81.7372	30.5352	0.14
752	101519	3	81.7346	30.5362	0.22
753	101520	3	81.7357	30.5367	0.24
754	101521	3	81.7379	30.5339	0.23
755	101522	3	81.7385	30.5345	0.25
756	101523	3	81.7371	30.5341	0.15
757	101524	3	81.7399	30.531	0.47
758	101525	3	81.5292	30.8309	5.75
759	101526	3	81.5126	30.7959	0.47
760	101527	3	81.5108	30.7956	0.29
761	101528	3	81.5115	30.7942	0.16
762	101529	3	81.512	30.7933	0.42
763	101530	3	81.521	30.7925	0.49
764	101531	3	81.5262	30.7936	0.2
765	101532	3	81.5417	30.784	0.21
766	101533	3	81.5547	30.781	6.51
767	101534	3	81.5532	30.7786	1.32
768	101535	3	81.5495	30.7803	0.37
769	101536	3	81.5458	30.7798	0.58
770	101537	3	81.5487	30.7814	1.51
771	101538	3	81.551	30.7816	0.36
772	101539	3	81.5473	30.7818	0.19
773	101540	3	81.5431	30.7789	0.12
774	101541	3	81.5443	30.7782	0.3
775	101542	3	81.5453	30.7779	0.18
776	101543	3	81.5467	30.7766	0.26
777	101544	3	81.5957	30.7962	1.37
778	101545	3	81.5954	30.7994	0.19
779	101546	3	81.5675	30.7697	0.36
780	101547	3	81.566	30.7698	0.09

781	101548	3	81.5636	30.7725	0.32
782	101549	3	81.5654	30.7743	0.92
783	101550	3	81.5634	30.7744	0.07
784	101551	3	81.5611	30.7725	0.27
785	101552	3	81.5638	30.7778	0.21
786	101553	3	81.5631	30.7784	0.06
787	101554	3	81.5631	30.7761	0.06
788	101555	3	81.5626	30.7761	0.04
789	101556	3	81.5558	30.7755	0.11
790	101557	3	81.565	30.7848	0.99
791	101558	3	81.5626	30.7823	0.19
792	101559	3	81.5611	30.7814	0.07
793	101560	3	81.5814	30.7771	0.35
794	101561	3	81.5041	30.7983	1.14
795	101562	3	81.5026	30.798	0.24
796	101563	3	81.5014	30.7982	0.16
797	101564	3	81.512	30.8041	0.15
798	101565	3	81.5247	30.7881	0.3
799	101566	3	81.526	30.7879	0.2
800	101567	3	81.5459	30.792	0.49
801	101568	3	81.5453	30.7926	0.06
802	101569	3	81.5453	30.7893	0.14
803	101570	3	81.5428	30.7895	0.19
804	101571	3	81.5484	30.7884	0.16
805	101572	3	81.5456	30.7884	0.06
806	101573	3	81.5468	30.7894	0.14
807	101574	3	81.5445	30.7894	0.12
808	101575	3	81.5424	30.7882	3.85
809	101576	3	81.5384	30.7929	0.89
810	101577	3	81.5398	30.7933	0.11
811	101578	3	81.5397	30.7918	0.09
812	101579	3	81.5617	30.7753	0.17
813	101580	3	81.5496	30.7777	0.08
814	101581	3	81.5515	30.7804	0.07
815	101582	3	81.5232	30.7869	0.15
816	101583	3	81.5206	30.7863	0.06
817	101584	3	81.5189	30.7857	0.06
818	101585	3	81.4691	30.8377	0.17
819	101586	3	81.2075	30.8943	1.88
820	101587	3	81.2003	30.8969	0.76
821	101588	3	81.1937	30.8978	3.56
822	101588	3	81.1934	30.8997	0.45

823	101589	3	81.1921	30.9031	0.5
824	101590	3	81.2285	30.886	2.67
825	101591	3	81.2252	30.8906	0.22
826	101592	3	81.226	30.8918	0.08
827	101593	3	81.2378	30.8927	0.23
828	101594	3	81.2372	30.8945	0.25
829	101595	3	81.2341	30.8939	0.19
830	101596	3	81.2316	30.8933	0.13
831	101597	3	81.2321	30.889	0.37
832	101598	3	81.2379	30.8908	3.59
833	101599	3	81.2226	30.8967	0.21
834	101600	3	81.1987	30.888	0.78
835	101601	3	81.2022	30.8879	0.43
836	101602	3	81.215	30.8855	7.52
837	101603	3	81.2222	30.8824	2.62
838	101604	3	81.2267	30.8853	0.3
839	101605	3	81.2256	30.8846	0.29
840	101606	3	81.231	30.8845	0.65
841	101607	3	81.2379	30.8937	0.56
842	101608	3	81.2168	30.8929	0.15
843	101609	3	81.2164	30.89	0.12
844	101610	3	81.2179	30.8907	0.09
845	101611	3	81.2167	30.8911	0.23
846	101612	3	81.2097	30.8879	0.56
847	101613	3	81.1867	30.8994	0.13
848	101614	3	81.1848	30.8964	0.1
849	101615	3	81.1869	30.8926	13.83
850	101616	3	81.1785	30.9052	0.68
851	101617	3	81.2721	30.8713	0.71
852	101618	3	81.2722	30.8697	0.68
853	101619	3	81.2721	30.8681	0.43
854	101620	3	81.273	30.8685	0.27
855	101621	3	81.2703	30.8693	0.25
856	101622	3	81.2744	30.8647	0.65
857	101623	3	81.272	30.8643	0.48
858	101624	3	81.2713	30.8659	0.2
859	101625	3	81.2731	30.866	0.17
860	101626	3	81.2741	30.8598	0.18
861	101627	3	81.2764	30.8648	0.09
862	101628	3	81.2758	30.8658	0.09
863	101629	3	81.3242	30.9052	1.05
864	101630	3	81.3184	30.8953	0.16

865	101631	3	81.3183	30.8948	0.08
866	101632	3	81.3166	30.8948	0.04
867	101633	3	81.3241	30.9024	0.76
868	101634	3	81.3214	30.9037	0.49
869	101635	3	81.3227	30.9051	4.52
870	101636	3	81.3245	30.908	0.15
871	101637	3	81.3245	30.9073	0.13
872	101638	3	81.3253	30.8999	0.15
873	101639	3	81.3247	30.9001	0.07
874	101640	3	81.3246	30.9003	0.03
875	101641	3	81.3241	30.9009	0.12
876	101642	3	81.3237	30.9012	0.07
877	101643	3	81.3245	30.9007	0.05
878	101644	3	81.3266	30.899	0.09
879	101645	3	81.3259	30.8992	0.04
880	101646	3	81.303	30.9205	0.34
881	101647	3	81.3019	30.9207	0.15
882	101648	3	81.3029	30.9214	0.14
883	101649	3	81.304	30.9217	0.22
884	101650	3	81.3061	30.9233	0.27
885	101651	3	81.3052	30.923	0.06
886	101652	3	81.3011	30.9188	0.3
887	101653	3	81.3018	30.9198	0.16
888	101654	3	81.2985	30.9165	0.19
889	101655	3	81.2971	30.9159	0.08
890	101656	3	81.2849	30.9056	2.49
891	101657	3	81.2861	30.9075	0.48
892	101658	3	81.2873	30.9101	0.25
893	101659	3	81.2871	30.9093	0.09
894	101660	3	81.2891	30.9098	0.08
895	101661	3	81.293	30.9098	0.27
896	101662	3	81.2934	30.9106	0.08
897	101663	3	81.2958	30.9138	0.26
898	101664	3	81.302	30.9134	0.08
899	101665	3	81.3019	30.9126	0.04
900	101666	3	81.3021	30.9139	0.02
901	101667	3	81.3017	30.9139	0.03
902	101668	3	81.2867	30.897	0.29
903	101669	3	81.2952	30.8908	0.75
904	101670	3	81.2938	30.8915	0.39
905	101671	3	81.2979	30.9356	0.2
906	101672	3	81.2869	30.9039	0.55

907	101673	3	81.2859	30.8992	0.77
908	101674	3	81.2706	30.9382	0.29
909	101675	3	80.7439	30.8231	266.71
910	101676	3	80.7113	30.8438	0.53
911	101677	3	80.7131	30.8429	0.23
912	101678	3	80.7339	30.8223	0.22
913	101679	3	80.7334	30.8202	0.19
914	101680	3	80.7186	30.8233	0.39
915	101681	3	80.7254	30.8294	0.19
916	101682	3	80.7205	30.8319	0.16
917	101683	3	80.7199	30.8324	0.05
918	101684	3	80.7197	30.8305	0.15
919	101685	3	80.7175	30.8289	0.06
920	101686	3	80.7101	30.843	0.29
921	101687	3	80.7098	30.8418	0.13
922	101688	3	80.7079	30.8402	0.05
923	101689	3	80.7091	30.8395	0.07
924	101690	3	80.7067	30.8415	0.09
925	101691	3	80.7076	30.8412	0.03
926	101692	3	80.7091	30.8449	0.08
927	101693	3	80.7209	30.8561	2.28
928	101694	3	80.7159	30.8451	0.58
929	101695	3	80.718	30.8422	0.09
930	101696	3	80.7133	30.8408	0.5
931	101697	3	80.7137	30.8389	0.12
932	101698	3	80.7143	30.8389	0.09
933	101699	3	80.7142	30.8384	0.09
934	101700	3	80.717	30.8347	0.05
935	101701	3	80.7176	30.8353	0.05
936	101702	3	80.7191	30.8392	0.06
937	101703	3	80.7196	30.8379	0.09
938	101704	3	80.7079	30.8501	0.09
939	101705	3	80.7066	30.8504	0.09
940	101706	3	80.7405	30.8134	0.24
941	101707	3	80.7351	30.8128	0.17
942	101708	3	80.7654	30.8152	0.37
943	101709	3	80.7631	30.8071	0.73
944	101710	3	80.7666	30.7956	0.43
945	101711	3	80.7679	30.7967	0.14
946	101712	3	80.7688	30.7966	0.08
947	101713	3	80.7659	30.7974	0.14
948	101714	3	80.7613	30.7796	0.47

949	101715	3	80.7634	30.7803	1.16
950	101716	3	80.7643	30.7818	0.24
951	101717	3	80.7654	30.7818	0.03
952	101718	3	80.7626	30.7578	0.06
953	101719	3	80.761	30.7601	0.13
954	101720	3	80.7808	30.7658	0.04
955	101721	3	80.7802	30.7666	0.3
956	101722	3	80.779	30.767	0.14
957	101723	3	80.788	30.7751	0.05
958	101724	3	80.7887	30.7752	0.17
959	101725	3	80.7877	30.7755	0.06
960	101726	3	80.787	30.7749	0.69
961	101727	3	80.7854	30.7738	0.55
962	101728	3	80.7924	30.7753	0.13
963	101729	3	80.7913	30.7745	0.38
964	101730	3	80.7692	30.8024	0.23
965	1537HWL	3	81.2324	30.687	25777.3
966	1567HWL	3	81.197	30.8924	0.4
967	1568HWL	3	81.1998	30.8931	1.06
968	1569HWL	3	81.2036	30.8929	1.12
969	1570HWL	3	81.2106	30.8937	1.94
970	1571HWL	3	81.2294	30.892	1.31
971	2651HWL	3	81.1937	31.182	53.01
972	2653HWL	3	81.2023	31.1919	30.42
973	2658HWL	3	81.1556	30.9782	2.48
974	2659HWL	3	81.155	30.9768	1.15
975	2665HWL	3	81.232	30.8912	2.3
976	2666HWL	3	81.2314	30.888	0.43
977	1565RS	3	81.133	30.9219	5.21
978	1566RS	3	81.1414	30.9198	1.06
979	2660RS	3	81.0942	30.9256	17.48
980	2661RS	3	81.1052	30.9244	2.16
981	2662RS	3	81.1091	30.9238	1.98
982	2663RS	3	81.1166	30.9243	11.88
983	2664RS	3	81.1728	30.9087	107.14
984	2672RS	3	80.9352	31.0015	30.67
985	2673RS	3	81.1379	30.9203	0.77
986	193SG	1	78.8703	32.1019	0.03
987	2144SG	1	78.3725	31.9729	0.03
988	2145SG	1	78.3734	31.9735	0.05
989	2146SG	1	78.3733	31.9742	0.05
990	2148SG	1	78.3855	31.9736	0.05

991	2149SG	1	78.3828	31.9764	0.02
992	2195SG	1	78.7011	31.9572	0.03
993	2196SG	1	78.7056	31.9559	0.03
994	2198SG	1	78.7079	31.9549	0.02
995	2207SG	1	78.6955	31.9002	0.05
996	2209SG	1	78.7003	31.8968	0.06
997	2210SG	1	78.7048	31.8962	0.03
998	2211SG	1	78.7047	31.8966	0.03
999	2212SG	1	78.705	31.8968	0.05
1000	2213SG	1	78.7118	31.8953	0.03
1001	2215SG	1	78.7152	31.8947	0.05
1002	393SG	1	78.6983	31.8973	0.04
1003	395SG	1	78.701	31.8958	0.03
1004	396SG	1	78.7026	31.8965	0.14
1005	397SG	1	78.704	31.8953	0.02
1006	398SG	1	78.7072	31.8966	0.07
1007	399SG	1	78.7128	31.8952	0.15
1008	402SG	1	78.7134	31.8956	0.03
1009	403SG	1	78.7138	31.8955	0.03
1010	404SG	1	78.714	31.8947	0.03
1011	405SG	1	78.7142	31.8939	0.16
1012	406SG	1	78.7218	31.893	0.08
1013	407SG	1	78.7221	31.8924	0.08
1014	411SG	1	78.7284	31.893	0.11
1015	448SG	1	78.7149	31.9497	0.06
1016	450SG	1	78.714	31.9514	0.1
1017	452SG	1	78.7107	31.9532	0.02
1018	455SG	1	78.7061	31.9548	0.16
1019	456SG	1	78.701	31.956	0.04
1020	457SG	1	78.7013	31.9578	0.26
1021	458SG	1	78.7003	31.9587	0.01
1022	461SG	1	78.7201	31.9914	0.28
1023	467SG	1	78.3838	31.9724	0.05
1024	468SG	1	78.3844	31.9728	0.04
1025	470SG	1	78.3861	31.9757	0.26
1026	471SG	1	78.3833	31.9771	0.02
1027	472SG	1	78.3829	31.9775	0.1
1028	473SG	1	78.3721	31.9721	0.16
1029	474SG	1	78.3709	31.9758	0.52
1030	475SG	1	78.3726	31.9765	0.09
1031	476SG	1	78.3739	31.977	0.05
1032	477SG	1	78.3734	31.9794	0.12

1033	838WL	2	77.959	31.481	1.59
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Based on LISS-IV satellite data, a total of 1953 lakes/wetlands could be delineated in comparison to 1632 lakes in 2021 and to 1359 lakes/high mapped in 2020. Further analysis reveals that 368 lakes mapped in Spiti basin out of 1953 lakes/high altitude wetlands reflecting reduction of 3% in comparison to 2021(379). The analysis further reveals that out 368 lakes/wetlands mapped in Spiti basin, 362 lakes / high altitude wetlands delineated were the small one with area less 5ha in comparison to 366 (2021) to 212 (2020), 5 lakes / high altitude wetlands falls within the areal range of 5-10 ha earlier it was 10 (2021) and 8 (2020). There has been only one big lake with area more than 10ha could be seen w.r.t. 3(2021) and 5(2020) (Fig: 10.15).

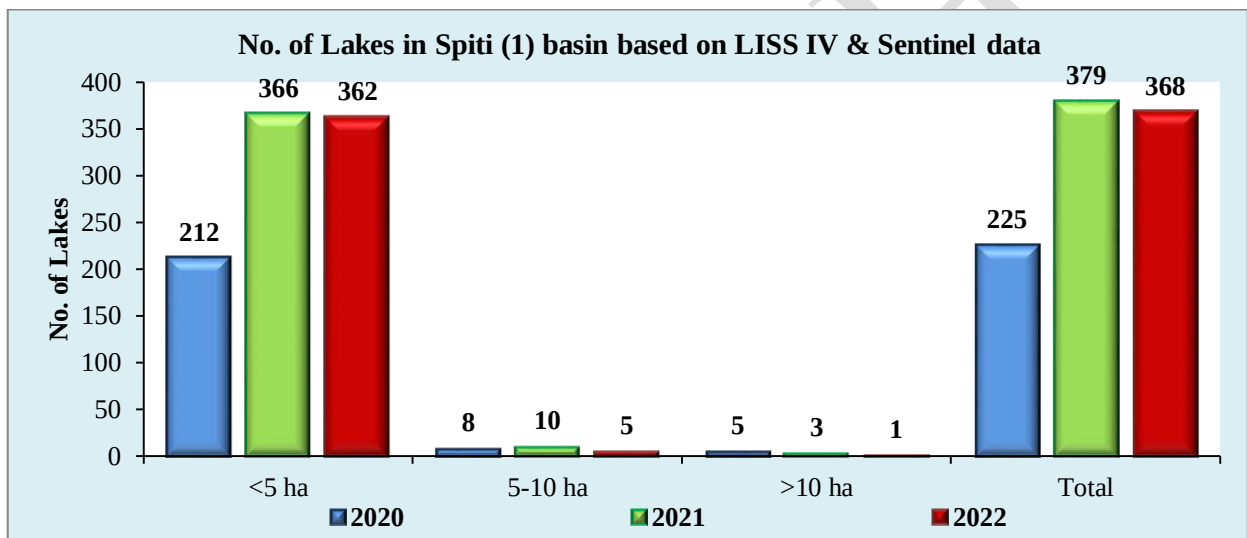


Fig. 10.15: No. of Lakes in Spiti basin (1) Based on LISS-IV and Sentinel Data

Likewise the 250 lakes/high altitude wetlands delineated in Lower Satluj basin indicating a reduction of 53% w.r.t. 529 lakes in 2021. Out of 250 lakes, 245 were smaller lakes/ high altitude wetlands with area less than 5ha were reduced in comparison to 2021(526) and 2020(539), respectively. There were 3 lakes identified within the areal range 5-10 ha and 2 big lakes could be mapped with area more than 10h in this basin (Fig: 10.16). In Upper Satluj basin, 1335 lakes mapped out indicating an increase of 84% in comparison to 2021(724) comprises of 1242 as the small one with area <5ha, 48 with area 5-10ha and 45 with area more than 10ha respectively (Fig: 10.17).

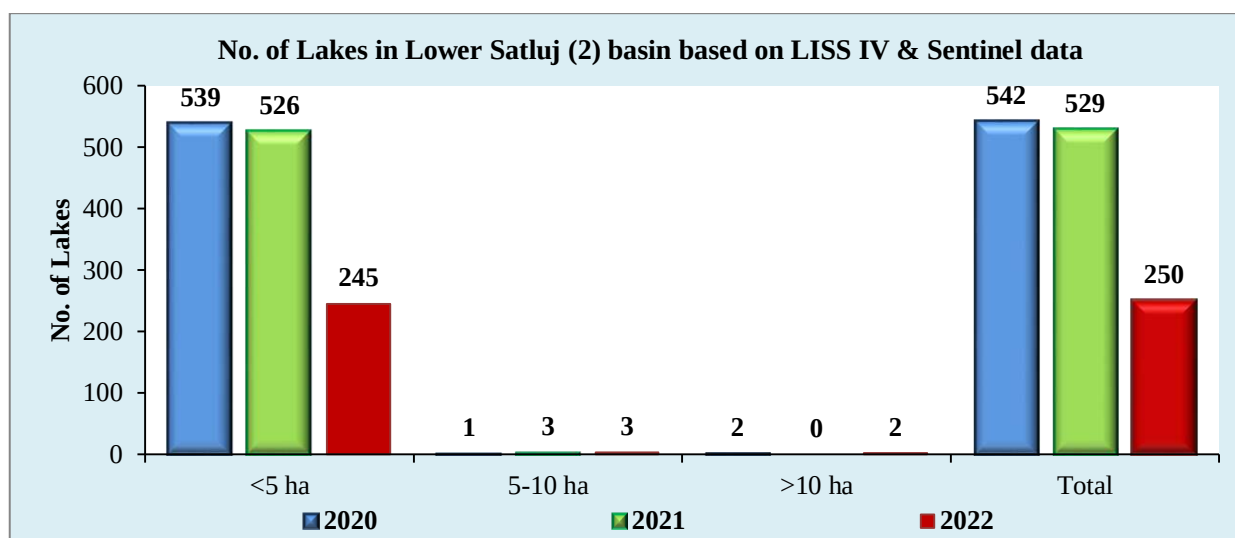


Fig.10.16: No. of Lakes in Lower Satluj basin (2) based on LISS-IV and Sentinel Data

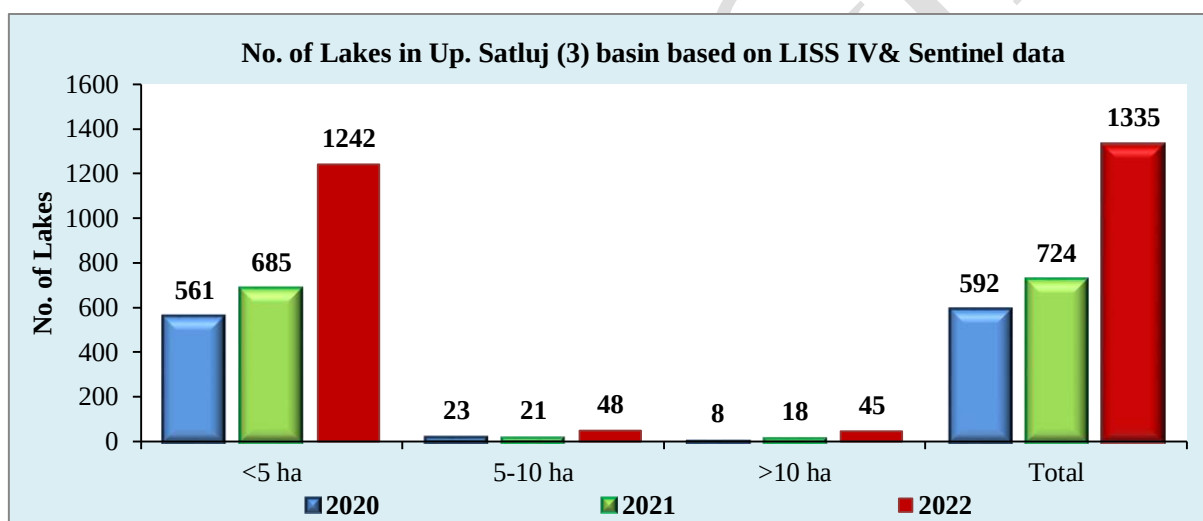


Fig. 10.17: No. of Lakes in Upper Satluj basin (3) based on LISS-IV and Sentinel Data

Further analysis of the data reveals that out of 1953 lakes/wetlands delineated, 1849 were the small one with area less than 5ha, 56 are within the area range of 5-10 ha and 48 were the one which have the area more than 10ha respectively. In other words, we can say that based on the LISS IV data, majority of the lakes /wetlands i.e.1849 (95%) were the small one with area less than 5ha, 56 (3%) were within the areal range of 5-10ha and 48 (2%) were the big one with area more than 10ha . Further, out of these 1953 lakes/wetlands, 37 lakes have been classified as high-altitude wetlands and the remaining 1916 as from the glacial origin.

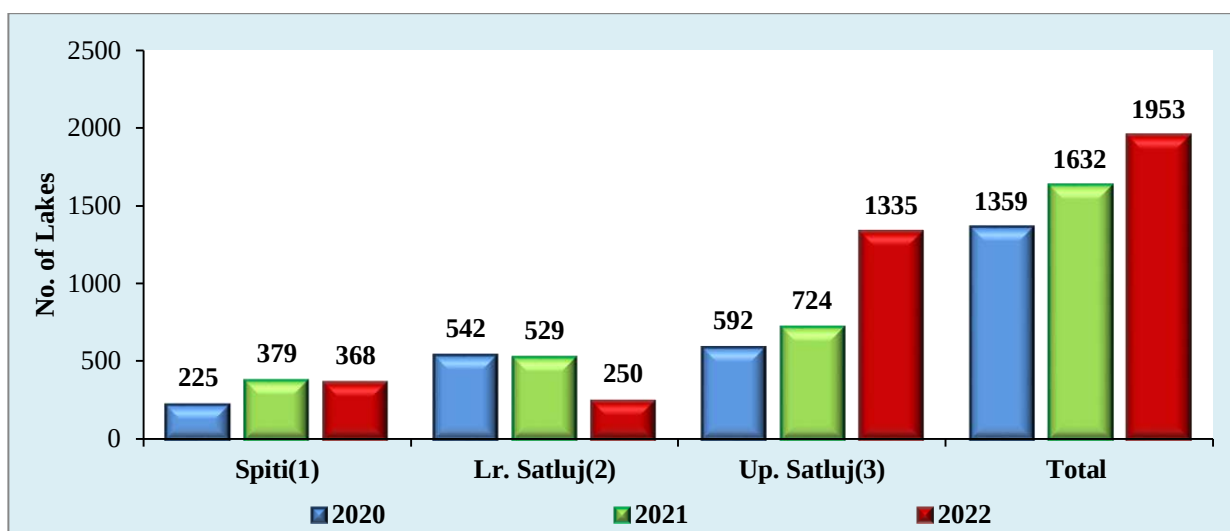


Fig. 10.18: No. of lakes in Satluj Basin based on LISS IV and Sentinel Data (2020- 2022)

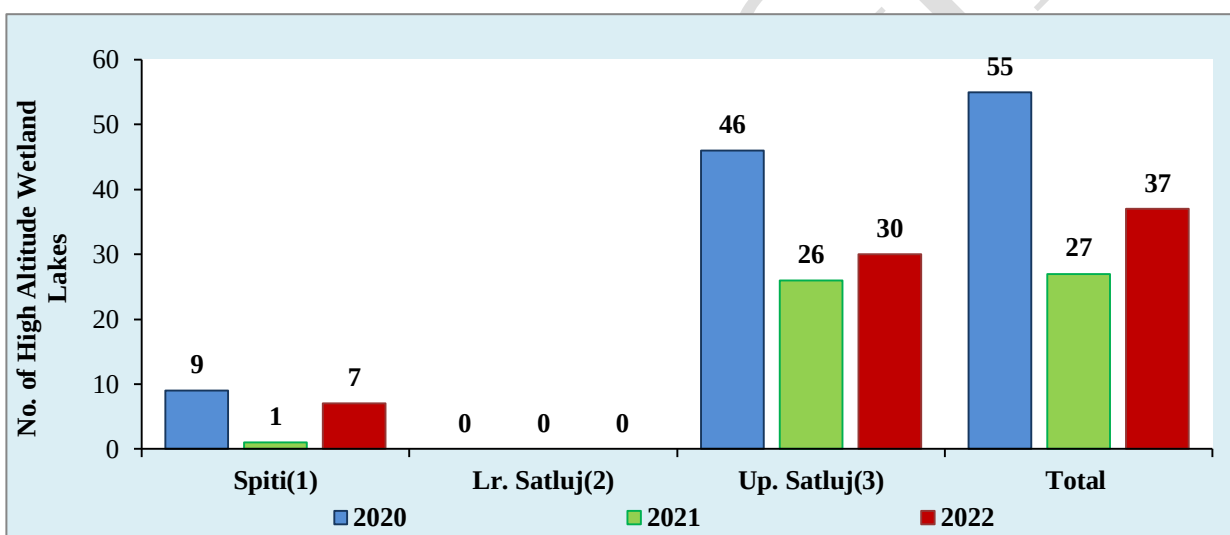


Fig. 10.19: No. of High Altitude wetland lakes in Satluj Basin based on LISS IV and Sentinel data (2020-2022)

The comparative analysis for the lakes mapped during 2022 with that of 2021 reveals that about 20% enhancement could be seen in the total number of lakes in comparison to 1632 (2021) reflecting an enhancement of about 84% (611) lakes in case of Upper Satluj basin, about 52% reduction in case of Lower Satluj basin i.e. from 529(2021) to 250(2022) and about 3% (11) reduction in case of Spiti basin could be noticed in 2022 in comparison to 2021. As far as the bigger lakes/wetlands with area more than 10ha were concerned, an increase of 27 lakes /wetlands i.e. 48 lakes (2022) in comparison to 21 (2021) could be observed reflecting a total increase of about 128% in the bigger lakes during this period (Fig: 10.21). The variation of the number of lakes is

mainly due to the data gaps available during 2021 and 2022. Thus from the above analysis based on LISS IV sensors, it is inferred that the level of information in the catchment has increased and more detailed information could be seen which would form the base line data for future investigations with higher resolutions satellite data.

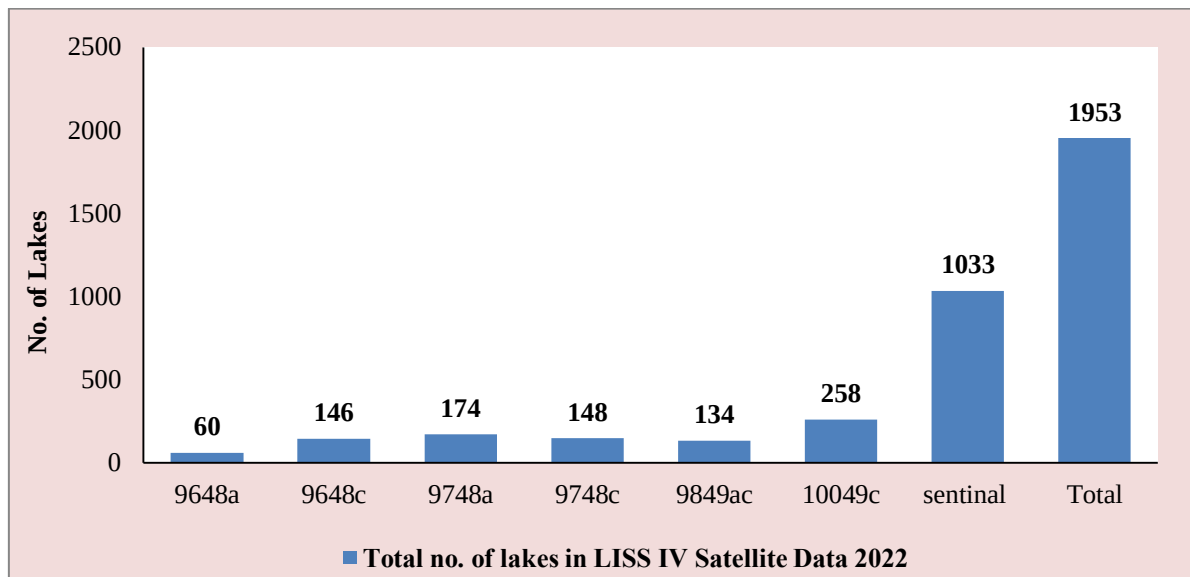


Fig. 10.20: Total no. of lakes in LISS IV and Sentinel Data 2022

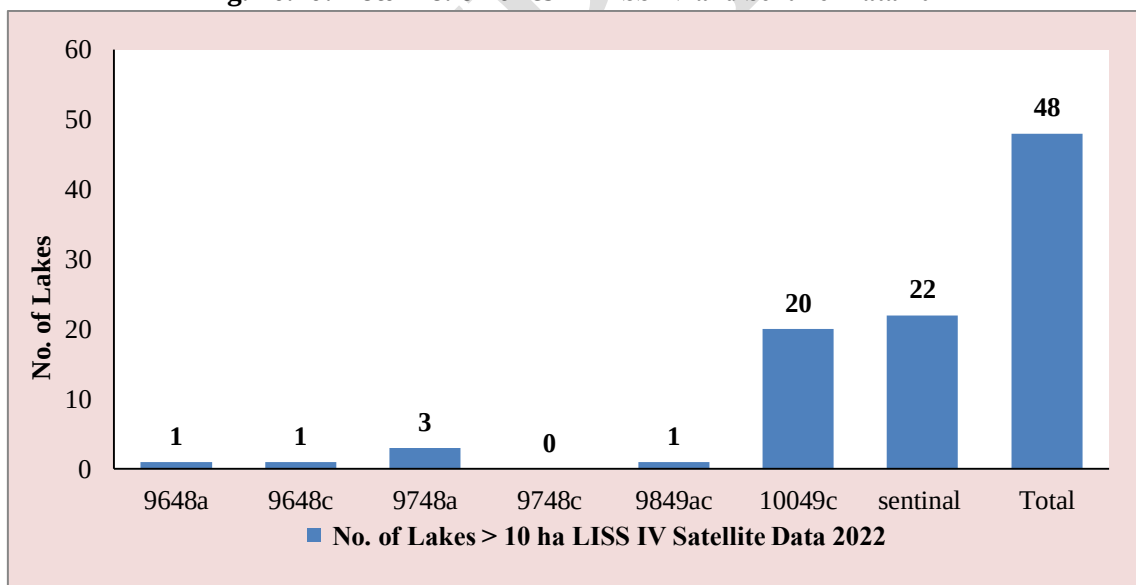


Fig. 10.21: No. of Lakes > 10 ha LISS IV and Sentinel Data 2022

The comparative analysis of the results obtained from AWiFS, LISS III and LISS IV as per Table: 10.7 between 2021 and 2022 reflects that Spiti basin is characterized by an reduction of 18% from AWiFS, enhancement of 42% from LISS III and further reduction by about 3% from LISS IV satellite data product. Likewise the Lower Satluj basin showed an enhancement by about

59 % in AWiFS, 6% from LISS III and a reduction of about 53% from LISS IV satellite data. The Upper Satluj basin does show reduction of about 4% from AWiFS, enhancement of about 9% from LISS III and an increase of about 84% from LISS IV data product. Further analysis in terms of level of information reveals that number of lakes in Spiti basin were 55 with AWiFS sensor to 183 with LISS III to 368 with LISS IV sensor. Likewise the Lower Satluj basins reflects an increase from 62 with AWiFS to 173 with LISS III to 250 with LISS IV and the Upper Satluj basin have 297 with AWiFS to 639 with LISS III to 1335 with LISS IV sensors respectively.

Table 10.8 Comparative analysis of three different sensors

Sr. no	Basin Name	AWiFS (56mts)			LISS -III (23.5mts)			LISS-IV (5.8mts)		
		2020	2021	2022	2020	2021	2022	2020	2021	2022
1	Spiti Basin (1)	62	67	55	197	129	183	225	379	368
2	Lower Satluj (2)	20	39	62	89	163	173	542	529	250
3	Upper Satluj (3)	279	308	297	707	588	639	592	724	1335
4	Total Satluj Basin	361	414	414	993	880	995	1359	1632	1953

11.0 Satellite view of lakes in Satluj Basin (LISS IV)

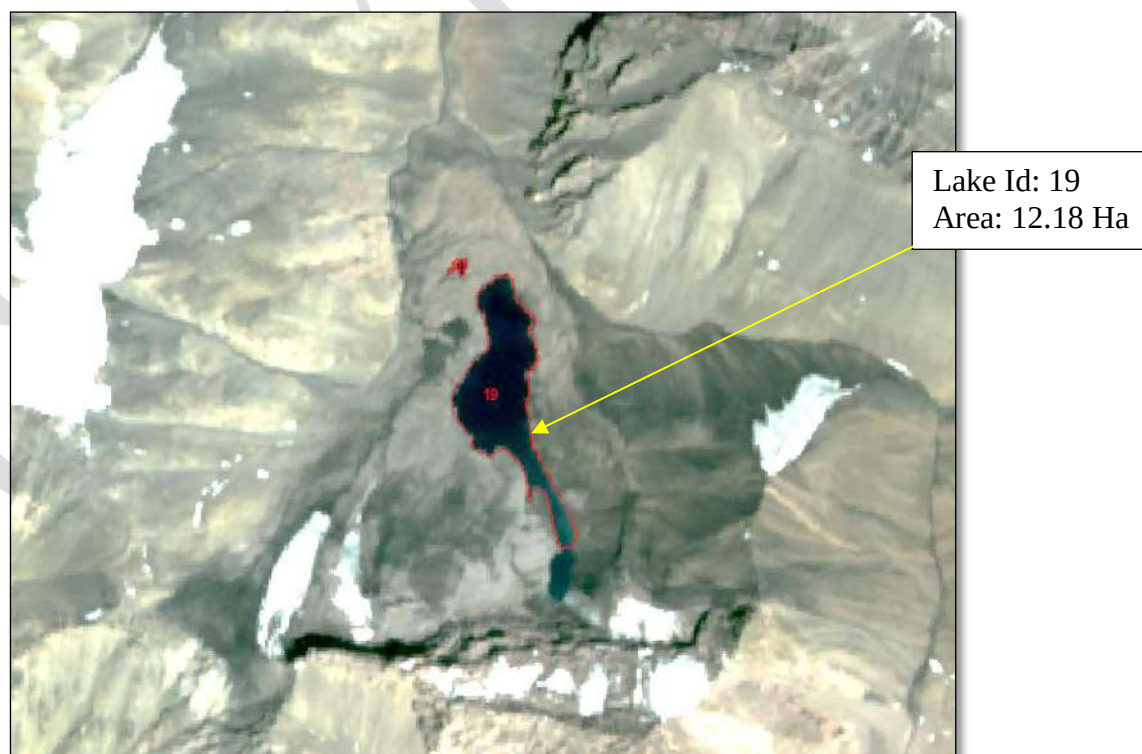
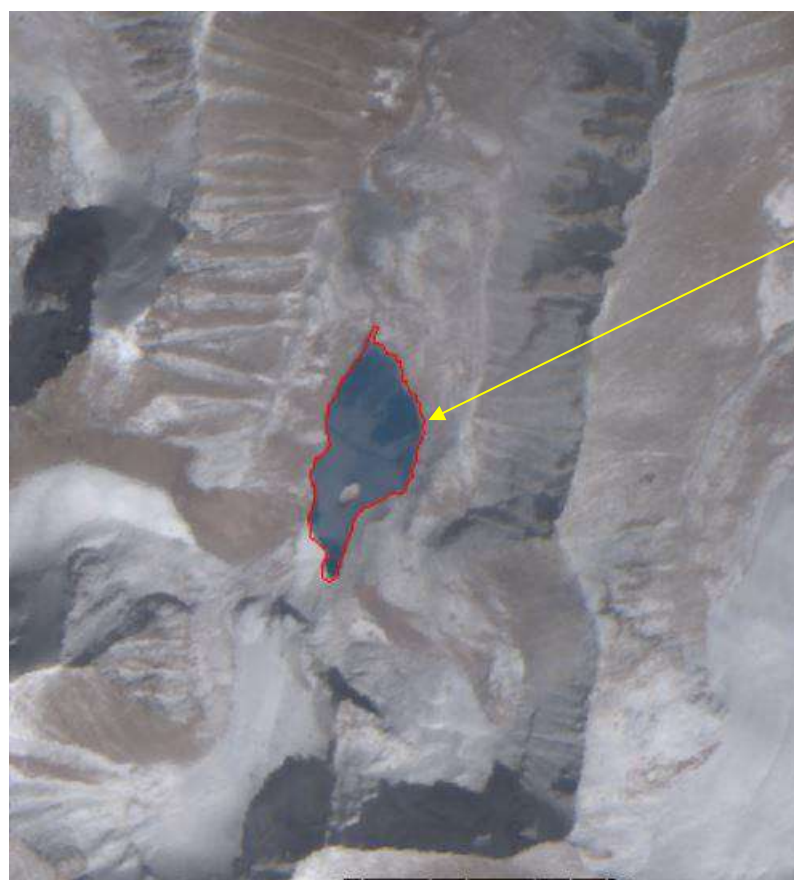


Fig No. 11.0 (a): Lake Id 19, L4, 96 48 (Spiti Basin), 15th October 2022



Lake Id: 100567
Area: 16.31 Ha

Fig No. 11.0 (b): Pro Glacial Lake in Spiti basin

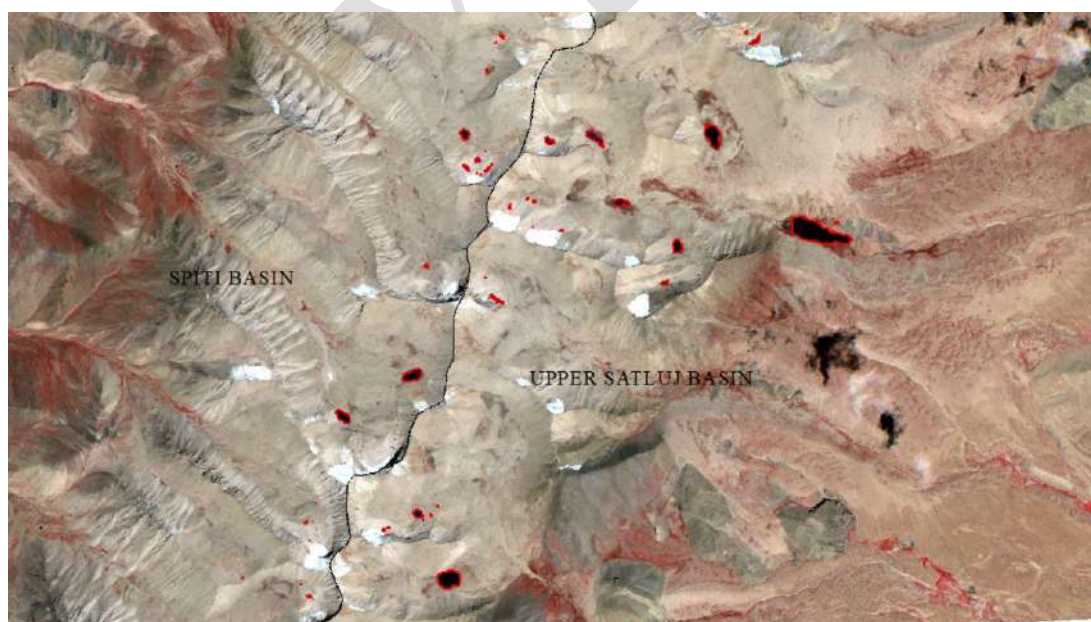


Fig No. 11.0 (c): Lakes in Spiti basin and Upper Satluj Basin

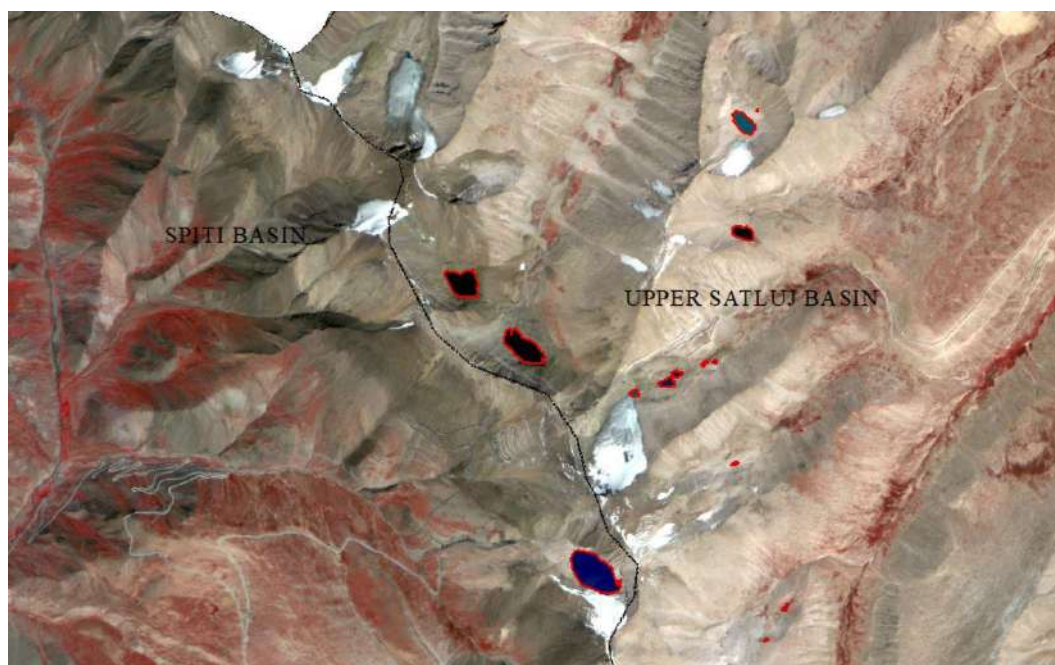


Fig No. 11.0 (d): Lakes in Spiti basin and Upper Satluj Basin

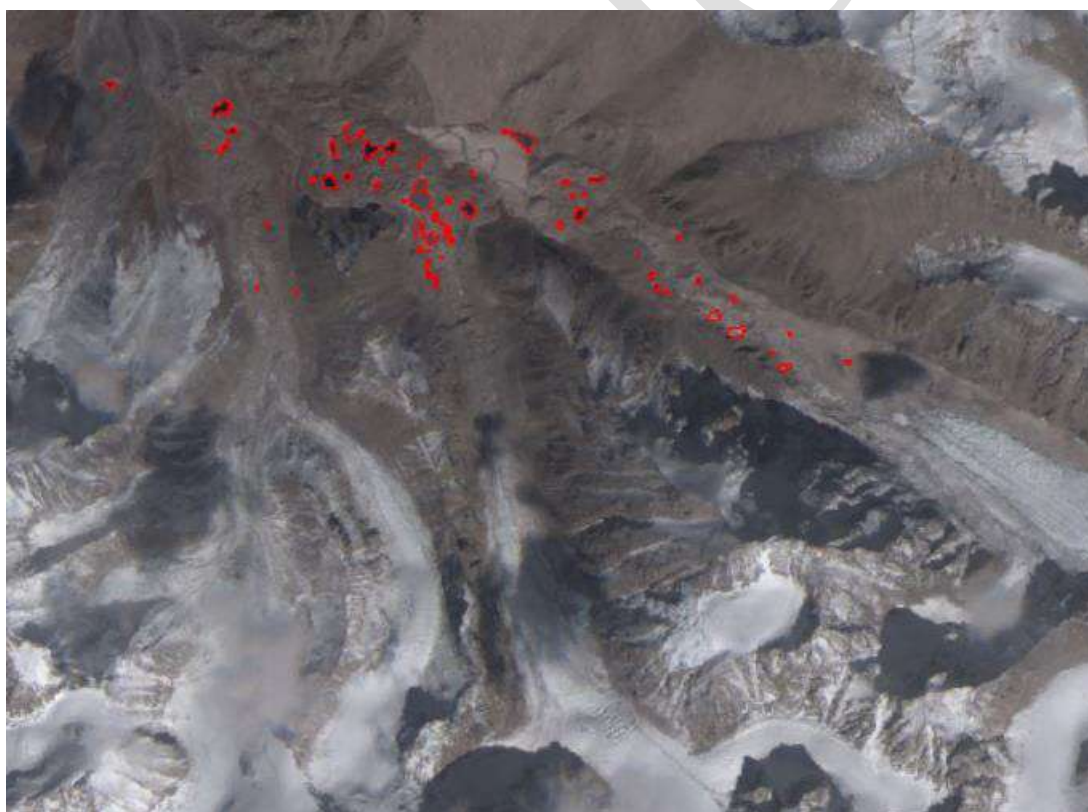


Fig No. 11.0 (e): Supra Glacial Lakes in Spiti basin



Fig No. 11.0 (f): Supra Glacial Lakes in Spiti basin

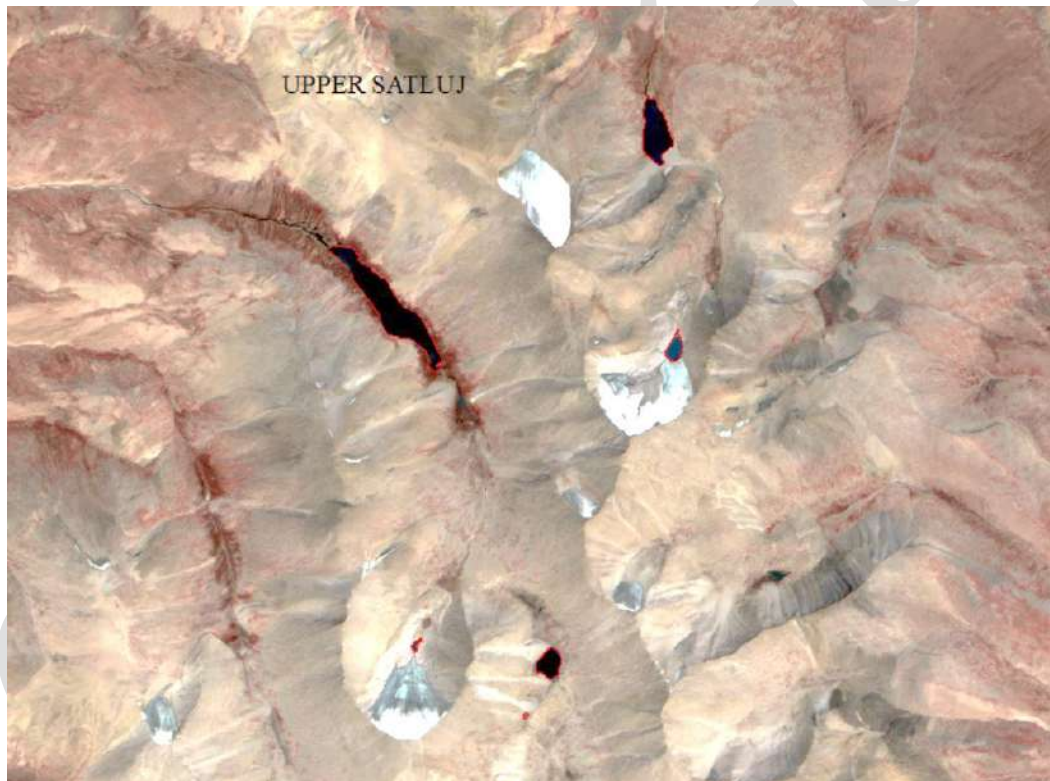


Fig No. 11.0 (g): No. of Lakes in Upper Satluj Basin

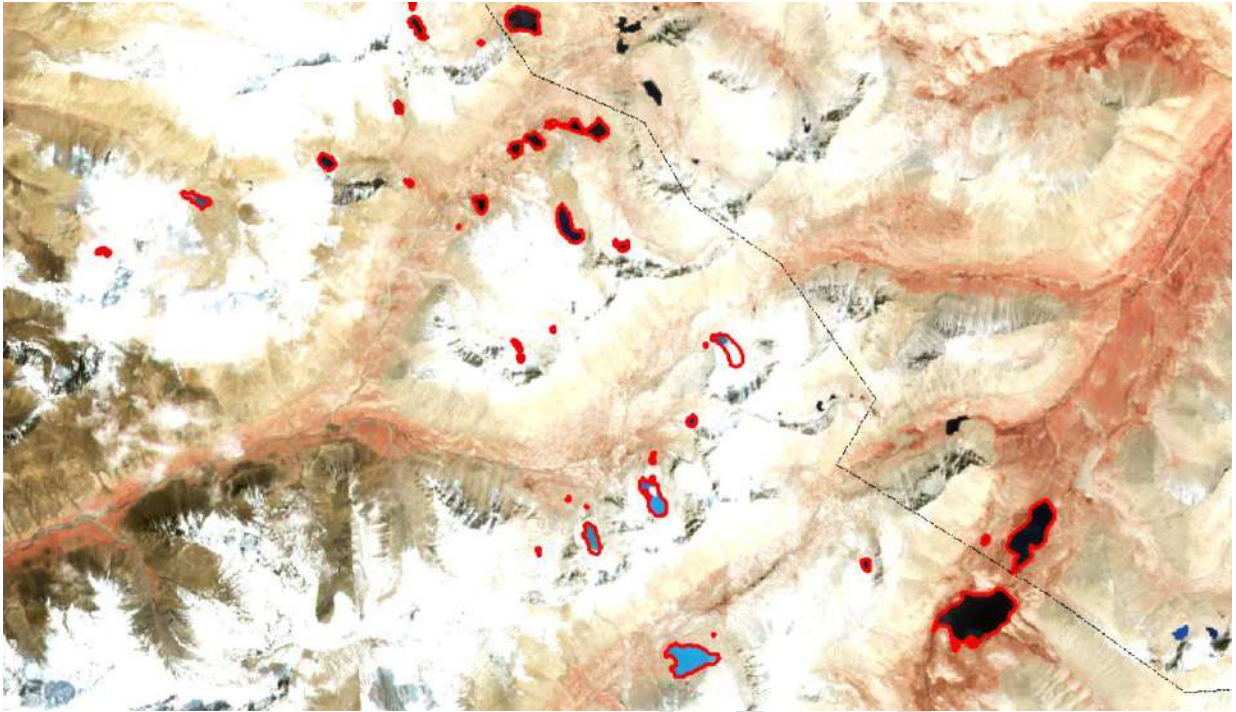


Fig No. 11.0 (h): No. of Lakes in Upper Satluj Basin



Fig No. 11.0 (i): Formation of lakes in River section along the upper catchment of Satluj, Upper Satluj Basin

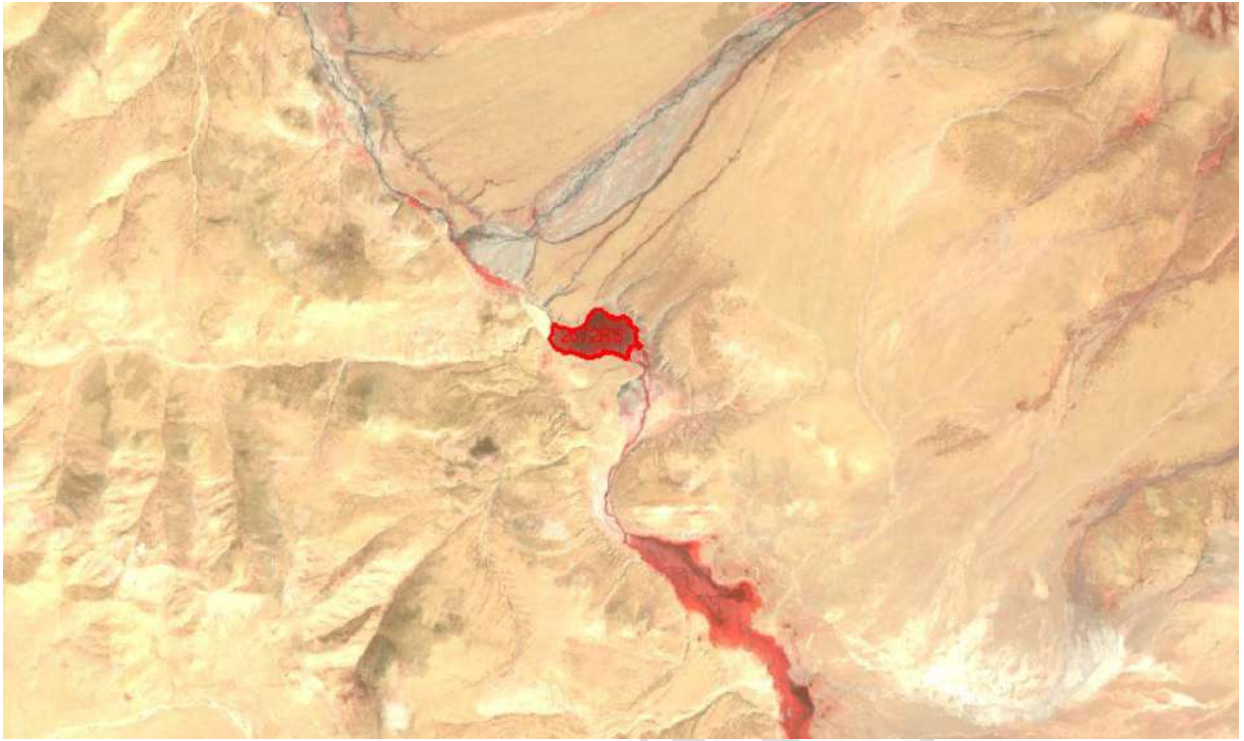


Fig No. 11.0 (j): Formation of lakes in River section along the upper catchment of Satluj, Upper Satluj Basin

Conclusion:

- The present study ‘**Monitoring of Glacial lakes/water bodies (2022)**’ has been carried out using RS, GIS & Image Interpretation techniques comprising the total catchment area of the Satluj River Basin right from its origin Mansarovar Lake in the Tibetan Himalayan Region up to Jhakri in Shimla district of Himachal Pradesh and the study is being carried out as part of Disaster Preparedness Plan of Satluj Jal Vidyut Nigam Ltd (SJVNL) Shimla since 2009.
- Monitoring has been carried out using IRS RS2&RS2A AWIFS data products having spatial resolution of 56mts during the ablation season from April to November along with a more detailed inventory with high resolution data product using IRS RS2&RS2A-LISS III and LISS IV sensors and Sentinel data products having spatial resolution of 23.5mts and 5.8 mts and 10mts respectively for the year 2022.
- The Parechhu Lake which is basically a Landslide Induced Lake (LLOFs) formed within a geomorphic depression along the Parechhu River course in the Tibetan catchment of the Trans Himalayan region has a vast damage history in Himachal Pradesh way back in 2005. Since then, this lake is being monitored regularly using high resolution LISS 3 and LISS 4 satellite data products from April to September during the ablation period and it's up to date information has been given to the concerned agencies such as the State Disaster Management Authority (SDMA), Govt. of Himachal Pradesh, and the SJVNL through online mode. However the observations made during the year has also been complied and been incorporated in the present technical report. During 2022, there was again satellite data limitation because of the cloud and snow cover impacts as a result of which only 04 scenes i.e. 18 April 2022, 12 May 2022, 5 June 2022, and 29 June 2022 were procured from NRSC Hyderabad on the basis of which the reporting was done. Based on the findings, there does not seem any threat from the lake but needs to be monitored regularly in order to avoid any eventuality arising out of this as per the past. However, on 04 July 2021, the water column in the inflow on the upstream of the landslide appears to be wide, whereas the outflow shows some tonal difference up to the landslide portion reflecting landslide effect on the river flow, which is very much clear in closer and normal view of the satellite data. The landslide that caused the blockade during the inception of this lake was from the left bank of the Parechhu River, but now the

another landside just opposite to the earlier one on the right bank has also started affecting the river course , which need close and regular monitoring during the ablation period.

- During the year 2022, the mapping and monitoring of glacial lakes was carried out using AWIFS, LISS III, Landsat 8, LISS IV and Sentinel satellite data. A total of 25 AWIFS data products were selected based on their quality and cloud /snow cover for the period April to November and were procured from NRSC Hyderabad and have been used in the analysis of the moraine dammed glacial lakes (GLOFs) and the high altitude wetlands in the catchment of the Satluj River from its origin i.e. Mansarovar Lake in the Tibetan Himalayan Region up to Jhakri i.e. the project site. Besides this, the LISS III (14), Landsat 8(6), LISS IV (12) and Sentinel satellite data during the period July to September /October was also used in the mapping and monitoring of glacial lakes in the study area. Based on the analysis from different sets of data, single vector layer has been generated for the each month from April to November for AWIFS and likewise for the LISS III & Landsat 8 and LISS IV & Sentinel data analysis.
- During April 2022, only 02 data products could be procured that too of not good quality when most of the area is under the influence of the seasonal snow cover as a result of which the surface area was not fully exposed. Based on the visual interpretation for the month of April 2022 only 26 lakes/wetland could be delineated, one lake each from the Spiti and Lower Satluj sub basin and 24 lakes from Upper Satluj Sub Basin comprising 2 lakes as the small one, 4 within 5-10 ha and 20 as the big one with area >10ha which includes predominantly the high altitude wetlands.
- Not much information could be derived during May 2022 because of the data quality, 02 data products were procured. From the satellite data, 5 lakes/wetlands were mapped out of which 1 lake in Spiti and 4 Lakes in Lower Satluj Sub basin.
- During the month of June 2022, one data product was procured having partial coverage covering mainly the Upper Satluj basin. Based on the satellite data interpretation, a total 338 lakes were mapped out in which 38 lakes in Spiti Sub basin, 14 in lower Satluj sub basin and 286 in Upper Satluj sub basin. Majority of lakes about 85 % falls in Upper Satluj basin while

Spiti and lower Satluj basin contributes 11% and 4%, respectively. Out of 338, 22% (75) of lakes were more than 10 ha and 38 lakes were high altitude wetlands in the Satluj basin.

- July to September is considered as the ideal period for carrying glaciological studies as most of the area during this period is free from snow cover impacts and is completely exposed and thus the glacier features are fully developed resulting to have maximum information from the glaciated regimes can be obtained. However sometime early snowfall during the second or third week of September may lead to have snowfall impacts resulting to have less information about the glaciers. Moreover this period also coincides with the monsoon season in the Himalayan region resulting to have a major limitation in procuring good quality cloud free data coverage.
- During the month of July 2022, satellite data was partially cloudy and the analysis of 2 data products having partial coverage reveals the presence of 122 lakes comprising 21 from Spiti, 16 from Lower Satluj and 85 from the Upper Satluj basins respectively. Based on the aerial distribution of these lakes, 35 lakes are the big one with area more than 10 ha and 26 are the High Altitude wetlands that too from the Upper Satluj basin.
- During August 2022, two data products could be procured and by virtue of the quality of the data and the coverage, it has become possible to delineate a total of 350 lakes in the entire catchment comprising 76 from Spiti, 61 from Lower Satluj and 213 from Upper Satluj sub basin in comparison to the 414 lakes, the maximum number that was observed in 2021. Further analysis of 350 lakes reveals that 229 lakes were such which have the area less than 5ha, 73 were within the areal range of 5-10 ha and 48 lakes were the big one with are more than 10ha. The analysis based on classification suggests that out of 350 lakes, 2 have been identified as the high-altitude wetlands from the Upper Satluj basin.
- During September 2022, four data products for 7th, 11th, 12th and 26th September 2022 could be procured that too with partial coverage. Based on the analysis of the data, 414 lakes could be delineated comprising 58 from Spiti, 59 from Lower Satluj and 297 from Upper Satluj basin. The areal distribution of 414 lakes suggest that 249 lakes were having area less than 5ha, 89 within areal range 5-10ha and 76 big one with area more than 10ha. Out of 414 lakes,

39 lakes have been classified as high latitude wetland whereas the remaining from the glacial origin.

- Temporal analysis of 414 lakes/wetlands further reveals that only 324 lakes/wetlands could be seen temporally with reference to 2021 out of which 205 lakes/wetlands showed an increasing trend whereas 119 showed a reducing trend in their water spread w.r.t 2021. As far as the contribution of each basin is concerned, Spiti basin is characterized by 58 lakes/wetlands, Lower Satluj by 59 and Upper Satluj basin by 297 lakes/wetlands reflecting that maximum (72%) of the total (414) formed part of Upper Satluj basin, 14% from lower Satluj and 14% from the Spiti basin during the month of September. The temporal analysis of the two dates reveals that the Spiti basin shows decrease of 09 lakes in 2022 w.r.t 2021 i.e. 67 (2021), comprising 39 lakes with area less 5ha, 12 lakes with area between 5-10ha and 7 lakes with more than 10ha, or in other words we can say that a reduction of (13%) could be seen in the Spiti basin as a whole between 2021 and 2022. Likewise in Lower Satluj basin, an increase of about 34% w.r.t 2021 is observed i.e. the number of lakes varies from 39(2021)to 59(2022) comprising 38 lakes having area less than 5ha, 15 lakes within the areal range of 5-10ha and 6 lakes having area more than 10ha. In Upper Satluj basin, a decrease of about 4% w.r.t 2021 could be seen in the total number of lakes mapped as the number varies from 308 (2021) to 297 (2022) comprising 172 lakes with area <5ha, 62 lakes with area between 5-10ha and 63 lakes with area >10ha.
- Thus from the analysis we can say about 72% of the total lakes falls in the Upper Satluj basin, 14% that from the Lower Satluj basin and about 14% from the Spiti basin. Further comparative analysis of the bigger lakes with area >10ha reflects that 17% enhancement could be seen in total number of lakes w.r.t 2021 and total number of lakes falling in this category varies 31(2019) to 62 (2020) to 66 (2021) to 76 (2022)out of which 12 are the high-altitude wetlands forming part of the Upper Satluj basin. Further it is found that the in Spiti basin, the number of lakes with area >10ha varies from 1 (2019) to 7 (2020) to 7 (2021) to 7 (2022), in Lower Satluj basin the number of such lakes varies from 0 (2019) to 2 (2020) to 6 (2021), 6 (2022) whereas in Upper Satluj basin the number of such lakes varies from 30 (2019) to 53 (2020) to 53 (2021) to 63 (2022).

- Although the number of total lakes in 2021 and 2022 remains the same i.e. 414, but the lakes with area more than 10 ha has increased from 66 (2021) to 76 (2022) which is mainly due to the fact that 13 lakes have shown an increase in their area w.r.t 2021 and have been counted in the next higher category from 5-10ha.
- When the total number of lakes based on AWiFS data is seen w.r.t. 2007(196) as the base line data , it is found that a there has been a gradual in their number with some abnormalities in the beginning, whereas a gradual increasing trend could be seen from 2012 onwards and the number varies from 128 (2012) to 130 (2013) to 192 (2014) to 241(2015) to 280 (2016) to 280 (2017) to 273 (2018) to 229 (2019) to 361(2020) to 414 (2021) and 414 (2022) reflecting an enhancement of about 223% in terms of the total number of lakes which includes lakes from the glacial origin as well as the high altitude wetlands with reference to the base line data of 2012 (128) and about 111% w.r.t that of 2007 (196). Out of 414 lakes mapped in 2022, 39 are the high altitude wetlands from Satluj basin in comparison to 33 w.r.t. 2021 and the remaining lakes are from the glacial origin. Further these 39 wetlands when seen based on their areal size, it is found that 14 wetlands are of small dimensions i.e. less than 5ha, 13 are of the area between 5-10ha and 12 are of the area more than 10 ha respectively.
- Although September is considered to be the end of the ablation season, but sometimes due to late winter onset and the delay in the snowfall, the area remains exposed even in the month of October and even November also. Thus, considering the AWIFS data availability on October and November, satellite data was procured and analyzed for delineation of various lakes/wetlands in the study area.
- In the month of October 2022, a total of 174 lakes in the entire catchment could be mapped, comprising 51 in the Spiti, 8 in the Lower Satluj, and 115 in the Upper Satluj sub basin. Out of 174 lakes, 88 have an area less than 5 ha, with 33 in the Spiti, 5 in the Lower Satluj, and 50 in the Upper Satluj basin. Further, 47 lakes were such that they fall within the area range of 5–10 ha, comprising 15 from the Spiti, 3 from the Lower Satluj, and 29 from the Upper Satluj basin. Similarly, 39 lakes with an area greater than 10 ha were classified as big lakes, with 3 from Spiti and 36 from the Upper Satluj basin.

- When comparing the 174 lakes and wetlands for their temporal analysis with that of 2021, only 98 lakes and wetlands could be compared, out of which 34 lakes and wetlands showed a reducing trend in their water spread, whereas 64 lakes and wetlands showed an increasing trend in their water spread with reference to the 2021 data.
- From the analysis of November 2022, most of the catchment area, as shown by the satellite data on the 3rd, 13th, 22nd, and 23rd of November under snow cover impact, only 93 lakes could be mapped due to the impact of fresh snow cover. Out of these 93 lakes, 11 in the Spiti Sub-basin, 11 in the Lower Satluj Sub basin, and 71 in the upper Satluj sub Basin respectively. In addition, out of 93 lakes mapped 47 had an area of less than 5 ha, 23 had an area between 5 and 10 ha, and 23 had an area greater than 10 ha. Based on their source, it was found that 30 lakes out of 93 were mostly high-altitude wetlands, with 8 having an area of less than 5 ha, 9 having an area between 5 and 10 ha, and 13 having an area of more than 10 ha.
- Further analysis reveals that out of 93 lakes, 10 lakes were such that they have been formed along the river course by virtue of damming of the water due to one or the other reason. Further these 93 lakes /wetlands were seen temporally w.r.t 2021, it was found that only 13 lakes/wetlands could be compared of which 5 lakes/wetlands were characterized by reduction in their water spread , whereas 8 lakes/wetlands showed an increase in their water spread w.r.t 2021.
- Along the course of main Satluj River and Spiti River, few isolated pockets have also been observed which shows accumulated water in the upper catchment of the Tibetan Himalayan Region. Thus the lakes/water bodies coded with abbreviation *RS with their ids* are some of the locations where accumulated water could be seen and these are the permanent features which needs regular monitoring in order to assess any temporal change in their behavior.
- The lakes with ids 1682RS (2.05ha), 1683RS (11.82ha), 1684RS (3.81ha), 1685RS (2.37ha), 1686RS (0.43ha), 1687RS (1.19ha), 9003RS (1.59ha), 9004RS (0.55ha) in Spiti basin, in Lower Satluj basin lakes with ids 9207RS (4.55ha), 9058RS (0.41ha), and in Upper Satluj basin , the lakes with ids 1557RS (71.15ha), 1771RS (13.73ha), 1772RS (4.89ha), 1775RS (5.57ha) 2170RS (2.32ha) and 10326RS (13.47) are some of the water bodies which have been developed along the nala sections in the different sub basins.

- As a whole the analysis of AWIFS data reveals the presence of total maximum number of lakes that could be mapped during 2022 varies from April (26), May (05), June (338), July (122), August (350), September (414), October (174) and November (93) and the variation in the number is mainly by virtue of data quality and its coverage and also the exposed area available for interpretation purpose (Fig. 9.1).
- Based on AWIFS data, the total number of lakes mapped from April onwards during 2018, 2019, 2020, 2021 and 2022 and suggest that the number varies from 15, 0, 5, 0, 26 (April), 18, 6, 0, 3, 5 (May), 38, 2, 0, 0, 338 (June), 151, 0, 0, 27, 122 (July), 84, 98, 0, 414, 350 (August), 273, 229, 62, 97, 414 (Sept), 93, 45, 71, 331, 174 (October) and 78, 126, 0, 25, 93 (November) reflects that the total number of lakes in Satluj catchment based on AWIFS data generally falls between 350-414 during 2018-2022 (**Fig. 9.2**).
- As far as the lakes with area more than 10ha is concerned, the total no of lakes that could be mapped is 48(August 2022), 76(September 2022) in comparison to 66(2021) and out of these 76 lakes, 74 lakes could be compared with that of 2021 data out of which 19 have showed a negative trend in their water spread, whereas 55 showed a positive trend and the 02 lakes could not be compared with that of non-availability of data during 2021. Further out of these 76 lakes, 13 were such which have come into bigger lake category in 2022 in comparison to 2021 by virtue of the increase in their size. In general the number of such lakes (>10ha) varies over the years as in the lakes with area 2018(69), 2019(51), and 2020(71), 2021(66) and 2022 (76) (**Fig. 9.4**).
- As far the lakes with area less than 5ha and between 5-10ha are concerned during 2021, their number keeps on varying and needs monitoring during the next ablations season wherein they may change their status as far as the water spread distribution is concerned as observed in 2022, where these category of lakes have been counted in the higher category 2022 because of the increase in their size.
- Based on the analysis for the updation of the detailed inventory of the lakes /wetlands using LISS satellite data products having spatial resolution of 23.5 mts during 2022, total number of lakes /wetlands mapped varies from 769 (2018) to 562(2019) to 993(2020) to 880(2021) to 995 (2022) and the variation is mainly due to the data gap during one or the other year by

virtue of the impact of snow and cloud cover as a result of which complete information could not be derived.

- Out of these total 995 lakes mapped in 2022, 850 lakes have been mapped as the small one with area less 5ha, 83 lakes with area 5-10ha and 62 lakes with area more than 10ha. Further out of 995 lakes mapped, 71 are mainly the high-altitude wetlands based on their source of origin.
- The comparative analysis based on LISS-III satellite data from 2018-2022 reveals an overall reduction of about 26% between 2018 -19 and further an enhancement by about 76% between 2019-20 and about 11% reduction between 2020-21 and again 13% enhancement between 2021-22 respectively. As far as the big lakes with area more than 10ha are concerned, total number of big lakes varies from 49 (2018) to 51 (2019) to 62(2020) to 56(2021) and 62 (2022) indicating a fluctuating trend in the lakes/wetlands with area >10ha based on LISS III data analysis.
- The total variation in the number of lakes mapped in Upper Satluj basin based on LISS III data varies from 495 (2018) to 437 (2019) to 707 (2020) to 588 (2021) to 639(2022) , in Lower Satluj basin the number varies from 98 (2018) to 52 (2019) to 89 (2020) to 163(2021) to 173(2022) and in case of Spiti sub basin it varies from 176 (2018) to 73 (2019) to 197 (2020) to 129(2021)to 183(2022) indicating a reduction of about 11% (2018-19) and enhancement by about 61% (2019-20) and about 16% reduction (2020-21) and further enhancement by about 9% (2021-22) in case of Upper Satluj basin, a reduction of about 46% (2018-19), enhancement by about 71% (2019-20) and further enhancement by about 83% (2020-21) and further enhancement by about 6% (2021-22) in case of Lower Satluj and a reduction of about 58% (2018-19) and enhancement by about 169% (2019-20) and further reduction by about 34% (2020-21) and further enhancement by about 41% (2021-22) in case of Spiti basin could be seen.
- Thus from the above analysis based on LISS III for the period 2022, it is clear that although the maximum number of lakes (about 64%) are being formed in the Upper Satluj basin , about 17% in the Lower Satluj basin and about 18% in the Spiti basin of the study area and majority of the lakes delineated in the entire study area during 2022 are small one with area less than

5ha (about 86%) , about 9 % are within 5-10 ha and about 5% with area more than 10ha reflects that the Upper Satluj basin is more susceptible for undergoing climate induced changes resulting to have higher number of such lakes than the Lower Satluj and Spiti basin.

- Thus, based on the analysis carried out by using two different sets of data and having different spatial resolution of the order of 56mts (AWIFS) and 23.5mts (LISS III), the results obtained using AWIFS does not indicate any change in the total number of lakes in comparison to 2021 but a reduction of 7% and 4% could be seen in case of Spiti and Upper Satluj basins respectively, whereas the Lower Satluj basin shows an enhancement of about 34% between 2021 & 2022. .
- Further the maximum lakes based on AWiFS data (72%) of the total 414 lakes have been mapped from Upper Satluj (72%), 14% each from Lower Satluj and Spiti basins respectively. In case of the bigger lakes with area >10ha, 15% increase could also be seen in 2022 (76) in comparison to 2021 (66) with majority of the lakes (63) forming part of the Upper Satluj basin, 6 from the Lower Satluj basin and 7 from the Spiti basin, out of which 13 are the high-altitude wetlands and the remaining 49 are from the glacial origin.
- Likewise, LISS-III data indicates an enhancement of about 13% in terms of the total lakes and about 11% enhancement in terms of the bigger lakes in comparison to 2021 in the entire Satluj catchment. Further based on comparative analysis, 9% enhancement in Upper Satluj basin, 6% in Lower Satluj basin and 41% enhancement in Spiti basin could be seen between 2021 & 2022 with maximum number of lakes (about 64%) are being formed in the Upper Satluj basin, about 17% in the Lower Satluj basin and about 18% in the Spiti basin of the study area.
- Classification of the lakes based on their origin suggest that, about 9% (39) of the total maximum lakes mapped during the month of September were the high altitude wetlands out of 414 lakes mapped from AWIFS satellite data and 7% (71) from the LISS III satellite data out of 995 total lakes mapped .Remaining lakes are the lakes from the glacial origin i.e. either these are formed at or near the glacier snouts known as Moraine Dammed Glacial Lakes or more commonly known as GLOFs or the Supra Glacial lakes i.e. within the glacier body in the ablations zones of the glaciers.

- The high altitude wetlands in the Upper Satluj basin are mainly formed due to the permafrost which is the common feature in the Tibetan Plateau region resulting into the appearance of such water bodies.
- The lakes /wetlands with ids RS mapped in Spiti and Upper Satluj basin although small except few but needs monitoring in order to avoid any situation that may lead to flash floods in the downstream in case if they burst.
- During the year 2022, using LISS IV (5.8 mts) another inventory of lakes/wetlands was prepared giving more precise information about the catchment wherein it has become possible to delineate the lakes/wetlands with area less than 23.5mts in the Satluj basin.
- The data which was available mainly falls within 96-48a, 96-48c, 97-48a, 97-48c, 97-49b, 98-49a, 98-48c, 98-49c, 100-49c path-row and to fill data gaps Sentinel data has been used and the temporal analysis could not done due to non-availability same segments data during 2022.
- Based on the above mentioned LISS-IV satellite data, a total of 1953 lakes/high altitude wetlands could be delineated comprising 368 (19%) from Spiti basin i.e. basin 1, 250 (13%) from the Lower Satluj basin i.e. basin 2 and 1335 (68%) from the Upper Satluj basin i.e. basin 3, out of which 37 lakes have been classified as high-altitude wetlands and the remaining 1916 as from the glacial origin.
- Further analysis of the data reveals that out of 1953 lakes/wetlands delineated, 1849 were the small one with area less than 5ha, 56 were within the area range of 5-10 ha and 48 were the one which have the area more than 10ha respectively in other words we can say that (94%) were the small one with area less than 5ha, (3%) were within the areal range of 5-10ha and (about 3%) were the big one with area more than 10ha.
- The comparative analysis based on three different sets of data from AWIFS, LISS III and LISS IV sensors reflects that in Spiti basin, the number of lakes delineated has been enhanced from 58 with AWIFS sensor to 183 with LISS III sensor and further 368 with LISS IV sensor in 2022 in comparison to 67 with AWIFS to 129 with LISS III to 379 with LISS IV in 2021. Likewise, in Lower Satluj basin, the 59 lakes delineated from AWIFS sensor increased to 173 in LISS III and 250 with LISS IV sensor in 2022 in comparison to 39, 163 and 529 with

AWIFS, LISS III and LISS IV sensors in 2021. Similarly, in Upper Satluj basin, the 297 lakes as delineated from AWiFS sensor has increased to 639 with LISS III and 1335 with LISS IV in 2022 in comparison to 308 with AWIFS, 588 with LISS III and 724 with LISS IV in 2021 respectively and the variation is mainly due to the data gap in LISS IV which mainly covers the areas falling in Spiti & Upper Satluj basins. Thus, from the above analysis based on LISS IV sensors, it is inferred that the level of information in the catchment has increased and more detailed information could be seen which would form the base line data for future investigations with higher resolutions satellite data.

- As far as the basin wise susceptibility is concerned, it is observed that based on the distribution of the lakes, the basin 3 i.e the Upper Satluj basin, the number of lakes is quite high in all the cases either in AWIFS (72%) or LISS III (64%) or LISS IV (68%) followed by Lower Satluj basin (approx. 15%, 17% and 13%) and Spiti basin (approx. 13%, 18% and 19%) and thus basin 3 i.e Upper Satluj basin seems to be more susceptible as far as moraine dammed lakes/water bodies are concerned in the study area.
- Thus, based on three sets of data base from AWIFS, LISS III and LISS IV for the year 2022, having spatial resolution of 56mts, 23.5mts and 5.8 mts, a complete inventory of the glacial lakes has been prepared in the Satluj catchment fulfilling the objectives as laid down in the National Guidelines for GLOF issued by National Disaster Management Authority (NDMA), Govt. of India during the year 2021. Although there are some data gaps in LISS IV data products due to non-availability of cloud freed data, but still information level has been increased illustrating more detailed insight of the catchment, which would further be refined during the next year.

12.1 Concluding Remarks:

The present study Monitoring of Glacial Lakes in Satluj Catchment has been carried out using IRS-RS2, AWIFS, IRS RS2 & RS2A LISS-III and IRS RS2A LISS -IV and Sentinel Satellite data products having spatial resolution of 56mts, 23.5mts and 5.8mts and 10mts for the year 2022 from April to November. The catchment area in the Satluj River basin was studied from upstream of Jhakri to Mansarovar Lake in the Tibetan Himalayan Region from where the Satluj River originates. The study was carried as part of the disaster preparedness plan of Satluj Jal Vidyut Nigam Ltd (SJVN Ltd) to assess the threat from the moraine dammed glacial lakes/water during the

year 2022. This study is being carried out regularly since 2009 during the ablation season (April to October/November) every year. During this year, the catchment area was studied during the ablation period from April to November using visual interpretation techniques and an inventory based on AWIFS, LISS III and LISS IV satellite data products was prepared in the Satluj River catchment and thereby assessing any change in their water spread area w.r.t the previous year.

In the present study, analysis has been carried out in the study area by using 25 AWIFS data products from April to November and LISS III coverage within the path row 96-48, 96-49, 97-48, 97-49, 98-48, 98-49, 99-49, 100-49 using IRSRS2/RS2A LISS-III data products and 96-48a, 96-48c, 96-49b, 97-48a, 97-48c, 98-48a, 98-48c, 100-49c using LISS IV data products. The data gap for LISS IV was tried to fill up with Sentinel data for 2022. In April 2022, not much information could be delineated because of the fact that April is considered to be the start of ablation season and very limited information could be obtained as most of the catchment area was under the snow cover impact. Due to non-availability of good quality cloud free and snow free AWiFS data products during May and June, very limited information could be derived for the catchment. Based on the observations derived for the month of April 2022, only 26 lakes/wetland could be delineated, one lake each from the Spiti and Lower Satluj sub basin and 24 lakes from Upper Satluj Sub Basin respectively. Likewise in May 2022 because of the data quality, only 5 lakes/wetlands were mapped out of which 1 lake in Spiti and 4 Lakes in Lower Satluj Sub basin and in June based on the observation, a total 338 lakes were mapped out comprising 38 lakes from Spiti Sub basin, 14 from Lower Satluj and 286 from the Upper Satluj sub basin. About 85 % of the lakes falls in Upper Satluj basin while Spiti and lower Satluj basin contributes 11% and 4%, respectively. Out of 338, 22% (75) of lakes were more than 10 ha and 38 lakes were high altitude wetlands in the Satluj basin.

July to September is generally considered as the ideal period for carrying glaciological studies as most of the area during this period is free from snow cover impacts and thus completely exposed and the glacier features are fully developed as result of which maximum information from the glaciated regimes can be obtained. But as this period also coincides with the monsoon season in the Himalayan region, so procuring good quality cloud free data coverage is a major challenge. During July 2022, because of the partial coverage only 122 lakes comprising 21 from Spiti, 16 from Lower Satluj and 85 from the Upper Satluj basins could be delineated out of which 35 lakes are the big one with area more than 10 ha and 26 are the High Altitude wetlands

that too from the Upper Satluj basin. From August 2022 satellite data, a total of 350 lakes in the entire catchment comprising 76 from Spiti, 61 from Lower Satluj and 213 from Upper Satluj sub basin in comparison to the 414 lakes, the maximum number that was observed in 2021 could be delineated. Further out of 350 lakes, 229 lakes were small one with area less than 5ha, 73 were within the areal range of 5-10 ha and 48 lakes were the big one with area more than 10ha.

During September 2022, four data products for 7th, 11th, 12th and 26th September 2022 were analyzed and based on the analysis 414 lakes could be delineated comprising 58 from Spiti, 59 from Lower Satluj and 297 from Upper Satluj basin. Further classification of 414 lakes suggest that 249 lakes were having area less than 5ha, 89 within areal range 5-10ha and 76 big one with area more than 10ha and 39 out of 414 lakes have been classified as high latitude wetland whereas the remaining from the glacial origin. Further only 324 lakes/wetlands could be seen temporally with reference to 2021 out of which 205 lakes/wetlands showed an increasing trend whereas 119 showed a reducing trend in their water spread w.r.t 2021. As far as the contribution of each basin is concerned, Spiti basin is characterized by 58 lakes/wetlands, Lower Satluj by 59 and Upper Satluj basin by 297 lakes/wetlands reflecting that maximum (72%) of the total (414) formed part of Upper Satluj basin, 14% from lower Satluj and 14% from the Spiti basin during the month of September. The temporal analysis of the two dates reveals that the Spiti basin shows decrease of 09 lakes in 2022 w.r.t 2021 i.e. 58 (2022) from 67 (2021) and comprising 39 lakes with area less 5ha, 12 lakes with area between 5-10ha and 7 lakes with more than 10ha, or in other words we can say that a reduction of (13%) could be seen in the Spiti basin as a whole between 2021 and 2022. Likewise in Lower Satluj basin, an increase of about 34% w.r.t 2021 is observed i.e. the number of lakes varies from 39 (2021) to 59(2022) comprising 38 lakes having area less than 5ha, 15 lakes within the areal range of 5-10ha and 6 lakes having area more than 10ha. In Upper Satluj basin, a decrease of about 4% w.r.t 2021 could be seen in the total number of lakes mapped as the number varies from 308 (2021) to 297 (2022) comprising 172 lakes with area <5ha, 62 lakes with area between 5-10ha and 63 lakes with area >10ha. Further comparative analysis of the bigger lakes with area >10ha reflects that 17% enhancement could be seen in total number of lakes w.r.t 2021 and total number of lakes falling in this category varies 31(2019) to 62 (2020) to 66(2021) to 76(2022) out of which 12 are the high-altitude wetlands forming part of the Upper Satluj basin. Further it is found that the in Spiti basin, the number of lakes with area >10ha varies from 1 (2019) to 7 (2020) to 7(2021) to

7(2022), in Lower Satluj basin the number of such lakes varies from 0 (2019) to 2 (2020) to 6(2021), 6(2022) whereas in Upper Satluj basin the number of such lakes varies from 30 (2019) to 53 (2020) to 53 (2021) to 63 (2022). Although the number of total lakes in 2021 and 2022 remains the same i.e. 414, but the lakes with area more than 10 ha has increased from 66 (2021) to 76 (2022) which is mainly due to the fact that 13 lakes with ids (71, 312, 423, 611, 658, 827, 1053, 1531, 8280, 8288, 8517, 211 HWL, 616 RS) which were in the aerial range of 5-10 ha during 2021 have shown an increase in their area during 2022 and have been counted in the next higher category i.e. more than 10ha. On comparing the total lakes in 2022 with that of base line data of 2007(196) a gradual increasing trend could be seen from 2012 onwards and the number varies from 128(2012) to 130(2013) to 192(2014) to 241(2015) to 280(2016) to 280(2017) to 273(2018) to 229(2019) to 361(2020) to 414(2021) and 414(2022) reflecting an enhancement of about 223% in terms of the total number of lakes which includes lakes from the glacial origin as well as the high altitude wetlands with reference to the base line data of 2012(128) and about 111% w.r.t that of 2007(196).

Based on the updated inventory of glacial lakes using LISS III satellite data during 2022, total number of lakes /wetlands mapped varies from 769 (2018) to 562 (2019) to 993 (2020) to 880 (2021) to 995 (2022). Out of these total 995 lakes mapped in 2022, 850 lakes have been mapped as the small one with area less 5ha, 83 lakes with area 5-10 ha and 62 lakes with area more than 10ha. Further out of 995 lakes mapped, 71 are mainly the high-altitude wetlands based on their source of origin. The comparative analysis based on LISS-III satellite data from 2018-2022 reveals an overall reduction of about 26% between 2018 -19 and further an enhancement by about 76% between 2019-20 and about 11% reduction between 2020-21 and again 13% enhancement between 2021-22 respectively. In terms of the bigger lakes/wetlands, the number varies from 49 (2018) to 51 (2019) to 62(2020) to 56(2021) and 62 (2022). Basin wise distribution of lakes based on LISS III reflects that in Upper Satluj basin, the number of lakes varies from 495 (2018) to 437 (2019) to 707 (2020) to 588 (2021) to 639 (2022), in Lower Satluj basin the number varies from 98 (2018) to 52 (2019) to 89 (2020) to 163(2021) to 173(2022) and in case of Spiti sub basin it varies from 176 (2018) to 73 (2019) to 197 (2020) to 129(2021) to 183(2022) reflecting an enhancement by about 9% (2021-22) in case of Upper Satluj basin, 6% (2021-22) in case of Lower Satluj and an enhancement by about 41% (2021-22) in case of Spiti basin. Further in Spiti basin, the lakes with ids 1682RS (2.05ha), 1683RS (11.82ha), 1684RS

(3.81ha), 1685RS(2.37ha),1686RS (0.43ha), 1687RS (1.19ha), 9003RS (1.59ha), 9004RS(0.55ha), in Lower Satluj basin lakes with ids 9207RS (4.55ha), 9058RS (0.41ha), and in Upper Satluj basin , the lakes with ids 1557RS (71.15ha), 1771RS (13.73ha), 1772RS (4.89ha), 1775RS (5.57ha) 2170RS (2.32ha) and 10326RS (13.47) are some of the water bodies which have been developed along the nala sections in the different sub basins and needs monitoring as they are the potential locations for causing flash floods downstream.

Further analysis of very high resolution satellite data of LISS IV, a total of 1953 lakes/high altitude wetlands have been mapped in the Satluj catchment in comparison to 1632 (2021) and 1359(2020) . Basin wise distribution of 1953 lakes /wetlands reveals that 368 (19%) lakes are from Spiti basin, 250 (13%) from the Lower Satluj basin and 1335 (68%) from the Upper Satluj basin i.e. basin 3, out of which 37 lakes have been classified as high-altitude wetlands and the remaining 1916 as from the glacial origin. Further out of 1953 lakes/wetlands delineated, 1849 were the small one with area less than 5ha, 56 were within the area range of 5-10 ha and 48 were the one which have the area more than 10ha respectively in other words we can say that (94%) were the small one with area less than 5ha, (3%) were within the areal range of 5-10ha and (about 3%) were the big one with area more than 10ha. Based on the analysis carried out using three different sets of satellite data i.e. AWIFS, LISS III and LISS IV, it is observed that in Spiti basin, the number of lakes delineated has been enhanced from 58 with AWIFS sensor to 183 with LISS III sensor and further 368 with LISS IV sensor in 2022 in comparison to 67 with AWIFS to 129 with LISS III to 379 with LISS IV in 2021. Likewise, in Lower Satluj basin, the 59 lakes delineated from AWIFS sensor increased to 173 in LISS III and 250 with LISS IV sensor in 2022 in comparison to 39, 163 and 529 with AWIFS, LISS III and LISS IV sensors in 2021. Similarly, in Upper Satluj basin, the 297 lakes as delineated from AWiFS sensor has increased to 639 with LISS III and 1335 with LISS IV in 2022 in comparison to 308 with AWIFS, 588 with LISS III and 724 with LISS IV in 2021 respectively and the variation is mainly due to the data gap in LISS IV which mainly covers the areas falling in Spiti & Upper Satluj basins. Thus, from the above analysis based on different sensors, it is inferred that the level of information has increased depending upon the sensor being used in the investigation i.e. LISS IV sensor provides the better information in comparison to AWIFS and LISS III about the catchment. The percentage increase with different sensors varies from 20% (2021-22) with LISS IV and 13% (2021-22) with LISS III, whereas no increase could be

observed with AWIFS data in case of total number of lakes but the lakes with area more than 10 ha has increased during 2021-22.

The Parechhu Lake is another potential vulnerable lake in the Satluj catchment that was formed in 2004 in the Trans Himalayan Region of the Tibetan Plateau by virtue of damming of the river course due to landslide. Since this lake is very much close to the Sumdo-Korik fault, which is prominent Geological Structure that may have activated resulting to landslides in the region. The lake was formed because of the landslide from the left bank in 2004 and since then this is being monitored regularly using space data. During 2022, the lake was monitored and does not show any major change in its water spread and seems to be stable based on the observations made which have been reported to SJVNL as well as to the Government during 2022 during June, July & October. But the presence of landslide on the upstream side of the lake depression and another one on the right bank is a likely threat for its damming again and thus needs to be monitored in order to assess any change in the water level by virtue of the landside which may block the river course causing major threat like that of the Parechhu formation during the year 2004.

To summarize that based on the observations made from the analysis of AWIFS, LISS III and LISS IV data products in the catchment area of Satluj Jal Vidyut Nigam Ltd. from upstream of Jhakari up to the Mansarover lake in the Tibetan region, it is concluded that the frequency of lake formations varies in each basin, which is evident from the different comparative analysis in all the three sub basins of the Satluj catchment. From the basin wise analysis, it is inferred that number of lakes delineated is much higher in the Tibetan Himalayan Region i.e. Upper Satluj basin in comparison to the other two basins i.e. Spiti and Lower Satluj basins, which signifies that Upper Satluj basin is more susceptible for the glacial lake formations and the permafrost leading to more lake formations i.e. the high altitude wetlands. This may be due to the fact that the temperatures over the high mountain regions are reported to be comparatively higher than the low lying areas which adversely affects the Himalayan glaciers thereby increasing the formation of moraine dammed glacial lakes in front of the glacier snouts at the higher reaches. Considering the geographical locations of these lakes, the space data has been proved to be very useful and has a great potential in monitoring such developments on the higher reaches as it would not be possible by any other conventional methods. Thus, using space data, the variation in the spatial extent of different category of lakes can be estimated, which would help in assessing their vulnerability if any arising out of the increasing water spread considering the Guidelines on Management of Glacial

Lake Outburst Floods (GLOFs), Landslide Lake Outburst Floods (LLOFs) of NDMA (MHA)-2020 of Govt. of India which suggest that detailed inventory of such lakes is required to be carried out on regular basis and with detailed analysis for the potential locations which includes field analysis as well. The recent tragedy of 2013 in the Uttarakhand Himalaya has also been correlated with the bursting of a lake having a total area of about 08 hectare in front of the snout of the Chorabari glacier that caused widespread damage in the downstream areas besides the heavy rainfall (Dobhal et.al.2013) and the recent tragedy of 2021 which was reported to be because of the ice avalanche resulting to temporary damming in the river course and causing flash floods downstream. Thus the magnitude of such lakes as far as the destruction is concerned cannot be overruled. Hence the lakes with area >10 hectare and the area between 5-10 hectare can be seen as the potential vulnerable sites considering the present trends in the climate science and the climate induced hazards threat thereof, for causing damage in case of bursting of any one of them by virtue of avalanche or any tectonic activity considering the high seismicity of the Himalayan region.. Thus, a proper monitoring of all such lakes using high resolution space data is essential, which is not possible by any other conventional methods in order to avoid any eventuality like that of the Parechhu and other instances of GLOFs (Glacier lake Outbursts Floods) in the Himalayan Region of Nepal and Bhutan and the recent incidents that had happened in Uttarakhand Himalaya, which will not only save the precious human lives but also the public and the Govt. property.

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