A TECHNICAL REPORT ON THE MONITORING OF GLACIAL LAKES/ WATER BODIES IN SATLUJ CATCHMENT USING RS & GIS TECHNIQUES (2020)

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Abstract	**With the projected increase in the frequency and intensity of extreme events including floods, droughts, landslides etc which are attributable to climate change, disaster management need greater attention. Susceptibility of the State of Himachal Pradesh to vagaries of climate change has now been well documented. Scientific insight gained from the analysis of multi spectral Satellite images carried out by the authors suggests that spatial extent of majority of glaciers is changing very fast leading to the formation of moraine dammed lakes. Formation of such lakes is 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 of the State. Various studies have been carried out on this vital issue of climate change and reveals that there is an alarming increase in such potential lakes which can be disastrous in the event of any break due to one or the other reasons. As per 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 LISSIII satellite data for the year 2019, 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 satellite data for the year 2020 in the Satluj catchment of SJVNL Hydro Electric Project. The interpretation has been carried out using ERDAS Imagine 9.3 software. The inventory of lakes prepared during 2020 has been compared with respect to the database generated during 2019 in order to assess the temporal variations if any. Monitoring has been done from April to November 2020 during the ablation season and the results thus obtained during 2020 have been compared with that of 2019. Regular monitoring of Parechhu Lake has also been done separately using LISS IV and LISS III data from April to September during 2020. Based on the baseline data for 2019(229) from AWIFS data, a total of 361 lakes have been identified in the Satluj catchment which shows enhancement of 132 lakes with respect to 2019 i.e about 57% enhancement in the total number of lakes and the lakes with area more than 10 ha varies from 79(2017) to 69(2018 to 31(2019) to 62(2020). Besides this an updated inventory of lakes in the entire catchment has also been prepared using LISS III satellite for the year 2020 which will form the baseline data for monitoring during the next ablation season. Based on the LISS III satellite data interpretation, a total of 993 lakes/wetlands have been delineated in comparison to 562 (2019) reflecting an increase of about 76% with respect to 2019. As far as the lakes with area more than 10 ha based on LISS III data is concerned, it varies from 52(2017) to 49(2018) to 5192019) to 52(2020) in the entire catchment. Few accumulated water bodies could also be seen in the Spiti basin which needs regular monitoring by virtue of their size and nature. The recent tragedy of 2013 in the Uttrakhand Himalaya has also been correlated with the bursting of a lake having a total area of about 08 ha in front of the snout of the Chorabari glacier that caused widespread damage in the areas beside the heavy rainfall., Thus the magnitude of such lakes as far as the destruction is concerned cannot be overruled. Hence the lakes with area > 10 ha and the area between 5-10 ha can be seen as the potential vulnerable sites for causing damage in case of bursting of any of them. Thus a proper monitoring of all such lakes is very much essential in the Himalayan region in view of the refcent 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.**
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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. 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 (CO_2), methane (CH_4), chlorofluorocarbons (CFC_s) 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 third assessment report of the Inter –Governmental Panel on Climate Change (IPCC, 2001) concludes that global average surface temperatures have increased by 0.6 ± 0.2° C during the 20th century and that, for the range of scenarios developed , the global average surface air temperature is projected to warm 1.4 to 5.8° C by 2100 relative to 1990. Through the recent release of 21-page report in Paris the Intergovernmental Panel on Climate Change (IPCC) observed that 'Warming of the Climate System is unequivocal as is now evident from observation of increase in global air and ocean temperatures, widespread melting of snow and ice and rising global mean sea land" 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.

Geological History of the Earth indicates that glacial dimensions are constantly changing with changing climate. There have been at least 17 major glacial advances (glaciations) in the last 1.6 million years alone (Goudie 1983). The most recent, the Last Glacial, reached its peak some 20,000 to 18,000 years ago and came to an end about 10,000 years ago (Goudie 1983). Glaciations are followed by "interglacial" periods, during which the glacier ice retreats as a result of global warming. The interglacial typically continues for about 10,000 years before the cooling or the next glacial begins. This cyclical activity is generally accepted to be caused by gradual changes in the earth's rotation, tilt and orbit around the sun, which affects the solar radiation the earth receives. This suggests that glaciers are constantly changing with time and these changes can profoundly affect the run off the Himalayan Rivers. In the Himalayas there are about 33,000 Sq .Km. area is covered by glaciers and this is one of the largest concentrations of glaciers outside the Polar Regions. Melt water from these glaciers forms an important source of runoff into the North Indian Rivers during the peak months.

Glacial cycles are punctuated by relatively short periods of localized cooling and warming, during which glaciers advance and retreat. The most recent cooling episode of the present interglacial commonly referred to as the "Little Ice Age" (LIA), affected parts of North America (Curry 1969), Asia (Chu ko-Chan1973) and Europe from about 1300 AD through to the later half of the 19th century. During the LIA (1550-1850 AD) glaciers were much longer than today (Yamada et.al.1998). It may have been the result of volcanic eruptions and the presence of volcanic ash in the atmosphere that caused cooling by reducing the amount of solar radiations reaching the earth's surface (lamb 1970). Changes to ocean currents have also been suggested, as has the tectonic activity, concentration of carbon dioxide in the atmosphere, and sunspot activity (Goudie 1983).

2. Present Scenario

Himalayan glaciers have also been found to be 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. Since the mid1970s the average air temperature

measured at 49 stations of the Himalayan region rose by 1° C with high elevation sites warming the most (Hasnain2000). 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). The DokrianiBamak glacier in Uttranachal Himalayas has retreated 20m in 1998, and the Gangotri glacier is reducing at a rate of 30m/year.

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 specially 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 adverse effect on their lifestyles.

Since the climate is an important determinant of geographical distribution, composition and productivity of forest, at the simplest level, changing pattern of climate will change the natural distribution limits for species or communities. In the absence of barriers it may be possible for species or communities to migrate in response to changing conditions.Vegetation zone move towards higher latitude following shifts in average temperature. These changes in turn, could have profound implications for traditional livelihood, industry, biodiversity, soil and water resources and hence agriculture productivity. More over these climate change induced effects would aggravate the existing stress due to non-climate factors, such as land use changes and unsustainable exploitation of natural resources. Some of the climate induced changes observed in the context of the mountain environment in Himachal Pradesh are as follows.

- Declining snow fall.
- Drying up of perennial streams.
- Temperate belt have shifted upward.
- Productivity of apple has been adversely affected.
- Rabi seasons has been shifted and shortened.
- The incidences of diseases and pests have become more severe.

2.1 Glaciation in the Indian Himalaya

A Glacier is a mass of ice, snow, water and rock debris flowing down a gradient. Based upon morphological characteristics of glaciers, they can be grouped into classes such as ice sheet, ice cap, and glacier constrained by topography. Ice sheet and ice cap are formed when underlying topography is fully submerged by ice and glacier flow is not influenced by topography. On the other hand, when glaciers are constrained by the surrounding topography and the shape of valley

influences their flow, then such glaciers are classified as valley glaciers, cirque glaciers and ice fields. Mountain glaciers as in Himalayas, Alps, Andes are basically constrained by topography and are predominantly of valley type. In Himalayas, glaciers are distributed from West in Kashmir to East in Arunachal Pradesh covering entire stretch of Himachal Pradesh, Uttarakhand, Nepal and Sikkim Bhutan. The distribution and intensity of glaciation is governed by latitude and altitude of the mountains. The earliest map showing glacier boundaries of Himalayan mountains are available in Survey of India Topographical Maps of 1962.

2.2 Glaciation in 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 glaciations 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 8ºC. 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.

Glaciers in the Himalayas are fast retreating like other ice mountains the world over. A recent study showed that the last three decades of the 20th century have been the hottest period in 1,000 years. The melting of the Gangotri glacier is accelerating at an average retreat rate of 30

meters annually. The rate between 1935 and 1990 was 18 meters per year and 7 meters annually between 1842 and 1935. The overall deglaciation from 1962 to 2001 in the Baspa basin of Himachal Pradesh has been estimated as 19%. ChhotaShigri glacier of Chandra valley also retreated by about 12% in the last one and half decade. The deglaciation processes are also noticeable for large glaciers in Ganga headwater like Gangotri which shows about 10% decrease during the last 18 years. The maximum retreat of 34.5 metres per year has been observed at Meola glacier in Dhauliganga river basin. The retreat of the Parbati glacier is reported to be unusual and more alarming.

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 weather 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 2018 was assessed and the conveyed to the State Government as well as to the SJVNL. Besides this during the year 2017, 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 2017 for both AWIFS and LISS -3 satellite data

2.3 Distribution of Glacial lakes in Himachal Himalaya

The comparative analysis based on the results obtained from the analysis of LISS III data products during 2019 have been done with that of results obtained from 2018 for all 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 (Basin3). Based on the LISS-III satellite data analysis (96-48,96-49,97-48,97-49,98- 48,98-49,99-49,100-49 and 146-38) for 2019,a total of 562lakes have been delineatedcomprising458 lakes as the small one with area less 5ha, 53 lakes with area 5- 10ha and 51 lakes with area more than 10ha. Maximum number of lakes mapped from LISS III data falls in the path-row96-48(153) and 99-49(238) (Fig 10.4.4C). Further out of 562 lakes mapped, 62 are mainly the high altitude wetlands comprising 1 from Spiti basin, 1 from Lr. Satluj and 60 from the Upper Satluj basin. The comparative analysis based on LISS-III satellite data reveals that total number of lakes varies from 581 (2016) to 642 (2017) to 769 (2018) and 562 (2019) indicating an overall increase of about 10% between 2016-17, and about 19% between 2017-18 and reduction of about 26% between 2018-19 respectively. As far as the big lakes with area more than 10ha are concerned, total number of big lakes varies from 55 (2017) to 49 (2018) to 51 (2019) indicating a fluctuating trend in the lakes with area >10ha.The total variation in the number of lakes mapped in Upper Satluj basin based on LISSS III data varies from 443 (2016) to 450 (2017) to 495 (2018) to 437 (2019), in Lower Satluj basin the number varies from 72 (2016) to 102 (2017) to 98 (2018) to 52 (2019) and in case of Spiti sub basin it varies from 66(2016)to90 (2017) to 176 (2018) to 73 (2019) (**Fig.9.7**) indicating about 1% increase (2016-17) and about 10% (2017-18) and a reduction of about 11% (2018-19) in case of Upper Saltuj basin, 41% increase between (2016-17) and about 2% reduction (2017-18) and a reduction of about 46% (2018-19) in case of Lower Satluj and about 36% increase between 2016-17 and about 95% increase between 2017-18 and a reduction of about 58% (2018-19) in case of Spiti basin could be seen. Further in Spiti basin the lakes with id's 1682 RS (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. All these water bodies are although small but needs monitoring **(Fig. 9.11)**.Thus from the above analysis, it is clear that

although the maximum number of lakes are being formed in the Upper Satluj basin of the study area, but the reduction in the total number of lakes could be seen in all basins which is mainly due to the non-availability of good quality snow free and cloud free LISS III satellite date coverage during 2019.

Thus to summaries based on the results obtained by using LISS III data products, the results obtained using AWIFS indicates an overall reduction of about 16% in total number of lakes mapped in 2019 in comparison to 2018 reflecting 40% reduction in case of Spiti basin, 53% from Lower Satluj and 10% from the Upper Satluj basin and the maximum lakes (89%) of the total 229 have been mapped from Upper Satluj, 3% and 7% from Lower Satluj and Spiti basins respectively. In case of the bigger lakes with area >10ha, a reduction of about 55% could also be seen in 2019 (31) in comparison to 2018 (69) with majority of the lakes (30) forming part of the Upper Satluj basin, 0 from the Lower Satluj basin and 1 from the Spiti basin, out of which 11 are the high altitude wetlands and the remaining 19 are from the glacial origin. Besides this on 5 November 2019, where in total 116 lakes have been mapped, out of which 51 lakes are with area more than 10ha comprising 17 lakes as the high altitude wetlands and the remaining 34 are the lakes from glacial origin as a whole in the entire study area. Likewise LISS-III data indicates a decrease of about 26% in terms of the total number of lakes with about 4% increase in case of the lakes with area more than 10ha. The comparative analysis based on LISS-III satellite data reveals that total number of lakes varies from 581 (2016) to 642 (2017) to 769 (2018) and 562 (2019) indicating an overall increase of about 10% between 2016-17, and about 19% between 2017-18 and reduction of about 26% between 2018-19 respectively. Thus the data base based on AWIFS data product is reflects a complete inventory of 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 well as not much snow could be seen on 3rd October 2017, whereas the LISS-III data products reflects a more detailed inventory of the lakes with a set of fine resolution (23.5mts) reflecting more detailed information about the lakes with small dimensions.

Table 2.3.1: Distribution of lakes in different sub basins in Himachal Pradesh based on LISS III satellite data analysis for 2019.

Sr 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)**

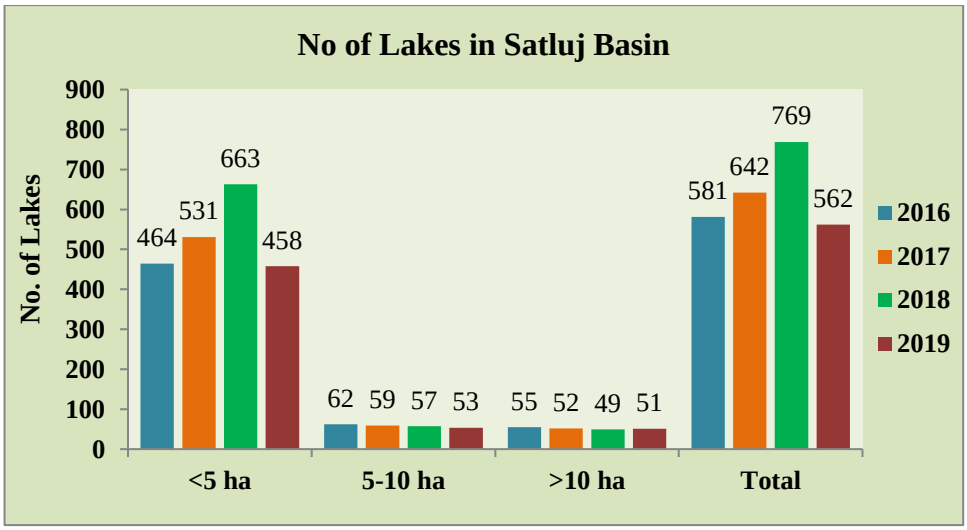


Fig.:2.3.1 Distribution of lakes in Satluj basin

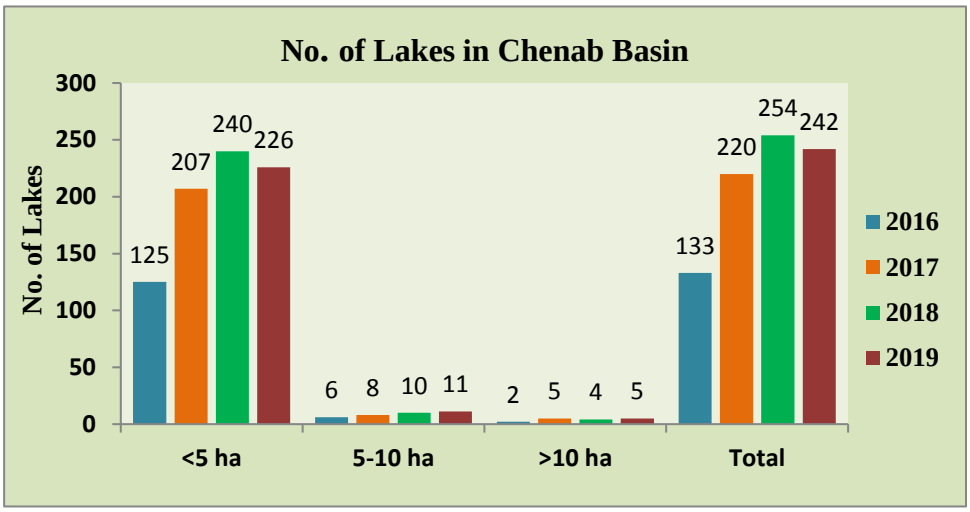


Fig.2.3.2. Distribution of lakes in Chenab basin

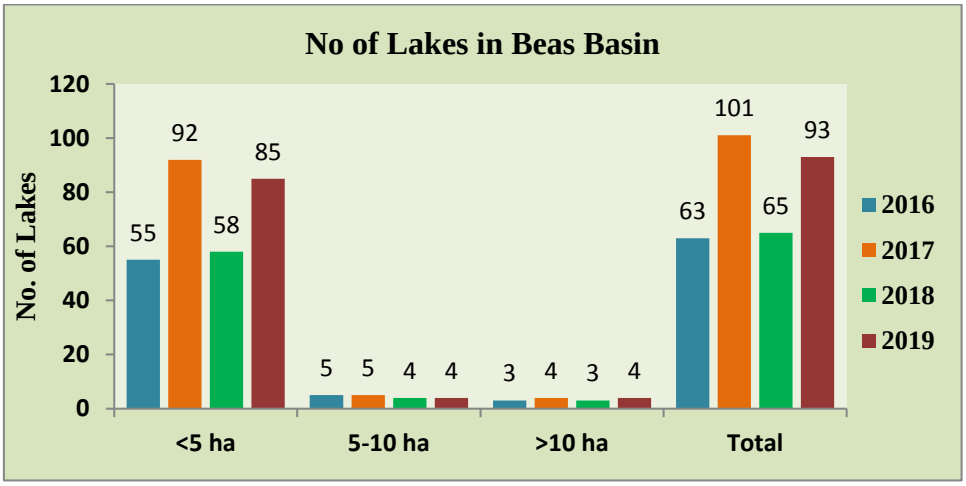


Fig.2.3.3 Distribution of lakes in Beas basin

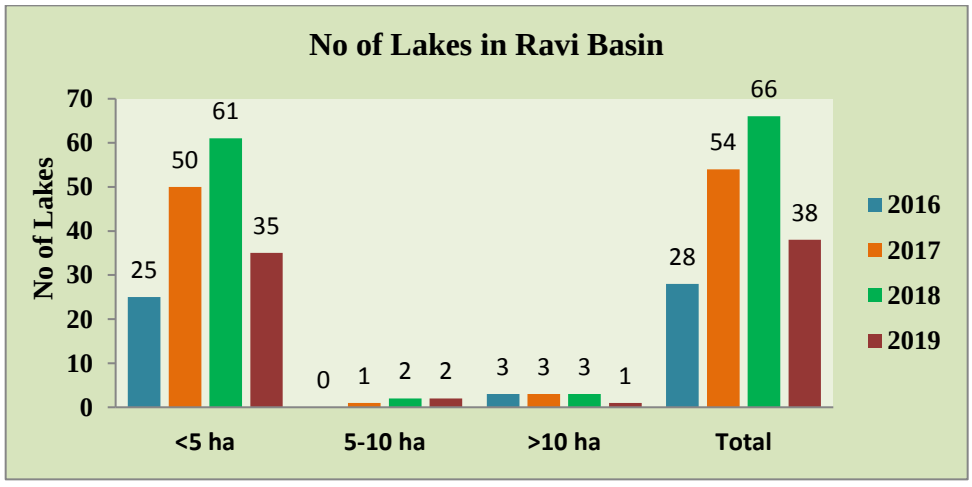


Fig.2.3.4 Distribution of lakes in Ravi basin

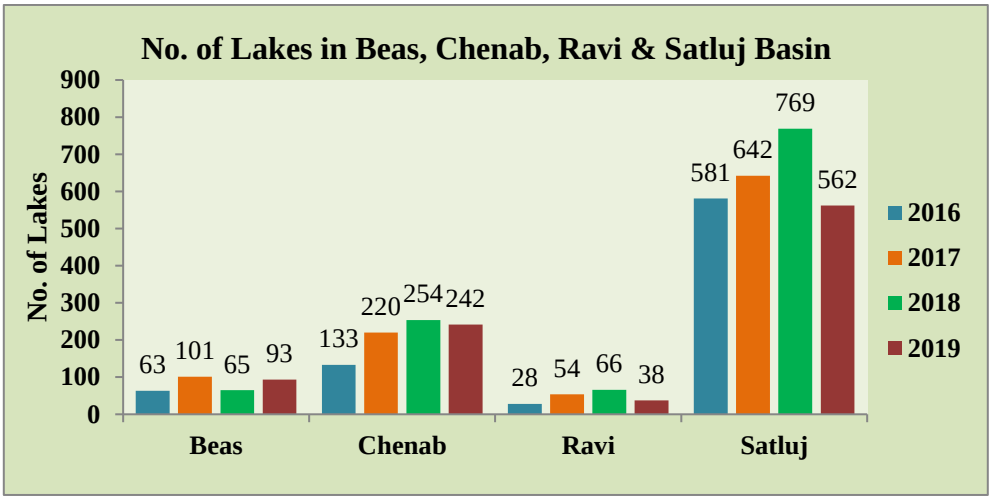


Fig.2.3.5: Distribution of lakes in Chenab, Beas, Ravi & Satluj basin

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 10ha. 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)

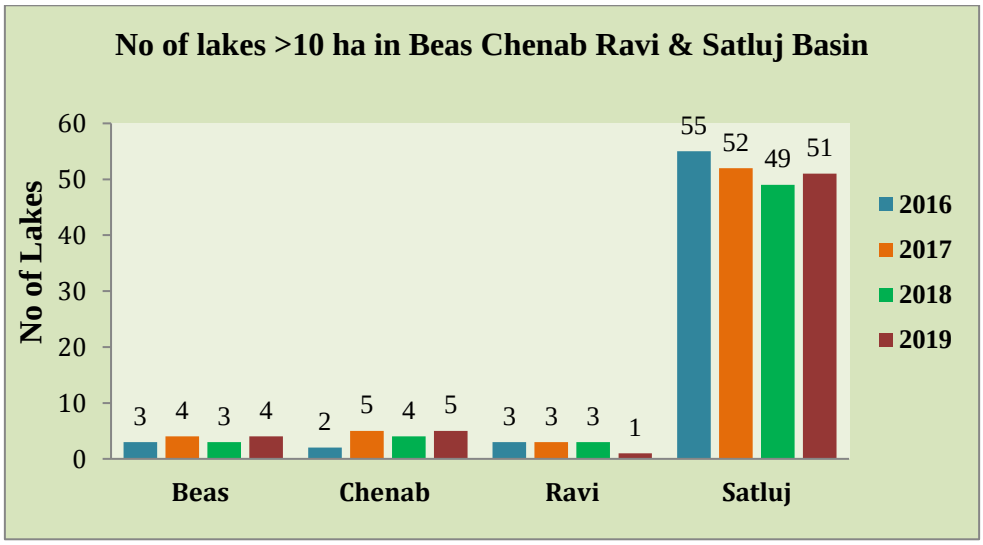


Fig.3.1 Distribution of lakes with area>10 Ha in Chenab, Beas, Ravi& Satluj basin in 2016, 2017, 2018 & 2019

3.1. Concluding Remarks

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-availably 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.

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 2020 based on the inventory of the lakes during the preceding year prepared using space data.

4.1 Study area and data used

The study area comprises mainly 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.). Earlier the study area was divided into four major sub basins i.e. Tso Morari as sub basin number 4, Spiti as sub basin number 1, Upper Tibet as 3 and Lower Satluj as sub basin number 2 (Fig 4.1) based on the information provided by NRSC Hyderabad, now it has been found while analyzing the Survey of India toposheet downloaded from internet that the Tso Morari Basin is an independent sub basin and does not contribute to the Satluj River System, thus as a result the study area has now been reduced to three sub basins viz. the Spiti Sub Basin(Basin No.1), Upper Satluj Basin(basin No. 3) and the Lower Satluj (basin No. 2) . 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 Sutlej 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 of IRS-P6 (Indian Remote Sensing) Satellite were used in the present study. The path–row of satellite coverage is shown in (Fig. 4.3) for IRS-P6 LISS-III sensor. Table 4.1 shows the satellite data used for the study purpose.

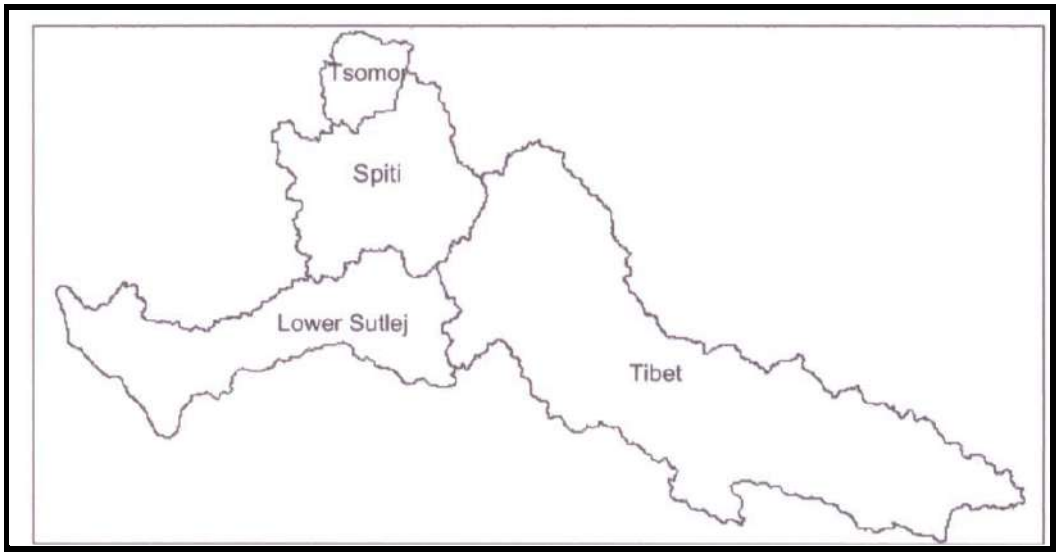


Fig. 4.1: Different regions in Satluj basin

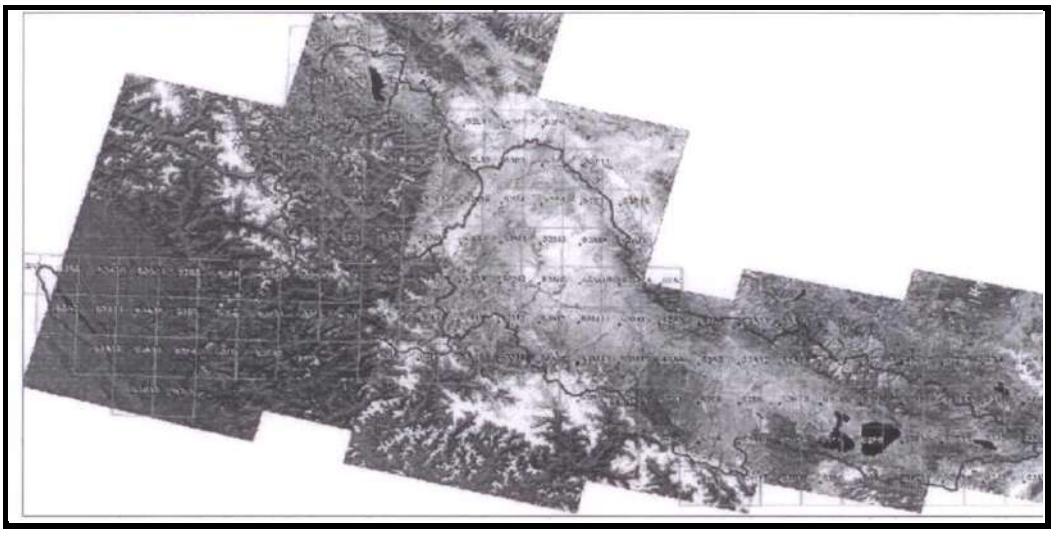


Fig. 4.2: False Colour Composite of Satellite images covering Satluj basin

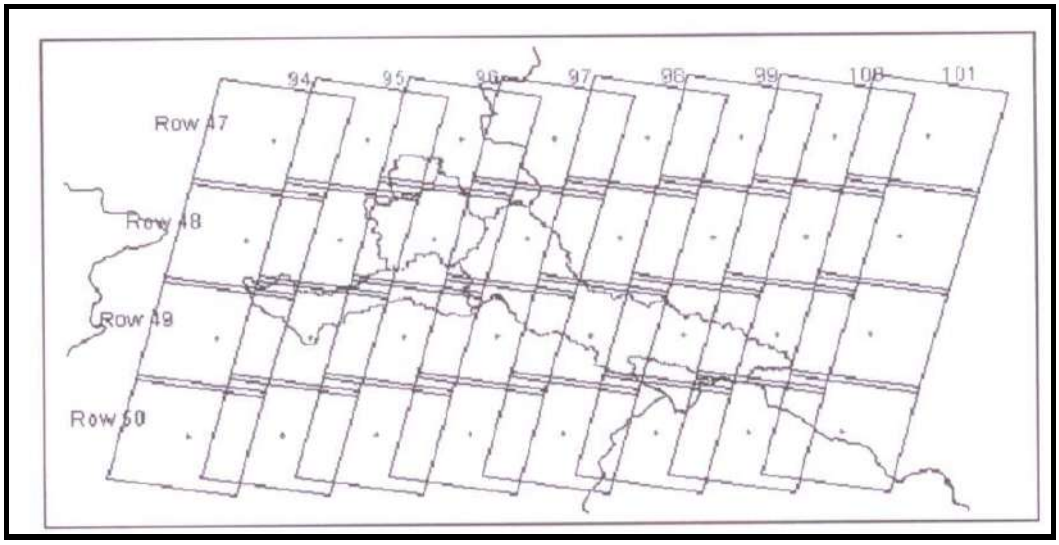


Fig. 4.3 IRS-P6 LISS-III Data Coverage over Sutlej Basin

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	16 April 20	94-49	Resourcesat2/AWIFS
2	02 Sep20	95-49	Resourcesat2/AWIFS
3	05 Sep 20	99-48	Resourcesat2/AWIFS
4	10 Sep 20	100-48	Resourcesat2/AWIFS
5	12 Sep20	97-49	Resourcesat2/AWIFS
6	21 Sep 20	94-48	Resourcesat2/AWIFS
7	29 Sep 20	99-48	Resourcesat2/AWIFS
8	01 Oct 20	96-47	Resourcesat2/AWIFS
9	16 Oct 20	99-49	Resourcesat2/AWIFS
10	30 Oct 20	97-49	Resourcesat2/AWIFS
LISS-III Satellite data used for monitoring in the study area			
Sr. No.	**Date of Pass**	**Path –Row**	**Satellite Sensor**
1	05 Sep 20	99-49	Resourcesat2/LISS III
2	07 Sep 20	96-48	Resourcesat2/LISS III
3	10 Sep20	100-49	Resourcesat2/LISS III
4	12 Sep 20	97-48	Resourcesat2/LISS III
5	12 Sep 20	97-49	Resourcesat2/LISS III
6	14 Sep 20	96-48	Resourcesat2/LISS III
LISS-IV Satellite data used for monitoring in the study area			
Sr. No	**Path –Row**	**Date of Pass**	**Satellite Sensor**
1	96-48A	07 Sep 20	Resourcesat2/2A/LISS IV
2	96-48A	08 Oct 20	Resourcesat2/2A/LISS IV
3	96-48B	01 Oct 20	Resourcesat2/2A/LISS IV
4	96-48C	08 Oct 20	Resourcesat2/2A/LISS IV
5	96-48D	14 Sep 20	Resourcesat2/2A/LISS IV

6	96-48D	01 Oct 20	Resourcesat2/2A/LISS IV
7	96-49A	08 Oct 20	Resourcesat2/2A/LISS IV
8	96-49B	01 Oct 20	Resourcesat2/2A/LISS IV
9	97-48A	12 Sep 20	Resourcesat2/2A/LISS IV
10	97-48B	19 Sep 20	Resourcesat2/2A/LISS IV
11	97-48C	12 Sep 20	Resourcesat2/2A/LISS IV
12	97-48D	19 Sep 20	Resourcesat2/2A/LISS IV
13	97-49A	12 Sep 20	Resourcesat2/2A/LISS IV
14	97-49B	12 Sep 20	Resourcesat2/2A/LISS IV
15	97-49C	12 Sep 20	Resourcesat2/2A/LISS IV
16	98-49A	17 Sep 20	Resourcesat2/2A/LISS IV
17	98-49C	17 Sep 20	Resourcesat2/2A/LISS IV
18	99-49B	29 Sep 20	Resourcesat2/2A/LISS IV
19	99-49D	05 Sep 20	Resourcesat2/2A/LISS IV

5.0 Methodology

The satellite data covering Sutlej basin during the months of April to November 2020 was browsed. The cloud free AWIFS satellite data for the year 2020 for monitoring of lakes during 2020 and the LISS-III images for further monitoring based on high resolution data for the year 2020 from IRS-RS2 &RS2A 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 2019 from AWIFS satellite data. Each of these satellite data sets was individually rectified with the reference image prepared from the downloaded TM 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 November2019. The flowchart explaining the methodology is given in (Fig. 5.1).

Besides this, as the AWIFS has the spatial resolution of 56m, the lake inventory prepared using LISS-III which has the spatial resolution of 23.5m, was compared with that of an updated inventory using high resolution LISS-III satellite data for the year 2019.All the cloud free

satellite images for the month of September 2020 were selected for making an updated inventory and were compared for their spatial variation with respect to that for the year 2018. 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 2020, another baseline database was prepared using LISS IV satellite data that has the spatial resolutions of 5.8mts. 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 can now be compared with the 2021databasefor 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.

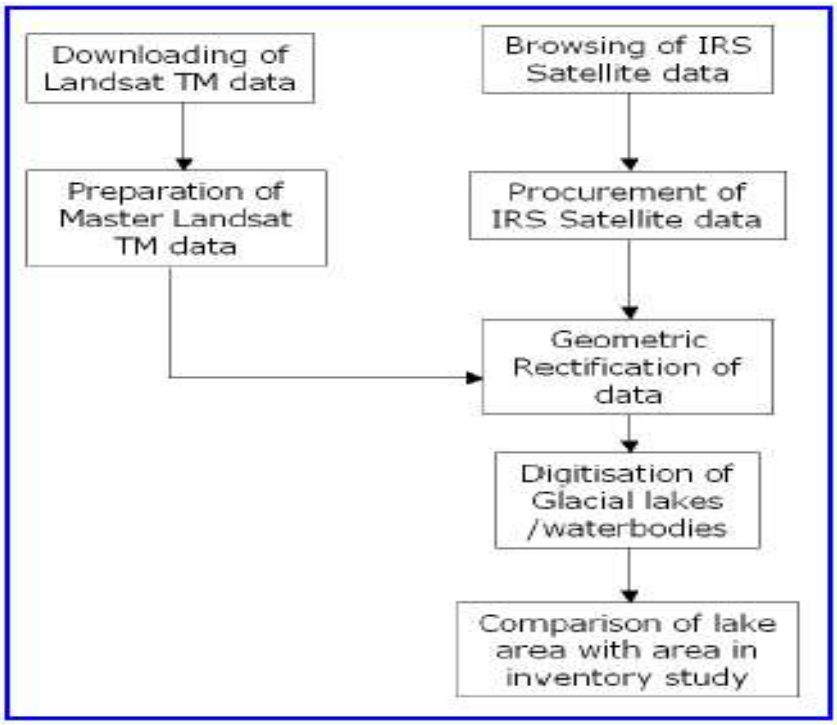


Fig.5.1: Flow Chart Methodology

6.0 Monitoring of Parechhu Lake during 2020

Parechhu lake which has been known for its damage and since 2001 is being monitored every year during the ablation season from April to September. This year also the lake was

monitored and its status was conveyed to all the stakeholders including SJVNL Shimla as well as the Government of Himachal Pradesh.

6.1 Observations derived from the satellite data analysis:

Parechhu Lake is a small geomorphic depression along the Parechhu River which 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 causes activation of the landslides which results in chocking of the river course in the downstream, this causes accumulation of the water in the depression. During the year 2020, the lake was regularly monitored and its findings about the water spread were reported to the SJVNL as well as to the Govt.

Fig 6.1: Satellite View of Parechhu Lake 96-48-LISS-III 10 June 2020

On analyzing the IRS RS2 LISS III Satellite data for 10 June 2020 the following observations were made.

- The water flow in the lake depression seems to be comparatively more on the peripheral side and on the upstream side and downstream side of the depression, whereas the central part does not show any accumulation.
- Slight accumulation is seen on upstream side of the depression and a small accumulation on the downstream side as well. .
- The inflow and outflow seems to be normal.
- Based on the satellite data interpretation, there does not seem to be any threat from the Parechhu Lake for the downstream areas. However continuous monitoring would be required as the ablation is still continuing for another 3-4 months and thus requires regular monitoring

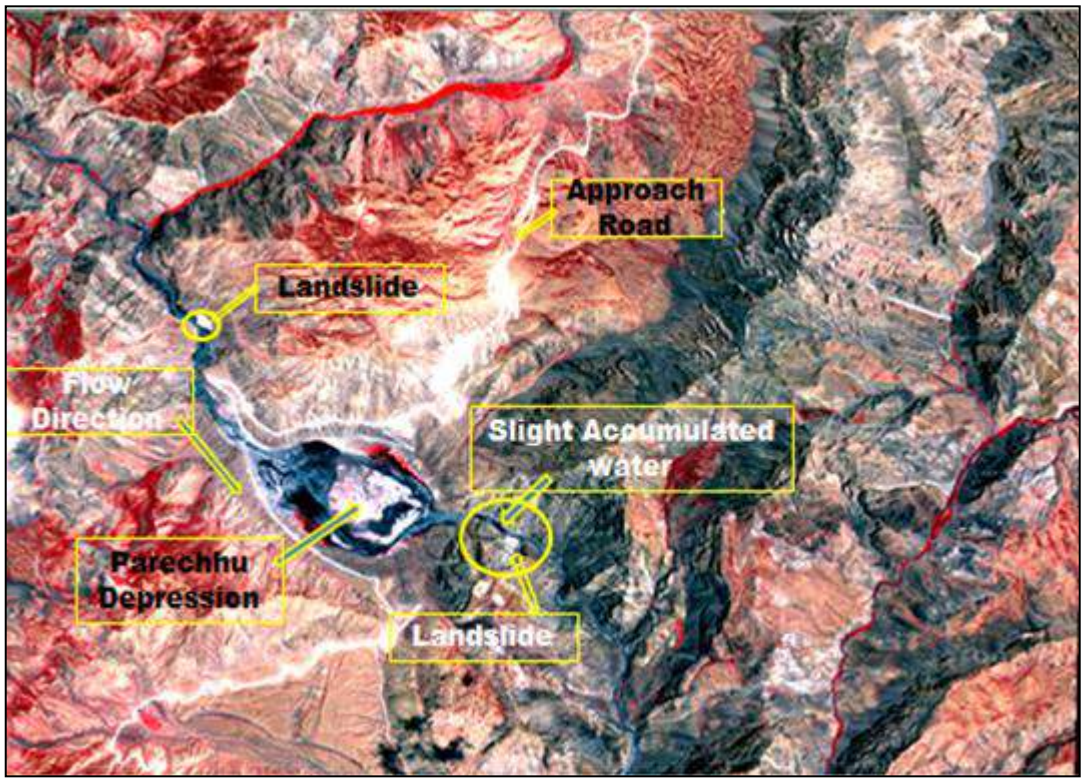


Fig 6.2: Satellite View of Parechhu Lake 96-48B -LISS-IV 27 June 2020

Observations:

On analyzing the IRS RS2 LISS IV-96-48-B-27 June 2020 Satellite data, the following observations were made.

Based on the analysis of IRS-R2-L4-96-48-B-27 June 2020 satellite data having spatial resolution of 5.8 mts , the following observations are made:-

- The accumulated water in the lake depression seems to be flowing through the peripheral sides, with some water on the upstream side.
- The central part is comparatively free from any accumulation except a small portion on the downstream side where some accumulation could be seen.
- The inflow and the outflow seems to be normal.
- Two landslides could be observed along the river course one on the upstream side of the depression on the left bank of the Parechhu River and the second on the downstream side of the depression on the right bank of the Parechhu River.
- Along the river course on the downstream side, slight accumulation of water could be seen which may have been resulted due to the encroachment of the landslide in the river course on the right bank.
- The landslide on the left bank on the upstream side also seems to encroaching the river course, but no significant change in the river flow could be seen.
- The region is now observed to be well connected because of the developmental activities like road network developed in the area.
- Based on the satellite data interpretation, there does not seem to be any threat from the Parechhu Lake as on day but needs regular monitoring till its freezing.

  Based on the analysis **of IRS-R2-L3-96-48-14 August 2020** satellite data having spatial resolution of 23 mts the following observations are made:-
- The water flow is mainly through the peripheral side along the upstream and downstream part of the depression and braiding in the upstream part of the depression could be seen.
- The central part is comparatively free from any accumulation except a small accumulation in the upstream part and a small patch in the frontal part.
- The inflow and the outflow seem to be normal. But the outflow seems to be comparatively reduced just after the landslide which was observed on 27th June 2020 along the right bank of the Parechhu River resulting to slight accumulation along the river course as observed on 27th June 2020.
- The landslide on the left bank on the upstream side does not show much change as observed on 27th June and the river flow seems to normal but having wide distribution along the flood plain.

- The upper catchment is free from seasonal snow cover and thus there is no melting from the seasonal snow cover in the Parechhu River catchment and whatever flow is there is being contributed by the permanent snow and glaciers in the catchment.
- The lakes which were identified in the adjoining Spiti catchment just upstream of Kaza on the left bank of Spiti River having small lakes along the small stream, seems to be normal in nature , but the water column in some of them seems to be little bit on higher side.
- The temporal analysis of these accumulated water bodies was carried out and found that there is not much change in their spatial extent w.r.t 2019 but 02 new water bodies could be seen having very shallow accumulation.
- The temporal changes in the areas of these water bodies is as under:

Lake Id	Area(hectare) 2019	Area(hectare) 2020	Change in Area
1682(RS)	0.40	0.46	(+)0.06
1683(RS)	1.09	1.30	(+)0.21
1684(RS)	1.96	1.98	(+)0.02
1685(RS)	1.44	3.95	(+)2.51
1686(RS)	1.60	1.45	(-)0.15
1687(RS)	1.57	1.40	(-)0.17
New	-----	2.12	Very shallow
New	-----	0.56	Very shallow

- Based on the above satellite data interpretation, there does not seem to be any threat from the Parechhu Lake as well as water bodies in Spiti catchment formed along river course as on day but needs regular monitoring to assess any threat in future.

7.0: Monitoring of glacial lakes and other water bodies using AWIFS Satellite data in Satluj catchment during 2020

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. In the present study the lakes which were mapped during 2020 have been used to assess the temporal variation with that of the lakes mapped during the preceding years. The status of lakes mapped during 2020 and their temporal variation with respects to 2019 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 demarkable, 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 cloud 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 16 April 2020

On analyzing the satellite data for 16 April 2020, it is found that the satellite image covers mainly the areas falling in the sub basin 1,2 & 3, but most of the area is under the impact of seasonal snow cover as a result only 18 lakes could be delineated from the satellite image **(Fig 7.1a)** out of which 10 are the high altitude wetlands and the remaining 8 are lakes formed along the river course**.** Further out of these 8 lakes, 4 lakes are such which have the area less than 5ha,1 lakes is having area between 5-10ha and 3 lakes are with area more than 10ha and all lakes forming part of the Upper Satluj sub basin i.e basin 3 **(Fig 7.1c)** . Likewise the remaining10 lakes are the high altitude wetlands forming part of the sub basin 3 out of which 3 are small one with area <5ha, 2 are within the areal range of 5-10ha and 5 are the big one with area more than10ha **(Fig 7.1d).** When these 18 lakes are seen temporally to the lakes mapped in April 2020, the temporal could not be done due to non -availability of information during 2019.

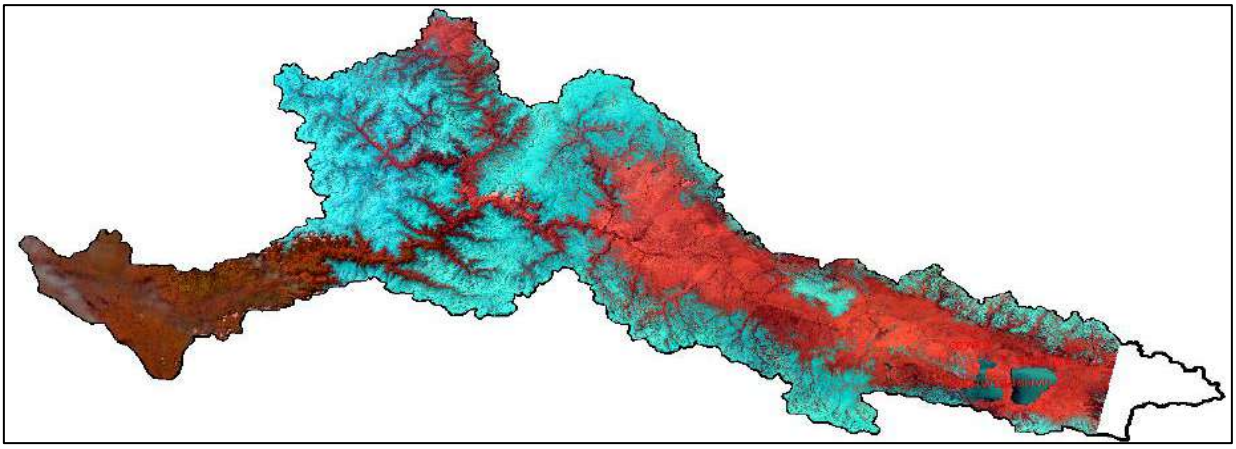


Fig. 7.1(a): IRS-R2-AWiFS-96-49-16-04-20

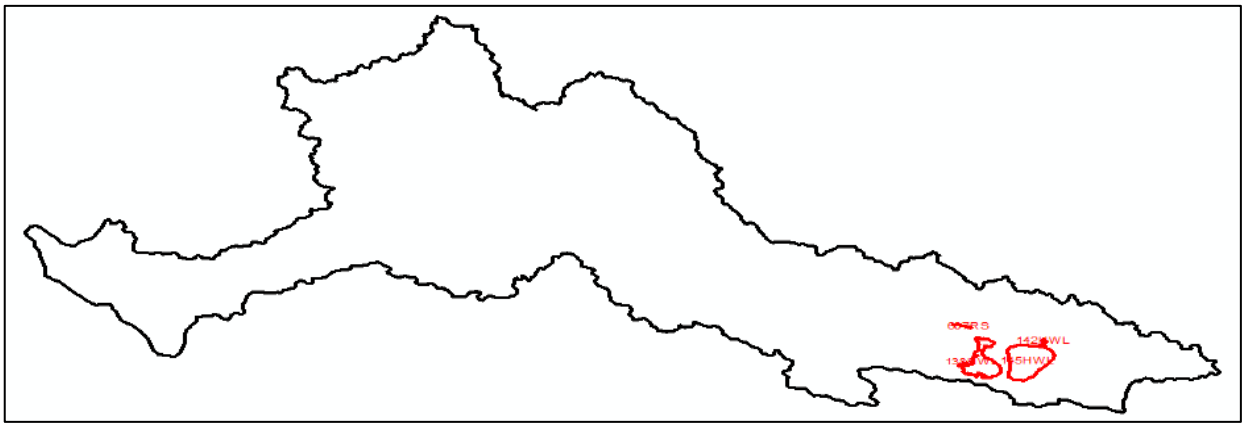


Fig. 7.1(b): IRS-R2-AWiFS-96-49-16-04-20 Interpreted Layer

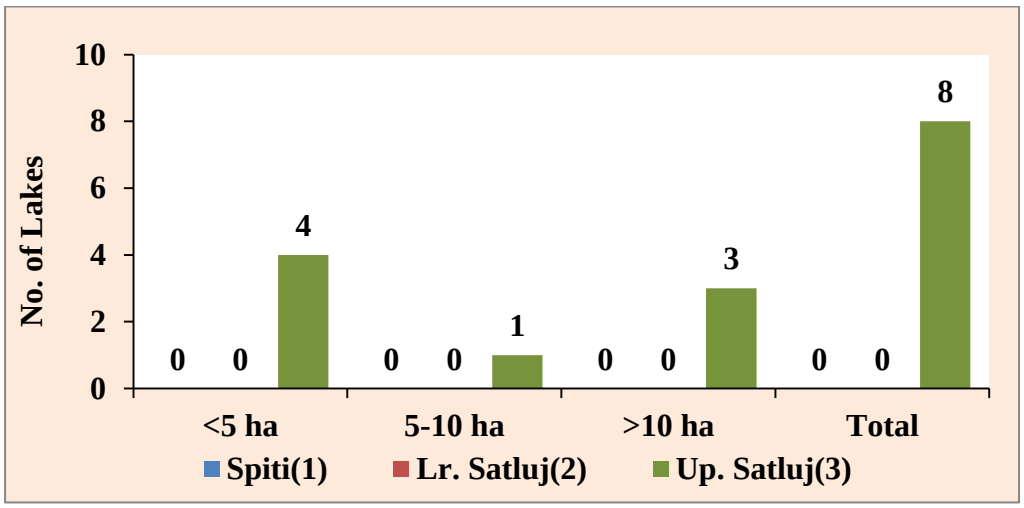


Fig. 7.1(c): No. of Lakes based on IRS-R2-AWiFS-96-49-16-04-20.

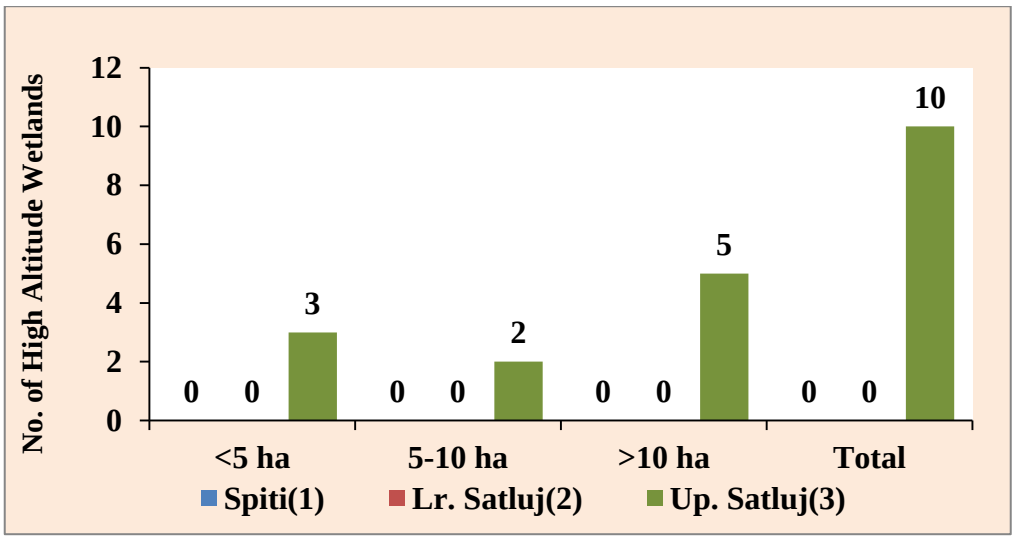


Fig. 7.1(d): No. High altitude wetlands based on IRS-R2-AWiFS-96-49-16-04-20.

Table: 7.1 Aerial Extent of lakes as on April 2020

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on April 2019 (ha.)	Aerial Extent on 16 April 2020 (ha.)	Change in Area w.r.t. May 2019 (ha.)
1	1022RS	3	81.1075	30.9264	------	1.41	------
2	138HWL	3	81.2361	30.6892	------	**25711.00**	------
3	142HWL	3	81.5677	30.8043	------	**250.24**	------
4	145HWL	3	81.4742	30.6861	------	**41702.10**	------
5	1474HWL	3	81.5691	30.7685	------	**18.51**	------
6	205HWL	3	81.5695	30.7894	------	4.51	------
7	206HWL	3	81.5728	30.7908	------	0.87	------
8	207HWL	3	81.5526	30.7859	------	7.29	------
9	210HWL	3	81.5533	30.7733	------	**111.04**	------
10	385HWL	3	81.5413	30.7798	------	3.97	------
11	607RS	3	81.1773	30.9108	------	**124.31**	------
12	608RS	3	81.0972	30.9265	------	14.92	------
13	616RS	3	81.1208	30.9259	------	**10.47**	------
14	8034HWL	3	81.559	30.7827	------	5.55	------
15	8245RS	3	81.1106	30.9253	------	1.79	------
16	8246RS	3	81.1383	30.9229	------	8.81	------
17	8247RS	3	81.1437	30.9214	------	1.97	------
18	8248RS	3	81.1483	30.9208	------	4.78	------

HWL- High Altitude Wetlands
RS- River Section

7.2: Status of lakes as on May 2020.

No good quality satellite data was available during May 2020, so no interpretation could be made during this month.

7.3: Status of lakes as on June 2020.

No good quality satellite data was available during June 2020, so no interpretation could be made during this month.

7.4: Status of lakes as on July 2020.

No good quality satellite data was available during July 2020, so no interpretation could be made during this month.

7.5: Status of lakes as on August 2020.

No good quality satellite data was available during August 2020, so no interpretation could be made during this month

7.6: Status of lakes as on 02 September2020.

On analyzing the satellite data for 02 September 2020, it is found that most of the area in the Upper Satluj and Lower Satluj basins is under the impact of cloud cover as a result of which partial information could be derived **(Fig. 7.6 a).** Based on the interpretation of the satellite data, a total of 161 lakes comprising 159 lakes from the glacial origin and only 2 lakes as the high-altitude wetland **(Fig.7.6 c & d)** one each from Spiti and Upper Satluj basin respectively. Out of these 159 lakes, 119 lakes are such which have the area less than 5ha out of which 44 lakes forms a part of the Spiti sub basin, 7 from the Lower Satluj and 68 lakes forms part of the Upper Satluj basins respectively. Besides this, 27 lakes are such which have the area between 5-10 ha with 10 lakes forming part of the Spiti sub basin and 17 that from the Upper Satluj sub basin. As far as the bigger lakes with area more than 10ha are concerned, there are 14 lakes which comprise of 3 falling in Spiti sub basin, 1 from the Lower Satluj basin and 10 from the Upper Satluj sub basin respectively. When these 161 lakes are seen temporally w.r.t.229 lakes as mapped on 09 September 2019 **(Table 7.6)** reveals that only 39 lakes could be compared out of which 32 lakes are showing a positive trend in their spatial coverage, whereas 07 lakes are showing negative trend w.r.t 2019 respectively and the lakes those could not be compared forms the base line data for next year monitoring.

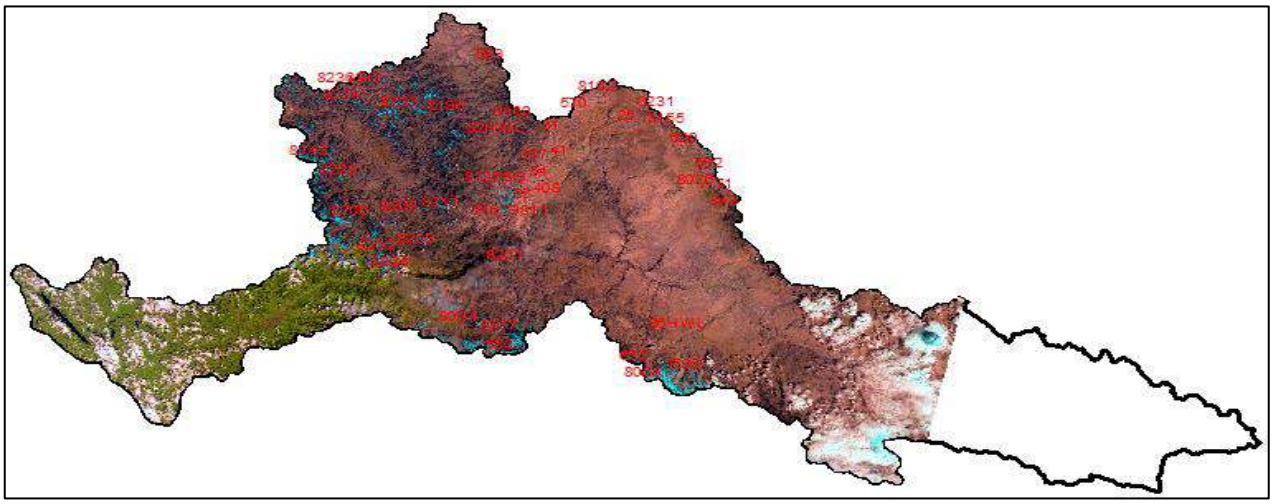


Fig.7.6 (a): IRS-R2-AWiFS-95-49-02-09-2020

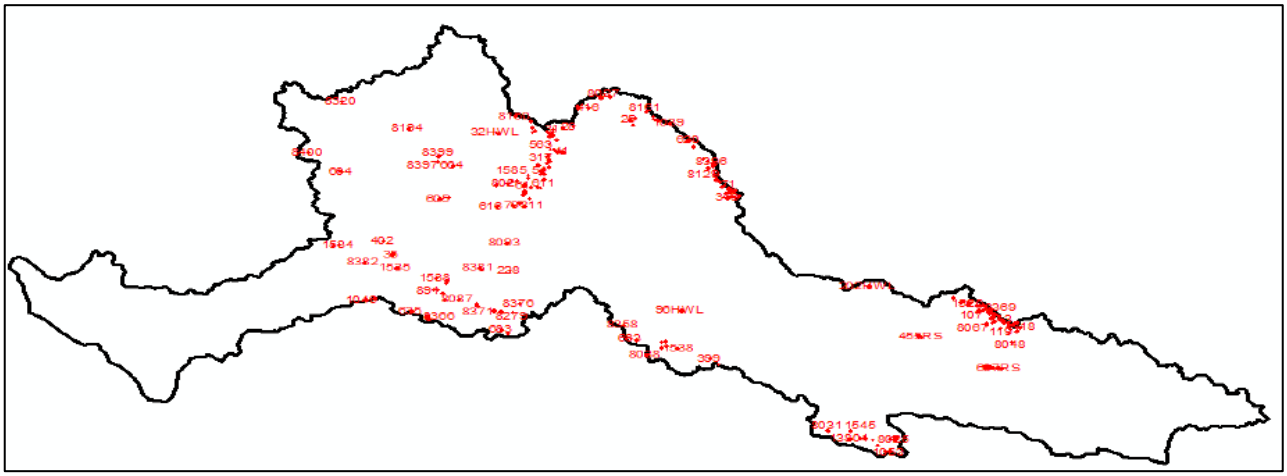


Fig.7.6 (b): IRS-R2-AWiFS-95-49-02-09-20 Interpreted Layer

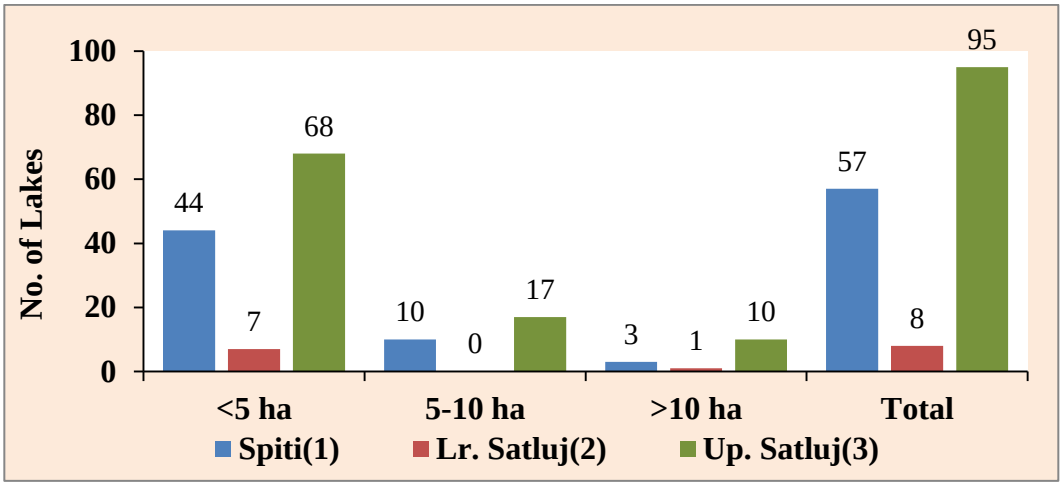


Fig. 7.6 (c): No. of Lakes based on IRS-R2-AWiFS-95-49-02-09-2020

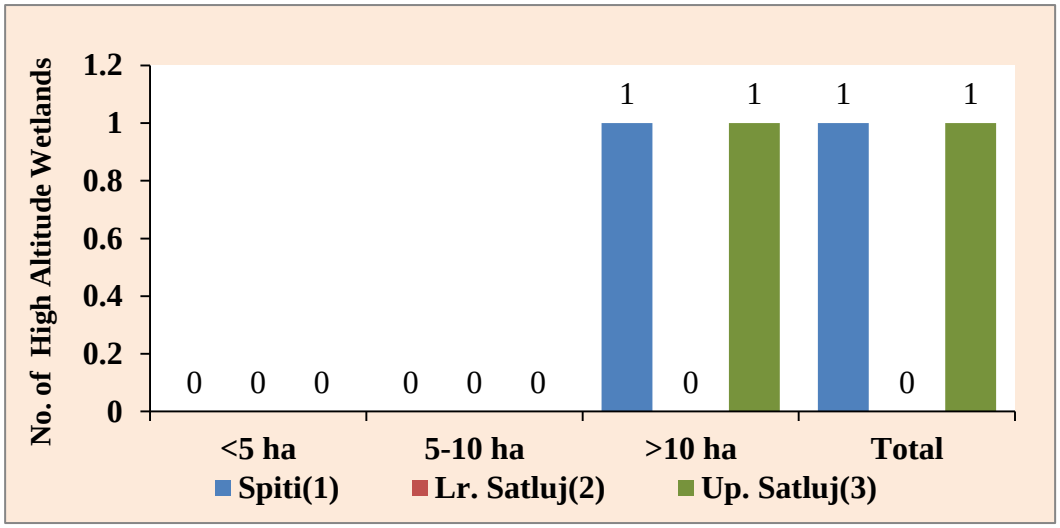


Fig. 7.6 (d): No. High altitude wetlands based on IRS-R2-AWiFS-95-49-02-09-2020

Table: 7.6 Aerial Extent of lakes as on 02 September2020

Sr No	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 09 Sept 2019 (ha.)	Aerial Extent on 02Sep 2020 (ha.)	Change in Area w.r.t. Sept.2019 (ha.)
1	23	3	32.3918	79.4179	**6.77**	**10.50**	**3.73**
2	25	3	32.3798	79.3934	**25.39**	**26.65**	**1.26**
3	28	3	32.3493	79.051	4.26	5.12	0.86
4	31	3	32.3408	79.0021	4.28	7.72	3.44
5	39	3	32.2269	79.0264	5.39	8.27	2.88
6	41	3	32.2119	79.0434	**21.17**	**25.53**	**4.36**
7	51	3	32.1245	78.943	3.02	6.32	3.30
8	54	3	32.1095	78.9329	5.43	**11.11**	5.67
9	55	3	32.1098	78.9413	6.78	**10.34**	3.56
10	61	1	32.0316	78.8448	**14.47**	**20.22**	**5.74**
11	65	1	31.9948	78.8454	**22.08**	**29.11**	**7.03**
12	71	3	31.9794	79.8731	7.59	7.47	-0.13
13	73	3	31.9721	79.8829	2.18	4.81	2.63
14	74	3	31.9704	79.8767	2.14	4.82	2.68
15	79	3	31.9213	78.7838	**19.51**	**17.86**	**-2..35**
16	81	3	32.023	79.8193	------	1.79	------
17	312	1	32.3276	78.9733	3.75	7.01	3.26
18	313	1	32.3222	78.9789	7.72	**10.23**	3.51
19	315	1	32.193	78.9726	2.70	7.06	4.37
20	317	3	32.1628	78.9779	5.70	9.57	3.87
21	343	3	31.9272	79.8658	**29.70**	**33.87**	**4.16**
22	404	1	32.2604	78.9779	------	2.45	------
23	408	3	32.0203	78.911	3.23	8.45	5.22
24	417	3	32.2178	79.7057	1.36	2.67	1.31
25	559	1	32.7129	78.7083	------	3.98	------
26	561	1	32.7099	78.6883	------	3.80	------
27	562	3	32.2791	79.0172	1.61	2.68	1.07
28	563	1	32.2281	78.9834	1.37	2.07	0.70
29	570	3	32.4487	79.1303	4.82	5.04	0.23
30	571	3	32.4653	79.1306	------	1.77	------
31	592	3	32.119	79.8047	------	3.28	------
32	610	3	32.0949	78.9472	4.05	7.90	3.85
33	611	3	32.0622	78.9428	5.14	6.34	1.20
34	616	1	31.9141	78.703	2.17	5.12	2.94
35	620	3	32.2561	79.6842	3.75	6.03	2.28
36	632	3	31.1463	79.3667	2.34	3.09	0.75
37	640	3	32.1318	78.9704	------	2.77	------
38	641	3	31.9607	79.896	------	5.59	------
39	641	3	31.9619	79.8939	------	1.54	------
40	663	3	31.1557	79.3424	------	3.09	------
41	683	3	31.228	78.6958	------	9.52334	------
42	804	1	32.0458	78.8317	2.07	3.65	1.57
43	811	3	31.9161	78.8419	**27.41**	**25.29**	**-2.88**
44	816	3	31.9651	79.8798	2.97	2.71	-0.26

45	884	3	31.9699	79.8899	------	3.85	------
46	885	3	31.9345	79.8833	1.61	2.70	1.09
47	1038	3	32.1275	79.8021	------	3.30	------
48	1531	3	31.972	78.8697	**4.23**	**10.77**	**6.55**
49	1532	3	31.9596	78.8674	2.11	6.28	4.17
50	1538	3	31.0953	79.5701	4.57	3.99	-0.57
51	1552	1	32.2569	78.9919	------	2.39	------
52	1585	1	32.0883	78.8635	------	3.08	------
53	8026	3	32.0312	79.8131	------	2.63	------
54	8027	3	32.5308	79.271	------	3.24	------
55	8028	3	32.1725	78.9728	------	1.78	------
56	8037	3	31.0628	79.4112	------	2.45	------
57	8038	3	31.0625	79.4144	------	9.75	------
58	8077	3	31.3281	78.6964	------	4.02	------
59	8084	3	31.3758	78.5802	------	1.59	------
60	8094	2	31.8997	78.7155	------	1.21	------
61	8095	2	31.9089	78.7101	------	1.19	------
62	8096	1	31.92	78.7038	------	1.19	------
63	8097	3	31.936	78.8149	------	1.81	------
64	8098	3	31.9327	78.8217	------	0.89	------
65	8099	3	31.9352	78.8225	------	2.09	------
66	8100	3	31.935	78.82	------	2.39	------
67	8101	1	31.9361	78.6858	------	1.50	------
68	8102	3	31.9315	78.8186	------	2.12	------
69	8105	3	31.9819	78.8378	------	**17.37**	------
70	8106	3	31.9578	79.8787	------	4.49	------
71	8107	3	31.9663	79.9001	------	4.83	------
72	8108	3	31.9671	78.813	------	4.62	------
73	8108	3	32.0063	78.9026	------	2.39	------
74	8109	1	32.0138	78.8454	------	2.49	------
75	8111	1	32.0224	78.8768	------	2.99	------
76	8112	3	31.9904	79.8381	------	1.51	------
77	8113	3	31.9941	79.8472	------	3.06	------
78	8115	1	32.0362	78.779	------	1.10	------
79	8116	3	32.0035	79.8563	------	2.12	------
80	8117	1	32.0443	78.758	------	2.54	------
81	8119	1	32.0469	78.7554	------	2.52	------
82	8120	1	32.0555	78.7838	------	1.76	------
83	8121	3	32.0197	79.828	------	4.43	------
84	8125	3	32.0299	79.8166	------	2.35	------
85	8126	3	32.0565	78.9047	------	1.24	------
86	8129	3	32.0804	79.804	------	3.84	------
87	8130	3	32.1218	78.951	------	1.48	------
88	8131	3	32.1221	78.9472	------	5.82	------
89	8132	3	32.1248	78.948	------	1.95	------
90	8134	1	32.1319	78.9274	------	2.99	------
91	8136	3	32.109	79.8019	------	1.50	------
92	8137	1	32.1446	78.9184	------	4.72	------
93	8138	3	32.1518	78.9629	------	2.47	------
94	8139	3	32.1236	79.7953	------	4.08	------
95	8141	1	32.1875	78.96	------	3.66	------
96	8141	3	32.2267	79.0065	------	3.64	------
97	8142	3	32.2105	79.0197	------	4.24	------
98	8143	1	32.2455	77.7599	------	3.88	------

99	8146	1	32.3026	78.9854	------	8.75	------
100	8154	3	32.352	79.407	------	5.08	------
101	8155	3	32.355	79.595	------	5.89	------
102	8157	3	32.3726	79.5342	------	2.11	------
103	8159	3	32.3944	79.5088	------	2.35	------
104	8160	1	32.4213	78.8164	------	8.91	------
105	8162	3	32.5089	79.2529	------	5.37	------
106	8169	3	31.3723	78.7943	------	2.99	------
107	8183	3	32.5153	79.2914	------	2.99	------
108	8196	1	32.4598	78.4731	------	7.55	------
109	8198	1	32.6974	78.7111	------	3.56	------
110	8199	1	32.7004	78.7334	------	3.58	------
111	8200	1	32.7098	78.7061	------	2.93	------
112	8201	2	31.6801	78.7434	------	1.20	------
113	8201	1	32.71	78.702	------	1.70	------
114	8202	2	31.7155	78.1759	------	1.77	------
115	8203	2	31.7817	78.2944	------	3.64	------
116	8204	2	31.7912	78.3071	------	2.40	------
117	8205	3	31.9105	78.8027	------	2.67	------
118	8206	1	31.9353	77.9628	------	1.82	------
119	8207	3	31.9295	78.7845	------	1.21	------
120	8208	1	31.9467	78.2185	------	2.08	------
121	8209	3	31.9314	78.7828	------	2.66	------
122	8210	3	31.9387	78.8085	------	1.81	------
123	8211	1	31.967	78.4157	------	8.14	------
124	8213	3	31.9578	79.892	------	1.13	------
125	8214	1	31.997	78.8489	------	2.43	------
126	8215	1	32.0133	78.8476	------	1.15	------
127	8216	1	32.0112	78.8498	------	1.21	------
128	8217	1	32.0161	78.8237	------	1.21	------
129	8218	3	32.0455	78.9031	------	1.83	------
130	8219	3	32.1152	79.8029	------	1.13	------
131	8220	2	31.9025	78.7197	------	2.69	------
132	8221	1	32.0495	78.7445	------	1.56	------
133	8222	1	32.0426	78.769	------	1.60	------
134	8223	1	32.1396	77.9135	------	4.27	------
135	8224	3	32.0767	79.8111	------	2.64	------
136	8225	1	32.0343	78.8725	------	5.12	------
137	8226	2	31.6631	78.166	------	**37.06**	------
138	8226	1	32.1262	78.9252	------	1.81	------
139	8227	1	32.1408	78.9482	------	0.90	------
140	8228	3	32.1216	79.7789	------	1.23	------
141	8229	1	32.3277	78.8968	------	1.49	------
142	8230	1	32.3365	78.9081	------	2.24	------
143	8231	1	32.4202	79.4723	------	1.22	------
144	8232	1	32.4235	79.4779	------	1.16	------
145	8233	3	32.4877	78.2317	------	3.64	------
146	8234	3	32.5269	77.9415	------	4.70	------
147	8235	3	32.494	79.1712	------	3.92	------
148	8237	3	31.9292	79.9021	------	2.13	------
149	8238	1	32.0381	78.7035	------	1.70	------
150	8239	1	32.0453	78.7516	------	1.21	------
151	8240	3	32.0139	79.8289	------	1.76	------

152	8241	1	32.073	78.8633	------	1.81	------
153	8242	3	32.061	79.8012	------	2.11	------
154	8243	1	32.7003	78.7197	------	1.53	------
155	8244	1	32.7087	78.7393	------	2.45	------
156	62SG	1	32.0195	78.8751	------	9.89	------
157	32HWL	1	32.3308	78.7166	**28.64**	**25.85**	**-2.79**
158	8122SG	1	32.0957	78.9145	------	1.82	------
159	8127SG	1	32.0607	78.8073	------	11.90	------
160	8156SG	3	32.3752	79.4191	------	1.79	------
161	8236SG	1	32.6095	77.9876	------	5.70	------
162	96HWL	3	31.3069	79.5996	**46.86**	**38.58**	**-8.28**

HWL- High Altitude Wetlands
RS- River Section
SG-Supra Glacial

7.7 Status of Lakes as on 05 Sep 2020

On analyzing the satellite data for 05 September 2020, it is found that the satellite image covers mainly the partial areas falling sub basin 1 & 3 **(Fig. 7.7a)** as a result of which only 46 lakes could be mapped in comparison to 229 lakes which were mapped in 09 September 2019 **(Fig. 7.7c & d)** and only 1 high altitude wetland that too from the Spiti sub basin having area between 5-10ha. Out of these 46 lakes, 30 lakes are such which have the area less than 5ha out of which 8 lakes forms a part of the Spiti sub basin and 22 lakes forms part of the Upper Satluj basins respectively. Besides this, 12 lakes are such which have the area between 5-10 ha with 05 lakes forming part of the Spiti sub basin and 7 that from the Upper Satluj sub basin. As far as the bigger lakes with area more than 10ha are concerned, there are 4 lakes which comprise of 1falling in Spiti sub basin and 3 from the Upper Satluj sub basin respectively **(Fig. 7.7 c & d).** When these 47 lakes are seen temporally w.r.t.229 lakes as mapped on 09 September 2019 **(Table 7.7)** reveals that only 15 lakes could be compared out of which 14 lakes are showing a positive trend in their spatial coverage, whereas 01 lakes are showing negative trend w.r.t 2019 respectively and the lakes those could not be compared forms the base line data for next year monitoring.

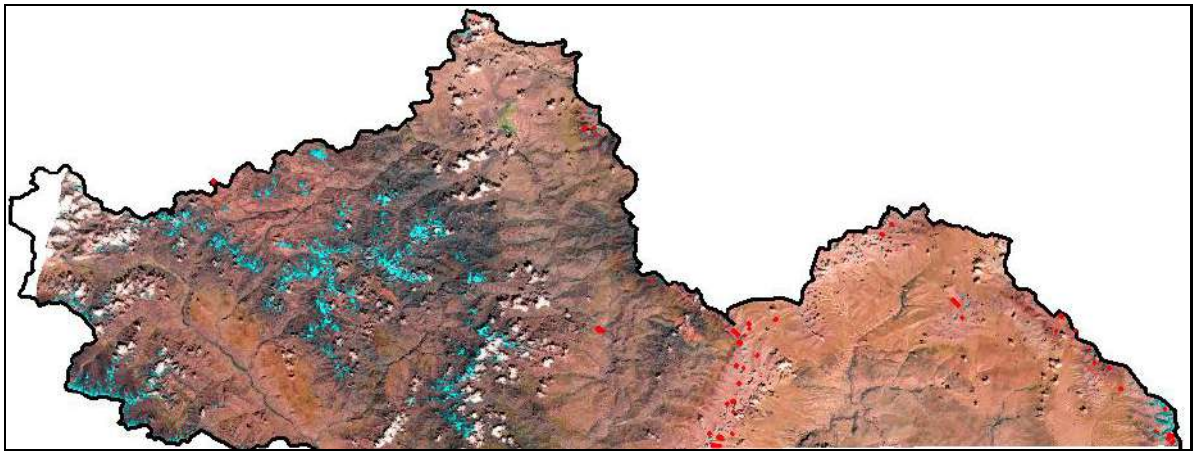


Fig.7.7 (a): IRS-R2-AWiFS-99-48-05-09-2020

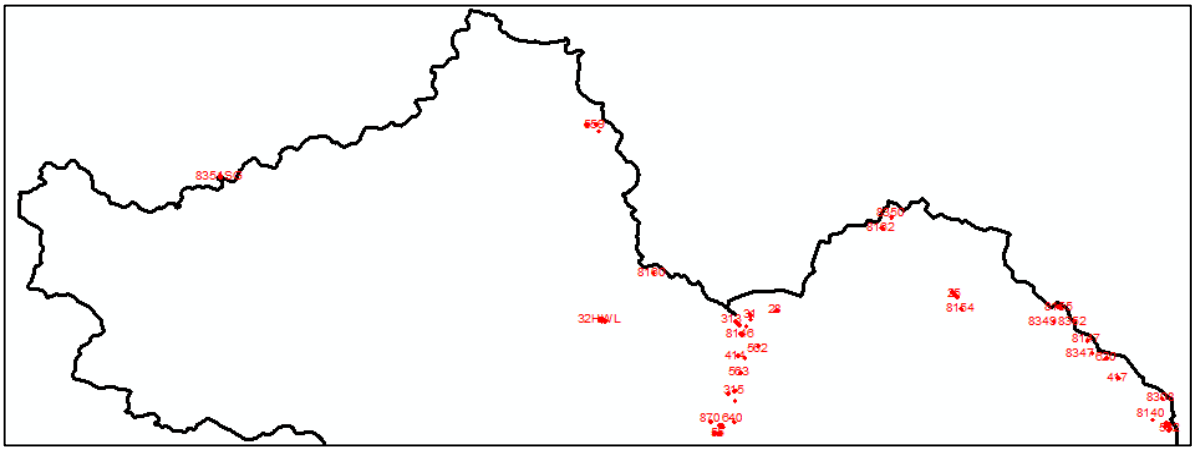


Fig.7.7 (b): IRS-R2-AWiFS-99-48-05-09-2020

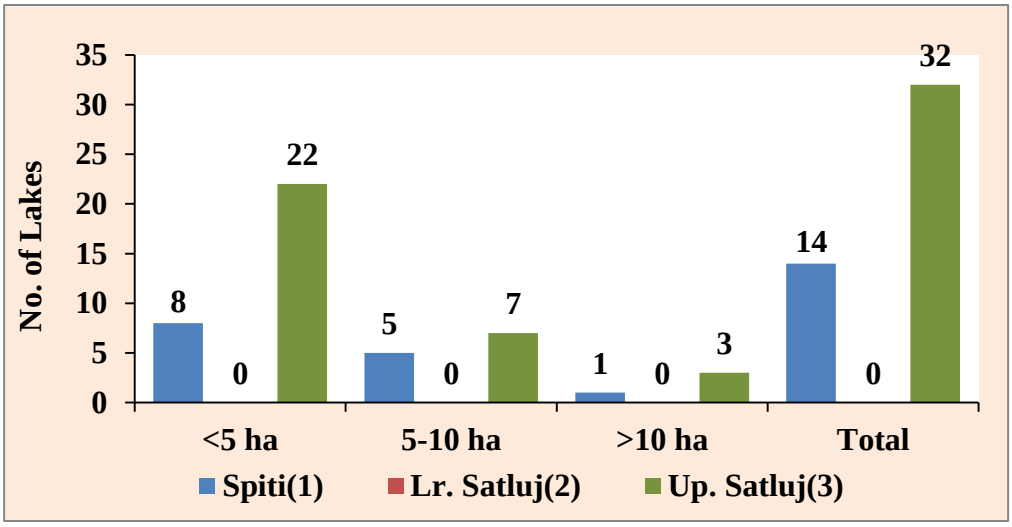


Fig. 7.7 (c): No. of Lakes based on IRS-R2-AWiFS-99-48-05-09-2020

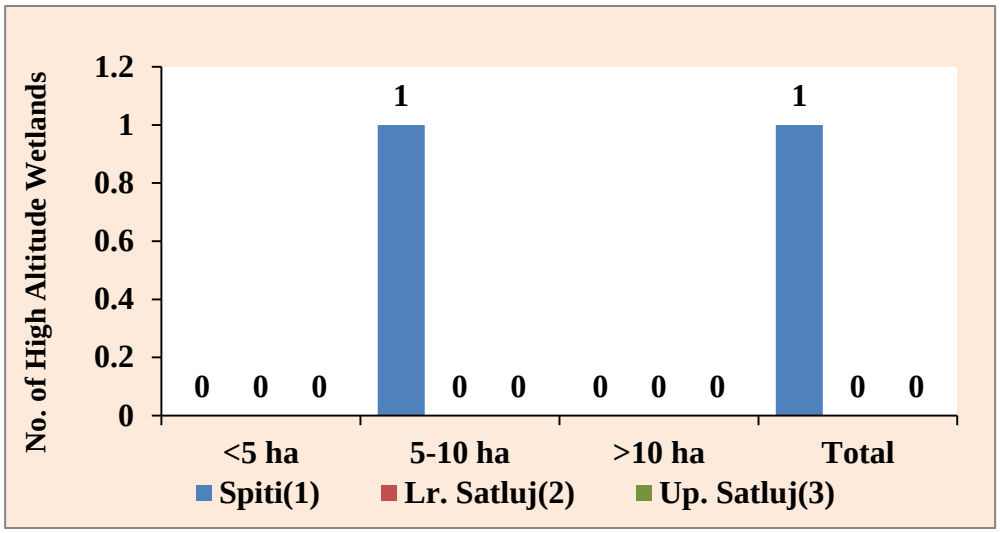


Fig. 7.7 (d): No. High altitude wetlands based on IRS-R2-AWiFS-99-48-05-09-2020

Table: 7.7 Aerial Extent of lakes as on 05 September2020

Sr.No	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 09 Sept 2019 (ha.)	Aerial Extent on 05 Sep 2020 (ha.)	Change in Area w.r.t. Sept.2019 (ha.)
1	25	3	79.3918	32.3778	**25.39**	**28.36**	**2.97**
2	28	3	79.0509	32.3466	4.26	6.03	1.77
3	31	3	79.0019	32.3382	**4.28**	**10.97**	**6.68**
4	51	3	78.9424	32.1221	3.02	6.81	3.79
5	54	3	78.9324	32.1069	5.43	8.51	3.08
6	55	3	78.9417	32.1069	**6.78**	**11.38**	**4.60**
7	312	1	78.973	32.325	3.75	6.85	3.11
8	313	1	78.9787	32.3193	7.72	9.38	2.67
9	315	1	78.9724	32.1904	2.70	6.76	4.07
10	414	1	78.9773	32.258	------	3.13	------
11	415	3	79.0013	32.3287	1.61	2.85	1.24
12	417	3	79.7052	32.2151	1.36	4.45	3.10
13	559	1	78.7062	32.7074	------	4.08	------
14	561	1	78.6883	32.7079	------	3.84	------
15	562	3	79.0168	32.2768	1.61	3.24	1.63
16	563	1	78.9829	32.2256	1.37	3.16	1.78
17	592	3	79.8039	32.1165	------	3.79	------
18	620	3	79.683	32.2538	3.75	7.23	3.49
19	640	3	78.97	32.1291	------	3.99	------
20	870	1	78.9264	32.1292	------	1.91	------
21	1038	3	79.8005	32.1255	------	3.60	------
22	1552	1	78.9913	32.2543	------	2.56	------
23	8028	3	78.9721	32.1704	------	2.03	------
24	8130	3	78.9504	32.1191	------	1.23	------
25	8131	3	78.9465	32.1193	------	5.69	------
26	8132	3	78.9475	32.1222	------	1.81	------

27	8139	3	79.7937	32.1211	------	3.51	------
28	8140	3	79.7695	32.1333	------	4.41	------
29	8141	1	78.9602	32.1848	------	2.86	------
30	8146	1	78.9848	32.3001	------	**14.75**	------
31	8147	3	79.6453	32.2872	------	2.89	------
32	8154	3	79.4051	32.3496	------	4.44	------
33	8155	3	79.5938	32.3523	------	6.57	------
34	8160	1	78.8163	32.419	------	6.92	------
35	8162	3	79.2534	32.5064	------	6.28	------
36	8188	3	79.7964	32.1276	------	4.89	------
37	8195	3	79.5895	32.3531	------	2.86	------
38	8308	3	79.7886	32.175	------	1.87	------
39	8323	1	78.7107	32.695	------	3.69	------
40	8346	3	79.8015	32.1126	------	1.31	------
41	8347	3	79.6551	32.262	------	3.16	------
42	8348	3	78.9938	32.316	------	2.53	------
43	8349	3	79.581	32.3257	------	1.96	------
44	8350	3	79.2708	32.5281	------	1.91	------
45	8352	3	79.6199	32.3266	------	2.44	------
46	32HWL	1	78.7173	32.3283	**28.64**	**25.85**	**-2.79**
47	8351SG	1	77.989	32.6067	------	5.71	------

HWL- High Altitude Wetlands
RS- River Section

7.8: Status of lakes as on 10 September 2020

On analyzing the satellite data for 10 September 2020, it is found that the satellite image covers mainly the areas falling sub basin 1, 2 & 3 due to the partial coverage of the satellite data **(Fig 7.8a)** as a result of which only 355 lakes could be mapped comprising 37 lakes from Spiti sub basin i.e. basin 1, 10 lakes from Lower Satluj i.e basin 2 and 252 in basin 3 i.e Upper Satluj basin. **(Fig.7.8c).** Further out of 355 lakes, 56 are the high altitude wetlands in the region **(Fig.7.8d).** Out of these 355 lakes mapped, 189 lakes are such which have the area less than 5ha out of which 24 lakes forms a part of the Spiti sub basin, 7 lakes forms part of the Lower Satluj basin and 158 lakes forms part of the Upper Satluj basins respectively. Besides this, 55 lakes are such which have the area between 5-10 ha with 07 lakes forming part of the Spiti sub basin, 3 forms part of the Upper Satluj basin and 45 that from the Upper Satluj sub basin. As far as the bigger lakes with area more than 10ha are concerned, there are 55 lakes which comprise of 6 falling in Spiti sub basin and 49 from the Upper Satluj sub basin respectively **(Fig.7.8c).**When these 355 lakes are seen temporally w.r.t.229 lakes as mapped on 09 September 2019 **(Table 7.8)** reveals that only 74 lakes could be compared out of which 64 lakes are showing a positive trend in their spatial

coverage, whereas 10 lakes are showing negative trend w.r.t 2019 respectively and the lakes those could not be compared forms the base line data for next year monitoring.

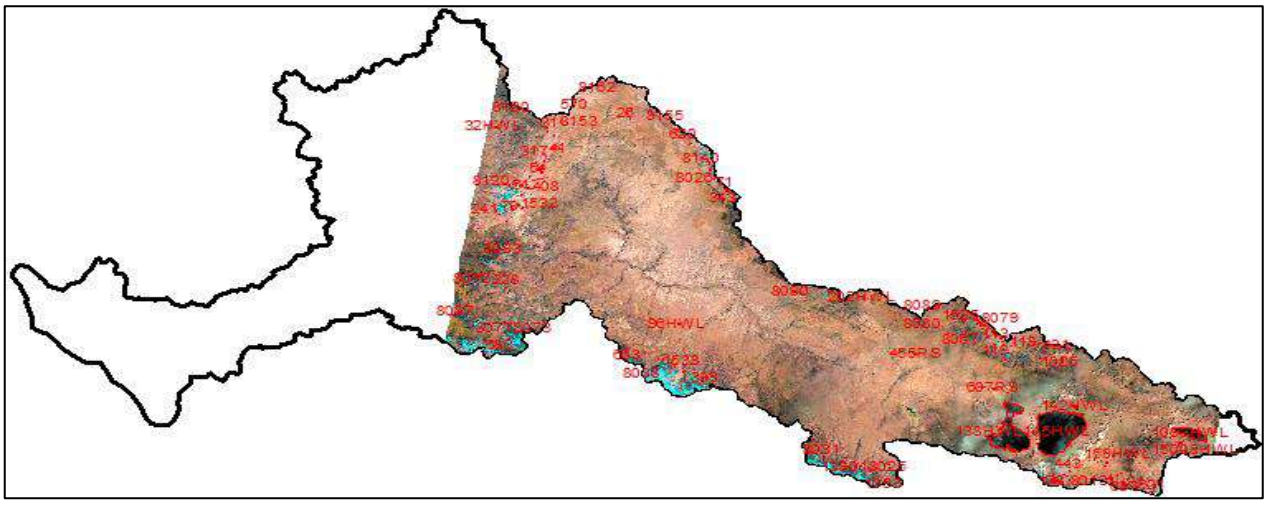


Fig.7.8 (a): IRS-R2-AWiFS-100-48-10-09-2020

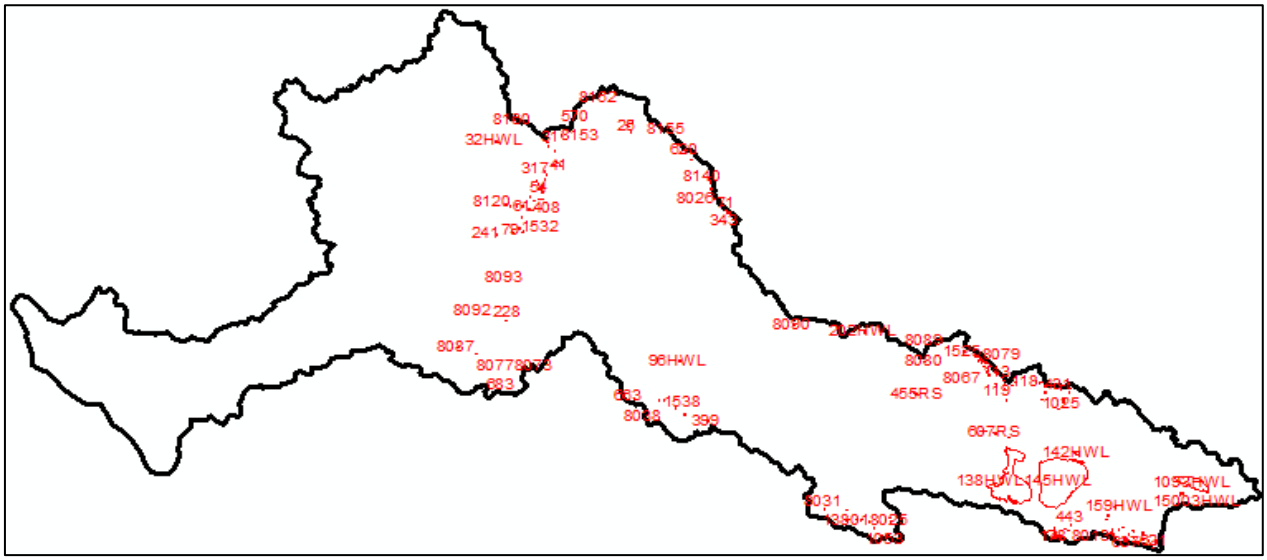


Fig.7.8 (b): IRS-R2-AWiFS-100-48-10-09-2020 Interpreted Layer

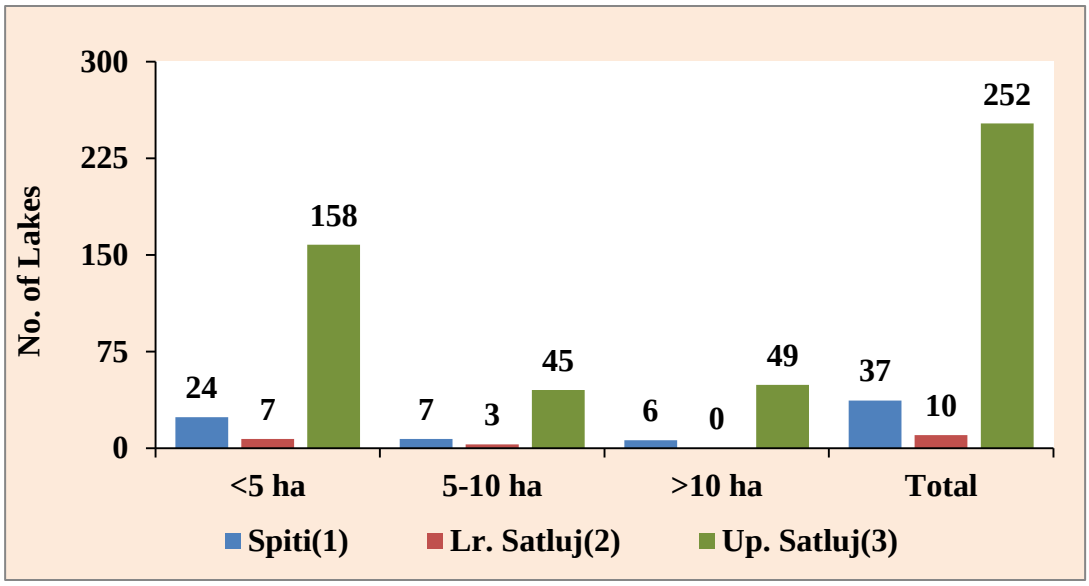


Fig. 7.8 (c): No. of Lakes based on IRS-R2-AWiFS-100-48-10-09-2020

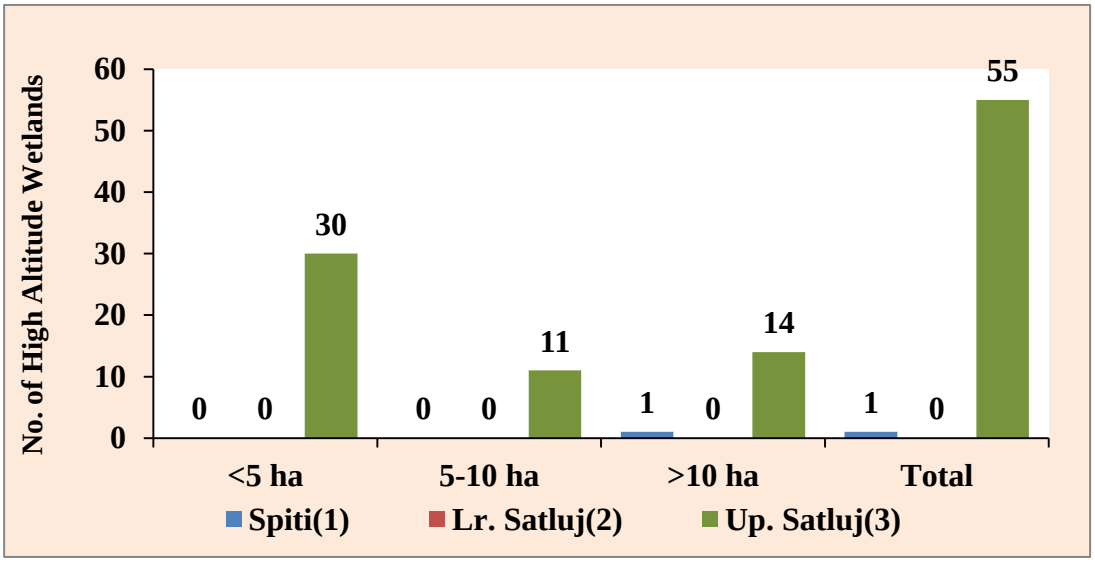


Fig. 7.8 (c): No. of High altitude wetlands based on IRS-R2-AWiFS-100-48-10-09-2020

Table: 7.8 Aerial Extent of lakes as on 10 September 2020

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 09 Sep 2019 (ha.)	Aerial Extent on 10 Sep 2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
1	23	3	79.4149	32.3925	**6.77**	**11.09**	**4.32**
2	25	3	79.3904	32.3803	**25.39**	**31.81**	**6.42**
3	28	3	79.0508	32.3492	4.26	5.21	0.95
4	31	3	78.999	32.3414	**4.28**	**10.73**	**6.44**
5	39	3	79.0244	32.2272	5.39	7.34	1.95
6	41	3	79.0423	32.2119	**17.70**	**18.06**	**0.36**

7	51	3	78.9399	32.1251	5.02	7.33	2.31
8	54	3	78.9303	32.1094	**10.43**	**12.25**	**2.81**
9	55	3	78.9393	32.1097	**8.78**	**10.97**	**2.20**
10	61	1	78.8421	32.0318	**24.47**	**26.79**	**2.31**
11	65	1	78.8431	31.9947	**23.08**	**24.29**	**1.21**
12	71	3	79.8712	31.9795	7.59	7.38	-0.22
13	73	3	79.8813	31.9719	2.18	4.83	2.65
14	74	3	79.875	31.9701	2.14	4.55	2.42
15	79	3	78.7818	31.9212	**21.51**	**24.29**	**3.78**
16	106	3	81.1026	31.2451	------	5.51	------
17	107	3	81.0835	31.2416	3.60	6.84	3.24
18	112	3	81.1482	31.2004	**12.16**	**16.39**	**4.23**
19	113	3	81.1945	31.1835	**53.36**	**56.84**	**3.48**
20	114	3	81.152	31.1799	**24.80**	**26.54**	**2.74**
21	118	3	81.2808	31.1389	**8.46**	**11.10**	**3.64**
22	119	3	81.2282	31.131	6.04	8.50	2.46
23	122	3	81.4353	31.1159	3.34	6.49	3.15
24	166	3	81.4303	30.4728	------	6.32	------
25	174	3	81.434	30.45	------	**11.21**	------
26	178	3	81.4339	30.4321	**203.62**	**217.48**	**13.86**
27	181	3	81.4626	30.4311	**14.90**	**19.23**	**4.32**
28	183	3	81.872	30.4283	------	**23.85**	------
29	193	3	81.8668	30.4001	------	9.12	------
30	196	3	81.8954	30.3918	**6.97**	**12.99**	**6.02**
31	228	2	78.7517	31.5549	------	5.75	------
32	241	1	78.6972	31.9149	------	8.89	------
33	312	1	78.9711	32.3279	3.75	6.88	3.13
34	313	1	78.9773	32.3221	3.72	7.31	3.59
35	315	1	78.9701	32.1932	2.70	6.00	3.30
36	317	3	78.9752	32.1634	5.70	8.16	2.46
37	343	3	79.8638	31.9269	**29.70**	**33.84**	**4.14**
38	399	3	79.7298	31.0302	**7.43**	**12.87**	**5.44**
39	408	3	78.9084	32.0203	3.23	8.50	5.27
40	414	1	78.9736	32.2608	------	3.01	------
41	415	3	78.9983	32.3311	1.61	3.95	2.34
42	416	3	79.1887	32.4535	------	2.95	------
43	417	3	79.7056	32.2179	1.36	2.76	1.40
44	422	3	81.0696	31.2353	------	2.67	------
45	423	3	81.1596	31.2194	6.70	9.57	2.87
46	424	3	81.2252	31.1508	1.31	1.89	0.58
47	426	3	81.5045	31.0958	------	9.28	------
48	427	3	81.3837	31.14	------	7.35	------
49	431	3	81.5027	31.1139	------	9.77	------
50	432	3	81.5194	31.084	------	4.37	------
51	443	3	81.5143	30.4824	------	7.74	------
52	445	3	81.4835	30.4631	3.07	2.46	-0.62
53	448	3	81.458	30.4392	2.97	4.47	1.50
54	562	3	79.0147	32.2791	1.61	3.03	1.42
55	563	1	78.9804	32.2277	1.37	2.95	1.58
56	570	3	79.1322	32.4479	4.82	4.80	-0.02
57	571	3	79.131	32.4644	------	4.14	------
58	592	3	79.8033	32.119	------	3.60	------
59	607	3	81.1334	31.2468	2.21	4.02	1.81

60	610	3	78.9445	32.095	4.05	5.91	1.86
61	611	3	78.9415	32.0625	**5.14**	**5.75**	**0.61**
62	620	3	79.682	32.2566	3.75	3.31	-0.44
63	621	3	81.9309	30.386	------	**86.25**	------
64	622	3	81.0852	31.2742	------	2.49	------
65	632	3	79.3682	31.145	2.34	4.67	2.32
66	634	3	81.1419	31.2477	------	8.29	------
67	636	3	81.0977	31.2707	3.01	3.45	0.44
68	637	3	81.8414	30.3861	**9.46**	**18.14**	**8.68**
69	638	3	81.831	30.3823	3.03	6.36	3.33
70	640	3	78.9679	32.1322	------	4.94	------
71	641	3	79.8936	31.9612	------	3.56	------
72	645	3	81.0895	31.268	5.15	8.25	3.11
73	646	3	81.1047	31.2647	2.63	2.43	-0.20
74	647	3	81.1054	31.261	2.74	4.45	1.71
75	648	3	81.1154	31.238	2.18	3.79	1.61
76	649	3	81.1221	31.2437	2.77	3.21	0.45
77	651	3	81.4018	31.1292	------	8.94	------
78	652	3	81.4245	31.1389	4.81	5.61	0.80
79	655	3	81.5139	31.1004	------	3.98	------
80	656	3	81.5318	31.0971	------	2.22	------
81	657	3	81.5463	31.1043	------	4.68	------
82	658	3	81.5432	31.1183	------	8.60	------
83	663	3	79.3437	31.1542	------	5.74	------
84	683	3	78.7032	31.2254	------	7.69	------
85	804	1	78.8295	32.046	2.07	4.00	1.92
86	811	3	78.8364	31.9172	**27.41**	**29.21**	**2.80**
87	816	3	79.878	31.9651	2.97	2.76	-0.21
88	825	3	81.1132	31.2517	1.04	1.61	0.57
89	827	3	81.1382	31.1958	7.33	8.80	1.47
90	828	3	81.1539	31.21	1.73	2.49	0.76
91	849	3	81.4996	30.4607	------	1.86	------
92	884	3	79.889	31.97	------	4.91	------
93	885	3	79.8805	31.9346	1.61	2.73	1.12
94	888	3	81.1481	31.2059	------	1.51	------
95	895	3	81.8433	30.3807	2.21	4.97	2.76
96	964	3	81.7667	30.4094	------	1.28	------
97	1004	3	81.5148	30.4783	------	3.87	------
98	1005	3	81.4807	30.4291	------	4.05	------
99	1006	3	81.4767	30.4277	------	1.58	------
100	1007	3	81.4143	30.4618	------	1.24	------
101	1008	3	81.4111	30.4578	------	1.89	------
102	1025	3	81.514	31.0369	1.04	2.73	1.69
103	1030	3	81.1781	31.1904	------	3.44	------
104	1038	3	79.8000	32.1279	------	1.85	------
105	1049	2	78.7358	31.5201	------	6.82	------
106	1052	3	80.5972	30.5467	------	1.75	------
107	1053	3	80.5921	30.4781	------	**16.36**	------
108	1133	3	81.8685	30.4203	------	**17.26**	------
109	1142	3	81.7748	30.4043	------	1.53	------
110	1149	3	81.7694	30.398	------	7.24	------
111	1508	3	81.4899	31.0076	------	1.82	------
112	1509	3	81.5513	31.0955	------	1.25	------

113	1510	3	81.5615	31.0953	------	1.85	------
114	1511	3	81.4261	31.0859	------	3.51	------
115	1512	3	81.4254	31.0813	------	1.96	------
116	1514	3	81.4079	31.0567	------	2.15	------
117	1515	3	81.4175	31.104	1.95	3.08	1.13
118	1517	3	81.3275	31.14	------	1.56	------
119	1518	3	81.226	31.1623	------	3.48	------
120	1519	3	81.2158	31.1659	------	3.09	------
121	1522	3	81.1156	31.1696	------	2.47	------
122	1524	3	81.0329	31.2944	1.88	4.66	2.78
123	1525	3	81.0319	31.2868	**17.37**	**20.37**	**4.00**
124	1531	3	78.8671	31.9722	**8.23**	**10.97**	**2.74**
125	1532	3	78.8641	31.9601	4.11	6.47	2.36
126	1538	3	79.5714	31.0938	4.57	5.90	1.33
127	1543	3	81.393	30.4559	------	3.45	------
128	1545	3	80.4022	30.5991	------	5.83	------
129	1546	3	79.5153	31.1329	------	4.61	------
130	1552	1	78.9886	32.2568	------	3.34	------
131	1585	1	78.8607	32.0885	------	1.81	------
132	8001	3	81.9134	30.3596	------	3.76	------
133	8002	3	81.9148	30.3707	------	1.61	------
134	8003	3	81.8793	30.3774	------	2.48	------
135	8004	3	81.826	30.3842	------	1.23	------
136	8005	3	81.8317	30.3859	------	1.86	------
137	8006	3	81.7963	30.3933	------	0.95	------
138	8010	3	81.4659	30.4288	------	3.39	------
139	8012	3	81.7414	30.4300	------	1.23	------
140	8013	3	81.697	30.4339	------	2.64	------
141	8014	3	81.3771	30.4526	------	3.51	------
142	8015	3	81.4154	30.4548	------	1.24	------
143	8017	3	81.7132	30.4423	------	1.24	------
144	8018	3	81.4926	30.4558	------	2.17	------
145	8019	3	81.4057	30.4672	------	1.30	------
146	8020	3	80.532	30.5129	------	3.04	------
147	8021	3	80.5339	30.5156	------	2.17	------
148	8022	3	81.4013	30.4784	------	1.55	------
149	8023	3	80.3819	30.5365	------	2.18	------
150	8024	3	80.5084	30.5427	------	1.23	------
151	8025	3	80.6211	30.5407	------	**30.32**	------
152	8026	3	80.4495	30.5555	------	3.38	------
153	8026	3	79.8105	32.0314	------	4.68	------
154	8027	3	80.4719	30.5547	------	**17.20**	------
155	8027	3	79.2696	32.5307	------	1.80	------
156	8028	3	80.6155	30.5554	------	4.03	------
157	8028	1	78.9701	32.1732	------	2.47	------
158	8029	3	80.6311	30.5553	------	1.54	------
159	8030	3	80.6155	30.5573	------	1.24	------
160	8031	3	80.2931	30.608	------	**12.02**	------
161	8036	3	79.7526	31.0418	------	5.85	------
162	8037	3	79.4095	31.0622	------	6.00	------
163	8038	3	79.4132	31.062	------	8.78	------
164	8039	3	79.6147	31.064	------	1.23	------
165	8040	3	79.6502	31.0741	------	1.90	------

166	8041	3	79.6478	31.0787	------	2.46	------
167	8041	3	81.4839	31.011	------	1.26	------
168	8042	3	81.4872	31.0078	------	1.27	------
169	8043	3	80.3382	30.5736	------	1.86	------
170	8044	3	79.5141	31.1064	------	2.76	------
171	8045	3	81.5194	31.0334	------	1.80	------
172	8046	3	81.5147	31.0403	------	1.58	------
173	8047	3	79.4901	31.1329	------	4.27	------
174	8048	3	81.2305	31.0612	------	4.56	------
175	8049	3	81.5151	31.0529	------	2.18	------
176	8050	3	81.5055	31.0741	------	1.24	------
177	8051	3	81.4817	31.0824	------	2.19	------
178	8052	3	81.5478	31.0805	------	1.82	------
179	8053	3	81.555	31.0926	------	2.07	------
180	8054	3	81.5304	31.0939	------	5.40	------
181	8056	3	81.4133	31.1056	------	2.49	------
182	8057	3	81.2581	31.1182	------	4.92	------
183	8058	3	81.4228	31.1154	------	2.52	------
184	8059	3	81.2629	31.1247	------	1.26	------
185	8060	3	81.5191	31.1126	------	2.47	------
186	8061	3	81.4753	31.1201	------	1.83	------
187	8062	3	81.1821	31.139	------	3.76	------
188	8063	3	81.2584	31.1409	------	1.85	------
189	8064	3	81.4133	31.136	------	1.85	------
190	8065	3	81.2212	31.1498	------	7.33	------
191	8066	3	81.4078	31.146	------	2.21	------
192	8067	3	81.1121	31.1614	------	3.28	------
193	8068	3	81.2005	31.1675	------	1.86	------
194	8069	3	81.2981	31.1831	------	1.89	------
195	8070	3	81.1304	31.1947	------	1.24	------
196	8071	3	78.8013	31.2969	------	1.95	------
197	8072	3	81.173	31.2114	------	1.25	------
198	8073	3	78.8755	31.3078	------	3.66	------
199	8074	3	81.1292	31.2204	------	4.32	------
200	8075	3	78.7903	31.3146	------	1.23	------
201	8076	3	81.1453	31.2325	------	1.55	------
202	8077	2	78.6929	31.328	------	3.49	------
203	8078	2	78.6984	31.3288	------	1.91	------
204	8079	3	81.1375	31.2357	------	**14.87**	------
205	8080	3	80.8315	31.2539	------	3.78	------
206	8081	3	81.091	31.2429	------	1.89	------
207	8082	2	78.7148	31.3384	------	1.26	------
208	8083	3	81.0283	31.2789	------	2.40	------
209	8084	2	78.5804	31.3747	------	2.18	------
210	8085	3	81.047	31.2884	------	1.52	------
211	8086	3	81.0129	31.2968	------	3.08	------
212	8087	2	78.4884	31.4029	------	5.13	------
213	8088	3	80.9553	31.3202	------	2.26	------
214	8089	3	80.8992	31.3434	------	1.24	------
215	8090	3	80.1838	31.4484	------	**19.18**	------
216	8091	2	78.7288	31.5103	------	1.84	------
217	8092	2	78.6062	31.5672	------	4.02	------
218	8093	2	78.7365	31.7119	------	2.76	------

219	8094	1	78.711	31.901	------	2.17	------
220	8095	1	78.7047	31.9092	------	2.06	------
221	8096	1	78.6993	31.9204	------	1.26	------
222	8097	3	78.8144	31.9356	------	8.26	------
223	8098	3	78.8208	31.9328	------	1.79	------
224	8099	3	78.8214	31.9351	------	1.78	------
225	8100	3	78.8193	31.9344	------	1.94	------
226	8101	1	78.6815	31.9366	------	1.24	------
227	8102	3	78.8172	31.9319	------	2.75	------
228	8103	3	78.8095	31.9665	------	7.82	------
229	8104	3	78.7945	31.974	------	2.71	------
230	8105	3	78.8358	31.9819	------	**13.76**	------
231	8106	3	79.8759	31.9583	------	4.94	------
232	8107	3	79.8975	31.9665	------	7.19	------
233	8108	3	78.9001	32.0065	------	1.91	------
234	8109	1	78.8427	32.014	------	3.48	------
235	8110	3	78.8922	32.0165	------	6.01	------
236	8111	1	78.8742	32.0226	------	4.90	------
237	8112	3	79.8344	31.9908	------	4.61	------
238	8113	3	79.8441	31.9943	------	5.57	------
239	8114	1	78.8123	32.0352	------	6.13	------
240	8115	1	78.7781	32.0361	------	3.36	------
241	8116	3	79.854	32.0029	------	2.13	------
242	8117	1	78.7572	32.044	------	2.63	------
243	8118	1	78.7605	32.0432	------	1.85	------
244	8118	1	78.7533	32.0468	------	0.97	------
245	8119	1	78.7575	32.0421	------	1.26	------
246	8119	1	78.7548	32.047	------	1.26	------
247	8120	1	78.78	32.0558	------	4.29	------
248	8121	3	79.825	32.0203	------	5.22	------
249	8123	1	78.8818	32.0748	------	6.39	------
250	8124	3	78.9257	32.0658	------	1.21	------
251	8125	3	79.8135	32.0302	------	1.52	------
252	8126	1	78.9009	32.0567	------	1.17	------
253	8127	1	78.8045	32.0609	------	**11.89**	------
254	8128	1	78.9048	32.1008	------	1.50	------
255	8129	3	79.8013	32.0806	------	4.25	------
256	8130	3	78.9489	32.1218	------	1.22	------
257	8131	3	78.9441	32.1223	------	5.17	------
258	8132	3	78.9448	32.125	------	1.83	------
259	8133	3	79.771	32.0971	------	3.35	------
260	8134	1	78.9236	32.1318	------	1.51	------
261	8135	3	79.7967	32.1079	------	2.06	------
262	8136	3	79.7998	32.1091	------	2.53	------
263	8137	1	78.9149	32.1445	------	4.31	------
264	8138	3	78.9596	32.1521	------	3.33	------
265	8139	3	79.7931	32.1235	------	3.63	------
266	8140	3	79.7682	32.1359	------	5.16	------
267	8141	1	78.9576	32.188	------	3.67	------
268	8142	3	79.0175	32.2106	------	2.98	------
269	8143	3	79.0084	32.2172	------	3.95	------
270	8144	3	78.9957	32.2273	------	1.23	------
271	8145	3	79.0042	32.2273	------	3.67	------

272	8146	1	78.9818	32.3024	------	**17.19**	------
273	8147	3	79.643	32.291	------	2.81	------
274	8148	3	79.1175	32.3366	------	2.35	------
275	8151	3	79.5719	32.3343	------	3.65	------
276	8153	3	79.1001	32.3568	------	4.35	------
277	8154	3	79.4038	32.3524	------	7.65	------
278	8155	3	79.5928	32.3551	------	4.88	------
279	8157	3	79.5323	32.3729	------	2.19	------
280	8158	3	79.5188	32.3791	------	1.53	------
281	8159	3	79.507	32.3947	------	1.74	------
282	8160	1	78.8131	32.4223	------	7.53	------
283	8161	3	79.2776	32.4798	------	1.53	------
284	8162	3	79.2523	32.5089	------	6.44	------
285	8163	3	79.2896	32.5155	------	2.55	------
286	8164	3	79.2955	32.5143	------	1.20	------
287	13801	3	80.4008	30.5531	------	**44.809**	------
288	18701	3	81.8482	30.3879	2.48	4.28	1.80
289	18901	3	81.8192	30.3916	**12.09**	**16.60**	**4.51**
290	1001HWL	3	81.7493	30.4488	1.37	1.55	0.18
291	1012HWL	3	81.5437	30.8195	------	2.44	------
292	1013HWL	3	81.5255	30.7777	------	2.20	------
293	1015HWL	3	81.2308	30.8933	------	2.48	------
294	1018HWL	3	81.2114	30.8954	2.11	1.99	-0.13
295	1019HWL	3	81.2082	30.8966	2.11	1.15	-0.96
296	1022RS	3	81.1109	30.9249	1.67	2.44	0.77
297	1093HWL	3	82.1359	30.6385	------	**6002.45**	------
298	1124HWL	3	81.8217	30.4389	------	6.70	------
299	1136HWL	3	81.7781	30.412	------	9.72	------
300	1139HWL	3	81.7983	30.4248	------	2.49	------
301	138HWL	3	81.234	30.6897	------	**26020.60**	------
302	142HWL	3	81.5683	30.8023	------	307.42	------
303	145HWL	3	81.4726	30.6858	------	**41888.20**	------
304	1474HWL	3	81.5671	30.7665	------	4.78	------
305	148HWL	3	81.5851	30.7625	------	**108.37**	------
306	15002HWL	3	82.0726	30.5975	------	**16.74**	------
307	15003HWL	3	82.0844	30.5932	------	**19.12**	------
308	159HWL	3	81.7415	30.5503	------	**16.48**	------
309	173HWL	3	81.6765	30.4494	------	9.37	------
310	1788HWL	3	82.1242	30.5728	------	3.19	------
311	179HWL	3	81.7143	30.431	------	**25.10**	------
312	184HWL	3	81.722	30.4226	------	**22.79**	------
313	185001HWL	3	81.7466	30.4104	------	9.82	------
314	187004HWL	3	81.7843	30.402	------	5.23	------
315	202HWL	3	80.541	31.3994	**55.51**	**54.73**	**-1.78**
316	205HWL	3	81.5667	30.7889	------	3.76	------
317	206HWL	3	81.5703	30.7902	------	1.17	------
318	207HWL	3	81.5499	30.7857	------	5.80	------
319	209HWL	3	81.5463	30.7739	------	4.02	------
320	210HWL	3	81.5548	30.7724	------	**59.00**	------
321	211HWL	3	81.7022	30.516	------	8.98	------
322	32HWL	1	78.7194	32.3302	------	**39.05**	------
323	385HWL	3	81.5389	30.7795	------	2.44	------
324	436HWL	3	81.6957	30.4988	1.38	1.87	0.49

325	437HWL	3	81.6933	30.4983	1.36	2.15	0.79
326	438HWL	3	81.7412	30.4034	------	5.28	------
327	439HWL	3	81.7227	30.4294	------	3.69	------
328	440HWL	3	81.7209	30.4495	2.47	5.61	3.14
329	441HWL	3	81.6991	30.4561	------	3.73	------
330	442HWL	3	81.6979	30.4321	------	5.72	------
331	455RS	3	80.7813	31.1097	------	**30.49**	------
332	607RS	3	81.1645	30.9144	------	**40.74**	------
333	608RS	3	81.0952	30.9269	**17.15**	**21.95**	**3.80**
334	616RS	3	81.1179	30.9256	**12.43**	**15.34**	**3.91**
335	62SG	1	78.8728	32.0195	------	**11.10**	------
336	677HWL	3	81.7078	30.5035	------	2.71	------
337	688HWL	3	81.8205	30.4096	------	**11.17**	------
338	8007HWL	3	81.7851	30.3961	------	1.26	------
339	8008HWL	3	81.7781	30.3999	------	1.20	------
340	8009HWL	3	81.7754	30.4026	------	1.28	------
341	8011SG	3	80.5687	30.4788	------	4.38	------
342	8016HWL	3	81.6994	30.4404	------	1.54	------
343	8032HWL	3	82.0641	30.5891	------	1.21	------
344	8033HWL	3	81.5414	30.7796	------	0.90	------
345	8034HWL	3	81.554	30.7854	------	1.31	------
346	8035HWL	3	81.204	30.8948	------	2.19	------
347	8055SG	3	81.2224	31.1117	------	3.79	------
348	8122SG	1	78.9072	32.0937	------	3.03	------
349	8156SG	3	79.415	32.3756	------	2.75	------
350	839HWL	3	81.8042	30.3923	------	4.06	------
351	840HWL	3	81.7931	30.3979	------	5.48	------
352	842HWL	3	81.7637	30.4216	------	3.19	------
353	844HWL	3	81.7721	30.4602	2.21	3.06	0.85
354	865HWL	3	81.7754	30.4003	------	3.69	------
355	96HWL	3	79.6004	31.3061	**46.86**	**40.08**	**-6.78**

7.9 Status of Lakes as on 12 September 2020

From the analysis of 12 September 2020 satellite data, it is found that the data covers the entire catchment of the study area and is clearly visible and fully exposed due to minimum snow cover and negligible cloud cover impacts, as result of which a total of 322 lakes could be delineated in comparison to the total of 229 lakes mapped in 2019 **(Fig. 7.9a & Fig. 7.9b)** comprising 62 lakes from basin 1, 20 from basin 2 and 240 lakes basin 3 respectively **(Fig. 7.9c).** Further analysis of 322 lakes based on their areal distribution pattern reveals that 200 lakes are such, which have the area less than 5ha comprising 43 lakes from the Spiti sub basin, 13 from the Lower Satluj and 144 from the Upper Satluj sub basin respectively. Likewise73 lakes are such which have area between 5-10 ha comprising12 from the Spiti, 5 from the Lower Satluj and 56 from the Upper Satluj sub basin respectively. Besides this, 49 lakes are such which have the area more than 10ha, out of which 7 lakes forms the part of the Spiti sub basin, 2 forms part of the

Lower Satluj sub basin and 40 lakes forms part of the Upper Satluj sub basin respectively **(Fig.7.9c).** Besides 322 lakes in the catchment, 40 lakes haven mapped as high-altitude wetlands comprising 1 from Spiti sub basin and 39 from Upper Satluj basin **(Fig.7.9d).** Further these 40 wetlands when seen based on their areal size, it is found that 19 wetlands have the area <5ha, 8 with area between 5-10ha and 13 high altitude wetlands with area more than 10ha.The temporal variation of 361 lakes when seen w.r.t. the 229 lakes as mapped on 09 Sept 2019, it is found that 39 lakes are showing an increase in their water spread, whereas 25 lakes are showing a reduction in their water spread w.r.t. 2019 data **(Table 7.9)** and those which could not be compared forms the base line data for their monitoring during next ablation season.

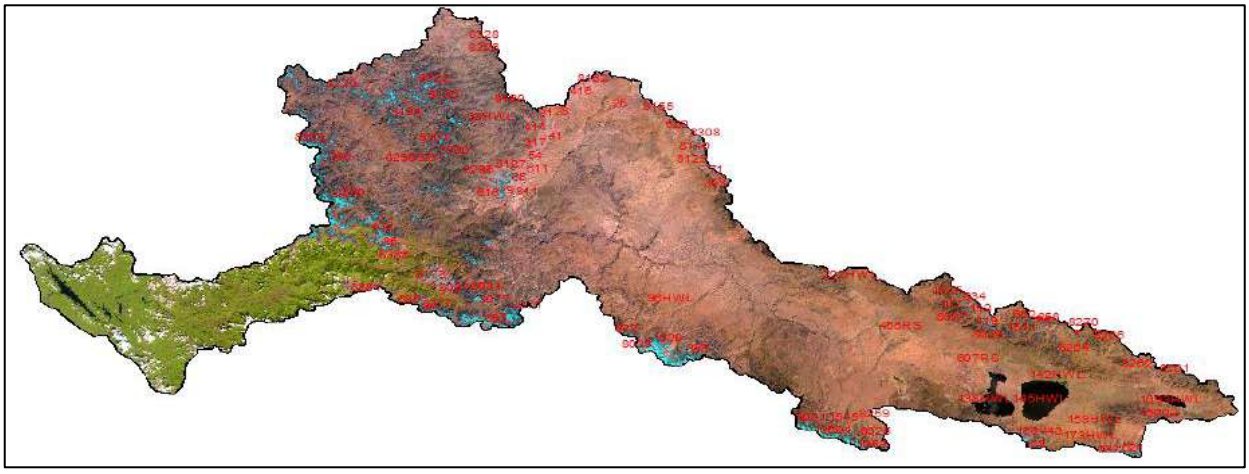


Fig.7.9 (a): IRS-R2-AWiFS-97-49-12-09-2020

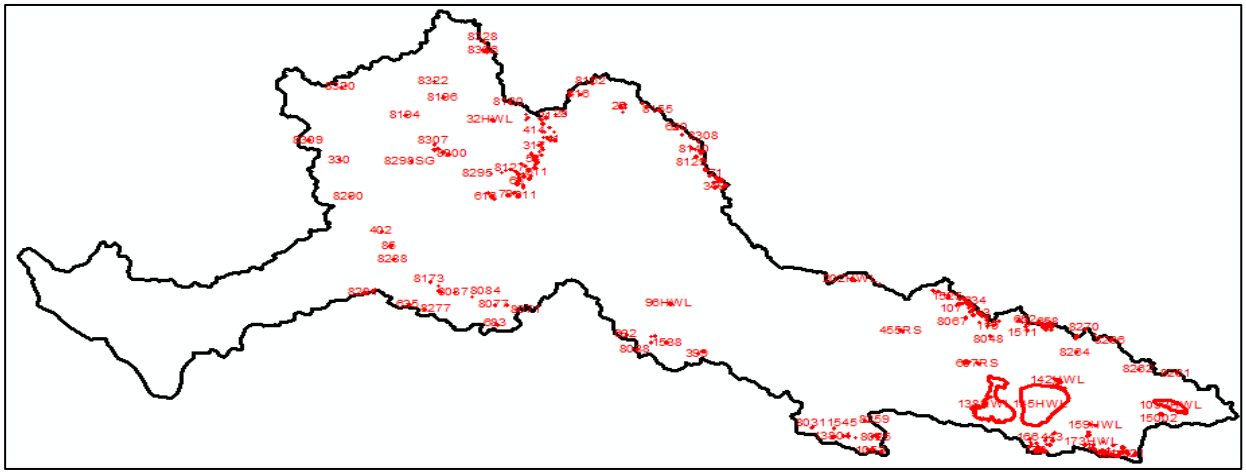


Fig.7.9 (b): IRS-R2-AWiFS-97-49-12-09-2020 interpreted layer

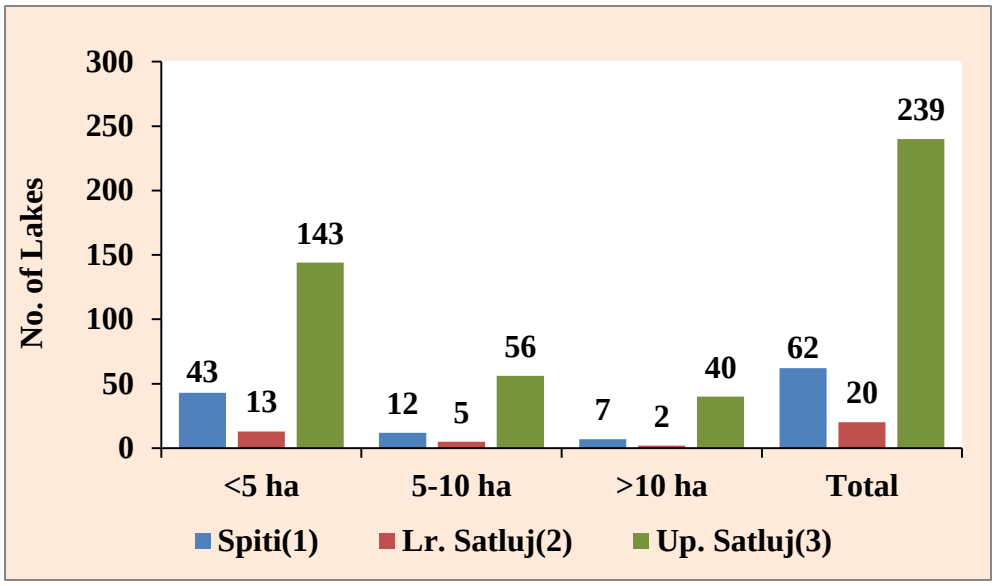


Fig. 7.9 (c): No. of Lakes based on IRS-R2-AWiFS-97-49-12-09-2020

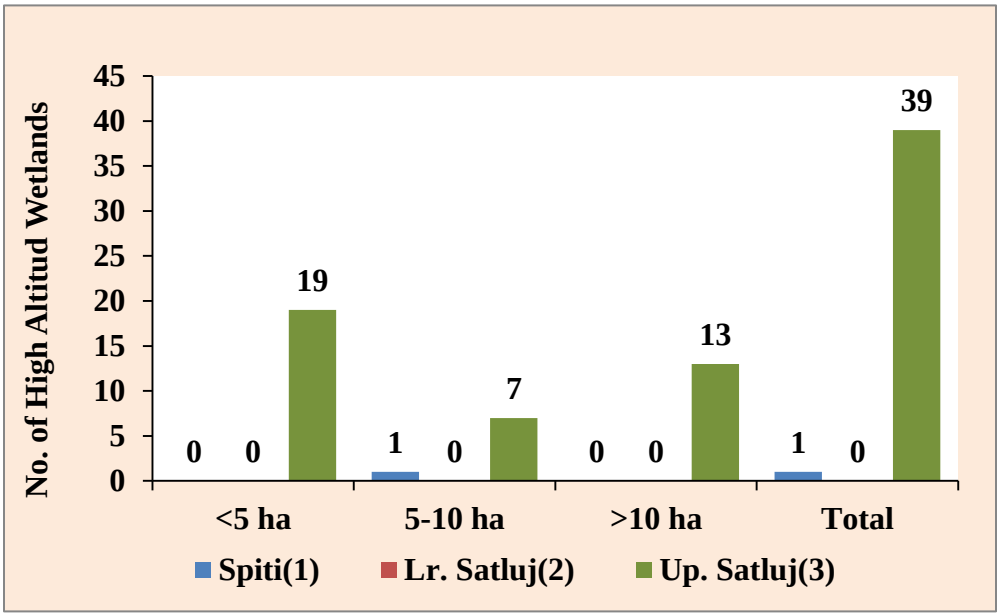


Fig. 7.9 (d): No. of High altitude wetlands based on IRS-R2-AWiFS-97-49-12-09-2020

Table: 7.9 Aerial Extent of lakes as on 12 September2020

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 09Sep 2019 (ha.)	Aerial Extent on 12 Sept. 2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
1	23	3	79.4186	32.392	**6.77**	**10.78**	**4.02**
2	25	3	79.3948	32.3799	**25.39**	**24.91**	**-0.48**
3	28	3	79.0535	32.3491	4.53	4.72	0.19
4	31	3	79.0036	32.3407	------	7.98	------
5	39	3	79.028	32.2261	------	8.58	------
6	41	3	79.0457	32.2115	------	**28.85**	------
7	51	3	78.9443	32.1243	------	6.14	------
8	54	3	78.934	32.1091	------	**14.00**	------
9	55	3	78.9431	32.1092	------	**10.72**	------
10	60	1	78.8741	32.0341	------	5.77	------
11	61	1	78.8457	32.0309	------	**24.52**	------
12	62	1	78.8761	32.0187	------	**13.17**	------
13	63	1	78.8778	32.0218	------	3.95	------
14	65	1	78.8463	31.9944	------	**26.79**	------
15	71	3	79.874	31.9785	------	8.98	------
16	73	3	79.884	31.9712	------	2.98	------
17	74	3	79.8774	31.9692	------	6.58	------
18	79	3	78.7851	31.9208	------	**25.27**	------
19	85	2	78.1685	31.6623	------	**46.37**	------
20	106	3	81.1046	31.2447	------	4.54	------
21	107	3	81.0851	31.241	2.73	8.41	5.68
22	112	3	81.1493	31.2005	**19.17**	**17.28**	**-2.88**
23	113	3	81.1956	31.1834	**50.16**	**53.04**	**2.88**
24	114	3	81.1537	31.1797	**28.85**	**30.20**	**2.35**
25	118	3	81.2819	31.1391	7.50	8.98	1.48
26	119	3	81.2286	31.1312	**4.25**	**10.38**	**6.12**
27	122	3	81.4365	31.1158	------	6.18	------
28	166	3	81.4336	30.4724	4.38	5.52	1.13
29	174	3	81.4365	30.4497	9.69	8.17	-1.52
30	178	3	81.4359	30.4318	**218.28**	**228.52**	**10.25**
31	181	3	81.4652	30.4308	**24.11**	**22.77**	**-1.34**
32	183	3	81.873	30.4286	------	**29.21**	------
33	193	3	81.868	30.4007	------	9.94	------
34	196	3	81.8955	30.3928	------	**15.38**	------
35	312	1	78.9745	32.3279	------	7.96	------
36	313	1	78.9799	32.322	------	7.42	------
37	315	1	78.9743	32.1929	------	3.81	------
38	317	3	78.9792	32.1626	------	9.04	------
39	319	3	78.8384	31.9818	------	**17.10**	------
40	330	1	77.9252	32.1308	------	4.77	------
41	330	1	77.9151	32.1386	------	3.03	------
42	343	3	79.8664	31.9262	**30.94**	**33.61**	**2.66**
43	399	3	79.7312	31.0304	**12.87**	**14.85**	**2.98**
44	402	2	78.1265	31.7416	------	3.56	------
45	408	3	78.9121	32.02	------	6.26	------
46	413	3	79.0076	32.2263	------	4.17	------
47	414	1	78.9789	32.2605	------	3.24	------

48	415	3	79.0033	32.3313	------	2.05	------
49	416	3	79.1892	32.4542	------	3.30	------
50	417	3	79.7079	32.2173	1.39	3.34	1.95
51	422	3	81.0711	31.2346	------	3.26	------
52	423	3	81.1616	31.2189	------	8.98	------
53	424	3	81.2261	31.1506	1.02	1.84	0.82
54	426	3	81.5057	31.0958	------	7.39	------
55	427	3	81.3856	31.1391	2.17	6.73	4.56
56	431	3	81.5057	31.1132	------	6.71	------
57	432	3	81.5209	31.0839	------	4.29	------
58	443	3	81.517	30.482	6.08	8.27	2.19
59	445	3	81.4857	30.4625	1.12	2.77	1.65
60	448	3	81.4599	30.4388	------	5.22	------
61	559	1	78.7074	32.7099	------	2.92	------
62	561	1	78.6897	32.7102	------	3.86	------
63	562	3	79.0187	32.2791	------	3.81	------
64	563	1	78.9845	32.2279	------	2.42	------
65	570	3	79.1329	32.4486	------	3.25	------
66	571	3	79.1329	32.4655	------	2.02	------
67	592	3	79.8061	32.1182	------	3.33	------
68	607	3	81.1348	31.2461	------	5.45	------
69	610	3	78.9485	32.0945	------	5.67	------
70	611	3	78.9445	32.0619	------	7.21	------
71	616	1	78.7022	31.9143	------	6.26	------
72	620	3	79.6858	32.256	------	6.33	------
73	621	3	81.9297	30.3861	------	**80.26**	------
74	622	3	81.0868	31.2737	------	2.99	------
75	623	3	79.8473	31.9935	------	4.52	------
76	625	3	79.8792	31.9574	------	4.50	------
77	632	3	79.368	31.1453	------	8.21	------
78	634	3	81.1428	31.2472	------	9.51	------
79	635	2	78.2553	31.342	------	**13.95**	------
80	636	3	81.1112	31.2705	1.83	5.28	3.45
81	637	3	81.843	30.3859	**14.06**	**20.72**	**6.66**
82	638	3	81.8322	30.3821	3.08	6.95	3.86
83	640	3	78.9717	32.1314	------	4.58	------
84	641	3	79.8967	31.96	------	4.29	------
85	645	3	81.0913	31.2672	5.82	8.18	2.36
86	646	3	81.1184	31.2645	------	2.80	------
87	647	3	81.1191	31.2613	3.28	5.13	1.84
88	648	3	81.1263	31.2383	6.06	4.55	-1.51
89	649	3	81.1321	31.2452	------	3.11	------
90	651	3	81.4034	31.1288	------	8.36	------
91	652	3	81.4263	31.1385	4.47	9.64	5.17
92	655	3	81.5152	31.1005	------	6.53	------
93	656	3	81.5323	31.0964	------	2.09	------
94	657	3	81.5472	31.104	------	6.43	------
95	658	3	81.5446	31.1179	**8.80**	**11.15**	**3.36**
96	663	3	79.3435	31.1548	------	5.23	------
97	683	2	78.6984	31.2262	------	5.16	------
98	804	1	78.8333	32.0455	------	3.57	------
99	811	3	78.8417	31.9162	------	**28.99**	------
100	816	3	79.8809	31.9643	------	2.74	------

101	825	3	81.1157	31.251	------	1.21	------
102	827	3	81.14	31.1962	7.89	5.92	-1.97
103	828	3	81.156	31.2097	------	2.42	------
104	849	3	81.5019	30.46	1.19	4.59	3.40
105	870	1	78.9276	32.1313	------	1.54	------
106	884	3	79.8915	31.9691	------	7.35	------
107	885	3	79.8839	31.9334	------	2.42	------
108	888	3	81.1495	31.2056	------	1.81	------
109	895	3	81.8445	30.38	------	5.64	------
110	964	3	81.7679	30.4095	------	1.25	------
111	1004	3	81.5173	30.4781	4.37	2.70	-1.67
112	1005	3	81.4827	30.4285	------	3.71	------
113	1006	3	81.4784	30.4271	------	1.83	------
114	1030	3	81.1802	31.19	------	1.84	------
115	1038	3	79.8032	32.1273	------	2.67	------
116	1038	3	79.7986	32.1293	------	3.50	------
117	1052	3	80.5999	30.5461	**6.75**	**11.15**	**4.40**
118	1053	3	80.5941	30.4777	**14.72**	**16.61**	**2.89**
119	1133	3	81.8696	30.4204	------	**22.06**	------
120	1139	3	81.7243	30.4291	------	2.17	------
121	1142	3	81.776	30.4022	------	1.22	------
122	1149	3	81.771	30.398	------	6.46	------
123	1155	3	79.8384	31.9896	------	4.20	------
124	1510	3	81.5627	31.0953	------	3.03	------
125	1511	3	81.4283	31.0849	------	4.01	------
126	1512	3	81.4275	31.0813	------	3.07	------
127	1515	3	81.4187	31.1039	------	4.84	------
128	1518	3	81.2273	31.1623	------	0.91	------
129	1519	3	81.2173	31.1655	------	1.83	------
130	1522	3	81.1179	31.1688	------	3.40	------
131	1524	3	81.0345	31.2935	2.39	5.47	3.08
132	1525	3	81.0339	31.2859	**16.33**	**19.67**	**3.33**
133	1531	3	78.8702	31.9713	------	**11.53**	------
134	1532	3	78.868	31.9595	------	3.08	------
135	1538	3	79.5708	31.0948	3.08	7.18	4.10
136	1543	3	81.3968	30.4551	------	2.18	------
137	1545	3	80.4058	30.5987	------	6.73	------
138	1546	3	79.5149	31.1331	------	4.86	------
139	1552	1	78.9928	32.2567	------	3.51	------
140	1564	3	78.8203	31.9312	------	2.91	------
141	1565	3	78.8231	31.9321	------	1.29	------
142	1566	3	78.8241	31.9348	------	1.15	------
143	1568	1	78.8465	32.0135	------	2.91	------
144	1585	1	78.865	32.0878	------	1.49	------
145	1604	3	78.9033	32.0065	------	1.80	------
146	1606	3	78.9992	32.2262	------	2.12	------
147	8005	3	81.8331	30.3856	------	1.24	------
148	8006	3	81.7969	30.3935	------	0.91	------
149	8011	3	80.5709	30.4787	------	2.56	------
150	8018	3	81.4957	30.4557	------	2.46	------
151	8019	3	81.4089	30.467	------	2.23	------
152	8022	3	81.4046	30.4779	------	1.62	------
153	8024	3	80.5098	30.5423	------	1.26	------

154	8025	3	80.624	30.5405	------	**27.88**	------
155	8026	3	80.4522	30.5549	------	5.75	------
156	8026	3	79.8148	32.0309	------	3.31	------
157	8027	3	80.475	30.555	------	**16.09**	------
158	8028	3	80.6186	30.5557	------	3.81	------
159	8028	1	78.9739	32.1725	------	1.16	------
160	8029	3	80.6326	30.555	------	1.89	------
161	8031	3	80.2934	30.6076	------	**13.41**	------
162	8037	3	79.4133	31.0621	------	3.65	------
163	8038	3	79.4166	31.0618	------	7.82	------
164	8047	3	79.493	31.1329	------	2.67	------
165	8048	3	81.2324	31.0614	------	6.09	------
166	8052	3	81.5495	31.0799	------	2.51	------
167	8053	3	81.5559	31.0922	------	1.34	------
168	8054	3	81.5313	31.0941	------	3.58	------
169	8056	3	81.4147	31.1056	------	2.66	------
170	8057	3	81.2595	31.1181	------	7.09	------
171	8058	3	81.4246	31.1146	------	3.01	------
172	8059	3	81.2636	31.1242	------	1.81	------
173	8060	3	81.5201	31.112	------	1.53	------
174	8061	3	81.4767	31.1196	------	2.38	------
175	8062	3	81.1837	31.1386	------	3.40	------
176	8063	3	81.2602	31.1407	------	2.46	------
177	8065	3	81.2231	31.149	------	**16.40**	------
178	8067	3	81.1139	31.1612	------	4.26	------
179	8068	3	81.2015	31.1668	------	1.26	------
180	8071	3	78.8054	31.2964	------	2.42	------
181	8074	3	81.1308	31.2196	------	3.88	------
182	8076	3	81.1469	31.232	------	2.11	------
183	8077	2	78.6974	31.3276	------	3.34	------
184	8079	3	81.1388	31.235	------	**10.92**	------
185	8081	3	81.0933	31.2425	------	1.24	------
186	8083	3	81.0301	31.278	------	2.45	------
187	8084	2	78.5832	31.3752	------	2.24	------
188	8086	3	81.015	31.2964	------	2.42	------
189	8087	2	78.4907	31.4028	------	6.61	------
190	8088	3	80.9571	31.3199	------	2.74	------
191	8094	1	78.7153	31.9002	------	1.47	------
192	8096	1	78.7039	31.9195	------	1.83	------
193	8099	3	78.8218	31.9343	------	2.12	------
194	8101	1	78.6856	31.9358	------	1.27	------
195	8107	3	79.9004	31.9657	------	5.12	------
196	8117	1	78.7588	32.0438	------	2.77	------
197	8118	1	78.7623	32.043	------	1.23	------
198	8120	1	78.7836	32.0547	------	2.50	------
199	8121	3	79.8276	32.0191	------	3.61	------
200	8123	1	78.8856	32.0739	------	3.55	------
201	8124	3	78.9277	32.0653	------	1.85	------
202	8125	3	79.8171	32.0288	------	1.83	------
203	8126	1	78.9042	32.0563	------	1.19	------
204	8127	1	78.8079	32.0602	------	**15.32**	------
205	8129	3	79.8039	32.0796	------	3.91	------
206	8131	3	78.9481	32.1217	------	4.88	------

207	8133	3	79.7752	32.0961	------	2.98	------
208	8136	3	79.8026	32.1084	------	2.05	------
209	8137	1	78.9196	32.1439	------	3.56	------
210	8138	3	78.9633	32.1513	------	2.10	------
211	8139	3	79.7956	32.1233	------	4.19	------
212	8140	3	79.7715	32.1352	------	5.31	------
213	8141	1	78.9607	32.1871	------	2.96	------
214	8142	3	79.0205	32.2102	------	3.39	------
215	8143	3	79.0112	32.2167	------	2.38	------
216	8146	1	78.9861	32.3021	------	**13.19**	------
217	8153	3	79.1048	32.3564	------	3.58	------
218	8154	3	79.4073	32.3522	------	3.30	------
219	8155	3	79.5959	32.3539	------	6.86	------
220	8157	3	79.5351	32.3727	------	1.59	------
221	8159	3	79.5097	32.394	------	2.17	------
222	8160	1	78.8175	32.4217	------	8.58	------
223	8162	3	79.2544	32.5089	------	4.15	------
224	8170	2	78.4211	31.4054	------	4.25	------
225	8171	2	78.4106	31.4137	------	2.09	------
226	8172	2	78.4109	31.44	------	2.42	------
227	8173	2	78.3699	31.4606	------	3.00	------
228	8194	1	78.2729	32.367	------	9.62	------
229	8196	1	78.4741	32.4599	------	**10.13**	------
230	8210	3	81.4686	30.4282	------	3.71	------
231	8236	3	79.7557	31.0419	------	7.27	------
232	8249	3	81.8546	30.3999	------	**21.30**	------
233	8250	3	80.6414	30.4639	------	1.16	------
234	8251	3	81.8884	30.4037	------	8.18	------
235	8252	3	81.4369	30.4716	------	1.85	------
236	8253	3	81.4789	30.4831	------	5.00	------
237	8254	3	81.4797	30.4882	------	1.92	------
238	8255	3	81.401	30.498	------	1.88	------
239	8256	3	81.4872	30.4975	------	2.44	------
240	8257	3	81.5267	30.5231	------	4.67	------
241	8258	3	81.7124	30.561	------	6.15	------
242	8259	3	80.564	30.6341	------	4.03	------
243	8260	3	81.5542	30.7762	------	4.48	------
244	8261	3	82.1732	30.8084	------	2.45	------
245	8262	3	81.9822	30.8425	------	4.25	------
246	8263	3	81.107	30.9254	------	1.60	------
247	8264	3	81.668	30.9503	------	3.10	------
248	8265	3	79.4928	31.0989	------	4.32	------
249	8266	3	81.8511	31.0065	------	**25.46**	------
250	8267	3	81.6694	31.0272	------	1.59	------
251	8268	3	81.6787	31.0403	------	2.78	------
252	8269	3	81.773	31.0445	------	4.21	------
253	8270	3	81.7245	31.0716	------	9.02	------
254	8271	3	81.2285	31.1178	------	2.78	------
255	8272	3	81.253	31.1172	------	4.05	------
256	8273	2	78.708	31.2192	------	2.72	------
257	8274	3	81.5268	31.1121	------	2.14	------
258	8275	3	81.4921	31.1233	------	3.01	------
259	8276	3	81.4859	31.1271	------	5.39	------

260	8277	2	78.3312	31.3141	------	2.78	------
261	8278	3	78.761	31.3241	------	1.77	------
262	8279	3	78.757	31.3262	------	1.18	------
263	8280	2	78.0117	31.4089	------	6.44	------
264	8281	2	78.0279	31.4107	------	8.65	------
265	8282	3	80.9838	31.3142	------	2.75	------
266	8283	2	78.069	31.4213	------	3.34	------
267	8284	2	78.0692	31.4251	------	2.39	------
268	8285	3	80.6862	31.3708	------	1.44	------
269	8286	3	80.5571	31.3946	------	3.38	------
270	8286	1	78.9034	32.0456	------	2.40	------
271	8287	2	78.1775	31.587	------	2.67	------
272	8288	2	78.1853	31.5877	------	8.71	------
273	8289	1	78.7197	31.9027	------	2.39	------
274	8290	1	77.9643	31.9339	------	3.59	------
275	8291	3	79.903	31.9287	------	2.08	------
276	8292	3	79.9206	31.9353	------	2.11	------
277	8293	3	79.8571	31.9512	------	2.70	------
278	8294	1	78.8492	31.9968	------	1.73	------
279	8295	1	78.7027	32.0381	------	2.72	------
280	8296	3	79.8188	32.0222	------	1.75	------
281	8297	1	78.8995	32.0587	------	9.38	------
282	8298	3	78.9382	32.0829	------	4.19	------
283	8299	3	78.9483	32.1243	------	1.84	------
284	8300	1	78.4888	32.1507	------	6.64	------
285	8301	1	78.4576	32.1629	------	2.06	------
286	8302	1	78.4631	32.1629	------	1.80	------
287	8303	1	78.4557	32.1645	------	1.46	------
288	8304	1	78.4135	32.1773	------	6.06	------
289	8305	1	78.4334	32.1831	------	2.41	------
290	8306	3	79.7554	32.1432	------	1.83	------
291	8307	3	79.7533	32.1466	------	2.76	------
292	8307	1	78.4185	32.2066	------	6.13	------
293	8308	3	79.791	32.1772	------	1.47	------
294	8309	1	77.7626	32.2447	------	5.29	------
295	8310	3	79.0453	32.254	------	1.25	------
296	8311	1	78.8972	32.3278	------	1.82	------
297	8312	1	78.9102	32.3369	------	3.08	------
298	8314	2	78.8994	32.3542	------	3.58	------
299	8315	3	79.5916	32.3557	------	1.52	------
300	8320	1	77.943	32.5273	------	3.56	------
301	8321	1	77.9668	32.5359	------	1.49	------
302	8322	1	78.429	32.5481	------	3.53	------
303	8323	1	78.7115	32.6976	------	2.69	------
304	8324	1	78.7202	32.7005	------	2.36	------
305	8325	1	78.7344	32.7006	------	1.79	------
306	8326	1	78.699	32.7069	------	5.61	------
307	8327	1	78.7091	32.713	------	4.80	------
308	8328	1	78.6983	32.7522	------	2.12	------
309	13801	3	80.4013	30.5529	------	**46.72**	------
310	15002	3	82.0737	30.5976	------	**12.17**	------
311	18701	3	81.8503	30.3878	------	6.21	------
312	18901	3	81.8211	30.3919	**16.02**	**15.10**	**-0.91**

313	187004	3	81.7854	30.402		6.18	-0.78
314	1012HWL	3	81.5444	30.8197	1.56	2.43	0.86
315	1013HWL	3	81.5263	30.7775	2.69	2.16	-0.53
316	1022RS	3	81.1109	30.9251	2.78	3.68	0.90
317	1093HWL	3	82.1347	30.6389	------	**5989.46**	------
318	1124HWL	3	81.8225	30.439	------	4.95	------
319	1136HWL	3	81.7786	30.4121	------	7.64	------
320	1139HWL	3	81.7992	30.4247	------	2.40	------
321	138HWL	3	81.2344	30.69	**26196.20**	**26190.10**	**-6.10**
322	142HWL	3	81.5683	30.8025	**281.56**	**295.80**	**14.25**
323	145HWL	3	81.4731	30.686	**41773.70**	**41804.20**	**-21.30**
324	148HWL	3	81.5822	30.7619	**164.78**	**154.75**	**-10.30**
325	15003HWL	3	82.0849	30.5931	------	**18.02**	------
326	159HWL	3	81.7417	30.5514	**12.43**	**12.74**	**0.31**
327	173HWL	3	81.6788	30.449	------	**11.21**	------
328	179HWL	3	81.7161	30.4302	------	**22.67**	------
329	184HWL	3	81.7241	30.4219	------	**21.52**	------
330	85001HWL	3	81.7478	30.4101	------	8.04	------
331	202HWL	3	80.5425	31.3993	**57.58**	**56.63**	**-1.95**
332	205HWL	3	81.5672	30.789	5.13	5.22	0.09
333	206HWL	3	81.5704	30.7907	3.12	0.89	-2.23
334	207HWL	3	81.5572	30.7824	------	3.70	------
335	210HWL	3	81.5557	30.7722	**48.90**	**45.46**	**-3.43**
336	211HWL	3	81.7026	30.516	9.70	8.27	-1.44
337	32HWL	1	78.7202	32.3305	**28.64**	**25.85**	**-2.79**
338	385HWL	3	81.5402	30.7792	7.09	2.83	-4.26
339	436HWL	3	81.6963	30.4991	2.37	1.87	-0.50
340	437HWL	3	81.6938	30.498	2.75	3.22	0.47
341	438HWL	3	81.7432	30.4029	------	3.73	------
342	440HWL	3	81.7225	30.4492	4.23	5.36	1.13
343	441HWL	3	81.702	30.4539	------	2.52	------
344	442HWL	3	81.7005	30.4317	------	7.41	------
345	455RS	3	80.7807	31.1103	**24.99**	**29.27**	**5.27**
346	606RS	3	81.1647	30.915	**31.22**	**32.39**	**1.17**
347	607RS	3	81.1025	30.9267	3.09	2.49	-1.60
348	608RS	3	81.0942	30.927	**20.09**	**18.29**	**-2.80**
349	616RS	3	81.1182	30.9255	**20.48**	**13.59**	**-6.88**
350	677HWL	3	81.7085	30.5034	2.63	1.85	-0.78
351	688HWL	3	81.8225	30.4104	------	8.23	------
352	8008HWL	3	81.7792	30.3995	------	1.32	------
353	8055SG	3	81.224	31.1117	------	3.07	------
354	8156SG	3	79.4195	32.3756	------	1.48	------
355	8298SG	1	78.295	32.1186	------	**13.20**	------
356	839HWL	3	81.8059	30.3921	------	4.91	------
357	840HWL	3	81.7945	30.3984	------	3.96	------
358	842HWL	3	81.7648	30.4215	------	4.28	------
359	844HWL	3	81.7722	30.4603	5.42	3.98	-1.44
360	865HWL	3	81.7765	30.3998	------	1.84	------
361	96HWL	3	79.6014	31.3064	**28.83**	**35.16**	**6.33**

HWL- High Altitude Wetlands
RS- River Section

7.10. Status of Lakes as on 21September 2020

From the analysis of 21 September 2020 satellite data, it is found that the data covers partial area of Upper Satluj basin, whereas the Lower Satluj and Spiti basins are fully covered but slight cloud cover impact could be seen. Based on the visual interpretation, it has become possible to delineate a total of 137 lakes in the entire catchment and 1 high altitude wetland **(Fig 7.10a & 7.10b)** in comparison to the 229 lakes, the maximum mapped in 2019, out of which maximum number of lakes (85) forms the part of the Upper Satluj sub basin i.e. basin 3, whereas 27 lakes forms part of the Lower Satluj sub basin respectively and 25 lakes forms part of the Spiti basin i.e sub basin 1 **(Fig. 7.10c).** Further analysis of 137 lakes based on their areal distribution pattern reveals that 72 lakes are such, which have the area less than 5 ha comprising 15 lakes from Spiti, 18 from the Lower Satluj and 49 from the Upper Satluj sub basin respectively. Likewise,35 lakes are such which have area between 5-10 ha comprising 6 from the Spiti, 7 from Lower Satluj and 22 from the Upper Satluj sub basin respectively. Besides this, 20 lakes are such which have the area more than 10ha comprising 4 from Spiti, 2 from Lower Satluj and 14 from the Upper Satluj sub basin respectively **(Fig. 7.10c).** The temporal variation of 138 lakes w.r.t.229 lakes as mapped on 18 Sept 2018, it is found that only 37 lakes could be compared out of which 35 lakes are showing an increase in their water spread , whereas 02 lakes are showing a reduction in their water spread w.r.t. 2018 data **(Table7.10).**

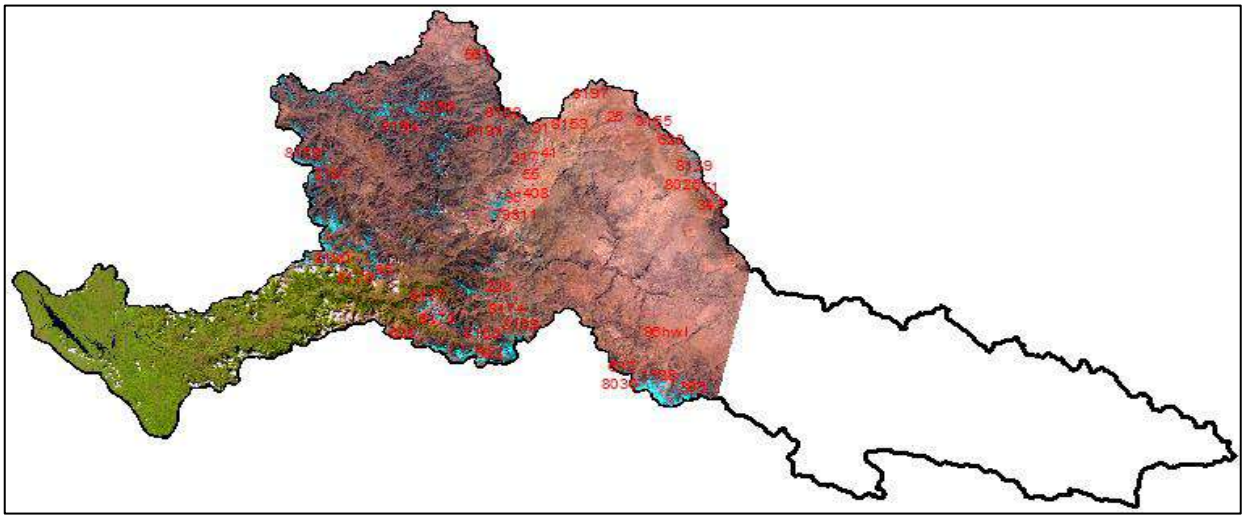


Fig.7.10 (a): IRS-R2-AWiFS-94-48-21-09-2020

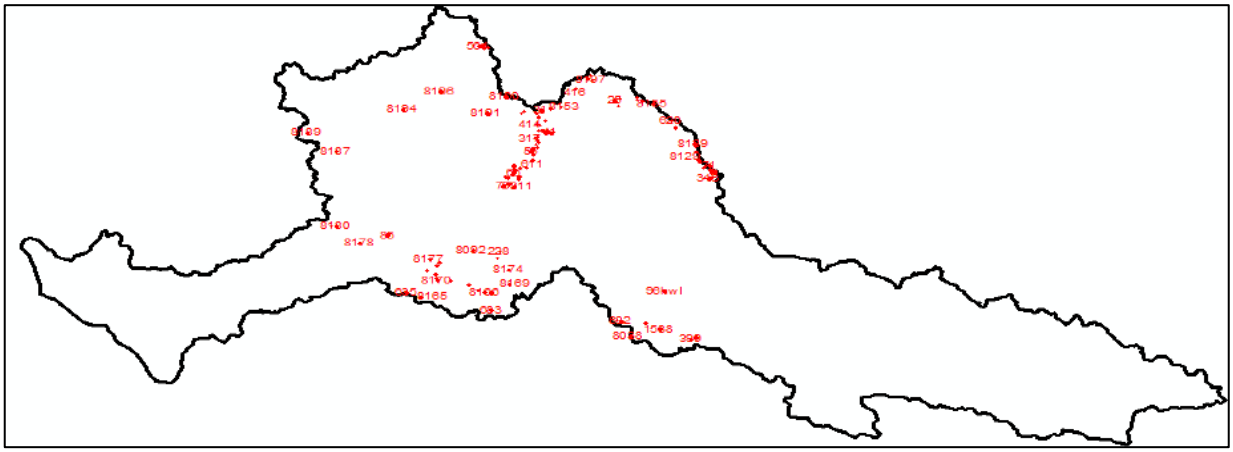


Fig.7.10 (b): IRS-R2-AWiFS-94-48-21-09-2020 Interpreted Layer

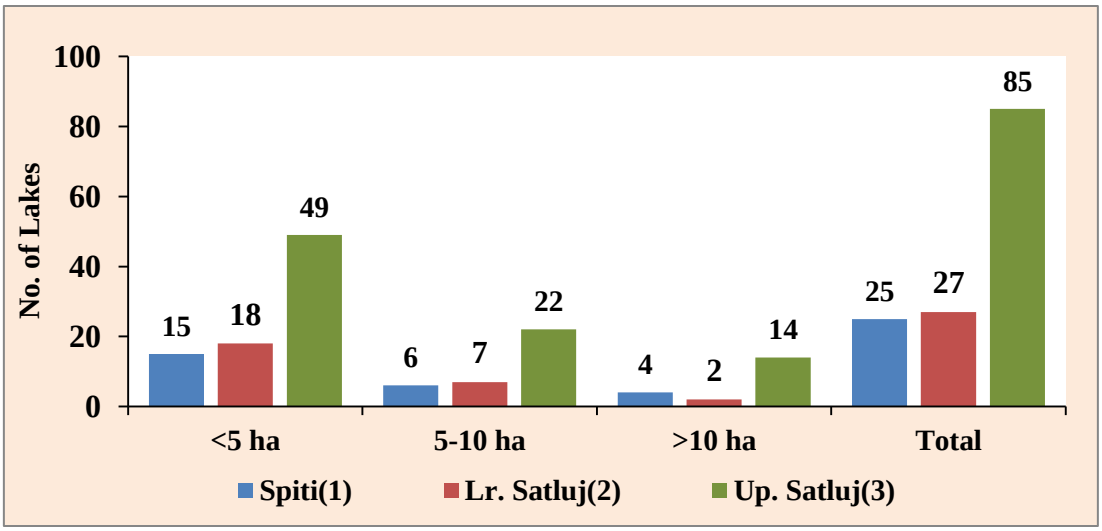


Fig. 7.10 (c): No. of Lakes based on IRS-R2-AWiFS-94-48-21-09-2020

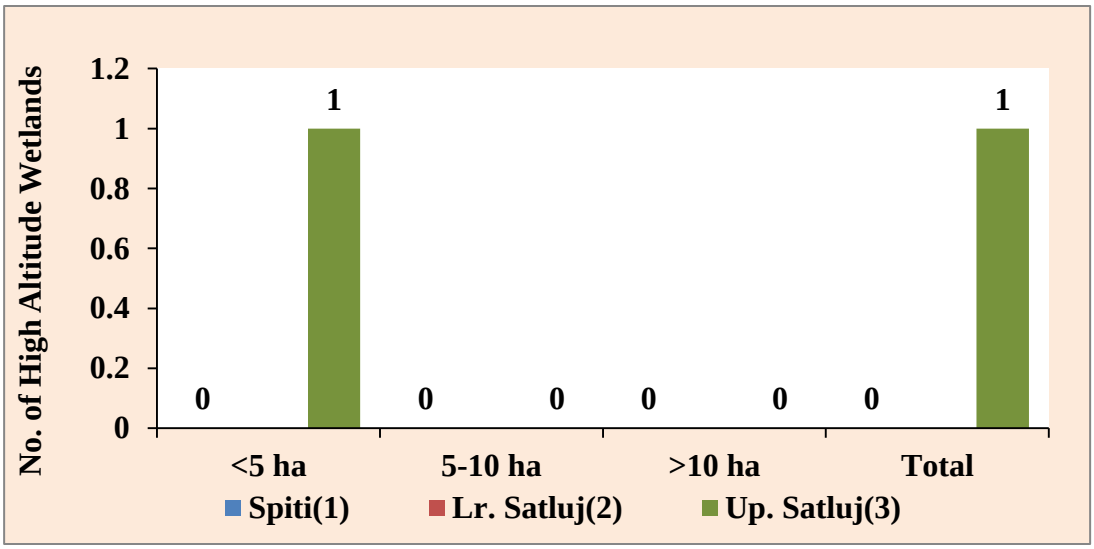


Fig. 7.10 (d): No. of High altitude wetlands based on IRS-R2-AWiFS-94-48-21-09-2020

Table: 7.10 Aerial Extent of lakes as on 21 September 2020

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 09 Sept 2019 (ha.)	Aerial Extent on 21 Sept 2020 (ha.)	Change in Area w.r.t. Sept.2019 (ha.)
1	23	32.389	79.4176	3	**6.58**	**10.12**	**3.55**
2	25	32.3767	79.3933	3	**25.39**	**26.30**	**1.91**
3	28	32.3464	79.05	3	4.26	7.62	3.36
4	31	32.3365	79.0027	3	**4.28**	**12.91**	**8.62**
5	39	32.2233	79.0269	3	5.39	8.39	3.00
6	41	32.209	79.0434	3	**17.70**	**28.74**	**11.04**
7	51	32.1217	78.9432	3	3.02	6.58	3.56
8	54	32.1068	78.9325	3	**5.43**	**11.07**	**5.64**
9	55	32.1067	78.9421	3	**6.78**	**11.85**	**5.08**
10	61	32.0293	78.8437	1	**24.47**	**22.49**	**-1.98**
11	62	32.0179	78.8744	1	**14.63**	**16.27**	**2.64**
12	65	31.9926	78.8441	1	**22.08**	**30.12**	**8.04**
13	71	31.9767	79.873	3	7.59	8.60	1.01
14	73	31.9692	79.8824	3	2.18	5.84	3.66
15	74	31.9677	79.8764	3	2.14	5.24	3.11
16	79	31.9189	78.7836	3	**19.51**	**23.53**	**4.02**
17	85	31.6604	78.1665	2	------	**38.76**	------
18	228	31.5532	78.7505	2	------	7.47	------
19	312	32.3244	78.9738	1	3.75	6.64	2.89
20	313	32.3193	78.9795	1	3.72	8.35	4.64
21	315	32.19	78.9727	1	2.70	4.77	2.07
22	317	32.1604	78.9778	3	5.70	7.05	1.35
23	343	31.9242	79.8652	3	**29.70**	**32.92**	**3.21**
24	399	31.0291	79.727	3	**7.43**	**11.17**	**3.74**
25	408	32.0176	78.91	3	3.23	5.73	2.50
26	414	32.2577	78.9781	1	------	2.74	------
27	415	32.3283	79.0026	3	1.61	3.00	1.40
28	416	32.451	79.1886	3	------	2.95	------
29	417	32.2147	79.7057	3	1.36	2.16	0.80
30	559	32.7098	78.7099	1	------	3.61	------
31	561	32.7069	78.6891	1	------	4.73	------
32	562	32.2764	79.0174	3	1.61	2.42	0.81
33	563	32.2252	78.9834	1	1.37	2.57	1.20
34	592	32.1159	79.8046	3	------	2.75	------
35	610	32.0919	78.9471	3	4.05	5.67	1.62
36	611	32.0597	78.9424	3	5.14	7.97	2.83
37	620	32.253	79.6849	3	3.75	8.56	4.81
38	632	31.1431	79.3673	3	2.34	6.24	3.90
39	635	31.3393	78.2535	2	------	**15.80**	------
40	640	32.1286	78.9704	3	------	4.00	------
41	641	31.958	79.8957	3	------	5.21	------
42	663	31.1527	79.3428	3	------	6.19	------
43	683	31.2251	78.6942	2	------	6.85	------
44	811	31.9138	78.8415	3	**17.41**	**29.94**	**12.53**

45	885	31.9315	79.883	3	1.61	3.14	1.52
46	1038	32.1249	79.8017	3	------	3.05	------
47	1049	31.5182	78.7338	2	------	5.23	------
48	1531	31.9696	78.8691	3	4.23	8.40	4.17
49	1532	31.9574	78.8674	3	2.11	3.29	1.18
50	1538	31.0929	79.5674	3	4.57	7.53	2.96
51	1552	32.2542	78.9917	1	------	1.55	------
52	8026	32.0284	79.8127	3	------	1.55	------
53	8027	32.5276	79.2711	3	------	1.81	------
54	8036	31.0398	79.7533	3	------	8.99	------
55	8037	31.06	79.4109	3	------	4.02	------
56	8038	31.0598	79.4138	3	------	7.05	------
57	8047	31.1307	79.4925	3	------	3.25	------
58	8077	31.3253	78.6966	2	------	3.06	------
59	8078	31.3262	78.7027	2	------	2.49	------
60	8084	31.3747	78.581	2	------	1.87	------
61	8087	31.4007	78.4889	2	------	2.74	------
62	8092	31.5644	78.6097	2	------	4.19	------
63	8097	31.9336	78.8142	3	------	3.34	------
64	8098	31.9308	78.8212	3	------	2.09	------
65	8099	31.933	78.8213	3	------	3.07	------
66	8100	31.9326	78.8195	3	------	3.07	------
67	8102	31.9294	78.8177	3	------	2.47	------
68	8103	31.9638	78.8117	3	------	8.54	------
69	8104	31.9712	78.7979	3	------	3.06	------
70	8105	31.9796	78.8363	3	------	**15.87**	------
71	8106	31.9554	79.8781	3	------	5.54	------
72	8107	31.9634	79.8998	3	------	6.13	------
73	8109	32.0117	78.8448	1	------	2.15	------
74	8112	31.9873	79.8381	3	------	3.56	------
75	8113	31.9913	79.8471	3	------	4.99	------
76	8116	31.9956	79.8682	3	------	6.62	------
77	8121	32.017	79.8279	3	------	4.02	------
78	8125	32.0272	79.8164	3	------	1.29	------
79	8128	32.17	78.9728	3	------	2.11	------
80	8129	32.0776	79.8038	3	------	4.36	------
81	8130	32.1191	78.9512	3	------	2.75	------
82	8131	32.1194	78.9472	3	------	2.32	------
83	8132	32.1221	78.948	3	------	1.74	------
84	8136	32.1063	79.8013	3	------	3.65	------
85	8138	32.1489	78.963	3	------	1.83	------
86	8139	32.1209	79.795	3	------	4.50	------
87	8141	32.1848	78.9606	1	------	1.47	------
88	8142	32.2078	79.02	3	------	2.44	------
89	8143	32.2147	79.0094	3	------	2.11	------
90	8144	32.2238	78.998	3	------	2.15	------
91	8145	32.2238	79.0061	3	------	2.71	------
92	8146	32.2996	78.9858	1	------	**11.23**	------
93	8153	32.3529	79.1054	3	------	3.28	------
94	8154	32.349	79.4072	3	------	4.50	------
95	8155	32.3519	79.5947	3	------	4.20	------
96	8157	32.3698	79.5349	3	------	1.83	------
97	8158	32.3817	79.5104	3	------	2.63	------

98	8159	32.3913	79.5092	3	------	1.80	------
99	8160	32.4187	78.817	1	------	9.11	------
100	8162	32.5056	79.2533	3	------	4.19	------
101	8165	31.3119	78.3278	2	------	5.27	------
102	8166	31.3306	78.6633	2	------	3.35	------
103	8167	31.3395	78.6274	2	------	3.07	------
104	8168	31.3726	78.5821	2	------	1.90	------
105	8169	31.3699	78.7932	3	------	3.12	------
106	8170	31.4033	78.4199	2	------	3.66	------
107	8171	31.4113	78.4094	2	------	1.53	------
108	8172	31.4374	78.4092	2	------	3.11	------
109	8173	31.4583	78.3673	2	------	1.86	------
110	8174	31.4493	78.7938	2	------	7.97	------
111	8175	31.484	78.4182	2	------	1.90	------
112	8176	31.503	78.4319	2	------	2.50	------
113	8177	31.5217	78.3841	2	------	4.75	------
114	8178	31.6193	78.0187	2	------	6.95	------
115	8179	31.7172	77.8724	2	------	4.66	------
116	8180	31.7167	77.8984	2	------	8.82	------
117	8181	31.7208	77.8999	2	------	2.54	------
118	8182	31.7216	77.902	2	------	1.81	------
119	8183	31.9943	78.8479	3	------	3.02	------
120	8184	31.9952	79.8726	3	------	3.31	------
121	8185	32.0202	79.8192	3	------	1.57	------
122	8186	32.1063	78.9472	3	------	1.74	------
123	8187	32.137	77.9146	1	------	5.79	------
124	8188	32.1271	79.7978	3	------	4.47	------
125	8189	32.2429	77.7603	1	------	4.66	------
126	8190	32.2157	79.0585	3	------	**21.04**	------
127	8191	32.328	78.7155	1	------	5.49	------
128	8192	32.3246	78.8979	1	------	1.22	------
129	8193	32.3338	78.9092	1	------	2.22	------
130	8194	32.3639	78.2726	1	------	**13.24**	------
131	8195	32.353	79.5903	3	------	1.27	------
132	8196	32.4567	78.4742	1	------	7.98	------
133	8197	32.4953	79.2759	3	------	4.38	------
134	8198	32.6944	78.7123	1	------	2.43	------
135	8199	32.6972	78.7343	1	------	4.00	------
136	8200	32.7066	78.7071	1	------	2.54	------
137	8201	32.7071	78.7032	1	------	1.84	------
138	96 HWL	31.3041	79.5997	3	**28.83**	**20.65**	**-8.18**

HWL- High Altitude Wetlands
RS- River Section

7.11 Status of Lakes as on 29 September 2020

From the analysis of 29 September 2020 satellite data, it is found that the data covers the entire catchment of the study area except some portion on the extreme southeastern side of the catchment. Because of the quality of the data, it has become possible to delineate only 256 lakes in the entire catchment in comparison to the 229 lakes which were mapped. Out of these 256 lakes,

maximum number of lakes (190) forms the part of the Upper Satluj sub basin, whereas 40 lakes forms part of the Spiti sub basin and 26 forms the part of Lower Satluj basin respectively **(Fig. 7.11c).** Further analysis of 256 lakes based on their areal distribution pattern reveals that 171 lakes are such, which have the area less than 5ha comprising 29 from Spiti, 21 from Lower Satluj and 121 from Upper Satluj sub basin. 47 lakes are such which have area between 5-10 ha comprising 6 each from Spiti, 4 from Lower Satluj and 37 Upper Satluj sub basins. Besides this, 38 lakes are such which have the area more than 10ha, out of which 5 lakes from Spiti basin, 1 lake forms the part of the Lower Satluj sub basin, 32lakes forms part of the Upper Satluj sub basin respectively **(Fig. 7.11c).** The temporal variation of 259 lakes when seen w.r.t. the 229 lakes as mapped on 09 Sept 2019, only 79 lakes could be seen temporally out of which 6 lakes are showing decreasing trend in their water spread, whereas 73 lakes are showing an increase in their water spread **(Table 7.11)** and the remaining forms base line data for monitoring during next ablation season.

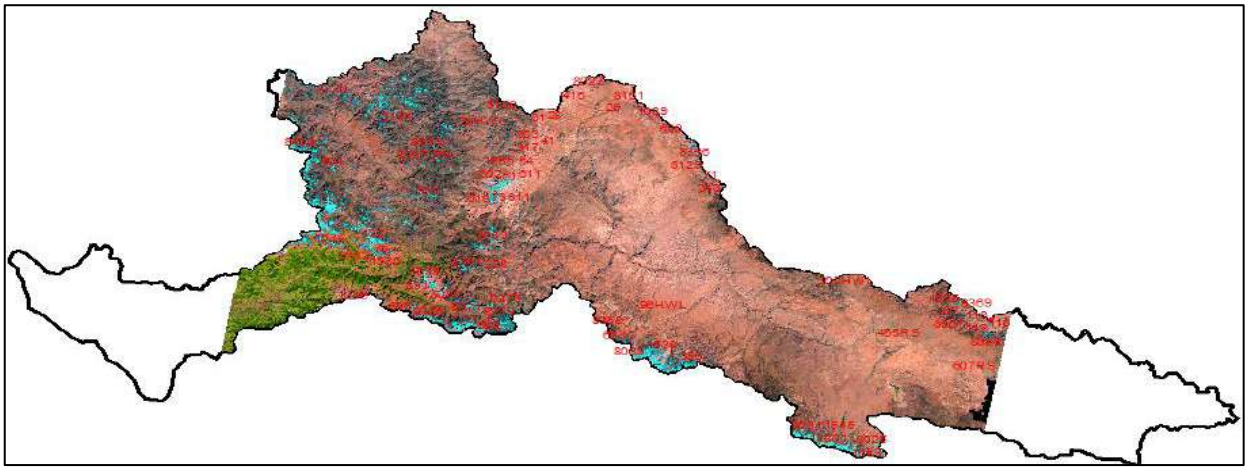


Fig.7.11 (a): IRS-R2-AWiFS-99-48-29-09-2020

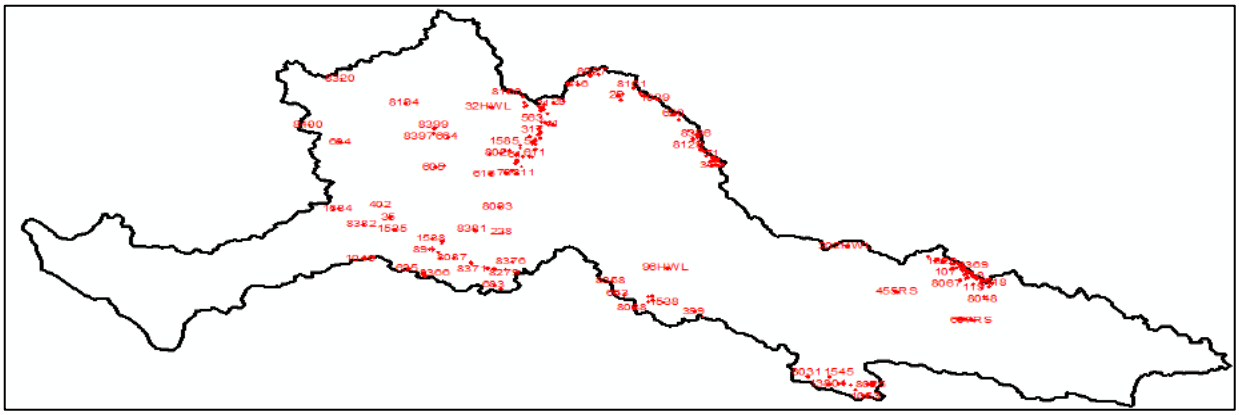


Fig.7.11 (b): IRS-R2-AWiFS-99-48-29-09-2020 Interpreted Layer

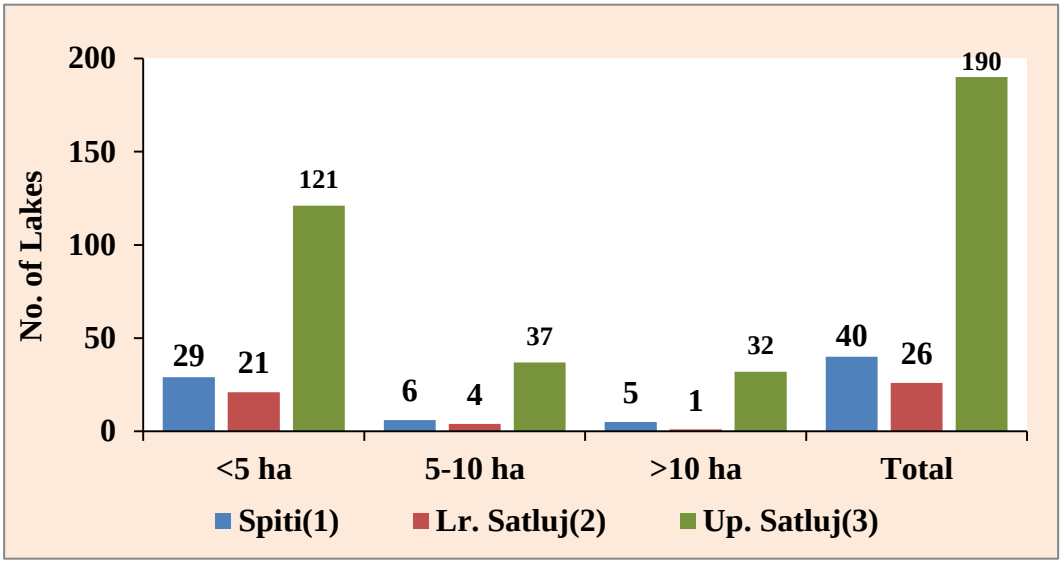


Fig. 7.11 (c): No. of Lakes based on IRS-R2-AWiFS-99-48-29-09-2020

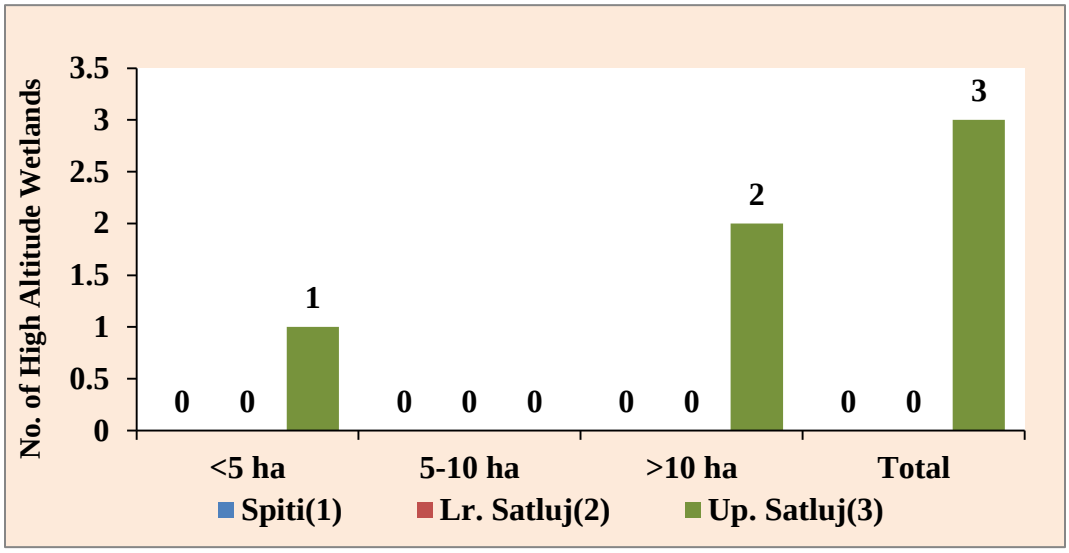


Fig. 7.11 (d): No. of High altitude wetlands based on IRS-R2-AWiFS-99-48-29-09-2020

Table: 7.11 Aerial Extent of lakes as on 29 September2020

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 09 Sept 2019 (ha.)	Aerial Extent on 29 Sept 2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
1	23	3	79.417	32.3895	**6.77**	**14.98**	**8.45**
2	25	3	79.3923	32.3773	**25.39**	**28.25**	**3.86**
3	28	3	79.0511	32.3464	4.26	5.43	1.17
4	31	3	79.0021	32.3379	4.28	8.12	3.84
5	35	2	78.1673	31.6606	------	**39.90**	------
6	39	3	79.0262	32.2238	5.39	6.70	1.31

7	40	3	79.0197	32.2079	2.12	3.72	1.60
8	41	3	79.0431	32.2093	**17.70**	**20.50**	**2.80**
9	51	3	78.9427	32.122	3.02	6.30	3.28
10	54	3	78.9322	32.1068	**5.43**	**10.91**	**5.47**
11	55	3	78.9414	32.107	6.78	8.85	2.07
12	61	1	78.8443	32.0288	**24.47**	**27.83**	**3.36**
13	62	3	78.8751	32.0176	**14.63**	**16.58**	**2.94**
14	65	1	78.8448	31.992	**22.08**	**25.64**	**3.56**
15	71	3	79.8716	31.977	**7.59**	**10.73**	**3.13**
16	73	3	79.8815	31.9698	2.18	6.39	4.22
17	74	3	79.8751	31.9678	2.14	3.80	1.66
18	79	3	78.7833	31.9186	**19.51**	**23.56**	**4.05**
19	106	3	81.1018	31.2435	------	6.78	------
20	107	3	81.0825	31.2397	3.60	7.72	4.12
21	112	3	81.147	31.1989	**8.16**	**16.37**	**8.21**
22	113	3	81.1938	31.1818	**53.36**	**59.85**	**6.49**
23	114	3	81.1512	31.1782	**16.80**	**27.63**	**10.82**
24	118	3	81.2795	31.1373	**6.46**	**12.62**	**6.16**
25	119	3	81.2273	31.1291	3.04	7.43	4.39
26	228	2	78.7509	31.5533	------	5.79	------
27	312	1	78.9733	32.3251	3.75	7.57	3.82
28	313	1	78.9788	32.3196	3.72	8.02	4.30
29	315	1	78.9726	32.1903	2.70	4.56	1.87
30	317	3	78.9777	32.1604	5.70	7.89	2.19
31	319	3	78.837	31.9795	**9.74**	**15.53**	**5.79**
32	330	1	77.9147	32.1366	------	3.10	------
33	343	3	79.8642	31.9247	**29.70**	**33.88**	**4.17**
34	399	3	79.7293	31.0281	**7.43**	**10.56**	**3.14**
35	402	2	78.1245	31.7393	------	2.75	------
36	405	2	78.4205	31.4032	------	3.36	------
37	408	3	78.9105	32.0177	3.23	4.82	1.59
38	412	1	78.96	32.1851	1.35	1.83	0.49
39	413	3	79.006	32.224	1.87	2.74	0.87
40	414	1	78.9775	32.2581	------	1.49	------
41	415	3	79.0012	32.3287	1.61	3.32	1.71
42	416	3	79.187	32.4515	------	4.28	------
43	417	3	79.7052	32.2154	1.36	2.99	1.63
44	422	3	81.0681	31.2335	------	2.85	------
45	423	3	81.1582	31.2186	6.70	4.31	-2.39
46	424	3	81.2213	31.1478	**1.31**	**10.92**	**9.61**
47	562	3	79.0165	32.277	1.61	2.47	0.86
48	563	1	78.9833	32.2258	1.37	1.55	0.18
49	564	3	78.9475	32.122	0.53	2.41	1.88
50	570	3	79.1309	32.446	4.82	1.82	-3.00
51	571	3	79.1302	32.4624	------	2.78	------
52	579	1	78.9186	32.1416	1.10	3.89	2.79
53	582	3	78.3264	31.3062	------	1.82	------
54	592	3	79.8035	32.116	------	2.76	------
55	604	1	77.9254	32.1286	------	3.12	------
56	605	1	78.4157	31.9645	------	**10.76**	------
57	607	3	81.1328	31.2447	2.21	5.27	3.06
58	610	3	78.9468	32.0921	4.05	3.65	-0.40
59	611	3	78.9428	32.0597	5.14	7.27	2.13

60	616	1	78.7013	31.912	2.17	7.62	5.45
61	620	3	79.6827	32.2536	3.75	6.77	3.02
62	622	3	81.0845	31.2721	------	2.75	------
63	625	3	79.8766	31.9557	3.51	3.65	0.14
64	632	3	79.3655	31.1434	2.34	4.40	2.05
65	634	3	81.1421	31.2456	------	5.28	------
66	635	3	78.2537	31.3395	------	**16.52**	------
67	636	3	81.1386	31.2467	3.01	3.36	0.35
68	636	3	81.1085	31.2698	3.01	7.09	4.08
69	639	1	78.9726	32.1705	0.54	3.03	2.49
70	640	3	78.9702	32.1293	------	3.70	------
71	641	3	79.8943	31.9584	------	6.69	------
72	645	3	81.0885	31.2661	5.15	7.88	2.73
73	646	3	81.1155	31.2633	2.63	2.22	-0.41
74	647	3	81.1163	31.2601	2.74	4.36	1.62
75	648	3	81.1241	31.2371	2.18	5.30	3.12
76	649	3	81.1298	31.2438	2.77	3.08	0.32
77	663	3	79.3413	31.1531	------	7.67	------
78	664	1	78.4877	32.1488	------	5.02	------
79	683	3	78.6964	31.2254	------	5.87	------
80	802	1	78.7581	32.0418	0.51	2.47	1.95
81	803	1	78.7611	32.0406	0.52	1.52	0.99
82	809	3	78.9624	32.1492	1.09	1.27	0.18
83	811	3	78.8406	31.9141	**17.41**	**28.94**	**11.53**
84	816	3	79.8787	31.9631	2.97	3.95	0.98
85	817	3	79.9186	31.9339	1.06	1.56	0.50
86	818	3	79.9005	31.9267	0.82	2.45	1.63
87	825	3	81.1126	31.25	1.04	2.76	1.73
88	827	3	81.1376	31.1942	**7.33**	**11.82**	**4.49**
89	828	3	81.1533	31.2081	1.73	3.76	2.03
90	884	3	79.8889	31.9673	------	6.86	------
91	885	3	79.8816	31.9319	1.61	3.70	2.08
92	888	3	81.1471	31.2039	------	1.86	------
93	891	2	78.3686	31.4583	------	1.83	------
94	1030	3	81.178	31.1891	------	1.81	------
95	1038	3	79.8008	32.1252	------	2.47	------
96	1039	3	79.5939	32.3523	------	5.19	------
97	1045	2	78.0273	31.4084	------	6.16	------
98	1046	2	78.011	31.4059	------	6.47	------
99	1052	3	80.5976	30.5447	------	**10.47**	------
100	1053	3	80.5922	30.4765	------	**14.60**	------
101	1518	3	81.2249	31.1609	------	1.90	------
102	1519	3	81.2154	31.1641	------	2.44	------
103	1522	3	81.1148	31.168	------	2.83	------
104	1522	3	81.1448	31.2309	------	2.14	------
105	1524	3	81.0321	31.2922	1.88	5.75	3.86
106	1525	3	81.0313	31.2844	**11.37**	**20.19**	**8.82**
107	1529	3	79.751	32.1446	------	1.88	------
108	1530	3	79.0098	32.2148	------	1.19	------
109	1532	3	78.8668	31.9573	2.11	4.64	2.53
110	1533	2	77.8715	31.7179	------	3.66	------
111	1534	2	77.9021	31.7208	------	4.64	------
112	1535	2	78.1855	31.5852	------	9.06	------

113	1536	2	78.0685	31.4192	------	1.88	------
114	1537	2	78.4096	31.4373	------	3.21	------
115	1538	3	79.5688	31.0928	4.57	5.98	1.41
116	1538	2	78.3826	31.5223	4.57	4.26	-0.30
117	1545	3	80.4032	30.597	------	5.95	------
118	1546	3	79.5131	31.1316	------	5.62	------
119	1585	1	78.8637	32.0857	------	2.80	------
120	8020	3	80.5319	30.5116	------	3.22	------
121	8021	3	80.5337	30.5138	------	2.61	------
122	8024	3	80.5084	30.541	------	1.89	------
123	8025	3	80.6213	30.5389	------	**27.08**	------
124	8026	3	80.4496	30.5537	------	4.66	------
125	8026	3	79.8113	32.0285	------	1.28	------
126	8027	3	80.4724	30.5531	------	**13.65**	------
127	8027	3	79.2711	32.5282	------	3.62	------
128	8028	3	80.6164	30.5556	------	2.15	------
129	8029	3	80.6309	30.5537	------	1.54	------
130	8031	3	80.2922	30.6059	------	**15.67**	------
131	8037	3	79.4105	31.0602	------	3.66	------
132	8038	3	79.4137	31.06	------	9.17	------
133	8044	3	79.5147	31.1039	------	2.50	------
134	8047	3	79.4911	31.1309	------	3.95	------
135	8048	3	81.2303	31.06	------	3.37	------
136	8057	3	81.2579	31.1166	------	6.16	------
137	8059	3	81.2624	31.1229	------	1.28	------
138	8062	3	81.1818	31.1374	------	3.71	------
139	8063	3	81.2584	31.1393	------	1.56	------
140	8067	3	81.111	31.1595	------	4.09	------
141	8068	3	81.1998	31.1657	------	1.78	------
142	8072	3	81.1724	31.209	------	2.76	------
143	8074	3	81.1283	31.219	------	1.57	------
144	8077	3	78.6962	31.3256	------	1.83	------
145	8078	3	78.7017	31.3262	------	1.51	------
146	8079	3	81.1368	31.2338	------	9.57	------
147	8083	3	81.0278	31.2766	------	2.47	------
148	8084	2	78.5802	31.374	------	1.28	------
149	8085	3	81.0467	31.2863	------	1.26	------
150	8086	3	81.0123	31.2947	------	3.08	------
151	8087	2	78.4892	31.4007	------	4.61	------
152	8088	3	80.9547	31.3186	------	2.09	------
153	8089	2	78.3891	31.4585	------	1.23	------
154	8090	2	78.4286	31.4908	------	1.86	------
155	8092	2	78.6096	31.5642	------	1.87	------
156	8093	2	78.7409	31.709	------	2.20	------
157	8097	3	78.8154	31.933	------	6.79	------
158	8098	3	78.8184	31.929	------	1.69	------
159	8099	3	78.8222	31.9328	------	5.93	------
160	8100	3	78.8203	31.9324	------	5.93	------
161	8106	3	79.8738	31.9578	------	3.48	------
162	8107	3	79.898	31.9639	------	6.09	------
163	8112	3	79.836	31.988	------	1.90	------
164	8113	3	79.8449	31.9917	------	2.74	------
165	8120	1	78.7826	32.0528	------	2.56	------

166	8121	3	79.8263	32.0177	------	5.07	------
167	8125	3	79.8148	32.0267	------	2.96	------
168	8127	1	78.8067	32.0581	------	**12.85**	------
169	8129	3	79.8022	32.0781	------	4.90	------
170	8133	3	79.7728	32.094	------	2.82	------
171	8135	3	79.7973	32.1058	------	2.00	------
172	8136	3	79.8005	32.1067	------	2.68	------
173	8139	3	79.7937	32.1214	------	4.31	------
174	8140	3	79.7692	32.1332	------	3.42	------
175	8146	1	78.9842	32.3006	------	9.68	------
176	8153	3	79.1032	32.3539	------	3.91	------
177	8154	3	79.4051	32.3496	------	5.68	------
178	8157	3	79.5332	32.3701	------	2.41	------
179	8158	3	79.5201	32.3766	------	0.61	------
180	8159	3	79.5082	32.392	------	1.21	------
181	8160	1	78.8161	32.419	------	6.48	------
182	8161	3	79.4771	32.4211	------	0.90	------
183	8162	3	79.2527	32.5067	------	2.72	------
184	8163	3	79.2913	32.5129	------	2.74	------
185	8164	3	79.2972	32.5118	------	1.79	------
186	8192	1	78.8964	32.325	------	2.43	------
187	8193	1	78.9082	32.3336	------	2.46	------
188	8194	1	78.2719	32.3635	------	8.25	------
189	8277	3	78.3294	31.315	------	1.55	------
190	8278	3	78.7592	31.3222	------	2.27	------
191	8279	3	78.7553	31.3232	------	2.51	------
192	8314	1	78.8984	32.3512	------	3.33	------
193	8320	1	77.9427	32.5245	------	3.14	------
194	8353	3	79.7668	30.9975	------	2.75	------
195	8354	3	79.4901	31.0972	------	3.44	------
196	8355	3	79.3187	31.1544	------	1.20	------
197	8356	3	78.7319	31.2011	------	1.56	------
198	8357	3	78.7236	31.2045	------	1.86	------
199	8358	3	79.3063	31.2325	------	3.08	------
200	8359	3	81.2427	31.1527	------	**16.61**	------
201	8360	3	81.2495	31.1609	------	1.23	------
202	8361	3	81.1398	31.1689	------	1.24	------
203	8362	3	81.2566	31.1628	------	4.36	------
204	8363	3	81.2657	31.1677	------	2.76	------
205	8364	3	78.3353	31.2941	------	1.88	------
206	8365	3	78.3264	31.3106	------	1.82	------
207	8366	3	78.3293	31.3117	------	2.47	------
208	8367	3	78.328	31.3138	------	1.86	------
209	8368	3	78.7567	31.3216	------	1.88	------
210	8369	3	81.1291	31.2309	------	**14.93**	------
211	8370	3	78.6626	31.3308	------	1.60	------
212	8371	3	78.6637	31.3327	------	1.84	------
213	8372	3	81.1349	31.247	------	1.20	------
214	8373	2	78.5821	31.3611	------	1.84	------
215	8374	2	78.5807	31.3649	------	1.24	------
216	8375	2	78.5785	31.3672	------	1.61	------
217	8376	3	81.0736	31.2697	------	**14.68**	------
218	8376	3	78.7955	31.3692	------	2.52	------

219	8377	3	80.9917	31.2881	------	8.06	------
220	8378	3	81.0002	31.2933	------	1.54	------
221	8379	2	78.4325	31.5029	------	1.48	------
222	8380	2	78.4334	31.5063	------	3.20	------
223	8381	2	78.6024	31.5747	------	2.17	------
224	8382	2	78.0209	31.6188	------	4.93	------
225	8383	1	78.7024	31.9172	------	1.25	------
226	8384	1	78.4613	31.972	------	**11.57**	------
227	8385	3	79.8561	31.9495	------	2.52	------
228	8386	3	79.892	31.9597	------	1.22	------
229	8387	3	79.8815	31.9656	------	1.76	------
230	8388	3	79.8662	31.9667	------	1.21	------
231	8389	3	78.9259	32.0146	------	1.48	------
232	8390	1	78.7018	32.0358	------	1.56	------
233	8391	3	79.8271	32.0114	------	1.90	------
234	8392	1	78.8632	32.0707	------	1.52	------
235	8393	3	79.7997	32.0587	------	3.12	------
236	8394	3	78.9296	32.0921	------	1.15	------
237	8395	3	78.9352	32.1066	------	1.77	------
238	8396	3	79.7965	32.1275	------	5.11	------
239	8397	1	78.4144	32.1739	------	1.26	------
240	8398	1	78.4111	32.1755	------	1.23	------
241	8399	1	78.4181	32.204	------	4.21	------
242	8400	1	77.7612	32.2423	------	5.08	------
243	8401	3	78.9978	32.224	------	2.15	------
244	8402	3	79.0022	32.3066	------	1.86	------
245	8403	1	78.9932	32.3162	------	3.11	------
246	8404	1	78.8915	32.3879	------	2.47	------
247	8405	3	79.5087	32.3821	------	1.53	------
248	13801	3	80.4	30.5519	------	**37.56**	------
249	1022RS	3	81.1089	30.9237	1.67	2.84	1.17
250	1505RS	3	81.129	30.9222	------	5.36	------
251	202HWL	3	80.5401	31.3978	**85.51**	**44.11**	**-41.40**
252	32HWL	1	78.718	32.3275	------	3.98	------
253	455RS	3	80.7788	31.1086	------	**28.96**	------
254	607RS	3	81.1625	30.9133	------	**35.02**	**35.02**
255	608RS	3	81.0935	30.9256	**7.15**	**24.35**	**17.20**
256	616RS	3	81.1166	30.9241	7.43	14.03	6.60
257	8011SG	3	80.5687	30.4772	------	4.30	------
258	8055SG	3	81.2219	31.11	------	2.76	------
259	96HWL	3	79.599	31.3056	**28.83**	**13.48**	**15.35**

HWL- High Altitude Wetlands
RS- River Section

7.12 Status of lakes as on 01 October 2020

From the analysis of the satellite data for 01 October 2020, it has become possible to delineate 232 lakes in the entire catchment comprising 55 from Spiti, 29 from Lower Satluj and 148 from Upper Satluj sub basin **(Fig.7.12a & 7.12b)**. On analyzing 232 lakes further, it is found that 155 lakes are such which have the area less than 5ha comprising 37 from Spit, 17 from Lower

Satluj and 99 from Upper Satluj basin. Further 45 lakes are such which falls within the areal range of 5-10ha comprising 12 from Spiti, 9 from Lower Satluj and 24 from Upper Satluj basin. Likewise 34 lakes are such which have the area more than 10ha and are considered big lakes comprising 6 from Spiti, 3 from Lower Satluj and 25 from Upper Satluj basin **(Fig. 7.12c).** Besides the 232 lakes, it is found that 14 lakes as the high altitude wetlands comprising 4 wetlands having area less than 5ha, 10 having area more than10ha and all these high altitude wetlands forms part of the Upper Satluj basin (13) and Spiti (1) basin respectively **(Fig. 7.12d).** On analyzing the 246 (2020) lakes with that of lakes that were mapped on 21 October 2019, only 17 lakes could be compared out of which 15 lakes/wetlands have shown an increasing trend in their water spread, whereas 02 lakes/wetlands shown a reducing trend in their water spread with reference to 2019 data **(Table7.12).** 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 2018 due to snow cover impacts or are the new one and thus mapped this year only. The 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 southeaster side downstream of the Mansarover Lake and the Rakas Tal (i.e lakes with 1ds 138 & 145) in the Tibetan Himalayan Region from where the Satluj originates

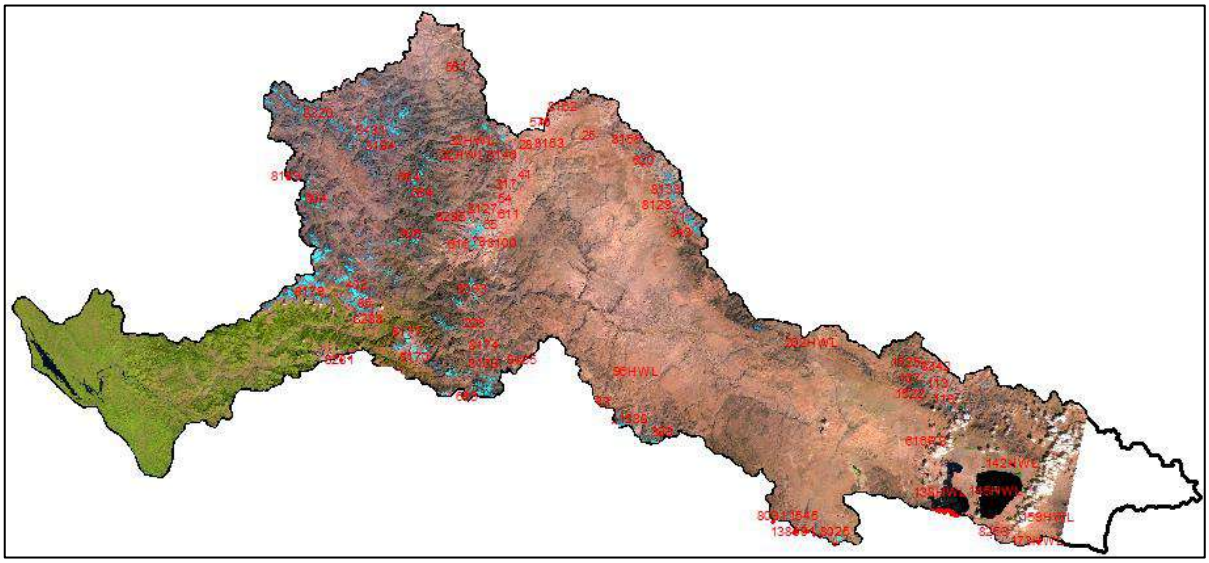


Fig.7.12 (a): IRS-R2-AWiFS-96-47-01-10-2020

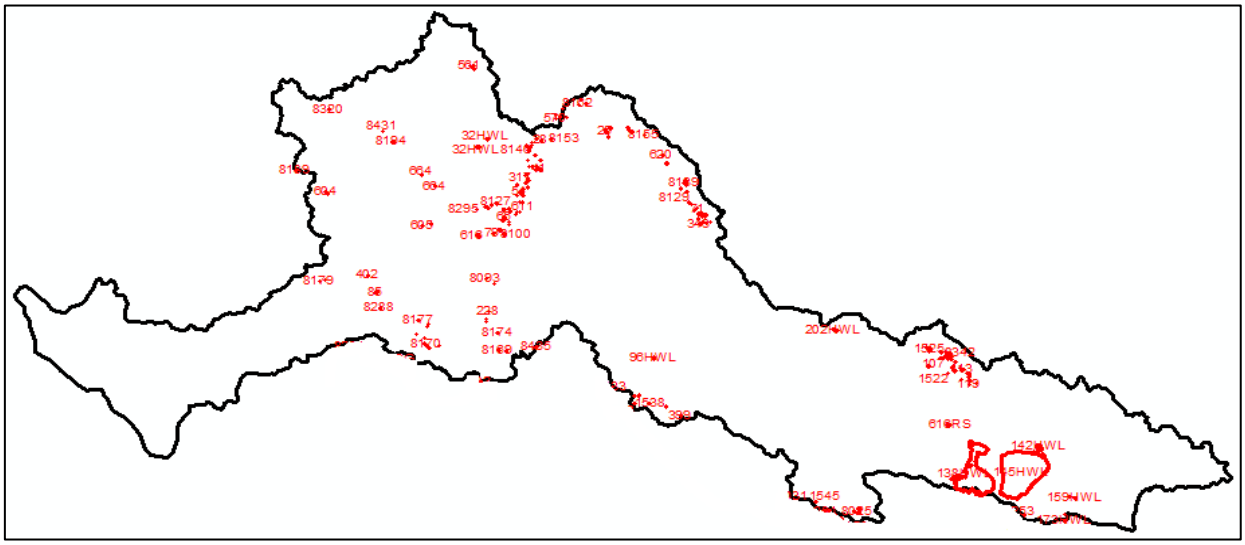


Fig.7.12 (b): IRS-R2-AWiFS-96-47-01-10-2020 Interpreted Layer

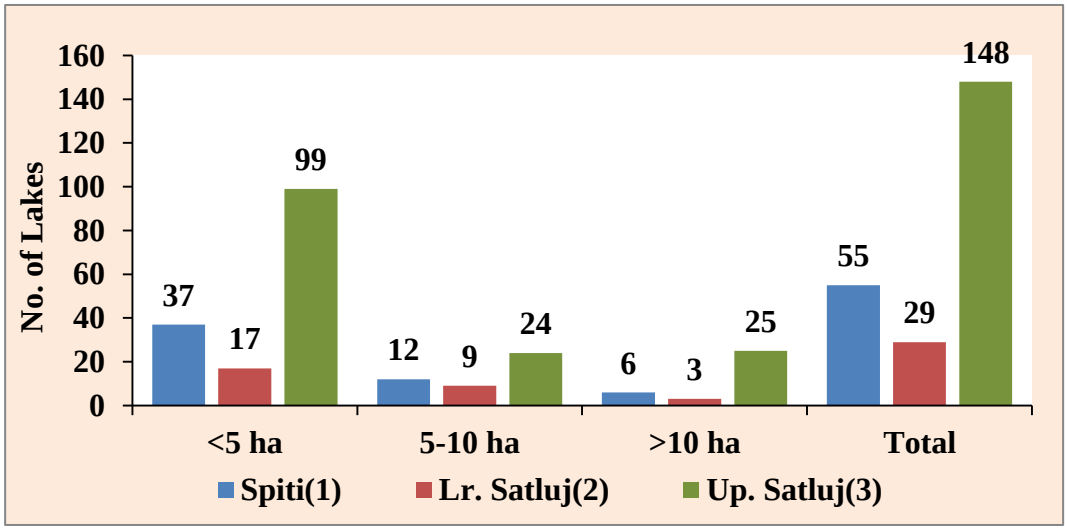


Fig. 7.12 (c): No. of Lakes based on IRS-R2-AWiFS-96-47-01-10-2020

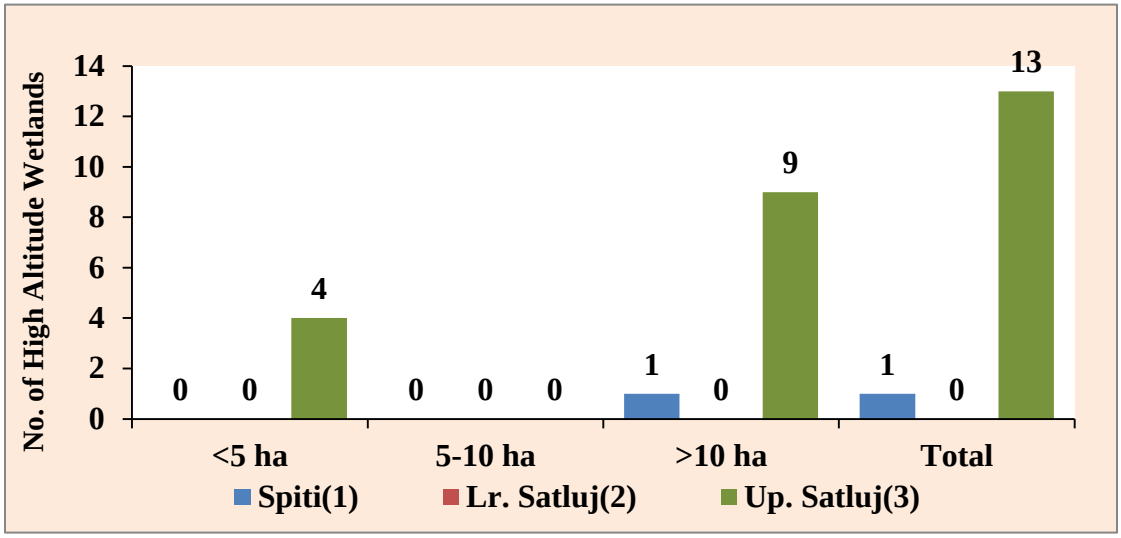


Fig. 7.12 (d): No. High altitude wetlands based on IRS-R2-AWiFS-96-47-01-10-2020

Table: 7.12 Aerial Extent of lakes as on 01 October2020

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 21Oct 2019 (ha.)	Aerial Extent on 01 Oct2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
1	23	3	79.3662	32.3575	**6.77**	**14.00**	**7.23**
2	25	3	79.3421	32.3452	**18.40**	**25.14**	**6.74**
3	28	3	79.0019	32.3136	6.51	7.42	0.91
4	31	1	78.9533	32.305	------	5.83	------
5	41	3	78.9932	32.1752	**17.17**	**24.51**	**7.34**
6	51	1	78.8929	32.0868	------	4.38	------
7	54	1	78.8827	32.0716	------	**10.73**	------
8	55	1	78.8919	32.0715	**5.97**	**10.67**	**4.71**
9	60	1	78.8223	31.9954	------	6.20	------
10	61	1	78.7944	31.9932	**12.64**	**22.37**	**9.73**
11	63	3	78.8261	31.9837	------	2.23	------
12	65	1	78.795	31.9558	**19.53**	**26.58**	**7.05**
13	71	3	79.8059	31.938	------	**11.71**	------
14	72	3	79.817	31.9429	------	8.62	------
15	73	3	79.8263	31.9357	------	3.98	------
16	74	3	79.8202	31.9336	------	5.30	------
17	79	2	78.734	31.8819	------	**22.77**	------
18	85	2	78.1165	31.6209	------	**38.52**	------
19	106	3	81.0354	31.2072	------	3.76	------
20	107	3	81.0156	31.2037	------	4.08	------
21	112	3	81.0801	31.1626	------	**17.14**	------
22	113	3	81.1262	31.1456	------	**51.89**	------
23	114	3	81.0844	31.1418	------	**25.41**	------
24	119	3	81.1601	31.0927	------	8.00	------
25	166	3	81.3549	30.4314	------	6.60	------
26	174	3	81.3578	30.4086	------	8.17	------
27	178	3	81.3573	30.3907	------	**222.56**	------
28	228	2	78.6978	31.514	------	6.50	------

29	312	1	78.9248	32.2917	3.78	6.06	2.28
30	313	1	78.9301	32.2861	16.99	7.57	-9.43
31	315	1	78.9228	32.156	------	4.94	------
32	317	1	78.928	32.1257	------	8.24	------
33	330	1	77.8796	32.0917	------	3.06	------
34	343	3	79.8091	31.89	**27.73**	**31.54**	**3.81**
35	399	3	79.6656	30.9891	**10.31**	**13.41**	**3.11**
36	402	2	78.0755	31.7006	------	4.29	------
37	408	3	78.8604	31.9815	3.27	5.32	2.04
38	414	1	78.9285	32.2241	------	2.15	------
39	415	1	78.9533	32.295	------	1.85	------
40	416	3	79.1387	32.4191	------	2.74	------
41	417	3	79.6526	32.1826	2.42	3.06	0.64
42	422	3	80.9526	31.1697	------	3.45	------
43	424	3	81.1582	31.1124	------	2.54	------
44	448	3	81.3813	30.3979	------	3.74	------
45	559	1	78.6638	32.6785	------	2.74	------
46	561	1	78.6435	32.6762	------	6.88	------
47	562	1	78.9678	32.2433	------	2.79	------
48	563	1	78.9339	32.1912	------	2.15	------
49	570	3	79.0821	32.4136	------	4.96	------
50	571	3	79.0824	32.4305	------	3.41	------
51	592	3	79.7499	32.0834	------	2.79	------
52	604	1	77.8688	32.0998	------	3.37	------
53	605	2	78.3672	31.9278	------	8.14	------
54	607	3	81.0651	31.2089	------	5.95	------
55	610	1	78.864	32.0579	------	4.25	------
56	611	1	78.892	32.0242	3.54	6.72	3.18
57	616	1	78.6518	31.8751	------	6.48	------
58	620	3	79.6311	32.2214	2.74	4.87	2.14
59	622	3	81.0179	31.2363	------	2.20	------
60	632	3	79.3065	31.1035	------	4.34	------
61	634	3	81.0745	31.2099	------	3.73	------
62	636	3	81.0418	31.2339	------	6.23	------
63	640	1	78.9203	32.094	------	3.08	------
64	641	3	79.8392	31.9243	------	2.95	------
65	645	3	81.0228	31.23	------	6.53	------
66	646	3	81.0493	31.2271	------	2.19	------
67	647	3	81.0501	31.2242	------	4.09	------
68	648	3	81.0566	31.201	------	2.82	------
69	649	3	81.0623	31.2079	------	3.69	------
70	663	3	79.2822	31.1129	------	4.33	------
71	664	1	78.4402	32.1129	------	7.10	------
72	664	1	78.3709	32.1686	------	4.47	------
73	683	2	78.6415	31.184	------	8.14	------
74	817	3	79.8629	31.8993	------	0.86	------
75	818	3	79.8452	31.8927	------	1.58	------
76	825	3	81.0466	31.2137	------	1.25	------
77	827	3	81.071	31.1576	------	8.57	------
78	828	2	78.2749	31.2727	------	1.31	------
79	884	3	79.8342	31.9333	------	4.00	------
80	885	3	79.8266	31.8973	------	3.01	------
81	1007	3	81.3382	30.4206	------	1.84	------

82	1008	3	81.3352	30.4165	------	2.54	------
83	1030	3	81.1113	31.1526	------	1.88	------
84	1038	3	79.7473	32.0925	------	2.51	------
85	1049	2	78.6814	31.4788	------	3.76	------
86	1052	3	80.5298	30.5031	------	5.26	------
87	1053	3	80.5242	30.4347	------	**15.76**	------
88	1518	3	81.1583	31.1243	------	1.55	------
89	1519	3	81.1482	31.1278	------	2.88	------
90	1522	3	81.0488	31.131	------	3.49	------
91	1524	3	80.9663	31.2566	------	5.34	------
92	1525	3	80.9659	31.2485	------	**17.41**	------
93	1531	3	78.8186	31.9334	------	7.03	------
94	1532	3	78.8172	31.9207	------	3.15	------
95	1538	3	79.5065	31.0533	------	5.41	------
96	1545	3	80.3353	30.5562	------	5.00	------
97	1546	3	79.4527	31.092	------	4.63	------
98	1575	1	78.6952	32.011	------	0.95	------
99	1606	1	78.9763	32.1898	------	6.75	------
100	8010	3	81.3872	30.3898	------	**20.34**	------
101	8015	3	81.3398	30.4133	------	1.26	------
102	8020	3	80.4631	30.4703	------	3.09	------
103	8021	3	80.4644	30.4728	------	1.83	------
104	8024	3	80.4325	30.4935	------	0.96	------
105	8025	3	80.5524	30.4975	------	**31.42**	------
106	8026	3	80.3824	30.5124	------	3.77	------
107	8026	3	79.7585	31.9952	------	1.57	------
108	8027	3	80.4043	30.5116	------	8.42	------
109	8027	3	79.2229	32.4965	------	1.50	------
110	8028	1	78.9231	32.1355	------	1.84	------
111	8029	3	80.5618	30.5123	------	1.87	------
112	8031	3	80.2225	30.5651	------	**12.78**	------
113	8037	3	79.3504	31.0199	------	5.35	------
114	8038	3	79.3537	31.0195	------	6.78	------
115	8040	3	79.5903	31.0322	------	2.66	------
116	8041	3	79.5895	31.034	------	2.17	------
117	8044	3	79.4309	31.0572	------	3.74	------
118	8055	3	81.1563	31.0731	------	3.58	------
119	8057	3	81.1921	31.0795	------	4.95	------
120	8062	3	81.1158	31.1003	------	2.78	------
121	8065	3	81.1547	31.111	------	8.66	------
122	8076	3	81.0913	31.1822	------	4.68	------
123	8076	3	81.0774	31.1948	------	0.93	------
124	8079	3	81.0695	31.1978	------	**12.19**	------
125	8086	3	80.9469	31.2587	------	3.08	------
126	8087	2	78.4358	31.3604	------	1.81	------
127	8091	2	78.6786	31.4682	------	1.25	------
128	8093	2	78.689	31.6706	------	3.06	------
129	8095	1	78.6598	31.8692	------	1.24	------
130	8097	3	78.766	31.8964	------	6.55	------
131	8099	3	78.7723	31.8962	------	1.48	------
132	8100	3	78.7908	31.8768	------	**31.27**	------
133	8102	3	78.7689	31.8929	------	1.78	------
134	8105	3	78.7872	31.9433	------	**11.20**	------

135	8106	3	79.8221	31.9215	------	2.52	------
136	8107	3	79.8433	31.9298	------	7.08	------
137	8108	3	78.8519	31.9677	------	1.26	------
138	8112	3	79.7818	31.9537	------	2.15	------
139	8113	3	79.7908	31.9578	------	3.08	------
140	8116	3	79.7998	31.9665	------	1.83	------
141	8117	1	78.7082	32.0057	------	2.17	------
142	8118	1	78.7117	32.0045	------	1.59	------
143	8119	1	78.7085	32.0031	------	1.80	------
144	8120	1	78.7326	32.0168	------	1.79	------
145	8124	1	78.8771	32.0276	------	2.10	------
146	8125	3	79.7723	31.9839	------	3.40	------
147	8125	3	79.7565	31.994	------	2.59	------
148	8127	1	78.7567	32.0222	------	**11.07**	------
149	8129	3	79.7489	32.0447	------	3.39	------
150	8130	1	78.9008	32.0844	------	1.57	------
151	8132	1	78.8975	32.087	------	1.24	------
152	8133	3	79.7197	32.0607	------	3.69	------
153	8136	3	79.7471	32.0734	------	4.30	------
154	8137	1	78.8687	32.1065	------	4.11	------
155	8138	1	78.9126	32.1143	------	1.62	------
156	8139	3	79.7396	32.0884	------	7.94	------
157	8140	3	79.7458	32.0972	------	3.14	------
158	8141	1	78.9107	32.1503	------	2.13	------
159	8142	1	78.9697	32.1737	------	2.43	------
160	8144	1	78.9481	32.1898	------	0.91	------
161	8145	1	78.9563	32.1901	------	2.76	------
162	8146	1	78.9358	32.2667	------	**14.07**	------
163	8153	3	79.0542	32.3207	------	1.60	------
164	8154	3	79.3552	32.3172	------	4.27	------
165	8155	3	79.5427	32.3203	------	4.56	------
166	8157	3	79.4825	32.3382	------	3.02	------
167	8159	3	79.4573	32.36	------	2.76	------
168	8162	3	79.2048	32.4742	------	4.83	------
169	8163	3	79.2431	32.4809	------	2.53	------
170	8164	3	79.2485	32.4798	------	0.92	------
171	8169	3	78.7403	31.3297	------	3.77	------
172	8170	2	78.3806	31.3501	------	1.21	------
173	8170	2	78.3679	31.3629	------	3.72	------
174	8171	2	78.3573	31.3708	------	1.53	------
175	8172	2	78.3571	31.3973	------	2.74	------
176	8173	2	78.3163	31.4182	------	1.46	------
177	8174	2	78.7394	31.4099	------	9.17	------
178	8175	2	78.3764	31.4504	------	1.55	------
179	8176	2	78.3805	31.4627	------	3.44	------
180	8177	2	78.3305	31.4824	------	6.72	------
181	8179	2	77.8226	31.6788	------	1.57	------
182	8182	2	77.8545	31.6822	------	1.36	------
183	8188	3	79.7436	32.0945	------	3.08	------
184	8189	1	77.717	32.2059	------	3.80	------
185	8194	1	78.2271	32.3294	------	**11.18**	------
186	8198	1	78.6663	32.6631	------	3.63	------
187	8200	1	78.6614	32.6755	------	2.11	------

188	8253	3	81.3996	30.4425	------	2.72	------
189	8254	3	81.4006	30.4477	------	0.94	------
190	8258	3	81.6346	30.5212	------	4.79	------
191	8279	3	78.7774	31.3235	------	1.28	------
192	8281	2	77.9758	31.367	------	5.30	------
193	8283	2	78.0173	31.3784	------	1.89	------
194	8288	2	78.1354	31.5449	------	8.41	------
195	8295	1	78.6533	31.9995	------	1.50	------
196	8310	3	78.9948	32.2179	------	1.83	------
197	8320	1	77.8993	32.4905	------	5.21	------
198	8342	3	81.0647	31.2242	------	**12.73**	------
199	8365	2	78.2766	31.2707	------	5.91	------
200	8384	2	78.4128	31.9349	------	9.40	------
201	8385	3	79.8006	31.9154	------	1.86	------
202	8389	3	78.8757	31.9786	------	1.26	------
203	8425	3	81.6035	30.4372	------	3.35	------
204	8426	3	79.4698	32.3445	------	1.23	------
205	8427	3	79.458	32.3502	------	3.33	------
206	8428	3	79.1039	32.4222	------	1.20	------
207	8429	3	79.1231	32.4597	------	2.19	------
208	8430	1	78.6533	32.6726	------	3.69	------
209	8431	1	78.1752	32.381	------	3.64	------
210	8432	3	79.2989	31.1101	------	1.83	------
211	8433	3	79.3209	31.1382	------	6.24	------
212	8434	3	80.9622	31.2407	------	1.81	------
213	8435	3	78.9369	31.3387	------	5.86	------
214	8436	2	78.7296	31.643	------	1.84	------
215	8437	3	81.3899	30.3873	------	1.90	------
216	8438	3	80.4912	31.357	------	3.68	------
217	8439	3	80.5485	30.5135	------	2.50	------
218	8440	1	78.9442	32.2826	------	1.52	------
219	8441	1	78.7021	32.0066	------	0.65	------
220	8442	3	78.77	31.8956	------	1.93	------
221	8443	1	78.9769	32.3221	------	7.57	------
222	138001	3	80.3313	30.5111	------	**34.19**	------
223	205HWL	3	81.4925	30.7502	------	3.82	------
224	206HWL	3	81.4956	30.7513	------	1.36	------
225	1022RS	3	81.0383	30.8859	------	1.89	------
226	138HWL	3	81.1599	30.6493	------	**25769.70**	------
227	142HWL	3	81.494	30.7632	------	**311.48**	------
228	145HWL	3	81.3959	30.6463	------	**42113.10**	------
229	148HWL	3	81.509	30.7235	------	**86.71**	------
230	159HWL	3	81.6632	30.5107	------	**12.75**	------
231	173HWL	3	81.6001	30.4085	------	**10.06**	------
232	202HWL	3	80.4762	31.3622	------	**44.58**	------
233	207HWL	3	81.482	30.7433	------	3.21	------
234	210HWL	3	81.4804	30.7335	------	**52.23**	------
235	32HWL	1	78.6712	32.2931	**28.64**	**33.54**	**4.90**
236	385HWL	3	81.4646	30.74	------	4.08	------
237	608RS	3	81.0299	30.8874	------	3.99	------
238	616RS	3	81.0454	30.8866	------	**14.30**	------
239	62SG	3	78.8246	31.9807	------	**12.75**	------
240	635SG	2	78.2016	31.2985	------	**14.98**	------

241	8011SG	3	80.5003	30.4351	------	2.76	------
242	8047SG	3	79.4312	31.0914	------	4.01	------
243	8122SG	1	78.8968	32.0568	------	2.78	------
244	8245RS	3	81.0343	30.8861	------	1.56	------
245	96HWL	3	79.5396	31.2659	**35.05**	**18.60**	**-16.45**
246	8188	3	79.7436	32.0945	------	3.08	------

HWL- High Altitude Wetlands
RS- River Section

7.13. Status of lakes as on 16 October 2020

From the analysis of satellite data for 16 October 2020, it is found that most of the area is free from any cloud cover impact and is clearly visible as a result of which 234 lakes and 54 high altitude wetlands could be mapped in the entire catchment. Further distribution of 234 lakes suggests that 35 from Spiti basin, 28 from Lower Satluj and 171 from Upper Satluj sub basin **(Fig. 7.13a &7.13b).** When these 234 lakes are further classified with reference to the areal distribution, it is found that 135 lakes are having area less than 5ha,42 lakes are within the aerial range 5-10 ha and 57 lakes are the big one having area more than 10ha, **(Fig.7.13c & Table 7.13).** Distribution 54 wetlands suggest that 30 wetlands are less than 5ha, 10 are within5-10ha and 14 are the big one with area more than 10ha **(Fig 7.13d).** Further only 19 lakes could be seen temporally out of which 14 lake/wetland is showing an increasing trend whereas the 5 is showing a reducing trend **(Table 7.13).**

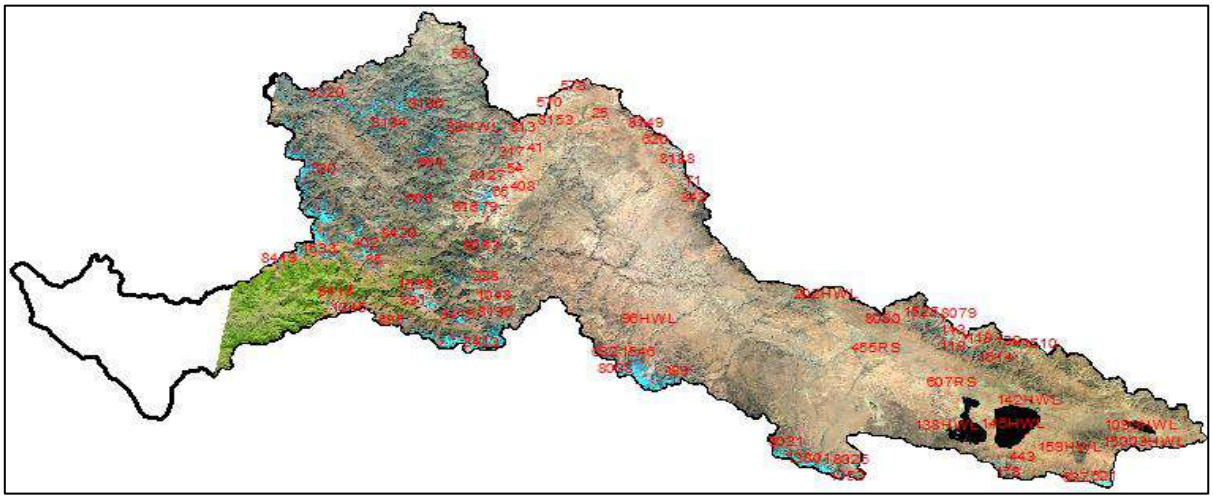


Fig.7.13 (a): IRS-R2-AWiFS-99-46-16-10-2020

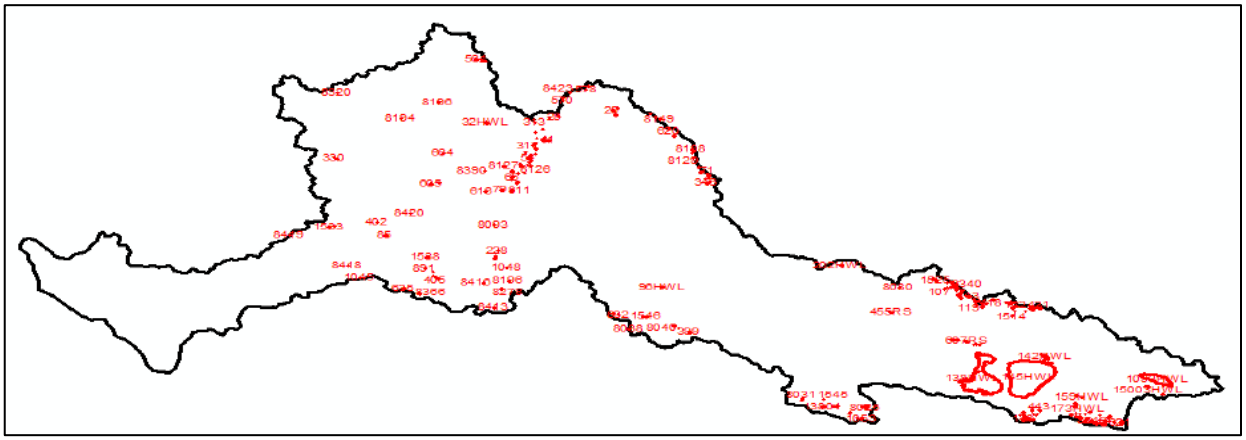


Fig.7.13 (b): IRS-R2-AWiFS-99-46-16-10-2020 Interpreted Layer

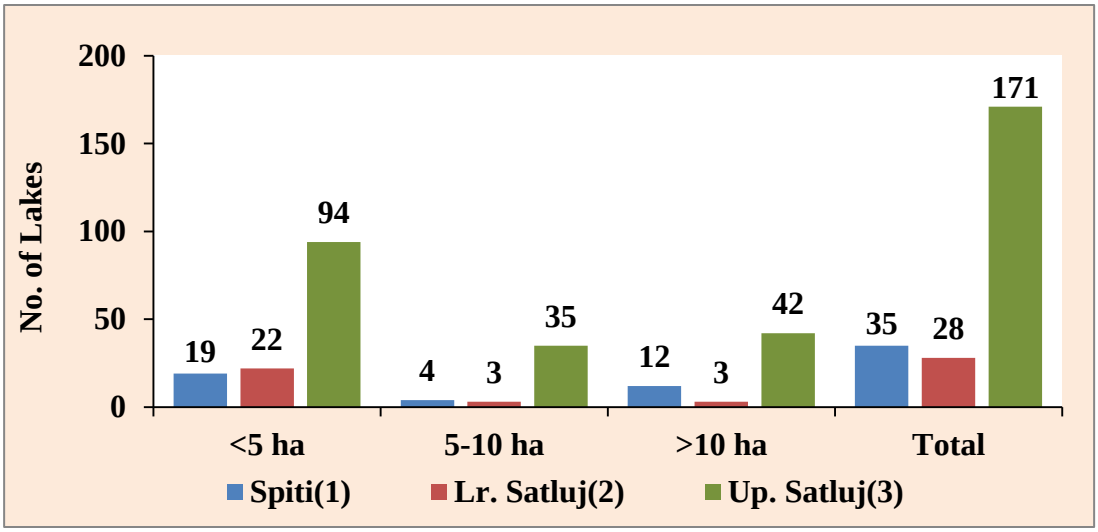


Fig. 7.13 (c): No. of Lakes based on IRS-R2-AWiFS-99-46-16-10-2020

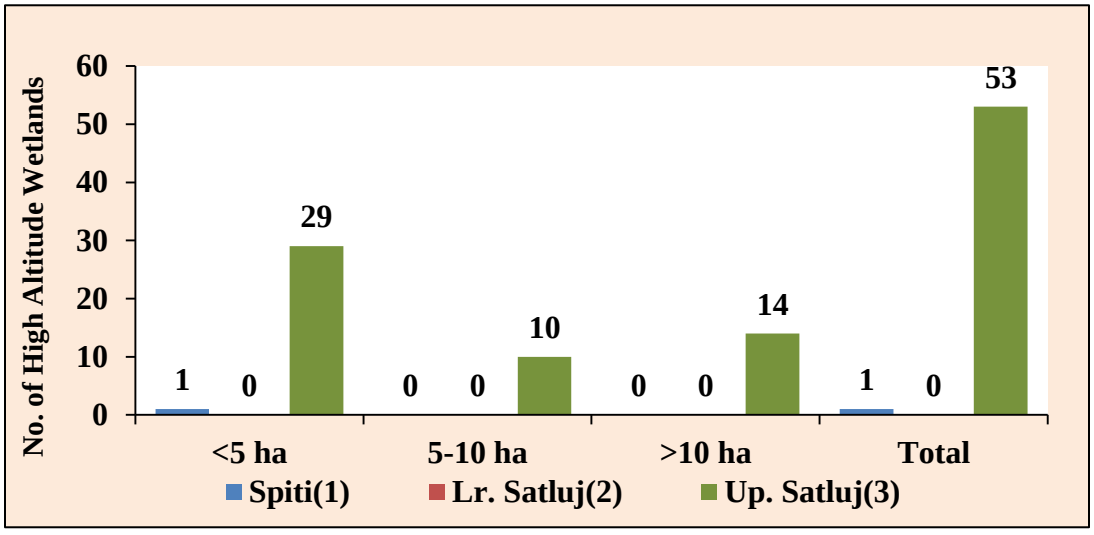


Fig. 7.13 (d): No. of High altitude wetlands based on IRS-R2-AWiFS-99-46-16-10-2020

Table: 7.13 Aerial Extent of lakes as on 16 October 2020

Sr. No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 21 Oct 2019 (ha.)	Aerial Extent on 16 Oct2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
1	23	3	79.4173	32.3915	6.77	8.68	1.91
2	25	3	79.393	32.3793	**18.40**	**26.31**	**7.91**
3	28	3	79.0541	32.3482	6.51	5.05	-1.46
4	39	3	79.0272	32.2261	6.84	8.76	1.92
5	40	3	79.02	32.2102	------	2.97	------
6	41	3	79.0451	32.2111	**17.17**	**24.39**	**7.22**
7	51	3	78.9431	32.1242	------	5.70	------
8	54	3	78.9328	32.1094	------	11.27	------
9	55	3	78.9425	32.1094	5.97	9.53	3.56
10	61	1	78.8449	32.0311	**12.64**	**22.57**	**9.93**
11	62	1	78.875	32.0187	**------**	**12.15**	**------**
12	65	1	78.8454	31.994	**19.53**	**25.33**	**5.80**
13	71	3	79.872	31.9793	------	9.05	------
14	73	3	79.8817	31.9717	------	4.40	------
15	74	3	79.8756	31.97	------	4.17	------
16	79	3	78.7835	31.9207	------	**22.74**	------
17	85	2	78.1674	31.6628	------	**44.38**	------
18	106	3	81.1038	31.2449	------	7.30	------
19	107	3	81.0848	31.2418	------	5.11	------
20	112	3	81.1487	31.2008	------	**19.94**	------
21	113	3	81.1959	31.1841	------	**52.04**	------
22	114	3	81.1531	31.1804	------	**31.72**	------
23	118	3	81.2808	31.1386	------	**24.40**	------
24	119	3	81.2287	31.1313	------	**10.88**	------
25	122	3	81.4362	31.1163	------	**10.94**	------
26	166	3	81.4308	30.4733	------	7.16	------
27	174	3	81.4341	30.4504	------	5.75	------
28	178	3	81.4337	30.4327	------	**208.19**	------
29	181	3	81.4633	30.4319	**------**	**18.80**	**------**
30	183	3	81.8713	30.4289	------	**27.89**	------
31	193	3	81.8669	30.4005	------	**14.18**	------
32	196	3	81.895	30.3925	**------**	**11.92**	**------**
33	228	2	78.7516	31.5555	------	9.22	------
34	312	1	78.9732	32.3269	3.78	7.81	4.03
35	313	1	78.9798	32.3212	**16.99**	**11.70**	**-5.29**
36	315	1	78.9727	32.1931	------	3.90	------
37	317	3	78.9784	32.163	------	8.62	------
38	319	3	78.8386	31.9807	------	**11.20**	------
39	330	1	77.9164	32.138	------	4.14	------
40	343	1	79.8649	31.9266	**27.73**	**33.98**	**6.25**
41	399	3	79.7313	31.0303	**10.31**	**17.24**	**6.93**
42	402	2	78.1257	31.7419	------	4.10	------
43	404	2	78.4076	31.4145	------	1.73	------
44	405	2	78.419	31.4062	------	3.32	------
45	408	3	78.911	32.02	3.27	4.39	1.12
46	412	1	78.9609	32.1873	------	2.40	------
47	414	1	78.9765	32.2603	------	2.40	------
48	417	3	79.7074	32.2168	2.42	2.16	-0.26

49	422	3	81.0701	31.2358	------	1.84	------
50	423	3	81.1602	31.2202	------	7.52	------
51	424	3	81.2236	31.1503	------	**19.23**	------
52	426	3	81.505	31.0963	------	7.56	------
53	427	3	81.3846	31.1401	------	8.82	------
54	431	3	81.5045	31.1139	------	8.58	------
55	432	3	81.52	31.0844	------	2.20	------
56	443	3	81.5145	30.4832	------	7.31	------
57	445	3	81.4834	30.4637	------	4.25	------
58	448	3	81.4578	30.4395	------	3.97	------
59	559	1	78.7079	32.7132	------	3.97	------
60	561	1	78.6882	32.7103	------	4.67	------
61	562	3	79.0176	32.2785	------	3.28	------
62	563	1	78.9835	32.2276	------	2.36	------
63	564	3	78.9481	32.1246	------	1.44	------
64	570	3	79.1316	32.4483	------	3.91	------
65	571	3	79.1309	32.465	------	2.95	------
66	574	3	79.2723	32.5298	------	2.43	------
67	578	3	79.2547	32.5085	------	3.84	------
68	579	1	78.9189	32.1441	------	3.87	------
69	592	3	79.8046	32.1183	------	3.29	------
70	604	1	77.9263	32.13	------	3.91	------
71	605	1	78.417	31.9665	------	7.97	------
72	607	3	81.1345	31.2469	------	4.06	------
73	610	3	78.948	32.0944	------	5.10	------
74	611	3	78.9437	32.062	3.54	8.39	4.85
75	616	1	78.6989	31.9142	------	**11.40**	------
76	620	3	79.6835	32.256	2.74	5.09	2.35
77	621	3	81.9302	30.3864	------	**81.73**	------
78	622	3	81.0856	31.274	------	3.35	------
79	625	3	79.877	31.958	------	5.80	------
80	632	3	79.3661	31.1456	------	8.23	------
81	635	2	78.2502	31.342	------	**23.86**	------
82	636	3	81.1106	31.2712	------	3.93	------
83	637	3	81.8419	30.3864	------	**19.65**	------
84	638	3	81.8313	30.3825	------	4.31	------
85	639	3	78.973	32.1725	------	1.21	------
86	640	3	78.9711	32.1312	------	2.40	------
87	646	3	81.1175	31.2657	------	1.87	------
88	647	3	81.1181	31.262	------	3.09	------
89	648	3	81.1259	31.2396	------	4.51	------
90	649	3	81.1316	31.2459	------	4.24	------
91	651	3	81.402	31.1292	------	6.16	------
92	652	3	81.4258	31.1389	------	5.17	------
93	655	3	81.5144	31.101	------	6.41	------
94	656	3	81.5323	31.0969	------	1.57	------
95	657	3	81.547	31.1046	------	3.70	------
96	663	3	79.3418	31.1553	------	4.43	------
97	664	1	78.4838	32.1454	------	2.42	------
98	664	1	78.4891	32.1508	------	8.41	------
99	810	3	78.9517	32.1214	------	1.16	------
100	811	3	78.8388	31.916	------	**28.37**	------
101	825	3	81.1148	31.2518	------	1.49	------

102	827	3	81.1393	31.1959	------	**10.34**	------
103	828	3	81.1551	31.2105	------	3.38	------
104	849	3	81.4995	30.461	------	2.79	------
105	885	3	79.882	31.9343	------	2.12	------
106	891	2	78.3657	31.461	------	4.37	------
107	895	3	81.8434	30.3811	------	4.29	------
108	1004	3	81.5148	30.4787	------	4.29	------
109	1005	3	81.4806	30.4294	------	1.52	------
110	1007	3	81.4145	30.4619	------	1.58	------
111	1008	3	81.4115	30.4585	------	1.85	------
112	1030	3	81.1796	31.1913	------	2.16	------
113	1038	3	79.8014	32.127	------	2.60	------
114	1039	3	79.5949	32.3542	------	4.75	------
115	1040	3	79.59	32.3546	------	5.64	------
116	1042	3	78.9374	32.0837	------	**12.97**	------
117	1045	2	78.0249	31.4111	------	8.56	------
118	1048	2	78.7946	31.4518	**4.84**	**16.38**	**11.54**
119	1049	2	78.7359	31.5208	------	3.79	------
120	1052	3	80.5986	30.5472	------	**11.79**	------
121	1053	3	80.5934	30.4789	------	**14.74**	------
122	1133	3	81.8684	30.4209	------	**20.92**	------
123	1142	3	81.7755	30.4028	------	1.23	------
124	1142	3	81.7749	30.4055	------	1.25	------
125	1149	3	81.7701	30.3986	------	4.59	------
126	1509	3	81.5522	31.0956	------	1.20	------
127	1510	3	81.562	31.0959	------	2.75	------
128	1511	3	81.4272	31.086	------	1.82	------
129	1514	3	81.4086	31.0571	------	4.51	------
130	1515	3	81.4181	31.1039	------	8.65	------
131	1519	3	81.2171	31.1657	------	4.83	------
132	1524	3	81.0338	31.2943	------	3.98	------
133	1525	3	81.0324	31.2867	------	**17.14**	------
134	1530	3	79.0103	32.2168	------	2.40	------
135	1532	3	78.8667	31.9598	------	3.87	------
136	1533	2	77.8704	31.721	------	3.33	------
137	1534	2	77.903	31.723	------	3.29	------
138	1536	2	78.0652	31.422	------	2.73	------
139	1537	2	78.4065	31.4401	------	1.81	------
140	1538	2	78.3782	31.5254	------	9.62	------
141	1545	3	80.404	30.5997	------	5.62	------
142	1546	3	79.5138	31.1335	------	4.48	------
143	8006	3	81.7963	30.3943	------	1.23	------
144	8010	3	81.4665	30.4294	------	2.14	------
145	8018	3	81.4932	30.4565	------	2.19	------
146	8020	3	80.533	30.5137	------	4.23	------
147	8025	3	80.6214	30.541	------	**32.55**	------
148	8026	3	80.4511	30.5565	------	4.65	------
149	8027	3	80.4738	30.5559	------	**12.34**	------
150	8029	3	80.6322	30.5558	------	1.80	------
151	8030	3	80.6176	30.5581	------	1.48	------
152	8031	3	80.2925	30.6056	------	**27.01**	------
153	8037	3	79.4119	31.0629	------	4.21	------
154	8038	3	79.415	31.062	------	7.34	------

155	8040	3	79.6511	31.0743	------	1.83	------
156	8040	3	79.6546	31.0759	------	1.17	------
157	8047	3	79.4918	31.1332	------	2.39	------
158	8051	3	81.4827	31.0825	------	2.77	------
159	8054	3	81.5312	31.0945	------	1.56	------
160	8056	3	81.4139	31.1062	------	1.78	------
161	8057	3	81.2598	31.118	------	7.72	------
162	8058	3	81.4238	31.1158	------	4.76	------
163	8059	3	81.2645	31.1249	------	1.22	------
164	8063	3	81.2592	31.1405	------	6.37	------
165	8064	3	81.4148	31.1354	------	4.49	------
166	8066	3	81.4088	31.1465	------	1.80	------
167	8074	3	81.1302	31.2214	------	1.20	------
168	8079	3	81.1386	31.2362	------	11.83	------
169	8080	3	80.8336	31.2541	------	2.74	------
170	8091	2	78.7327	31.5099	------	1.83	------
171	8093	2	78.7386	31.7118	------	3.29	------
172	8111	1	78.8764	32.022	------	4.13	------
173	8112	3	79.8362	31.9903	------	4.23	------
174	8113	3	79.8455	31.9942	------	2.38	------
175	8121	3	79.8266	32.0201	------	4.86	------
176	8123	1	78.8871	32.0737	------	**14.26**	------
177	8124	3	78.9285	32.0649	------	1.76	------
178	8126	1	78.8986	32.0582	------	**16.69**	------
179	8127	1	78.8065	32.0603	------	**14.58**	------
180	8129	3	79.8031	32.0801	------	6.17	------
181	8135	3	79.7982	32.107	------	1.83	------
182	8149	3	79.6382	32.3186	------	7.55	------
183	8153	3	79.1034	32.356	------	4.63	------
184	8154	3	79.4059	32.3515	------	4.49	------
185	8169	3	81.0136	31.2969	------	5.85	------
186	8188	3	79.7978	32.1294	------	6.79	------
187	8194	1	78.2737	32.3661	------	**11.28**	------
188	8196	3	78.7985	31.3714	------	2.76	------
189	8196	1	78.4733	32.4588	------	**11.58**	------
190	8249	3	81.8537	30.3999	------	**31.98**	------
191	8253	3	81.4759	30.4834	------	6.67	------
192	8254	3	81.4766	30.489	------	0.91	------
193	8258	3	81.7118	30.5614	------	2.44	------
194	8278	2	78.7609	31.3242	------	1.19	------
195	8320	1	77.9425	32.5273	------	3.25	------
196	8323	1	78.7097	32.6974	------	2.46	------
197	8324	1	78.7188	32.7001	------	1.33	------
198	8325	1	78.7333	32.7001	------	2.08	------
199	8335	3	79.3584	31.1526	------	1.54	------
200	8340	3	81.1311	31.2329	------	**14.58**	------
201	8342	3	81.1339	31.2623	------	**12.22**	------
202	8352	3	79.6207	32.3287	------	1.78	------
203	8359	3	81.2445	31.1547	------	**14.57**	------
204	8365	2	78.3261	31.3087	------	1.20	------
205	8366	2	78.3291	31.3138	------	3.24	------
206	8384	1	78.4598	31.974	------	9.96	------
207	8385	3	79.8564	31.9519	------	1.49	------

208	8390	1	78.7008	32.038	------	3.38	------
209	8406	3	81.7017	30.4961	------	1.88	------
210	8407	3	81.8394	30.3931	------	1.60	------
211	8408	3	82.1573	30.5448	------	3.97	------
212	8410	3	79.677	31.0564	------	1.82	------
213	8411	3	79.5072	31.1318	------	1.79	------
214	8412	2	78.7194	31.2123	------	1.17	------
215	8413	2	78.7159	31.2128	------	1.75	------
216	8414	3	81.3203	31.1596	------	**13.38**	------
217	8415	2	78.3303	31.3015	------	2.41	------
218	8416	2	78.6675	31.3626	------	1.52	------
219	8417	2	78.4332	31.3929	------	1.22	------
220	8418	2	77.9606	31.4834	------	1.50	------
221	8419	2	77.6608	31.6763	------	4.42	------
222	8420	2	78.3018	31.7924	------	2.78	------
223	8421	3	78.8707	31.9638	------	8.19	------
224	8422	1	78.8922	32.066	------	**11.95**	------
225	8423	3	79.1726	32.4934	------	1.73	------
226	8424	1	78.6811	32.7091	------	0.91	------
227	13801	3	80.4025	30.5546	------	**40.99**	------
228	18701	3	81.8489	30.3888	------	6.78	------
229	18901	3	81.8194	30.3919	------	**13.50**	------
230	1001HWL	3	81.7493	30.4492	------	1.35	------
231	1013HWL	3	81.5256	30.7779	------	1.55	------
232	1474HWL	3	81.5666	30.7683	------	8.66	------
233	184HWL	3	81.7224	30.4225	------	**16.98**	------
234	385HWL	3	81.5389	30.7796	------	2.46	------
235	436HWL	3	81.6953	30.4993	------	1.84	------
236	438HWL	3	81.7414	30.4039	------	3.67	------
237	439HWL	3	81.7228	30.4301	------	3.31	------
238	440HWL	3	81.7211	30.4498	------	7.71	------
239	441HWL	3	81.6993	30.4561	------	2.37	------
240	442HWL	3	81.6976	30.4325	------	3.72	------
241	8011SG	3	80.569	30.48	------	3.25	------
242	8016HWL	3	81.6998	30.4409	------	1.78	------
243	8035HWL	3	81.2013	30.8945	------	1.85	------
244	1012HWL	3	81.5437	30.8198	------	1.90	------
245	1015HWL	3	81.2335	30.8928	------	1.84	------
246	1015HWL	3	81.2311	30.8936	------	1.90	------
247	1018HWL	3	81.2122	30.8957	------	1.28	------
248	1019HWL	3	81.2077	30.8963	------	1.93	------
249	1022RS	3	81.1104	30.9258	------	3.21	------
250	1093HWL	3	82.1351	30.6391	------	**5953.51**	------
251	1124HWL	3	81.8218	30.4399	------	3.15	------
252	1136HWL	3	81.7784	30.4127	------	8.94	------
253	138HWL	3	81.2337	30.6896	------	**25923.20**	------
254	142HWL	3	81.5675	30.8028	------	**343.56**	------
255	145HWL	3	81.4723	30.6863	------	**41785.60**	------
256	148HWL	3	81.5834	30.7629	------	**111.22**	------
257	15002HWL	3	82.0726	30.5979	------	9.03	------
258	15003HWL	3	82.0844	30.5932	------	**11.87**	------
259	159HWL	3	81.7413	30.5507	------	**14.37**	------
260	173HWL	3	81.6765	30.4499	------	8.46	------

261	179HWL	3	81.7145	30.4314	------	**21.96**	------
262	185001HWL	3	81.747	30.4108	------	8.57	------
263	187004HWL	3	81.7851	30.4024	------	6.77	------
264	202HWL	3	80.5417	31.4001	------	**41.19**	------
265	205HWL	3	81.5667	30.7892	------	4.63	------
266	206HWL	3	81.5701	30.7908	------	1.78	------
267	207HWL	3	81.5563	30.7828	------	3.06	------
268	209HWL	3	81.5417	30.7746	------	**29.43**	------
269	210HWL	3	81.5547	30.7728	------	**64.12**	------
270	211HWL	3	81.7023	30.5164	------	8.93	------
271	32HWL	1	78.7216	32.3299	6.26	4.83	-1.43
272	437HWL	3	81.6931	30.4983	------	2.12	------
273	455RS	3	80.7808	31.1107	------	**28.07**	------
274	607RS	3	81.1638	30.9153	------	**38.36**	------
275	608RS	3	81.098	30.9273	------	**28.95**	------
276	616RS	3	81.1182	30.9264	------	**20.35**	------
277	677HWL	3	81.7077	30.5036	------	1.84	------
278	688HWL	3	81.8212	30.4104	------	7.21	------
279	8008HWL	3	81.7781	30.4002	------	1.19	------
280	839HWL	3	81.8014	30.3903	------	**12.62**	------
281	839HWL	3	81.8046	30.393	------	3.06	------
282	8409HWL	3	81.1989	30.8942	------	1.27	------
283	840HWL	3	81.79	30.3943	------	5.52	------
284	840HWL	3	81.7934	30.3981	------	4.52	------
285	842HWL	3	81.7639	30.4221	------	3.96	------
286	844HWL	3	81.7717	30.4606	------	3.32	------
287	865HWL	3	81.7759	30.4007	------	4.35	------
288	96HWL	3	79.6011	31.3075	**35.05**	**14.30**	**-20.74**

HWL= Highland Wetland
RS= River Section

7.14 Status of lakes as on 30 October 2020

From the analysis of satellite data for 30 October 2020, it is found that the catchment is still clear from the fresh snow cover and is clearly visible as a result of 138 lakes could be mapped in the entire catchment comprising 3 from Spiti, 8 from Lower Satluj and 127 from the Upper Satluj sub basin **(Fig.7.14a &7.14b).** Besides this 34 high altitude have also mapped in the catchment comprising 1 from Spiti and 33 from Upper Satluj basin **(Fig.7. 14c),** Further when these 138 lakes are further classified with reference to the areal distribution, it is found that 59 lakes are having area less than 5ha, 38 lakes are within the aerial range 5-10 ha and 41 lakes are the big one having area more than 10ha, **(Fig.7.14c & Table 7.14).** Likewise, 34 wetlands when seen based on their areal distribution, found that 18wetlands having area less than 5ha, 05wetlands are within the aerial range 5-10 ha and 11 wetlands are the big one having area more than 10ha, **(Fig.7.14c).** The temporal analysis of 13 lakes suggest that 9 are showing an increasing in their water spread and 4 are showing a reduction in their water spread with respect to 2019 **(Table 7.14).**

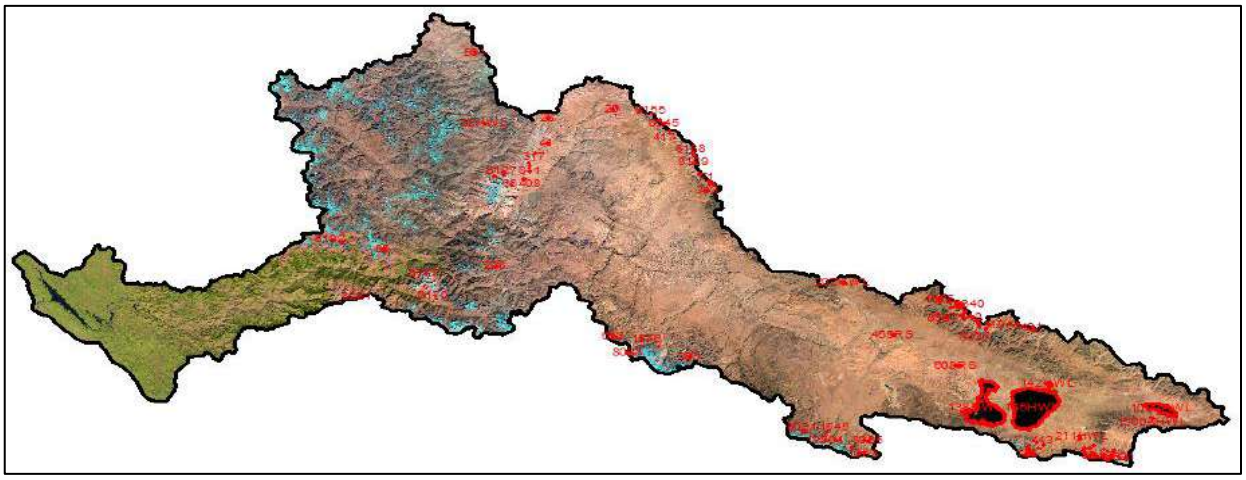


Fig.7.14 (a): IRS-R2-AWiFS-97-49-30-10-2020

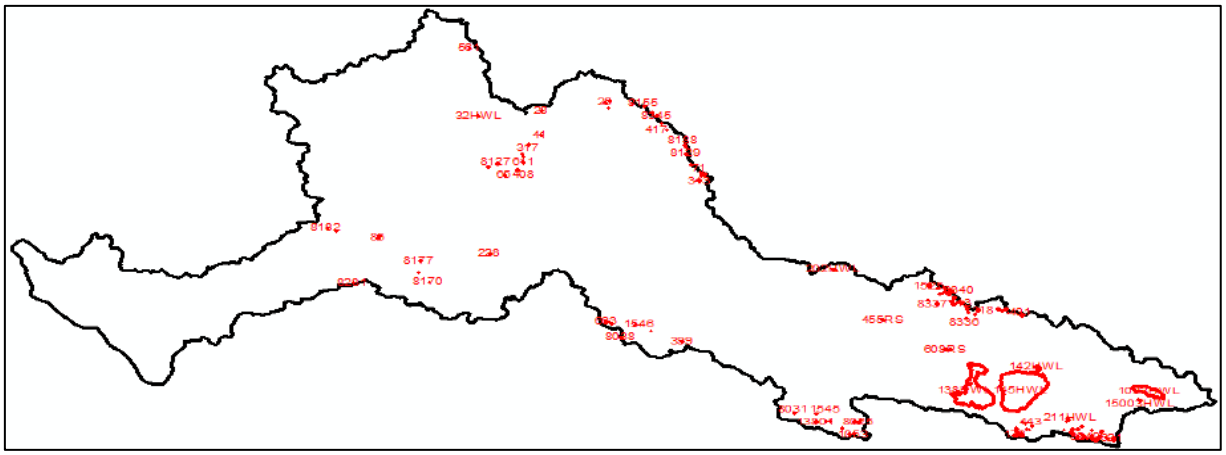


Fig.7.14 (b): IRS-R2-AWiFS-97-49-30-10-2020 Interpreted Layer

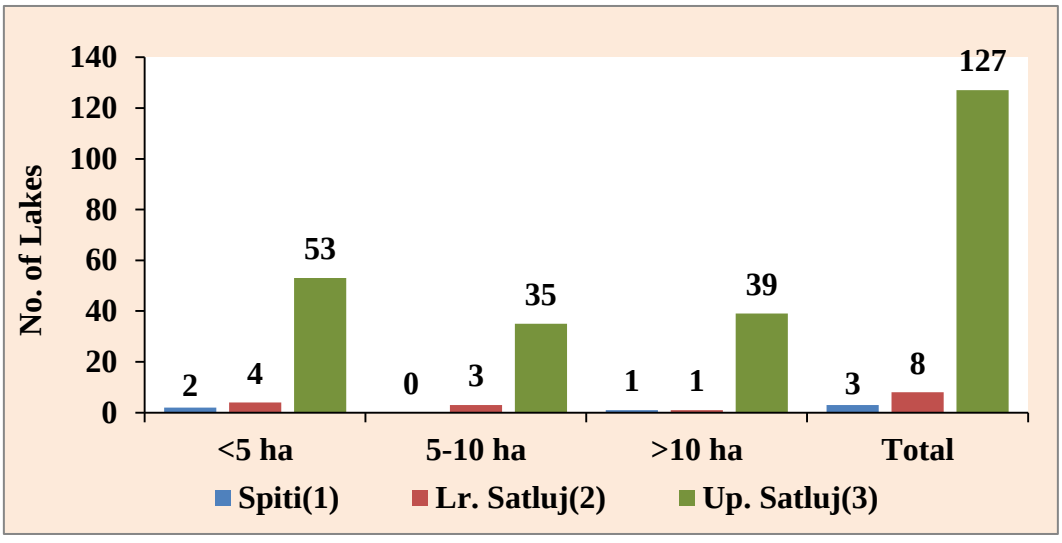


Fig. 7.14 (c): No. of Lakes based on IRS-R2-AWiFS-97-49-30-10-2020

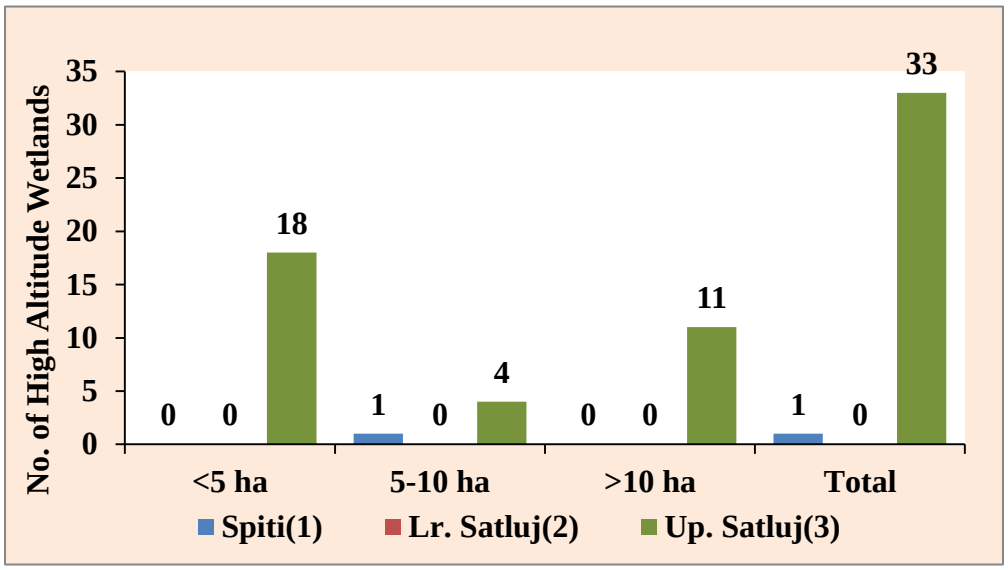


Fig. 7.14 (d): No. of High altitude wetlands based on IRS-R2-AWiFS-97-49-30-10-2020

Table: 7.14 Aerial Extent of lakes as on 30 October 2020

Sr. No	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 21 Oct 2019 (ha.)	Aerial Extent on 30 October 2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
1	18	3	81.4623	30.4319		**18.42**	
2	23	3	79.4164	32.3898	**6.77**	**13.13**	**6.37**
3	25	3	79.3933	32.3806	**18.40**	**23.25**	**4.85**
4	28	3	79.053	32.3489	6.51	5.09	-1.42
5	41	3	79.045	32.2117	**17.17**	**24.47**	**7.29**
6	55	3	78.9415	32.1095	5.97	3.22	-2.74
7	65	3	78.8452	31.9944	**19.53**	**20.28**	**0.75**
8	71	3	79.8727	31.9789	------	6.55	------
9	73	3	79.8826	31.9716	------	3.67	------
10	74	3	79.8764	31.9696	------	5.42	------
11	85	2	78.1675	31.6628	------	**39.86**	------
12	106	3	81.1024	31.2453	------	6.03	------
13	107	3	81.0824	31.2419	------	7.61	------
14	112	3	81.1475	31.2009	------	**18.39**	------
15	113	3	81.1938	31.184	------	**52.35**	------
16	114	3	81.1516	31.1805	------	**27.39**	------
17	118	3	81.2802	31.1389	------	**15.97**	------
18	119	3	81.2273	31.1316	------	7.57	------
19	122	3	81.4338	31.1166	------	7.31	------
20	166	3	81.4314	30.4727	------	5.67	------
21	174	3	81.4341	30.4505	------	6.97	------
22	178	3	81.4334	30.4326	------	**222.77**	------
23	183	3	81.8703	30.4294	------	**28.19**	------
24	193	3	81.8658	30.401	------	**10.58**	------
25	196	3	81.8942	30.3925	------	**11.97**	------
26	228	2	78.7512	31.5557	------	8.23	------
27	317	3	78.9777	32.1625	------	6.84	------

28	343	3	79.8655	31.9265	**27.73**	**33.00**	**5.27**
29	399	3	79.73	31.0309	**10.31**	**10.27**	**-0.03**
30	408	3	78.9114	32.0201	3.27	5.31	2.04
31	417	3	79.7069	32.2172	2.42	1.79	-0.63
32	423	3	81.16	31.2186	------	**19.29**	------
33	424	3	81.2252	31.1513	------	2.69	------
34	426	3	81.5025	31.0968	------	6.45	------
35	427	3	81.3833	31.1401	------	1.52	------
36	431	3	81.5023	31.1143	------	9.27	------
37	443	3	81.5142	30.4824	------	6.05	------
38	445	3	81.4834	30.4636	------	4.76	------
39	448	3	81.4575	30.4399	------	4.61	------
40	561	1	78.6887	32.7104	------	3.81	------
41	592	3	79.8049	32.1186	------	1.77	------
42	594	3	79.8274	32.0193	------	3.02	------
43	607	3	81.1326	31.2468	------	3.59	------
44	610	3	78.948	32.0945	------	4.79	------
45	611	3	78.9436	32.0623	3.54	7.07	3.53
46	620	3	79.6839	32.2564	**2.74**	**10.87**	**8.14**
47	621	3	81.9291	30.3869	------	**80.04**	------
48	622	3	81.0844	31.2743	------	2.39	------
49	625	3	79.8781	31.9577	------	3.30	------
50	632	3	79.3667	31.1459	------	6.05	------
51	634	3	81.1413	31.248	------	7.89	------
52	636	3	81.1088	31.2718	------	5.49	------
53	637	3	81.8407	30.3869	------	**14.46**	------
54	638	3	81.83	30.3826	------	2.76	------
55	641	3	79.8951	31.9601	------	2.46	------
56	646	3	81.1167	31.2656	------	2.42	------
57	647	3	81.1169	31.262	------	5.47	------
58	648	3	81.1241	31.2391	------	2.43	------
59	649	3	81.1298	31.2458	------	2.76	------
60	649	3	81.1505	31.2521	------	3.91	------
61	651	3	81.4005	31.1299	------	6.07	------
62	652	3	81.4238	31.1394	------	5.42	------
63	655	3	81.5117	31.1018	------	6.34	------
64	663	3	79.341	31.1553	------	**16.26**	------
65	816	3	79.88	31.9643	------	3.31	------
66	825	3	81.1133	31.2517	------	1.83	------
67	827	3	81.1378	31.1972	------	8.40	------
68	828	3	81.1536	31.2104	------	2.12	------
69	849	3	81.4996	30.4609	------	1.81	------
70	895	3	81.8425	30.3814	------	3.80	------
71	1004	3	81.5144	30.4788	------	2.24	------
72	1030	3	81.1788	31.1905	------	2.03	------
73	1038	3	79.8023	32.1278	------	1.71	------
74	1052	3	80.5982	30.547	------	**11.06**	------
75	1053	3	80.5927	30.478	------	**15.13**	------
76	1133	3	81.8671	30.4214	------	**17.81**	------
77	1142	3	81.7743	30.4028	------	1.23	------
78	1149	3	81.7692	30.3987	------	4.33	------
79	1519	3	81.2157	31.1661	------	3.04	------
80	1524	3	81.0326	31.2945	------	2.76	------

81	1525	3	81.0326	31.2854	------	**25.27**	------
82	1538	3	79.5697	31.0953	------	3.47	------
83	1545	3	80.404	30.5991	------	4.59	------
84	1546	3	79.5144	31.1338	------	7.27	------
85	8011	3	80.5689	30.479	------	5.55	------
86	8020	3	80.5325	30.5133	------	3.65	------
87	8021	3	80.5343	30.5163	------	1.20	------
88	8025	3	80.6213	30.5404	------	**29.10**	------
89	8026	3	80.451	30.555	------	5.86	------
90	8027	3	80.4729	30.5548	------	9.73	------
91	8029	3	80.6317	30.5558	------	2.14	------
92	8031	3	80.2927	30.608	------	**14.03**	------
93	8037	3	79.4118	31.0626	------	4.17	------
94	8038	3	79.4146	31.0623	------	5.76	------
95	8047	3	79.4917	31.1323	------	5.80	------
96	8057	3	81.2584	31.1182	------	8.15	------
97	8064	3	81.4137	31.1358	------	3.08	------
98	8065	3	81.2216	31.1496	------	**12.09**	------
99	8079	3	81.1368	31.2359	------	9.89	------
100	8107	3	79.8996	31.9657	------	5.98	------
101	8117	1	78.7584	32.0435	------	3.27	------
102	8127	1	78.8075	32.0599	------	**21.72**	------
103	8129	3	79.8039	32.0802	------	3.42	------
104	8149	3	79.6374	32.3168	------	4.59	------
105	8154	3	79.4067	32.3524	------	5.17	------
106	8155	3	79.595	32.355	------	5.22	------
107	8157	3	79.5349	32.3727	------	2.72	------
108	8170	2	78.4214	31.4054	------	3.02	------
109	8173	2	78.3691	31.4602	------	1.58	------
110	8177	2	78.3819	31.5251	------	9.03	------
111	8182	2	77.9016	31.7226	------	2.40	------
112	8188	3	79.7982	32.1297	------	3.28	------
113	8249	3	81.8525	30.3992	------	**32.09**	------
114	8281	2	78.027	31.4107	------	5.83	------
115	8286	3	80.5563	31.3948	------	3.28	------
116	8329	3	81.7189	30.4465	------	1.21	------
117	8330	3	81.4304	30.4668	------	3.75	------
118	8331	3	81.4338	30.4665	------	8.78	------
119	8332	3	81.4775	30.4892	------	1.25	------
120	8333	3	81.468	30.5008	------	2.39	------
121	8334	3	81.1052	30.9264	------	2.40	------
122	8335	3	79.3588	31.1525	------	2.21	------
123	8336	3	81.2129	31.0983	------	**13.66**	------
124	8337	3	81.066	31.184	------	**18.88**	------
125	8338	3	81.1654	31.1842	------	4.67	------
126	8339	3	81.0194	31.2093	------	3.73	------
127	8340	3	81.1303	31.2328	------	**14.81**	------
128	8341	3	81.1458	31.2584	------	2.73	------
129	8342	3	81.1323	31.2622	------	**13.15**	------
130	8343	3	81.0746	31.2718	------	**19.25**	------
131	8344	2	77.9475	31.7036	------	2.35	------
132	8345	3	79.6614	32.298	------	**17.54**	------
133	13801	3	80.401	30.5539	------	**34.12**	------

134	18701	3	81.8479	30.3885	------	4.59	------
135	18901	3	81.8187	30.392	------	**16.88**	------
136	187004	3	81.784	30.4023	------	5.16	------
137	1001HWL	3	81.749	30.4492	------	1.73	------
138	1013HWL	3	81.5239	30.7784	------	1.54	------
139	1022RS	3	81.1091	30.926	------	1.82	------
140	1093HWL	3	82.1318	30.6401	------	**5861.89**	------
141	1124HWL	3	81.8207	30.4396	------	4.90	------
142	1136HWL	3	81.777	30.4129	------	7.29	------
143	138HWL	3	81.2324	30.6902	------	**25755.60**	------
144	142HWL	3	81.5659	30.8036	------	**326.92**	------
145	145HWL	3	81.4708	30.687	------	**41859.70**	------
146	1474HWL	3	81.565	30.769	------	1.21	------
147	148HWL	3	81.5826	30.7635	------	**105.90**	------
148	15002HWL	3	82.0712	30.5984	------	9.51	------
149	15003HWL	3	82.0825	30.5939	------	**12.36**	------
150	173HWL	3	81.6762	30.4499	------	**11.35**	------
151	179HWL	3	81.7143	30.431	------	**23.31**	------
152	184HWL	3	81.7224	30.4227	------	**19.39**	------
153	185001HWL	3	81.7464	30.4108	------	8.26	------
154	202HWL	3	80.5415	31.4005	------	**29.45**	------
155	205HWL	3	81.5648	30.79	------	4.88	------
156	206HWL	3	81.5681	30.7918	------	1.23	------
157	210HWL	3	81.5534	30.7733	------	**54.12**	------
158	211HWL	3	81.7012	30.5169	------	9.14	------
159	32HWL	1	78.7208	32.3295	6.26	7.35	1.09
160	385HWL	3	81.5375	30.7801	------	4.31	------
161	436HWL	3	81.6941	30.4992	------	1.85	------
162	438HWL	3	81.7415	30.4036	------	3.47	------
163	439HWL	3	81.7227	30.4296	------	2.76	------
164	440HWL	3	81.7209	30.4495	------	4.38	------
165	455RS	3	80.7828	31.1087	------	**12.67**	------
166	608RS	3	81.0943	30.9278	------	**23.53**	------
167	616RS	3	81.1162	30.9264	------	**16.92**	------
168	677HWL	3	81.7063	30.5037	------	2.17	------
169	688HWL	3	81.8197	30.4099	------	4.82	------
170	840HWL	3	81.7929	30.398	------	2.80	------
171	842HWL	3	81.7635	30.4219	------	3.41	------
172	865HWL	3	81.7747	30.4009	------	1.83	------

HWL-Highland Wetland
RS-River Section

8.0: Inventory of lakes based on LISS III satellite data for 2020:

IRS LISS-III Resourcesat 2 satellite data having spatial resolution of 23.5mts have been used for generating a more detailed inventory of glacial lakes/high altitude wetlands in Satluj catchment and was compared with that of the information generated for the year 2019 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 2020 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 2020 , good quality data could not obtained by virtue of the area under the impact of snow cover for a longer period and the thereafter the cloud cover during the monsoon season. The study area is covered by LISS-III coverage mainly by seven number of scenes within 96-48, 97-48, 97-49, 98-49, 99-49 and 100-49 path and rows and have been 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 of 7 Sept 2020 and 14 Sept 2020 **(Fig.8.4a)** shows that the area is not fully exposed but is under the impact of partial cloud cover as a result of which not much information could be derived. Likewise under path row 96-49 no data could be obtained resulting to have data gap in the information during 2020 falling within 96-49 path -row. The study area covered under path row 97-48 for the period 12 Sept 2020 **(Fig 8.5a)** and 97-49 for 12 Sept.2020 **(Fig 8.6a)** the coverage is almost clear and maximum information could be derived. On the extreme eastern part of the study area which is covered by 98-48 is missing resulting to have data gap in 2020. Likewise the area covered under path row 99-49 for 5 Sept.2020 **(Fig.8.7a)** and 100-49 covered by 5 Sept.2020 **(Fig 8.8a)** does also show the partial cloud cover impacts, but it has become possible to extract information to some extent. Thus, based on the above LISS III satellite data products for the above mentioned path and rows, a total of 993 lakes could be mapped in the entire catchment (197 in Spiti basin i.e sub basin 1, 89 in Lower Satluj basin i.e sub basin 2 and 707 in Upper Satluj i.e sub basin 3) 197 in comparison to 562 lakes delineated in 2019 and a total of 769 lakes as mapped in 2018. The difference in the total number of lakes is mainly due to the non-availability of good quality snow free and cloud free data coverage.

Further detailed analysis for 2020 based on different path and rows, it is found that the area being covered under the path-row 96-48, a total of 362 lakes were delineated out of which 5 lakes have been classified as high-altitude wetland that too from the Spiti basin in comparison to 153 (2019) lakes and 275 lakes (2018) respectively. Further analysis reveals that out of 362 lakes majority of the lakes (192) as small one with area less than 5ha out of which 177 lakes forms part of the Spiti sub basin, 48 from the Lower Satluj and 103 from the Upper Satluj sub basin respectively. Likewise 21 lakes are within the aerial range of 5-10ha, out of which 10 lakes are

from Spiti, 1 lake from the Lower Satluj and 10 from the Upper Satluj sub basin, whereas 8 lakes are the big one having area more than 10ha comprising 05 from the Spiti, and 03 from the Upper Satluj sub basin respectively **(Fig.8.4b).** Further analysis based on their classification reveals that out of 362 lakes, only 5 lakes are the high altitude wetland that too from the Spiti sub basin, 2 are with area less than 5 ha and 3 having area more than 10ha **(Fig.8.4c).** Likewise, from the satellite data covering path-row 96-49, no information could be derived due to non-availability of good quality data.

Based on the satellite data interpretation covering path row 97-48, a total of 115 lakes could be mapped comprising 4 lakes from Spiti basin, 1 from Lower Satluj basin and 109 from Upper Satluj basin (**Fig.8.5b)** in comparison to 59 lakes of 2019 and 52(2018) respectively. Further analysis of 115 lakes suggest that 107 lakes are of area less than 5ha, falling 4 lakes in Spiti, 1 in Lower Satluj and 102 from Upper Satluj basin. Besides this, 05 lakes are within the aerial range of 5-10ha and 02 lakes are having area more than 10ha and all these falls in the upper Satluj sub basin **(Fig. 8.5b**) and only one lake is high altitude wetland that too from the Spit sub basin and with area less than 5 ha **(Fig. 8.5c)** . Likewise from the data interpretation covering 97-49, a total of 93 lakes could be mapped forming 39 from Lower Satluj and 54 from Upper Satluj basin in comparison to 27 lakes (2019) and 20 lakes (2018). Out of these 93 lakes mapped in 2020, 88 lakes are the small one with area less than 5ha comprising 38 from Lower Satluj and 50 from Upper Satluj basin respectively. Likewise 05 falling within the aerial range of 5-10 ha, 1 from Lower Satluj and 4 from Upper Satluj basin, there was no lake with area more than 10ha could be mapped (**Fig.8.6b).** Further 3 high altitude wetland could also be mapped comprising 2 with area <5ha and 1 with are area >0ha and all falling in Upper Satluj basin **(Fig.8.6c)**

Area covered under path row 99-49 and 100-49 mainly falls in Upper Satluj sub basin and based on interpretation in 99-49, a total of 256 (2020) against of 238 (2019) lakes have been mapped forming part of the Upper Satluj basin. Further, out of which 213 are the small one with area less than 5ha against of 185 lakes (2019) indicating an increase of about 15% (28) lakes in 2020 in comparison to 2019. Likewise22 lakes mapped in 2020 are within areal range of 5-10ha indicating a reduction of about 21% (6 lakes) in comparison to 28 lakes as mapped in 2019 and21 lakes are such which have the area more than 10ha indicating a reduction of about 16% (4 lakes) in comparison to 25 lakes as mapped in 2019(25%) (**Fig. 8.7b).** Further 51 lakes have been classified s high altitude wetlands in 2020 from 99-49 path-row out of which 32 are small one with area less than 5ha against 45as mapped in 2019 within this areal range, 7 high altitude wetlands

are within the real range of 5-10ha in comparison to 4 that of 2019 and 21 are the big one with area more than 10ha in comparison to 11(2019) **(Fig. 8.7c).** Likewise, in 100-49 a total of 92 lakes have been mapped in comparison to 37 lakes of 2019 and comprise of 85 lakes with area less than 5ha, 2 between 5-10ha and 5 having area more than 10ha. Likewise 21 lakes have been mapped as high altitude wetlands in comparison to 8 as mapped in 2019 and comprises of 17 with area less than 5ha, 1 with area between 5-10ha and 3 having area more than 10ha **(Fig. 8.8b and Fig.8.8c)** .

Based on the further analysis of LISS III satellite data, it has been found that total number of lakes in Upper Satluj basin varies from 450 (2017) to 495 (2018) to 437 (2019) to 707 (2020) thus by indicating an increase of 250 lakes w.r.t. 2017 and 212 lakes w.r.t. 2018 and 270 w.r.t. 2019 data or in other words we can say that the increase is of the order of about 57%, 42%, and about 61% with reference to 2017, 2018 and 2019 database is observed respectively **(Fig.8.3)** and this variation is mainly due the non-availability of difference in the good quality snow free and cloud free data coverage and area of interest during 2017, 2018 2019 based on LISS III satellite data. Likewise in Lower Satluj basin, total number of lakes mapped in 2019 varies from 102 (2017) to 98 (2018) to 52 (2019) to 89 (2020) thus by indicating a decrease of about 11% (12 lakes), 9% (9 lakes) and enhancement by about 71% (37 lakes) with reference to 2017, 2018 and 2019 **(Fig.8.2)** and this large variation is again mainly due to the non-availability of good quality satellite data. Similarly in Spiti basin, the variation in the total number of lakes is from 90 (2017) to 176 (2018) to 73 (2019) to 197 (2020) thus by indicating an increase of about 118% (107 lakes) w.r.t. 2017, 11% (21 lakes) w.r.t to 2017 &18 and 169% (124 lakes) w.r.t. to 2019 respectively **(Fig.8.1)** and the difference is mainly due to the data quality which is either due to snow cover or cloud cover impacts as a result of which there is always a variation in the total number of lakes delineated between. Further analysis of these 993 lakes mapped in the entire Satluj basin using LISS-III satellite data in 2020 reveals that total number of lakes with area more than 10 ha varies from 52 (2017) to 49 (2018) to 51 (2019) to 52 (2020). Likewise based on the analysis for 2020 using LISS-III products, the total number of lakes with area less than 5ha are 878 (2020) in comparison to 458 (2019) in comparison to 663 (2018) indicating an enhancement of 420 lakes in comparison to 2019 and 215 lakes as that of 2018. Likewise the lakes within the aerial range of 5-10 ha shows an increase of 2 lakes w.r.t 2019 (61), 6 lakes in comparison to 2018(57) 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 1682 RS to 1687RS 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.

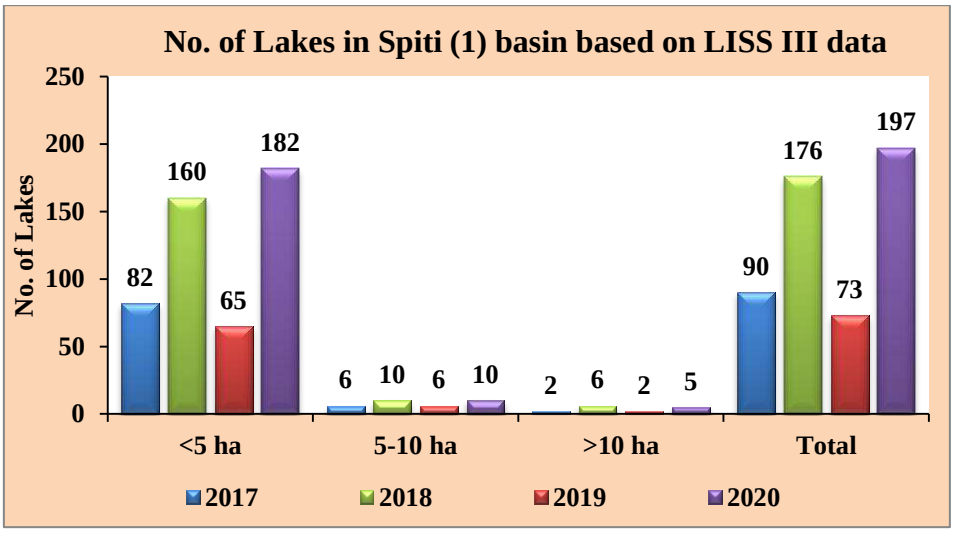


Fig. 8.1:No. of Lakes in Spiti (1) basin based on LISS III data

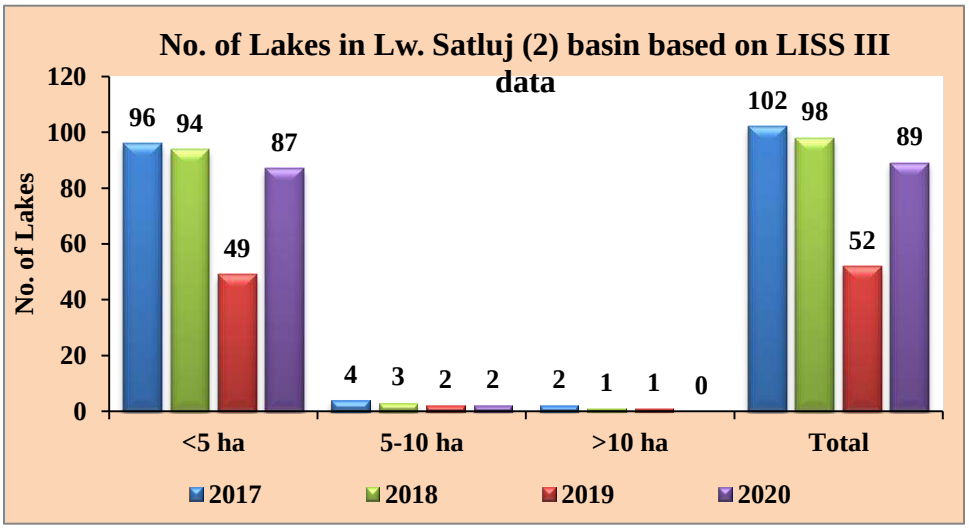


Fig. 8.2: No. of Lakes in Lw. Satluj (2) basin based on LISS III data

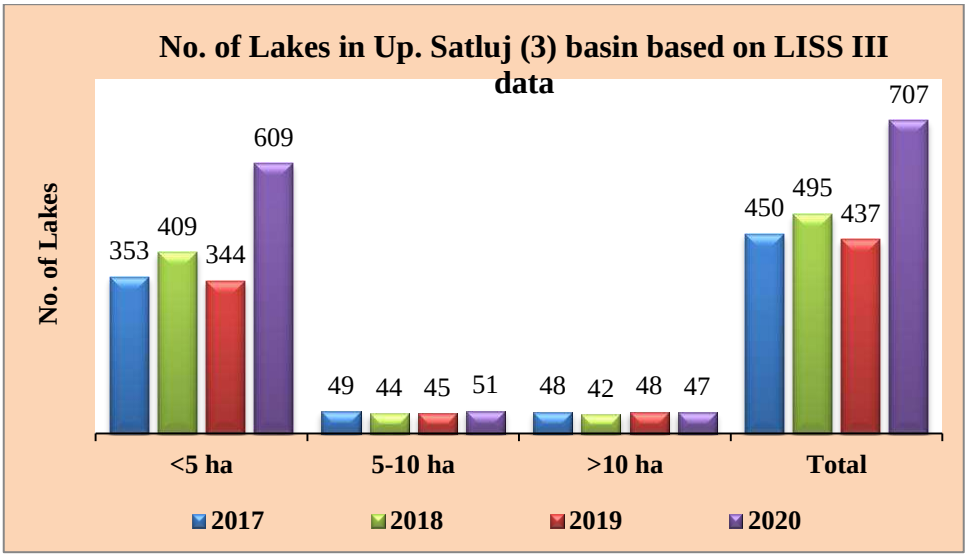


Fig. 8.3:No. of Lakes in Up. Satluj (3) basin based on LISS III data

Table 8.1: Distribution of Lakes as per satellite data interpretation for the year 2020 using LISS-III sensor

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 20 August 2019 (ha.)	Aerial Extent on 16 Oct 2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
IRS RS2 LISS III 96-48							
1	4	1	78.69650	32.75000	------	0.24	------
2	37	1	78.68850	32.70740	5.30	4.10	-1.19
3	38	1	78.70840	32.71060	2.56	3.23	0.67
4	56	3	78.94120	32.10730	------	8.57	------
5	57	3	78.93250	32.10710	------	9.53	------
6	58	3	79.00210	32.33850	------	7.31	------
7	59	3	79.00170	32.32870	1.68	2.38	0.70
8	61	1	78.97300	32.32530	7.18	6.21	-0.97
9	64	1	78.97760	32.25820	------	2.26	------
10	65	1	78.97900	32.31950	7.68	8.14	0.46
11	67	3	79.04270	32.20930	**25.68**	**26.09**	**1.40**
13	68	3	79.02600	32.22420	6.30	6.98	0.68
14	69	1	78.86330	32.07040	2.54	0.96	-1.58
15	70	3	79.00960	32.21480	1.80	2.16	0.36
16	71	3	79.00570	32.22450	2.60	2.18	-0.42
17	72	1	78.98310	32.22580	2.28	2.00	-0.28
18	73	3	78.97540	32.20640	------	0.40	------
19	74	1	78.97250	32.19070	4.76	4.19	-0.56
20	75	1	78.96030	32.18510	3.30	2.51	-0.79
21	76	3	78.97250	32.17050	1.59	1.42	-0.17
22	77	3	78.97760	32.16060	9.77	8.77	-1.00
23	78	1	78.75370	32.04520	------	0.17	------
24	79	3	79.01920	32.20820	2.54	2.56	0.02
25	80	1	78.91860	32.14160	2.58	3.08	0.50
26	81	1	78.92670	32.12920	1.04	0.79	-0.26
27	82	1	78.94260	32.12230	4.47	3.83	-0.64
28	83	1	78.75300	32.04290	0.47	0.23	-0.25

29	84	3	78.95070	32.11950	1.37	1.37	0.00
30	85	3	78.94710	32.10660	1.08	0.86	-0.22
31	86	3	78.94740	32.10460	1.10	0.23	-1.88
32	88	3	78.94690	32.09240	5.83	3.73	-2.10
33	89	3	78.92930	32.09230	0.80	0.73	-0.07
34	93	3	78.94250	32.06010	6.92	7.26	0.34
35	94	3	78.91060	32.01780	6.39	6.23	-0.16
36	95	1	78.87640	32.01990	2.21	2.91	0.70
37	95	3	78.90190	32.00420	2.21	1.83	-0.38
38	97	1	78.87470	32.01700	5.73	8.12	2.40
39	99	1	78.84430	32.02920	**14.72**	**17.82**	**3.11**
41	101	1	78.84480	31.99240	**21.10**	**22.79**	**1.68**
42	103	3	78.86690	31.95730	3.85	4.49	0.64
43	105	3	78.83610	31.97820	1.37	1.14	-0.23
44	106	3	78.83680	31.98070	5.63	6.57	0.95
45	112	1	78.68490	31.93370	------	1.03	------
46	119	3	78.82810	31.93110	------	0.28	------
47	120	1	78.69290	31.93060	------	0.23	------
48	122	3	78.78350	31.91860	**16.86**	**17.77**	**0.91**
49	124	1	78.69430	31.92990	------	0.22	------
50	126	1	78.69100	31.92890	------	0.29	------
51	127	1	78.69540	31.92890	------	0.46	------
52	131	1	78.70230	31.91750	0.71	0.69	-0.02
53	132	3	78.80160	31.90820	------	0.96	------
54	133	3	78.78460	31.90670	------	0.23	------
55	135	3	78.78570	31.90590	------	0.46	------
56	136	3	78.78490	31.90570	------	0.12	------
57	143	3	78.78990	31.88260	------	0.74	------
58	147	3	78.80060	31.87570	------	0.92	------
59	147	3	78.80030	31.87540	------	0.70	------
60	148	3	78.80280	31.87350	------	0.34	------
61	148	3	78.80220	31.87320	------	0.40	------
62	151	1	77.92530	32.12870	------	1.89	------
63	152	1	77.91450	32.13660	2.47	2.23	-0.23
64	153	2	78.15950	31.66180	------	0.28	------
65	162	2	78.42970	31.49500	------	0.74	------
66	165	2	78.42570	31.48960	------	0.29	------
67	166	2	77.95880	31.48110	------	1.68	------
68	405	2	78.42020	31.40330	3.14	2.71	-0.43
69	552	1	78.69820	32.70410	3.90	3.74	-0.16
70	570	3	78.92730	32.06320	0.92	1.36	0.44
71	586	1	78.70160	31.91200	5.56	3.82	-1.74
72	589	1	78.71830	31.90060	1.39	0.87	-0.52
73	801	1	78.89200	32.38780	------	1.80	------
74	810	1	78.83160	32.04360	------	2.20	------
75	811	1	78.80660	32.05840	9.86	8.77	-1.09
76	814	1	78.74450	32.04730	0.90	0.97	0.07
77	816	1	78.74500	32.04590	0.32	0.35	0.03
78	819	1	78.75460	32.04460	0.81	0.86	0.05
79	820	1	78.75610	32.04470	0.66	0.45	-0.21
80	821	1	78.75790	32.04170	1.76	2.23	0.47
81	822	1	78.76140	32.04070	0.65	0.34	-0.31
82	825	1	78.76910	32.04020	0.55	0.35	-0.20

83	848	2	78.74090	31.70880	2.23	2.25	0.01
84	854	2	78.60950	31.56420	2.92	2.43	-0.49
85	885	3	79.25330	32.50610	------	2.89	------
86	887	3	79.28750	32.51920	------	0.91	------
87	890	3	79.29150	32.51240	------	2.40	------
88	891	3	79.29770	32.51160	1.21	0.68	-0.53
89	891	2	78.36800	31.45830	1.21	1.09	-0.12
90	998	1	78.70630	32.70710	1.11	1.70	0.59
91	999	1	78.68170	32.70640	1.10	0.74	-0.35
92	1001	1	78.27210	32.36300	------	**14.21**	------
93	1013	3	79.01700	32.27680	3.06	2.67	-0.40
94	1016	3	79.03410	32.23780	------	0.91	------
95	1022	1	78.70220	32.03570	0.95	0.92	-0.02
96	1033	3	78.78590	31.90490	0.52	0.41	-0.11
97	1035	1	78.70460	31.88680	0.80	1.01	0.21
98	1049	2	78.73470	31.51840	4.14	3.76	-0.38
99	1207	2	78.39900	31.73160	------	2.16	------
100	1210	2	78.60180	31.57450	------	0.69	------
101	1211	2	78.60030	31.57500	------	0.40	------
102	1212	2	78.59980	31.57360	------	0.40	------
103	1213	2	78.73140	31.50760	1.45	1.27	-0.18
104	1219	2	78.43220	31.50310	1.61	1.25	-0.36
105	1220	2	78.43310	31.50620	0.61	0.81	0.20
106	1227	1	78.81610	32.41880	------	7.21	------
107	1230	1	78.87240	32.03180	5.06	4.44	-0.62
108	1231	1	78.75870	32.03910	0.45	0.58	0.12
109	1232	1	78.77950	32.03300	0.97	0.95	-0.02
110	1234	1	78.41560	31.96460	6.45	7.57	1.12
111	1234	3	78.81840	31.92910	1.21	1.21	0.00
112	1237	3	78.82300	31.93020	0.73	0.24	-0.50
113	1238	3	78.82190	31.93300	1.26	0.55	-0.71
114	1241	1	78.69340	31.92750	------	0.23	------
115	1242	2	78.29290	31.77940	------	1.60	------
116	1243	2	78.30530	31.78960	------	1.32	------
117	1244	1	77.94260	32.52440	------	3.63	------
118	1246	1	77.96610	32.53330	------	1.07	------
119	1247	1	78.47330	32.45730	------	6.29	------
120	1248	1	78.48090	32.37600	------	0.57	------
121	1250	1	78.50230	32.34360	------	2.80	------
122	1251	1	78.49520	32.34140	------	0.40	------
123	1252	1	78.41800	32.20430	------	4.00	------
124	1253	1	78.48760	32.14770	------	**13.27**	------
125	1257	2	78.10360	31.77800	------	1.02	------
126	1258	2	78.10150	31.77750	------	1.91	------
127	1259	3	78.81200	31.96400	3.97	4.43	0.47
128	1260	3	78.86870	31.96940	------	9.01	------
129	1620	2	78.40910	31.43750	------	0.92	------
130	1623	2	78.40970	31.41150	0.64	0.80	0.16
131	1626	2	78.42150	31.39880	0.71	0.69	-0.02
132	1640	2	78.42840	31.49060	1.62	0.86	-0.76
133	1641	2	78.38240	31.52260	------	5.61	------
134	1642	2	78.60100	31.57620	------	0.12	------
135	1647	3	78.79380	31.88020	0.64	0.45	-0.19

136	1647	3	78.79350	31.88010	0.64	0.28	-0.35
137	1648	3	78.79370	31.88220	0.96	0.73	-0.23
138	1648	3	78.79350	31.88180	0.96	0.73	-0.23
139	1652	3	78.82150	31.93030	0.45	0.57	0.12
140	1654	3	78.84020	31.91370	**22.28**	**22.03**	**-0.25**
141	1655	1	78.84530	32.01140	------	2.46	------
142	1656	1	78.75180	32.04270	0.76	0.68	-0.08
143	1658	1	78.77820	32.03410	0.45	0.59	0.14
144	1660	1	78.78730	32.03100	0.20	0.23	0.03
145	1661	3	78.90290	32.04330	------	1.37	------
146	1662	3	78.90400	32.05410	------	0.86	------
147	1663	3	78.82010	31.93230	0.47	0.97	0.50
148	1664	1	78.89480	32.06480	------	0.46	------
149	1665	1	78.90570	32.07630	------	0.34	------
150	1666	1	78.88500	32.07200	------	2.14	------
151	1667	1	78.88650	32.07370	------	0.28	------
152	1668	1	78.86390	32.08580	1.64	0.97	-0.67
153	1671	3	79.04430	32.25170	------	1.20	------
154	1672	1	78.89640	32.32510	------	0.90	------
155	1673	1	78.43290	32.18090	------	0.81	------
156	1674	1	78.46180	32.38130	------	0.74	------
157	1676	2	78.07870	31.70200	------	0.99	------
158	1688	1	78.08100	32.61030	------	0.40	------
159	1689	1	77.98950	32.60640	------	4.32	------
160	1692	1	78.70290	32.70730	0.40	0.28	-0.11
161	1693	1	78.70180	32.70720	0.40	0.28	-0.12
162	1694	1	78.70100	32.70500	1.37	1.12	-0.26
163	1695	3	79.11970	32.33390	------	0.56	------
164	1696	3	79.11740	32.34640	------	0.45	------
165	1700	3	79.15250	32.45460	------	0.62	------
166	1701	3	79.18730	32.45160	------	2.79	------
167	1702	3	79.17140	32.49110	------	2.45	------
168	2100	2	78.71700	31.53100	2.38	1.41	-0.97
169	2107	2	78.48880	31.40070	3.19	3.81	0.61
170	2113	3	78.81630	31.93280	2.77	2.15	-0.62
171	2115	3	78.81350	31.93370	0.45	1.27	0.82
172	2117	3	78.82760	31.93020	0.27	0.17	-0.10
173	2118	3	78.82640	31.92990	3.18	0.29	-2.90
174	2118	1	78.36830	32.31430	3.18	1.87	-1.31
175	2119	3	78.82410	31.92940	1.66	0.22	-1.43
176	2120	1	78.22800	32.09020	1.74	2.33	0.60
177	2132	3	79.13070	32.44630	------	5.02	------
178	2133	3	79.13070	32.46280	------	3.28	------
179	2134	3	79.10380	32.35380	------	3.18	------
180	2135	3	79.05130	32.34630	------	3.69	------
181	2136	2	78.79280	31.44930	------	6.19	------
182	5000	1	77.92990	32.57060	------	0.98	------
183	5002	1	77.96520	32.52970	------	0.17	------
184	5005	1	78.07940	32.57030	------	0.45	------
185	5009	1	78.22020	32.41520	------	0.81	------
186	5010	1	78.22150	32.41430	------	0.23	------
187	5015	1	78.30520	32.47470	------	0.40	------
188	5019	1	78.41260	32.17500	------	3.90	------

189	5020	2	78.12410	31.73950	------	2.79	------
190	5021	2	78.11680	31.74870	------	0.62	------
191	5023	2	78.11280	31.81070	------	0.24	------
192	5040	1	78.82740	32.42120	------	0.28	------
193	5044	1	78.89280	32.39650	------	0.52	------
194	5045	1	78.90870	32.33410	2.44	1.89	-0.55
195	5045	1	78.90710	32.33270	2.44	0.73	-1.70
196	5047	3	78.99010	32.31520	------	0.72	------
197	5048	3	78.99330	32.31610	0.94	1.03	0.08
198	5049	3	78.99420	32.31690	0.25	0.57	0.31
199	5052	1	78.99130	32.25480	1.83	0.96	-0.87
200	5055	1	78.98310	32.22080	------	0.74	------
201	5056	1	78.98520	32.22180	0.42	0.35	-0.07
202	5057	1	78.98700	32.22060	------	0.34	------
203	5058	3	78.99760	32.22430	1.25	1.08	-0.17
204	5059	3	79.01670	32.20250	------	0.40	------
205	5061	1	78.96850	32.18040	------	0.75	------
206	5063	3	78.96260	32.14940	1.22	1.53	0.32
207	5063	1	78.95490	32.14340	1.22	0.91	-0.31
208	5064	3	78.97020	32.12930	2.78	3.53	0.75
209	5064	3	78.95950	32.13700	2.78	0.46	-2.32
210	5065	1	78.94820	32.13850	------	0.40	------
211	5068	3	78.94750	32.12230	1.41	1.08	-0.33
212	5073	1	78.90700	32.14420	1.27	1.14	-0.13
213	5074	1	78.90810	32.09850	1.17	0.86	-0.31
214	5075	3	78.92590	32.09400	0.45	0.23	-0.22
215	5077	1	78.80250	32.08100	0.31	0.28	-0.03
216	5079	1	78.80610	32.08020	0.35	0.41	0.05
217	5081	1	78.81810	32.07020	1.20	0.69	-0.51
218	5088	1	78.81420	32.03270	------	0.35	------
219	5089	1	78.81600	32.03250	------	1.66	------
220	5090	1	78.84730	32.01090	------	0.23	------
221	5091	1	78.82320	32.01360	------	1.23	------
222	5092	1	78.84920	32.00860	------	0.91	------
223	5093	1	78.85090	32.00810	------	0.34	------
224	5094	1	78.84820	31.99460	------	1.73	------
225	5095	3	78.84370	31.98780	0.33	0.47	0.13
226	5098	3	78.79750	31.97140	------	1.31	------
227	5099	3	78.79540	31.93320	------	0.28	------
228	6000	3	78.78070	31.92900	------	6.57	------
229	6001	3	78.78340	31.92700	------	2.09	------
230	6002	1	78.72410	31.88920	------	1.22	------
231	6003	1	78.69970	31.88920	------	0.29	------
232	6004	1	78.71230	31.89450	0.40	0.28	-0.12
233	6005	1	78.70850	31.90620	------	0.46	------
234	6013	3	78.83760	31.97710	1.19	1.19	0.00
235	6014	3	78.83550	31.98000	0.30	0.29	-0.01
236	6015	1	78.68850	32.75610	0.39	0.91	0.51
237	6016	1	78.69620	32.75460	0.69	0.68	-0.01
238	6017	1	78.69800	32.74970	0.49	1.25	0.76
239	6018	1	78.71830	32.74670	------	2.84	------
240	6019	1	78.68920	32.73030	0.94	0.74	-0.20
241	6020	1	78.69100	32.70760	0.34	0.23	-0.12

242	6022	1	78.71100	32.69470	------	3.40	------
243	6023	1	78.71920	32.69730	------	1.19	------
244	6024	1	78.73930	32.70610	------	1.93	------
245	6025	1	78.73880	32.70460	------	0.23	------
246	6026	1	78.73660	32.69940	------	0.62	------
247	6027	1	78.73350	32.69780	------	2.29	------
248	6029	3	79.11710	32.45920	------	0.85	------
249	6034	3	78.79670	31.93300	------	0.40	------
250	6036	1	78.78050	32.03200	0.56	0.88	0.31
251	6037	1	78.83450	32.03620	------	0.46	------
252	6038	1	78.87180	32.10050	------	0.35	------
253	6047	3	78.81120	31.94110	------	0.27	------
254	6049	1	77.76120	32.24250	------	1.60	------
255	6075	3	79.27110	32.52790	------	1.42	------
256	7091	3	78.96970	32.35150	------	0.63	------
257	7092	2	78.38590	31.51570	------	1.72	------
258	7094	3	78.80970	31.95100	------	0.46	------
259	7095	2	78.02090	31.61910	------	3.78	------
260	7096	2	77.75150	31.57020	------	0.82	------
261	7097	2	77.75790	31.60770	------	0.35	------
262	7098	1	78.62800	31.87950	------	0.80	------
263	7099	1	78.88330	32.07270	------	0.40	------
264	8000	1	78.98540	32.29990	------	**12.66**	------
265	8001	1	78.04160	32.34510	------	0.46	------
266	8002	1	78.06220	32.32370	------	0.40	------
267	8003	1	77.96500	32.16750	------	1.54	------
268	8004	1	77.96220	32.16500	------	1.08	------
269	8005	1	78.52480	32.74670	------	7.81	------
270	8006	1	78.89840	32.35140	------	2.33	------
271	8007	1	78.88080	32.35210	------	0.75	------
272	8008	3	78.92340	31.46740	------	1.06	------
273	8009	1	78.61900	31.85610	------	1.02	------
274	8010	3	79.11870	32.45770	------	0.23	------
275	8011	3	79.11730	32.45820	------	0.28	------
276	8012	3	79.11550	32.45870	------	0.29	------
277	8014	3	78.94340	32.36130	------	0.58	------
278	8015	3	78.96930	32.34480	------	0.46	------
279	8016	3	79.00070	32.35700	------	0.47	------
280	8017	3	78.82600	31.93230	------	0.23	------
281	8018	3	78.81680	31.93180	------	0.35	------
282	8019	3	78.95890	32.35630	------	1.04	------
283	8020	3	78.95610	32.35530	------	0.17	------
284	8021	1	78.85170	32.00750	------	0.52	------
285	8022	1	78.78280	32.05280	------	1.32	------
286	8023	3	78.87420	31.96560	------	0.51	------
287	8024	3	78.93780	32.10410	------	0.23	------
288	8026	3	78.96390	32.14330	------	0.34	------
289	8027	1	78.73050	32.69480	------	0.34	------
290	8028	1	78.70330	32.70590	------	0.29	------
291	8029	1	78.69650	32.72990	------	0.40	------
292	8030	1	78.69570	32.75570	------	0.23	------
293	8031	1	78.45040	32.88700	------	7.33	------
294	8032	1	77.82690	32.52800	------	0.68	------

295	8033	1	77.93130	32.39610	------	0.56	------
296	8034	1	77.76190	32.37490	------	0.11	------
297	8035	1	78.13270	31.97960	------	1.02	------
298	8036	1	78.21730	31.94470	------	1.09	------
299	8037	1	78.69340	31.92990	------	0.45	------
300	8038	1	78.69760	31.92720	------	0.34	------
301	8039	1	78.70110	31.93560	------	0.34	------
302	8040	1	78.75040	32.04280	------	0.17	------
303	8041	3	78.77380	31.91460	------	0.46	------
304	8042	3	78.88230	32.09690	------	0.29	------
305	8043	3	79.28580	32.51570	------	0.46	------
306	8044	3	79.27890	32.47690	------	1.15	------
307	8045	3	79.16520	32.48880	------	0.23	------
308	8046	2	78.11400	31.79110	------	0.23	------
309	8047	2	78.38900	31.47660	------	1.10	------
310	8048	1	78.99670	31.53270	------	0.46	------
311	8049	1	78.02350	32.30440	------	0.23	------
312	8050	1	78.02640	32.30630	------	0.34	------
313	8051	1	78.02770	32.30690	------	0.33	------
314	8052	1	78.03390	32.30500	------	0.34	------
315	8053	1	78.03290	32.24170	------	0.35	------
316	8054	1	78.27630	32.01490	------	0.92	------
317	8055	1	78.28110	32.01760	------	0.29	------
318	8056	1	78.27450	32.02850	------	0.35	------
319	8057	1	78.52710	32.70200	------	0.97	------
320	8058	1	77.81000	32.37940	------	0.40	------
321	8060	1	78.27040	32.36710	------	0.29	------
322	8061	1	78.27010	32.36490	------	1.02	------
323	8061	1	78.46190	32.16080	------	0.79	------
324	8062	1	78.30250	32.47590	------	2.10	------
325	8063	1	78.31540	32.47730	------	0.29	------
326	8064	1	77.96980	32.37300	------	0.29	------
327	8065	2	78.44780	31.86810	------	0.23	------
328	8066	1	78.94550	32.13980	------	0.23	------
329	8067	1	78.92050	32.14320	------	0.23	------
330	8068	1	78.17470	32.04990	------	0.29	------
331	8069	2	78.40030	31.72960	------	0.79	------
332	8070	2	78.54250	31.49820	------	0.46	------
333	8071	1	78.54820	32.69530	------	0.40	------
334	8072	2	78.71020	31.55550	------	0.59	------
335	8073	2	78.20100	31.90500	------	0.34	------
336	8074	2	78.20300	31.88150	------	0.29	------
337	8075	2	78.21540	31.87090	------	0.52	------
338	8076	2	78.20250	31.85660	------	0.17	------
339	8097	1	78.22150	32.41030	------	0.16	------
340	8098	1	78.22070	32.40870	------	0.23	------
342	8099	1	78.05140	32.56360	------	0.80	------
343	9004	2	78.41860	31.48360	------	0.23	------
344	9005	2	78.41580	31.40010	------	0.35	------
345	9006	1	78.62770	31.87940	------	0.93	------
346	9007	1	78.62790	31.88430	------	0.12	------
347	9313HWL	1	78.50220	32.34540	------	0.29	------
348	9314HWL	1	78.98740	32.20100	------	0.92	------

349	9315	1	78.74450	32.04500	------	0.40	------
350	11685RS	1	78.08250	32.42240	------	2.95	------
351	1650SG	1	78.71380	31.89790	0.75	1.08	0.33
352	1682RS	1	78.09280	32.43050	0.40	0.51	0.11
353	1683RS	1	78.08990	32.42750	1.09	0.58	-0.51
354	1684RS	1	78.08860	32.42610	1.96	1.75	-0.20
355	1686RS	1	78.06970	32.40440	1.60	1.09	-0.51
356	1687RS	1	78.06730	32.40180	1.57	1.17	-0.40
357	49HWL	1	78.72380	32.32540	7.43	8.82	1.40
358	8059RS	1	77.99510	32.42020	------	3.43	------
359	8083HWL	3	78.78380	31.93080	------	0.34	------
360	9002HWL	2	78.09570	31.79950	------	0.35	------
361	83(3)	3	78.9471	32.1198	1.51	1.58	-0.08
362	9002	2	78.0957	31.7995	------	0.35	------

Table 8.2: Distribution of Lakes as per satellite data interpretation for the year 2020 using LISS-III sensor

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 12October 2019 (ha.)	Aerial Extent on 12 Oct 2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
IRS RS2 LISS III 97-48							
1	149	3	78.74100	31.70890	------	2.25	------
2	152	3	78.75050	31.66120	------	0.65	------
3	155	3	78.75130	31.55310	------	5.38	------
4	184	3	78.58250	31.37280	**23.32**	**24.54**	**1.22**
5	198	3	79.81690	32.02070	1.16	0.92	-0.24
6	199	3	79.82550	32.01770	3.26	2.82	-0.44
7	200	3	79.83540	31.98800	3.74	3.03	-0.71
8	201	3	79.84460	31.99190	2.91	4.20	1.29
9	202	3	79.87090	31.97690	8.32	8.70	0.37
10	203	3	79.88090	31.96940	3.44	4.75	1.31
11	204	3	79.87470	31.96780	3.65	4.14	0.49
12	205	3	79.39130	32.37720	------	0.65	------
13	207	3	79.87630	31.95580	3.52	4.06	0.54
14	208	3	79.85540	31.94960	1.51	1.41	-0.10
15	209	3	79.86400	31.92450	**33.76**	**32.42**	**-1.34**
16	210	3	79.88120	31.93190	2.41	2.54	0.12
17	211	3	79.90050	31.92690	0.94	2.50	1.56
18	652	3	79.59260	32.35220	4.99	5.58	0.60
19	665	3	79.88850	31.96720	4.12	4.68	0.56
20	806	3	79.47620	32.42100	1.15	0.73	-0.41
21	894	3	79.41580	32.38920	10.15	9.15	-1.00
22	895	3	79.40440	32.34950	3.62	3.13	-0.48
23	900	3	79.58860	32.35320	1.39	1.31	-0.08
24	1007	3	79.47570	32.41790	0.60	0.92	0.32
25	1008	3	79.47040	32.41740	0.45	0.23	-0.22
26	1014	3	79.68200	32.25360	5.25	5.80	0.54
27	1017	3	79.70440	32.21510	1.92	3.33	1.41
28	1029	3	79.91810	31.93360	1.36	1.55	0.19
29	1728	3	79.50720	32.38210	2.24	1.94	-0.30
30	1731	3	79.79990	32.12510	1.86	3.03	1.17

31	1732	3	79.80160	32.12570	2.35	0.29	-2.06
32	1733	3	79.80280	32.11640	1.35	2.36	1.01
33	1734	3	79.80120	32.11220	0.60	1.01	0.41
34	1738	3	79.87820	31.96280	2.40	2.11	-0.29
35	1739	3	79.87330	31.95800	0.79	0.96	0.17
36	2121	3	79.90450	31.91720	1.33	1.08	-0.25
37	2122	3	79.86530	31.96680	0.31	0.23	-0.08
38	2123	3	79.81400	32.02710	0.94	1.26	0.32
39	2124	3	79.79940	32.05890	0.85	1.14	0.29
40	2125	3	79.77770	32.06230	0.24	0.40	0.16
41	2128	3	79.64450	32.28720	0.89	1.43	0.54
42	2129	3	79.58040	32.32550	1.00	0.79	-0.20
43	2130	3	79.57170	32.33120	0.94	1.31	0.38
44	2131	3	79.53210	32.37020	1.85	2.43	0.58
45	2142	3	79.77330	32.11970	------	0.22	------
46	2143	3	79.75040	32.14430	------	1.49	------
47	2144	3	79.76200	32.13360	------	0.23	------
48	2145	3	79.79980	32.10960	------	0.52	------
49	2146	3	79.76850	32.13290	------	3.37	------
50	2147	3	79.79990	32.10630	------	1.94	------
51	2147	3	79.79670	32.10530	------	0.57	------
52	2147	3	79.77210	32.09590	------	0.35	------
53	2150	3	79.80150	32.07800	------	4.03	------
54	2151	3	79.81120	32.03990	------	0.34	------
55	2152	3	79.80950	32.02790	------	0.80	------
56	2153	3	79.87940	31.95140	------	0.65	------
57	6079	3	79.77670	32.11900	0.50	0.68	0.18
58	6083	3	79.81150	32.02920	0.99	2.62	1.63
59	6086	3	79.87280	31.95910	0.30	0.39	0.10
60	6089	3	79.91420	31.92500	0.89	0.91	0.01
61	6090	3	79.87490	31.93970	0.40	0.68	0.28
62	9008	3	79.41680	32.37290	------	1.54	------
63	9009	3	79.39750	32.36950	------	0.58	------
64	9010	3	79.40220	32.34560	------	0.68	------
65	9011	3	79.38150	32.32960	------	0.23	------
66	9012	3	79.37230	32.31730	------	0.28	------
67	9013	3	79.37290	32.33290	------	0.22	------
68	9014	3	79.50680	32.39160	------	1.71	------
69	9015	3	79.52830	32.38940	------	0.62	------
70	9016	3	79.51900	32.37610	------	0.97	------
71	9017	3	79.56170	32.35280	------	0.34	------
72	9018	3	79.65240	32.23490	------	1.25	------
73	9019	3	79.78790	32.17480	------	0.51	------
74	9020	3	79.79560	32.17240	------	1.59	------
75	9021	3	79.79760	32.13420	------	1.31	------
76	9022	3	79.79590	32.12730	------	4.38	------
77	9023	3	79.79300	32.12110	------	3.65	------
78	9024	3	79.78400	32.10630	------	0.40	------
79	9025	3	79.80250	32.12300	------	0.23	------
80	9026	3	79.77210	32.09410	------	2.37	------
81	9027	3	79.81280	32.07430	------	0.29	------
82	9028	3	79.81230	32.05860	------	0.74	------
83	9029	3	79.80170	32.06110	------	0.23	------

84	9030	3	79.82660	32.01140	------	0.28	------
85	9031	3	79.82980	32.01690	------	0.40	------
86	9032	3	79.85390	32.00050	------	1.07	------
87	9033	3	79.89760	31.96400	------	4.68	------
88	9034	3	79.89370	31.95840	------	3.92	------
89	9035	3	79.89170	31.95980	------	0.57	------
90	9036	3	79.88960	31.95510	------	0.46	------
91	9037	3	79.88100	31.96550	------	0.46	------
92	9038	3	79.88890	31.93470	------	1.03	------
93	9039	3	79.92580	31.93980	------	1.08	------
94	9040	3	79.08410	31.61860	------	0.34	------
95	9041	3	78.48100	31.41360	------	0.86	------
96	9042	3	78.74170	31.67840	------	0.17	------
97	9043	3	78.73760	31.67540	------	0.23	------
98	9044	3	79.33000	32.55330	------	2.04	------
99	9045	3	79.31830	32.55330	------	0.50	------
100	9046	3	79.32970	32.55960	------	2.67	------
101	9047	3	79.36350	32.52450	------	0.56	------
102	9048	3	78.58150	31.37460	------	0.63	------
103	9049	3	78.60600	31.38780	------	0.23	------
104	9050	1	78.94220	32.36090	------	0.46	------
105	9052	2	78.74400	31.73300	------	2.12	------
106	9053	3	79.75200	32.14350	------	0.23	------
107	9054	3	79.80090	32.11080	------	0.23	------
108	9055	1	78.88270	32.39820	------	0.52	------
109	9056	3	79.39270	32.35130	------	0.29	------
110	9057	3	79.82100	32.01600	------	1.16	------
111	9058	1	78.89100	32.39620	------	0.75	------
112	9059	3	79.91180	31.92450	------	0.35	------
113	9060	3	79.91340	31.92310	------	0.28	------
114	9051HWL	1	78.87900	32.41280	------	2.44	------
115	2148	3	79.7721	32.0959	------	0.35	------

Table 8.3: Distribution of Lakes as per satellite data interpretation forthe year 2020 using LISS-III sensor

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 12 October 2019 (ha.)	Aerial Extent on 12 Oct 2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
IRS RS2 LISS III 97-49							
1	156	2	78.73620	31.54230	------	1.06	------
2	183	2	78.74440	31.37430	------	0.62	------
3	186	2	78.72260	31.36640	------	0.41	------
4	188	2	78.58170	31.36500	------	0.46	------
5	189	2	78.72400	31.36250	------	1.44	------
6	192	2	78.73370	31.35840	------	1.85	------
7	193	2	78.66830	31.35940	------	0.29	------
8	194	2	78.66550	31.35390	------	0.35	------
9	195	2	78.73100	31.34990	------	0.23	------
10	196	2	78.71750	31.33940	------	2.19	------
11	1066	3	79.51330	31.13160	5.31	5.51	0.20
12	1290	3	79.31890	31.15440	0.81	0.46	-0.35

13	1291	3	79.34150	31.15320	3.98	3.60	-0.38
14	1292	3	79.35750	31.15030	1.52	1.16	-0.36
15	1293	3	79.36180	31.14970	0.41	0.34	-0.07
16	1294	3	79.36580	31.14360	4.44	4.13	-0.31
17	1295	3	79.41060	31.06050	3.99	3.99	0.00
18	1296	3	79.41420	31.05990	0.98	6.60	5.62
19	1297	3	79.43770	31.11470	0.37	0.58	0.21
20	1297	3	79.41560	31.06190	0.37	0.46	0.09
21	1301	3	79.43660	31.11160	0.45	1.36	0.90
22	1538	3	79.56900	31.09260	------	2.73	------
23	1643	2	78.78440	31.45660	------	1.34	------
24	2136	2	78.79360	31.44970	7.41	7.96	0.55
25	2141	3	78.79620	31.36950	1.50	1.96	0.46
26	6043	3	79.75360	31.03990	------	5.90	------
27	6092	3	79.49130	31.13110	1.26	1.50	0.24
28	6093	3	79.49060	31.09750	1.62	3.66	2.04
29	7050	3	78.77090	31.36090	------	0.64	------
30	7051	3	78.75990	31.32210	------	1.26	------
31	7091	3	79.60780	31.03110	1.40	1.50	0.10
32	7094	3	79.65180	31.07210	0.91	1.69	0.78
33	7095	3	79.65480	31.07390	0.46	0.99	0.53
34	7096	3	79.72950	31.02840	7.82	6.63	-1.19
35	9061	3	79.81610	31.02600	------	1.15	------
36	9062	3	79.64890	31.07720	------	0.83	------
37	9063	3	79.37960	31.15960	------	0.52	------
38	9064	2	78.58290	31.36090	------	0.81	------
39	9065	2	78.57800	31.37040	------	0.29	------
40	9066	2	78.58160	31.36920	------	0.11	------
41	9067	2	78.71760	31.33620	------	0.52	------
42	9068	2	78.71710	31.33850	------	0.24	------
43	9069	2	78.73330	31.36140	------	0.23	------
44	9070	3	78.79300	31.31260	------	0.35	------
45	9071	3	78.87800	31.30560	------	1.81	------
46	9072	3	78.88190	31.30440	------	0.23	------
47	9073	3	78.88940	31.29520	------	0.35	------
48	9074	3	79.57580	31.30750	------	0.23	------
49	9075	3	79.61830	31.32950	------	0.52	------
50	9076	3	79.61530	31.33030	------	0.40	------
51	9077	3	79.90890	31.26780	------	1.04	------
52	9078	3	79.91170	31.30800	------	0.58	------
53	9079	3	78.98660	31.37670	------	0.46	------
54	9080	3	79.43510	31.11390	------	0.18	------
55	9081	3	79.66340	31.08480	------	0.28	------
56	9082	3	78.94600	31.66570	------	1.51	------
57	9083	2	78.60030	31.57240	------	0.61	------
58	9084	2	78.63440	31.51770	------	0.64	------
59	9085	2	78.73910	31.54560	------	0.16	------
60	9086	2	78.75230	31.55680	------	0.46	------
61	9087	3	79.77760	31.00280	------	0.41	------
62	9088	3	79.77080	31.00940	------	0.22	------
63	9089	3	79.77080	31.01070	------	0.23	------
64	9090	3	79.79320	31.06140	------	0.85	------
65	9091	3	79.82110	31.05840	------	0.12	------

66	9092	3	79.82220	30.99560	------	0.49	------
67	9093	2	78.68160	31.34640	------	0.12	------
68	9094	2	78.68220	31.34930	------	0.17	------
69	9095	2	78.68060	31.34740	------	0.18	------
70	9096	2	78.67870	31.36430	------	0.23	------
71	9097	2	78.68470	31.36720	------	0.23	------
72	9098	2	78.68500	31.36620	------	0.23	------
73	9099	2	78.68560	31.36420	------	0.53	------
74	9100	2	78.68290	31.36860	------	0.11	------
75	9101	2	78.67960	31.36140	------	0.92	------
76	9102	2	78.66360	31.35560	------	0.18	------
77	9103	2	78.66410	31.35770	------	0.17	------
78	9104	3	79.76720	30.99780	------	1.50	------
79	9105	3	78.87600	31.30780	------	0.29	------
80	9106	3	78.91590	31.34620	------	0.29	------
81	9107	3	79.51090	31.19720	------	0.77	------
82	9108	2	78.73820	31.54450	------	0.75	------
83	9109	3	79.81450	31.03300	------	0.23	------
84	9110	3	79.82100	30.99380	------	0.23	------
85	9111	3	79.56240	31.09500	------	0.52	------
86	9112	2	78.67750	31.35460	------	0.23	------
87	9113	2	78.66540	31.36110	------	0.29	------
88	9114	2	78.66580	31.35950	------	0.46	------
89	9115	2	78.66540	31.36020	------	0.17	------
90	9116	2	78.66550	31.35650	------	0.17	------
91	9117	3	79.51470	31.10420	------	0.65	------
92	9118	3	79.51610	31.10470	------	0.58	------
93	1063HWL	3	79.59910	31.30470	**40.03**	**37.97**	**-3.05**
94	1743HWL	3	79.30640	31.23280	4.06	4.09	0.03
95	6091HWL	3	79.30180	31.23990	0.66	0.35	-0.31
96	9119SG	3	79.51260	31.08870	------	3.15	------

Table 8.4: Distribution of Lakes as per satellite data interpretation for the year 2020 using LISS-III sensor

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 22 Oct 2019 (ha.)	Aerial Extent on 12 Oct 2020 (ha.)	Change in Area w.r.t. Oct 2019(ha.)
IRS RS2 LISS III 99-49							
1	166	3	81.42910	30.47150	6.05	5.36	-0.69
2	173	3	81.67510	30.44770	7.50	8.98	1.48
3	174	3	81.43240	30.44880	8.92	8.37	-0.55
4	178	3	81.43240	30.43060	**201.14**	**203.61**	**2.47**
5	423	3	81.15940	31.21750	------	6.41	------
6	424	3	81.16620	31.20860	------	0.23	------
7	983	3	81.39240	30.45410	2.89	4.20	1.31
8	1126	3	81.73990	30.42890	------	1.19	------
9	1137	3	81.81920	30.40840	8.57	7.55	-1.02
10	1142	3	81.77320	30.40350	0.51	0.97	0.45
11	1143	3	81.85280	30.40280	0.75	0.63	-0.12
12	1144	3	81.78300	30.40060	5.23	6.59	1.37
13	1145	3	81.77380	30.40120	1.17	1.15	-0.02
14	1146	3	81.86540	30.39900	**10.60**	**9.80**	**-0.80**

15	1147	3	81.77390	30.39910	3.12	2.93	-0.18
16	1148	3	81.77660	30.39840	0.60	0.92	0.32
17	1149	3	81.76810	30.39680	5.42	6.32	0.90
18	1150	3	81.79140	30.39660	4.02	3.68	-0.34
19	1151	3	81.78390	30.39510	2.18	1.73	-0.45
20	1152	3	81.77340	30.39500	1.27	0.92	-0.36
21	1154	3	81.79470	30.39240	0.82	0.75	-0.07
22	1155	3	81.81770	30.39040	**14.27**	**15.04**	**0.77**
23	1157	3	81.83740	30.39150	2.34	2.91	0.57
24	1158	3	81.80260	30.39110	4.12	3.68	-0.44
25	1159	3	81.81360	30.39150	0.71	0.58	-0.14
26	1162	3	81.84750	30.38850	0.30	0.35	0.04
27	1163	3	81.84350	30.38800	0.46	0.23	-0.23
28	1164	3	81.83980	30.38490	**16.08**	**13.92**	**-2.16**
29	1165	3	81.84690	30.38660	4.52	4.03	-0.49
30	1166	3	81.83010	30.38470	1.08	0.74	-0.34
31	1167	3	81.82410	30.38310	0.96	0.46	-0.50
32	1168	3	81.82960	30.38090	4.71	3.67	-1.04
33	1395	3	81.41240	30.46000	2.71	1.84	-0.87
34	1396	3	81.41430	30.45340	------	1.11	------
35	1443	3	81.76120	30.98870	1.40	1.87	0.48
36	1445	3	81.72170	31.07060	7.61	7.38	-0.24
37	1446	3	81.72370	31.05680	0.50	0.40	-0.10
38	1448	3	81.68460	31.02810	0.85	0.96	0.11
39	1449	3	81.68360	31.02750	0.52	0.51	0.00
40	1453	3	81.54150	31.11670	9.74	8.90	-0.83
41	1454	3	81.54470	31.10270	6.09	5.61	-0.48
42	1457	3	81.56020	31.09400	2.32	1.89	-0.43
43	1458	3	81.54660	31.07910	1.91	1.92	0.02
44	1459	3	81.53040	31.09520	1.95	1.98	0.02
45	1462	3	81.51830	31.08260	2.04	2.33	0.29
46	1463	3	81.51360	31.03870	1.90	1.37	-0.54
47	1465	3	81.51820	31.03060	0.46	0.23	-0.23
48	1469	3	81.50460	31.07210	0.92	1.07	0.15
49	1471	3	81.51200	31.09960	4.23	2.20	-2.03
50	1472	3	81.50290	31.09450	5.60	4.39	-1.21
51	1473	3	81.47990	31.08050	3.24	3.20	-0.04
52	1475	3	81.42570	31.08380	3.38	0.75	-2.63
53	1476	3	81.42420	31.08000	1.26	1.65	0.39
54	1477	3	81.40660	31.05540	3.09	3.26	0.17
55	1479	3	81.41580	31.10250	2.80	1.54	-1.26
56	1480	3	81.41200	31.10420	1.37	1.42	0.05
57	1481	3	81.42200	31.11380	1.16	1.07	-0.09
58	1482	3	81.43500	31.11380	5.41	9.22	3.81
59	1483	3	81.42330	31.13730	5.48	5.58	0.11
60	1484	3	81.40690	31.14430	1.91	2.00	0.09
61	1485	3	81.41270	31.13410	1.97	1.20	-0.78
62	1486	3	81.40610	31.12520	1.46	1.03	-0.43
63	1487	3	81.40060	31.12740	5.79	4.67	-1.11
64	1488	3	81.38260	31.13810	8.32	7.75	-0.57
65	1493	3	81.26310	31.12440	0.31	0.34	0.02
66	1495	3	81.55450	30.78100	3.60	6.96	3.35
67	1496	3	81.20600	31.07370	0.94	0.51	-0.43

68	1497	3	81.19580	31.09540	0.46	0.80	0.34
69	1499	3	81.22700	31.12930	6.13	5.20	-0.94
70	1501	3	81.23090	31.14310	0.31	0.51	0.20
71	1502	3	81.23210	31.14580	0.46	0.68	0.23
72	1503	3	81.23460	31.14860	0.45	0.46	0.00
73	1505	3	81.22450	31.14930	1.79	1.88	0.09
74	1509	3	81.19940	31.16560	1.03	0.69	-0.33
75	1510	3	81.19370	31.18200	**52.93**	**51.98**	**-0.94**
76	1511	3	81.17770	31.18900	1.67	1.65	-0.02
77	1512	3	81.15110	31.17840	**21.47**	**21.06**	**-0.41**
78	1513	3	81.13990	31.16880	1.06	0.91	-0.14
79	1514	3	81.11120	31.15970	2.60	2.24	-0.36
80	1516	3	81.12960	31.19310	0.91	0.62	-0.28
81	1518	3	81.14700	31.19890	**12.19**	**11.24**	**-0.95**
82	1519	3	81.14710	31.20380	0.77	1.02	0.25
83	1526	3	81.14440	31.23090	2.10	1.78	-0.32
84	1527	3	81.13660	31.23380	**11.37**	**10.05**	**-1.32**
85	1528	3	81.14060	31.24590	**8.82**	**10.58**	**1.76**
86	1529	3	81.12960	31.24380	3.38	2.57	-0.81
87	1530	3	81.12400	31.23720	3.60	3.32	-0.28
88	1531	3	81.12540	31.25750	0.31	0.22	-0.08
89	1532	3	81.11590	31.26020	4.75	3.19	-1.56
90	1533	3	81.11560	31.26340	1.63	1.93	0.29
91	1534	3	81.10840	31.26970	3.93	3.39	-0.53
92	1535	3	81.08420	31.27230	1.77	1.72	-0.06
93	1537	3	81.08850	31.26610	5.38	6.55	1.17
94	1539	3	81.10170	31.24360	4.58	3.98	-0.61
95	1543	3	81.06800	31.23370	2.88	3.04	0.15
96	1547	3	81.03220	31.29230	5.79	5.10	-0.69
97	1548	3	81.03110	31.28460	**17.41**	**16.00**	**-1.41**
98	1549	3	81.02780	31.27660	2.31	1.47	-0.84
99	1550	3	81.01230	31.29500	3.06	3.00	-0.05
100	1551	3	81.01130	31.33160	0.70	0.34	-0.36
101	1552	3	81.13240	31.24480	4.38	3.63	-0.75
102	1553	3	81.13510	31.24690	0.71	1.46	0.74
103	1554	3	81.26190	31.12320	0.92	1.08	0.17
104	1562	3	81.82150	30.38990	1.69	1.33	-0.37
105	1564	3	81.84180	30.37920	3.93	3.37	-0.57
106	1565	3	81.85080	30.39810	**19.13**	**21.43**	**2.29**
107	1744	3	81.00100	31.28670	0.75	0.68	-0.07
108	1745	3	81.01970	31.37460	2.16	2.25	0.09
109	1748	3	81.01820	31.20650	2.83	2.82	-0.01
110	1749	3	81.15600	31.21790	------	0.23	------
111	1751	3	81.13630	31.16160	1.42	1.03	-0.39
112	1753	3	81.32100	31.17270	1.00	0.97	-0.03
113	1754	3	81.32160	31.16050	0.39	1.17	0.78
114	1755	3	81.32580	31.13840	2.75	1.94	-0.82
115	1756	3	81.45720	31.01400	0.61	0.45	-0.17
116	1781	3	81.48220	30.46170	2.46	2.67	0.21
117	2171	3	81.08480	31.26970	0.79	0.58	-0.22
118	2173	3	81.13750	31.19430	6.04	7.20	1.17
119	2174	3	81.17310	31.20970	3.87	2.77	-1.10
120	2178	3	81.66630	31.02640	1.98	1.93	-0.05

121	2179	3	81.66720	30.94880	2.93	2.79	-0.14
122	2180	3	81.84980	31.00530	**23.56**	**24.90**	**1.34**
123	2183	3	81.83010	30.38650	0.39	0.23	-0.15
124	2184	3	81.81450	30.40130	0.44	0.18	-0.26
125	2185	3	81.77800	30.39100	0.80	0.69	-0.11
126	2190	3	80.95190	31.34160	0.75	0.51	-0.24
127	2191	3	80.95430	31.31860	1.97	1.92	-0.05
128	2195	3	81.41010	30.45640	2.12	2.21	0.08
129	6037	3	80.47080	30.55150	------	4.69	------
130	6038	3	80.44990	30.55350	------	2.84	------
131	6094	3	80.63110	30.55360	------	1.60	------
132	7029	3	81.40060	30.47690	1.02	1.49	0.47
133	7037	3	81.48150	30.46280	0.31	0.23	-0.08
134	7043	3	81.75710	30.40090	0.86	1.15	0.29
135	7060	3	81.36620	31.12570	0.46	0.62	0.17
136	7064	3	81.31210	31.14960	0.80	0.46	-0.34
137	7065	3	81.31190	31.14740	0.60	0.12	-0.49
138	7066	3	81.29700	31.18120	1.94	2.89	0.95
139	7067	3	81.24750	31.10680	0.79	0.35	-0.45
140	7074	3	81.11360	31.24030	1.47	1.70	0.23
141	7075	3	81.09030	31.24160	0.50	0.47	-0.03
142	7076	3	81.09040	31.24060	0.45	0.46	0.00
143	7079	3	81.07290	31.25910	0.46	0.41	-0.05
144	7080	3	81.07160	31.27340	0.20	0.29	0.09
145	7081	3	81.06860	31.27610	0.30	0.51	0.21
146	7082	3	81.02400	31.28110	1.72	0.74	-0.98
147	7089	3	81.80340	30.40750	0.26	0.29	0.03
148	7090	3	81.84590	30.41010	0.50	0.46	-0.05
149	9121	3	81.91300	30.36930	------	1.38	------
150	9122	3	80.98550	30.71270	------	0.29	------
151	9123	3	80.97970	30.71690	------	0.34	------
152	9124	3	80.83790	31.26410	------	0.22	------
153	9125	3	80.83550	31.26370	------	0.11	------
154	9126	3	80.84090	31.26210	------	0.22	------
155	9127	3	81.20340	30.89280	------	0.79	------
156	9128	3	81.19970	30.89310	------	1.71	------
157	9129	3	81.19690	30.89240	------	0.46	------
158	9130	3	80.99730	31.27520	------	0.11	------
159	9131	3	80.98650	31.35360	------	0.59	------
160	9132	3	80.63560	30.46200	------	0.29	------
161	9133	3	80.53220	30.51110	------	3.31	------
162	9134	3	81.36420	30.70150	------	7.23	------
163	9135	3	81.77810	30.67790	------	1.08	------
164	9136	3	81.77860	30.67850	------	0.34	------
165	9137	3	81.72040	30.61110	------	1.10	------
166	9138	3	81.56350	30.77240	------	0.35	------
167	9139	3	81.56570	30.77400	------	0.45	------
168	9140	3	81.56490	30.77470	------	0.23	------
169	9141	3	81.55650	30.78010	------	0.63	------
170	9142	3	81.59570	30.79610	------	1.60	------
171	9143	3	81.56750	30.76960	------	0.57	------
172	9144	3	81.56610	30.76980	------	0.34	------
173	9145	3	81.53520	30.77640	------	0.35	------

174	9146	3	81.53240	30.77620	------	0.39	------
175	9147	3	81.36800	30.59530	------	**20.91**	------
176	9148	3	81.39260	30.45610	------	0.34	------
177	9149	3	81.39360	30.45610	------	0.22	------
178	9150	3	81.42580	30.41670	------	**18.62**	------
179	9151	3	81.89990	30.64800	------	0.63	------
180	9152	3	81.71210	30.44090	------	2.05	------
181	9154	3	81.77170	30.38880	------	0.12	------
182	9155	3	81.76550	30.40830	------	2.00	------
183	9156	3	81.81290	30.38600	------	0.23	------
184	9157	3	81.84470	30.39020	------	0.57	------
185	9160	3	80.43600	30.51970	------	0.68	------
186	9162RS	3	80.39930	30.55080	------	**41.96**	------
187	9163	3	80.40310	30.59730	------	4.33	------
188	9164	3	80.44610	30.64960	------	0.35	------
189	9165	3	80.49640	30.88290	------	3.22	------
190	9166	3	80.50820	30.54090	------	0.91	------
191	9187	3	80.50610	30.53380	------	0.29	------
192	9188	3	80.56950	30.49110	------	0.23	------
193	9189	3	80.63980	30.46260	------	1.09	------
194	9190RS	3	80.62110	30.53880	------	**23.90**	------
195	9191	3	80.62520	30.54320	------	0.71	------
196	9192	3	80.59770	30.54480	------	7.83	------
197	9193	3	80.61650	30.55430	------	0.92	------
198	9194	3	80.61630	30.55540	------	1.17	------
199	9195	3	80.62010	30.57230	------	0.70	------
200	9196	3	80.62660	30.54480	------	0.12	------
201	9197	3	80.56300	30.63250	------	4.30	------
202	9198	3	80.55180	30.68280	------	0.23	------
203	9199	3	80.57640	30.67280	------	0.85	------
204	9200RS	3	80.74470	30.82220	------	**628.42**	------
205	9201	3	80.75330	30.72590	------	0.57	------
206	9202	3	80.77000	30.73360	------	2.30	------
207	9203	3	80.76130	30.77960	------	0.65	------
208	9204	3	80.75770	30.77490	------	2.36	------
209	9205	3	80.76460	30.78120	------	5.36	------
210	9206	3	80.97020	31.33770	------	0.17	------
211	9207	3	81.07290	31.29310	------	0.17	------
212	9209	3	81.13360	31.19520	------	0.28	------
213	9210	3	81.22450	31.16070	------	1.14	------
214	9211	3	81.23200	31.14900	------	0.80	------
215	9212	3	81.24190	31.14240	------	0.23	------
216	9213	3	81.24630	31.14290	------	0.23	------
217	9214	3	81.25800	31.13930	------	0.69	------
218	9215	3	81.22200	31.11030	------	1.77	------
219	9216	3	81.24940	31.10550	------	0.23	------
220	9217	3	81.25150	31.11600	------	1.20	------
221	9218	3	81.26180	31.12400	------	0.12	------
222	9219	3	81.25790	31.11670	------	2.92	------
223	9220	3	81.41040	31.16640	------	0.28	------
224	9221	3	81.37100	31.09270	------	1.32	------
225	9222	3	81.43230	31.09200	------	0.28	------
226	9223	3	81.42400	31.08390	------	0.96	------

227	9224	3	81.44850	31.10990	------	0.23	------
228	9225	3	81.50330	31.06420	------	0.86	------
229	9226	3	81.53070	31.09420	------	0.34	------
230	9227	3	81.54680	31.09180	------	0.23	------
231	9228	3	81.51250	31.03520	------	2.90	------
232	9229	3	81.51830	31.03180	------	0.51	------
233	9230	3	81.55440	31.02690	------	0.68	------
234	9231	3	81.89240	30.95350	------	4.79	------
235	9232	3	81.89220	30.94680	------	5.50	------
236	9233	3	81.90010	30.94710	------	0.51	------
237	9234	3	81.97910	30.84120	------	3.71	------
238	9235	3	80.44710	30.65030	------	0.23	------
239	9236	3	80.44730	30.64890	------	0.23	------
240	9237	3	80.50150	30.53450	------	0.35	------
241	9238	3	80.50910	30.51200	------	0.40	------
242	9239	3	80.51220	30.51150	------	0.11	------
243	9240	3	80.52850	30.51490	------	0.29	------
244	9241	3	80.64020	30.46000	------	1.27	------
245	9242	3	81.23450	31.14730	------	0.28	------
246	9243	3	81.25630	31.10640	------	0.23	------
247	9244	3	81.39340	31.12840	------	0.46	------
248	1557RS	3	81.17040	30.91040	**92.85**	**85.56**	**-7.29**
249	1771RS	3	81.09210	30.92540	**14.99**	**12.04**	**-2.95**
250	1772RS	3	81.10000	30.92560	3.52	4.02	0.50
251	1773RS	3	81.10900	30.92370	2.52	2.77	0.25
252	1774RS	3	81.11710	30.92410	**12.93**	**15.07**	**2.13**
253	1776RS	3	81.13680	30.92070	**13.98**	**13.65**	**-0.33**
254	2170RS	3	81.10480	30.92440	2.05	3.48	1.43
255	455RS	3	80.78280	31.10630	**------**	**10.65**	**------**
256	1011HWL	3	81.52890	30.83100	------	2.41	------
257	1031HWL	3	81.52390	30.77630	1.71	2.25	0.53
258	1039HWL	3	81.70090	30.51450	**12.16**	**13.34**	**1.18**
259	1088HWL	3	81.54200	30.81840	1.38	1.66	0.28
260	1090HWL	3	81.54060	30.77800	1.87	2.27	0.39
261	1092HWL	3	81.56470	30.76770	**14.13**	**19.38**	**5.25**
262	1122HWL	3	81.81620	30.43900	0.48	0.17	-0.31
263	1123HWL	3	81.81780	30.43910	0.55	0.34	-0.21
264	1124HWL	3	81.82010	30.43770	4.48	4.07	-0.42
265	1136HWL	3	81.77650	30.41060	7.57	7.12	-0.46
266	1139HWL	3	81.79690	30.42340	2.90	2.68	-0.23
267	1355HWL	3	81.54830	30.78160	1.28	2.62	1.34
268	1356HWL	3	81.54580	30.77960	0.65	0.94	0.30
269	1358HWL	3	81.55290	30.77840	2.04	1.39	-0.65
270	1363HWL	3	81.54060	30.77350	**22.24**	**38.84**	**16.60**
271	1375HWL	3	81.36050	30.70260	**28.96**	**35.13**	**6.16**
272	1383HWL	3	81.21050	30.89360	2.63	1.80	-0.83
273	1384HWL	3	81.20730	30.89430	1.92	1.49	-0.43
274	138HWL	3	81.23240	30.68840	**25920.90**	**25922.90**	**1.99**
275	139HWL	3	81.56560	30.80150	------	350.91	------
276	145HWL	3	81.47110	30.68450	**41573.40**	**41567.00**	**-6.40**
277	172HWL	3	81.71970	30.44840		6.54	
278	1782HWL	3	81.73800	30.54830	**30.65**	**27.08**	**-3.56**
279	1784HWL	3	81.71060	30.55970	2.68	2.40	-0.28

280	1786HWL	3	81.74960	30.54170	1.03	0.96	-0.07
281	179HWL	3	81.71280	30.42960	------	**25.00**	------
282	184HWL	3	81.72070	30.42110	------	**19.46**	------
283	185HWL	3	81.74520	30.40920	------	9.20	------
284	205HWL	3	81.56530	30.78790	6.38	6.68	0.30
285	207HWL	3	81.54850	30.78430	6.34	5.65	-0.69
286	208HWL	3	81.55290	30.78380	2.55	2.17	-0.38
287	210HWL	3	81.55350	30.77110	**63.72**	**69.07**	**5.35**
288	211HWL	3	81.70640	30.50190	1.99	2.00	0.02
289	2165HWL	3	81.55080	30.78160	0.30	0.34	0.04
290	2166HWL	3	81.54940	30.78020	0.35	0.34	-0.01
291	2167HWL	3	81.59060	30.76170	**250.31**	**255.97**	**5.66**
292	257HWL	3	81.56880	30.78920	1.74	1.61	-0.12
293	282HWL	3	81.72120	30.42800	------	3.45	------
294	385HWL	3	81.53730	30.77810	5.32	5.06	-0.26
295	692HWL	3	81.77010	30.45900	------	4.19	------
296	7040HWL	3	81.69820	30.43910	------	0.81	------
297	7042HWL	3	81.74810	30.40480	------	0.24	------
298	7047HWL	3	81.69010	30.55440	1.40	0.86	-0.53
299	7088HWL	3	81.76220	30.42040	3.70	3.70	0.01
300	9153HWL	3	81.78480	30.46150	------	0.17	------
301	9158HWL	3	81.74830	30.44740	------	2.00	------
302	960HWL	3	81.69140	30.49650	2.65	4.01	1.36
303	961HWL	3	81.69410	30.49730	2.01	2.53	0.52
304	962HWL	3	81.70020	30.49440	1.34	1.22	-0.12
305	966HWL	3	81.73990	30.40230	------	5.24	------
306	968HWL	3	81.69770	30.45460	------	3.51	------
307	969HWL	3	81.69690	30.43090	------	5.83	------

Table 8.5: Distribution of Lakes as per satellite data interpretation forthe year 2020 using LISS-III sensor

Sr.No.	Lake Id. Number	Basin Number	Longitude	Latitude	Aerial Extent on 10 Oct 2020 (ha.)
6) IRS RS2 LISS III 100-49					
1	181	3	81.4619	30.4299	**17.94**
2	970	3	81.5129	30.4812	7.44
3	971	3	81.5132	30.477	3.62
4	972	3	81.4918	30.4546	2.27
5	973	3	81.4955	30.4536	0.58
6	978	3	81.4566	30.4378	3.99
7	979	3	81.4332	30.4708	0.94
8	989	3	81.4754	30.4263	2.21
9	990	3	81.4793	30.4277	3.71
10	996	3	81.4982	30.4593	2.22
11	1102	3	81.4861	30.4793	0.40
12	1117	3	81.4648	30.4441	0.65
13	1128	3	81.8705	30.4269	**24.07**
14	1133	3	81.8671	30.419	**14.43**
15	1141	3	81.8844	30.4034	1.50
16	1153	3	81.9294	30.3843	**69.23**
17	1156	3	81.8939	30.3904	**10.85**
18	1447	3	81.7269	31.0517	1.09

19	1777	3	81.4654	30.4273	4.10
20	1778	3	81.4687	30.4279	0.70
21	1779	3	81.47	30.428	0.64
22	1780	3	81.4666	30.4226	0.23
23	7035	3	81.4832	30.4649	0.35
24	9244	3	81.9474	30.3499	1.57
25	9245	3	81.936	30.3655	0.29
26	9246	3	81.9382	30.366	0.77
27	9247	3	81.9621	30.4791	0.34
28	9248	3	81.9886	30.5486	0.35
29	9249	3	81.85	30.5142	2.01
30	9250	3	82.0144	30.5468	1.05
31	9251	3	81.8953	30.5407	1.00
32	9252	3	81.8937	30.5409	0.92
33	9253	3	82.0342	30.5573	0.87
34	9254	3	82.0348	30.5564	0.41
35	9255	3	82.0354	30.5734	0.64
36	9256	3	82.039	30.5729	0.23
37	9257	3	82.0577	30.5703	1.32
38	9258	3	82.0626	30.5696	0.58
39	9259	3	82.0623	30.5875	0.92
40	9260	3	82.1189	30.5449	1.62
41	9261	3	81.4733	30.4287	0.23
42	9262	3	81.4738	30.4264	0.29
43	9263	3	81.4869	30.4094	3.13
44	9264	3	81.432	30.4715	0.35
45	9265	3	81.4327	30.4715	0.46
46	9266	3	81.5583	30.4634	1.45
47	9267	3	82.2668	30.5608	4.45
48	9268	3	82.2622	30.5619	1.67
49	9269	3	82.2563	30.5638	0.23
50	9270	3	82.2552	30.5647	0.23
51	9271	3	82.1173	30.6854	1.52
52	9272	3	81.9926	30.8795	0.64
53	9273	3	81.9938	30.8789	0.46
54	9274	3	81.9947	30.8771	0.75
55	9275	3	82.1704	30.8076	2.71
56	9276	3	82.3563	30.7321	3.28
57	9277	3	82.2343	30.7312	0.92
58	9278	3	82.2523	30.5674	0.52
59	9279	3	82.2512	30.5664	0.99
60	9280	3	82.247	30.5801	1.67
61	9281	3	82.2243	30.5883	1.21
62	9282	3	82.2265	30.5835	0.86
63	9283	3	82.2163	30.5866	0.34
64	9284	3	82.2181	30.5858	1.15
65	9285	3	82.2176	30.5802	3.43
66	9286	3	82.1796	30.5849	1.68
67	9287	3	82.2471	30.5947	0.45
68	9288	3	82.2363	30.6151	0.46
69	9289	3	81.8778	30.3762	2.20
70	9290	3	81.8807	30.377	0.58
71	9291	3	81.9123	30.3586	0.99

72	9292	3	81.7433	30.5062	1.62
73	9293	3	81.8389	31.0114	0.58
74	9294	3	81.8591	31.0086	0.17
75	9295	3	81.5925	30.7548	0.35
76	9296	3	81.0399	30.6062	0.74
77	9297	3	80.9977	30.6959	5.35
78	9298	3	81.0066	30.7119	1.53
79	9299	3	80.9998	30.7029	0.80
80	9300	3	81.0028	30.7083	0.29
81	9301	3	80.9955	30.705	0.46
82	9302	3	81.4972	30.4542	0.23
83	9303	3	81.4845	30.4793	0.23
84	9304	3	81.4843	30.4657	0.35
85	9305	3	81.4859	30.4651	0.23
86	9306	3	81.427	30.4671	0.59
87	9307	3	81.9918	30.88	0.17
88	9308	3	81.4962	30.454	0.35
89	9309	3	81.8858	30.3818	1.77
90	9310	3	81.5774	30.4568	0.24
91	9311	3	81.6858	30.4477	0.23
92	9312	3	81.686	30.4411	0.34
93	1093HWL	3	82.1345	30.6371	**6012.98**
94	1094HWL	3	82.071	30.5963	**12.70**
95	1095HWL	3	82.0827	30.5915	**14.44**
96	1766HWL	3	81.7905	30.8807	0.76
97	1787HWL	3	82.1152	30.5851	1.46
98	1788HWL	3	82.1225	30.5713	1.86
99	1789HWL	3	82.1558	30.5427	4.72
100	1790HWL	3	82.2145	30.5936	6.37
101	1791HWL	3	82.2262	30.6235	0.86
102	1792HWL	3	82.2267	30.6226	0.64
103	1793HWL	3	82.2342	30.6189	1.33
104	1794HWL	3	82.2445	30.599	2.96
105	1795HWL	3	82.2457	30.5968	2.26
106	1796HWL	3	82.2414	30.5889	0.75
107	1797HWL	3	82.2456	30.5835	2.22
108	1798HWL	3	82.2361	30.5848	0.63
109	1802HWL	3	81.9902	30.5461	2.90
110	1804HWL	3	81.9692	30.4727	3.14
111	1805HWL	3	81.9623	30.4719	0.35
112	1808HWL	3	81.9593	30.4557	2.27
113	2188HWL	3	81.735	30.5537	3.91

HWL= High Altitude Wetland
RS= River Section

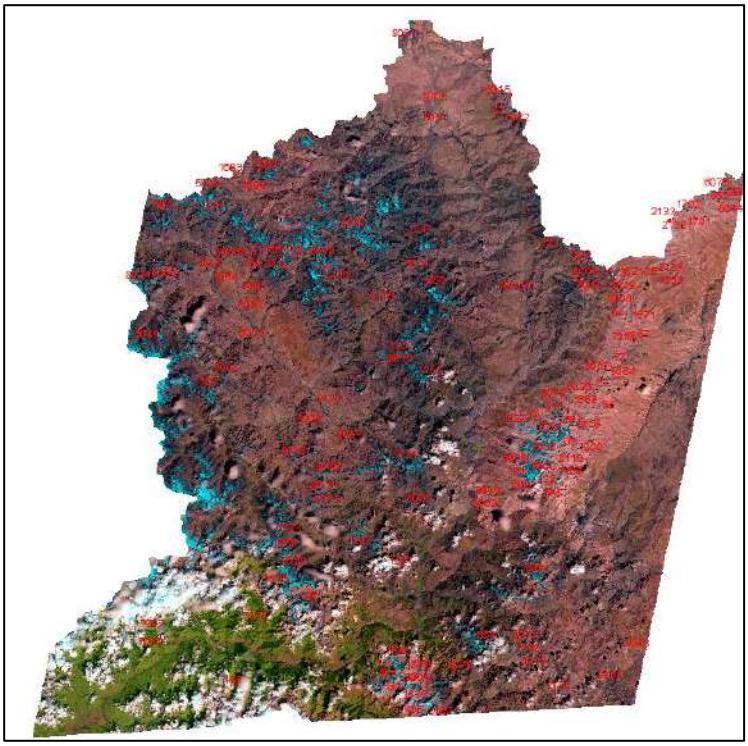


Fig.8.4a: Resourcesat-2 LISS III image 96-48, 14 September 2020 & the Interpreted layer

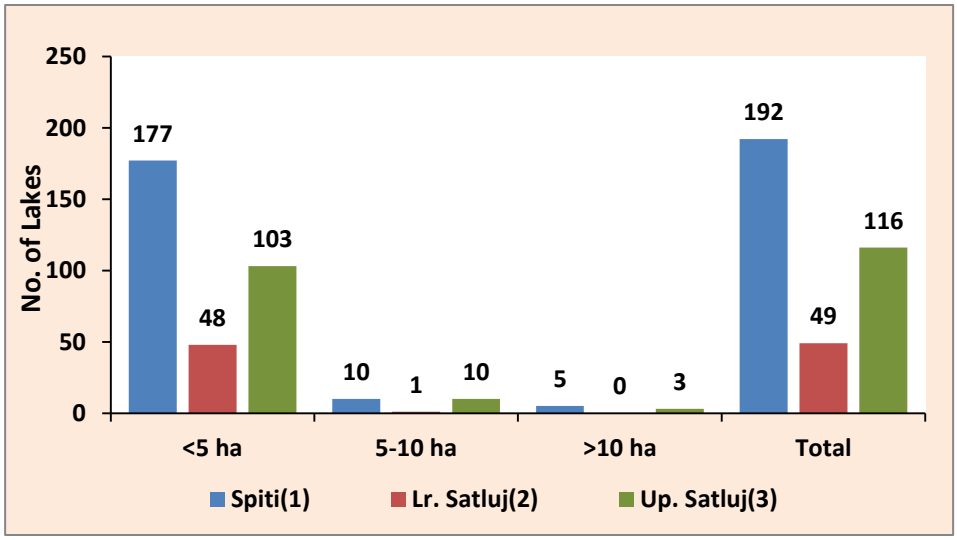


Fig.8.4b: No of lakes based on Resourcesat-2 LISS III image 96-48, 14 September 2020

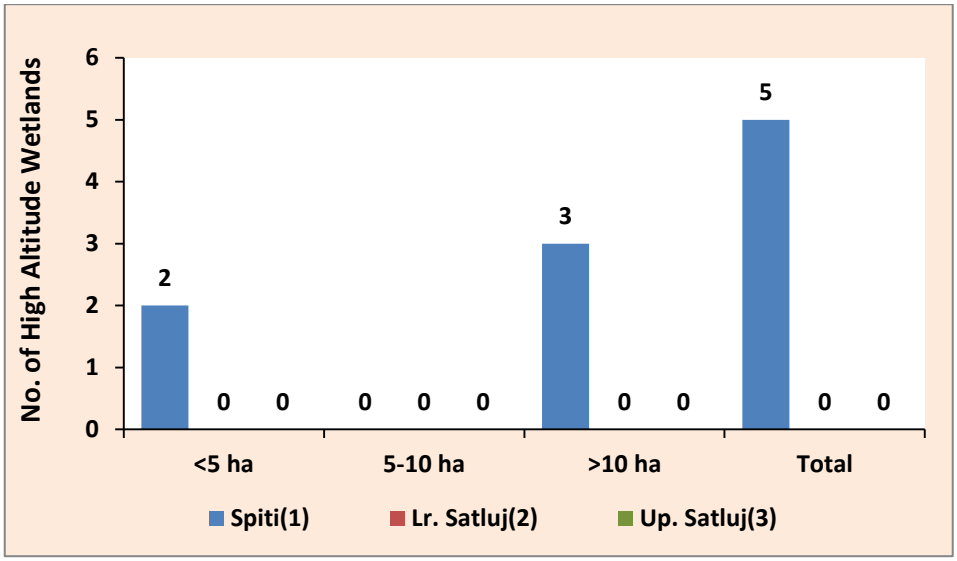


Fig.8.4c: No. of high altitude wetlands based on Resourcesat-2 LISS III image 96-48, 14 September 2020

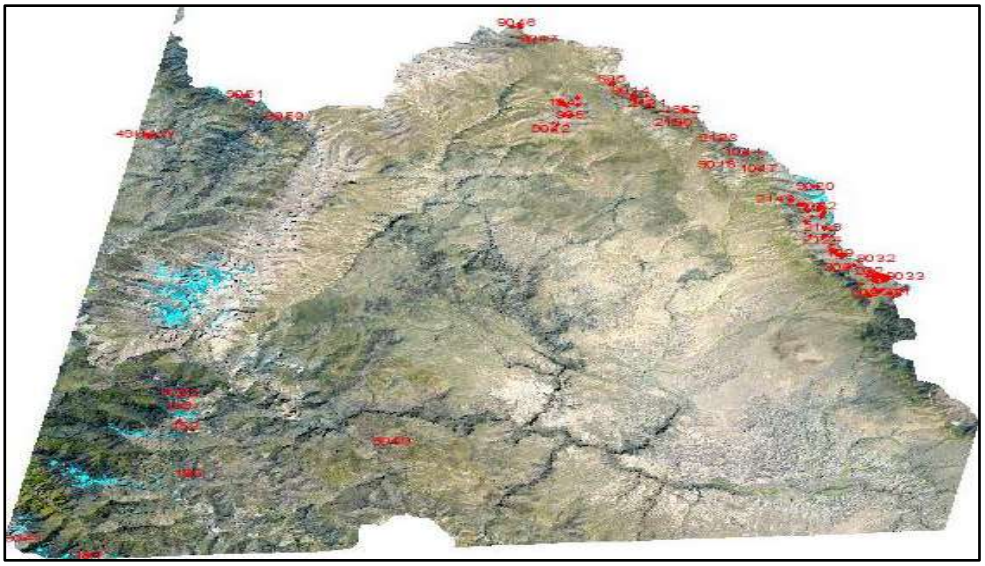


Fig.8.5a: Resourcesat-2 LISS III image 97-48, 12 September 2020& theInterpreted layer

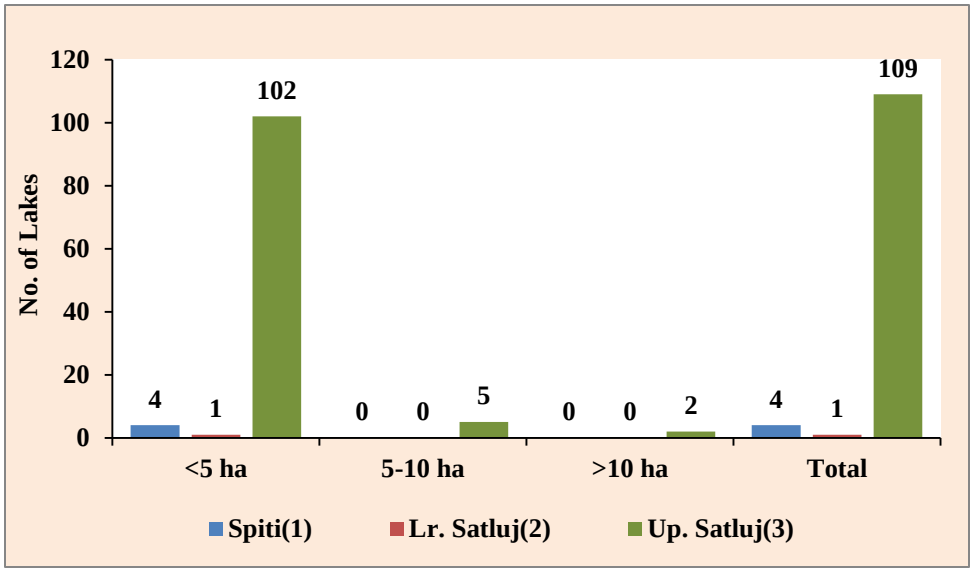


Fig. 8.5b: No. of lakes based on Resourcesat-2 LISS III image 97-48, 12 September 2020

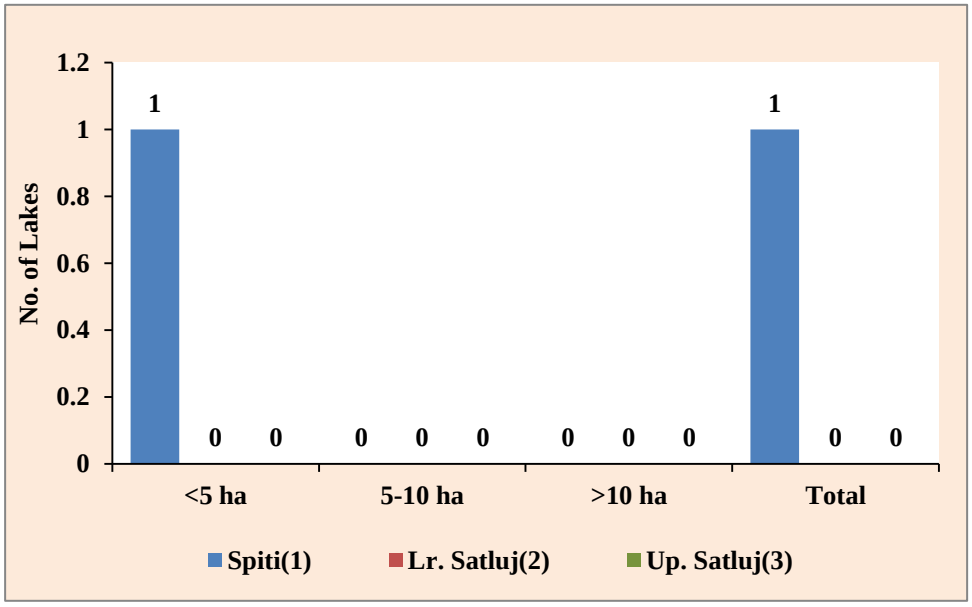


Fig.8.5c: No. of high altitude wetlands based on Resourcesat-2 LISS III image 97-48, 12 September 2020

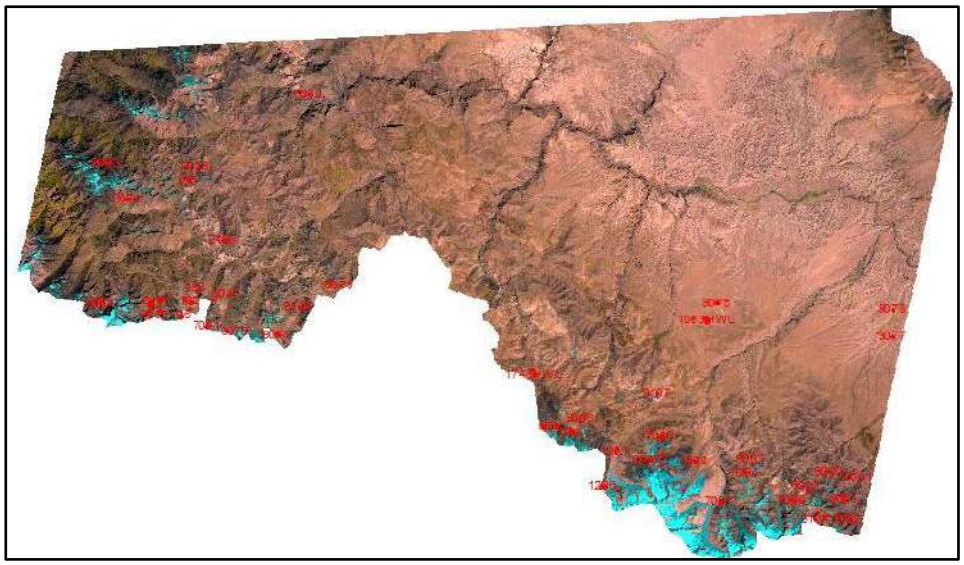


Fig.8.6a: Resourcesat-2 LISS III image 97-49, 12 September 2020& the Interpreted layer

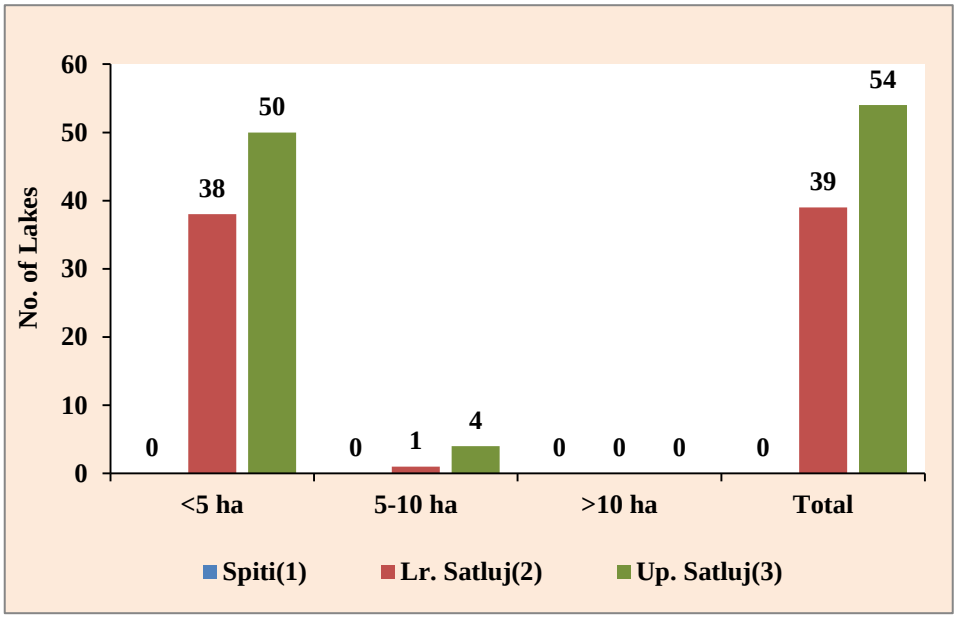


Fig.8.6b: No. of lakes based on Resourcesat-2 LISS III image 97-49, 12 September 2020

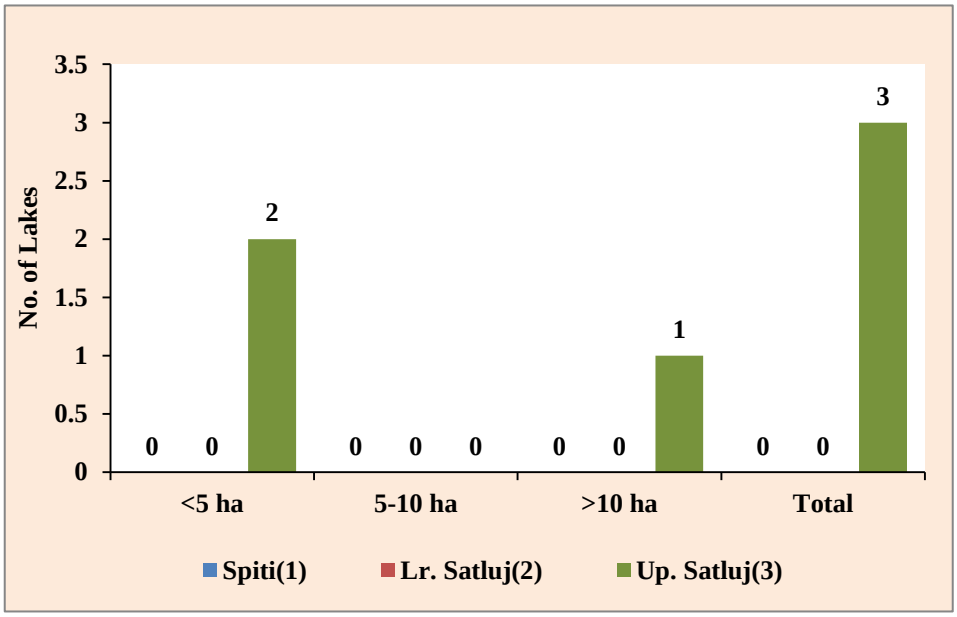


Fig.8.6c: Resourcesat-2 LISS III image 97-49, 12 September 2020& the Interpreted layer

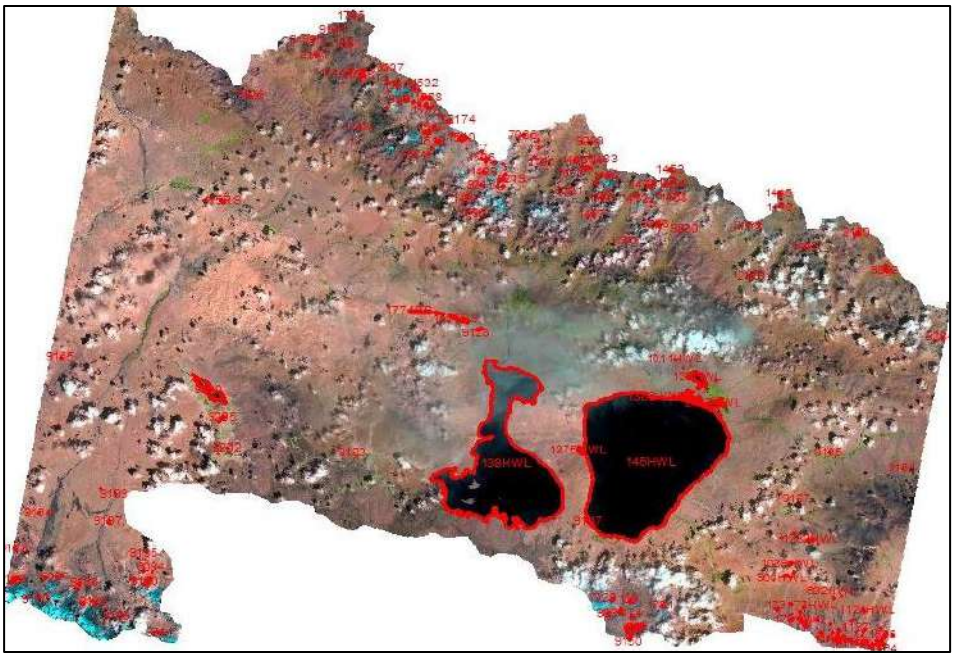


Fig.8.7a: Resourcesat-2 LISS III image 99-49, 05 September 2020& the Interpreted layer

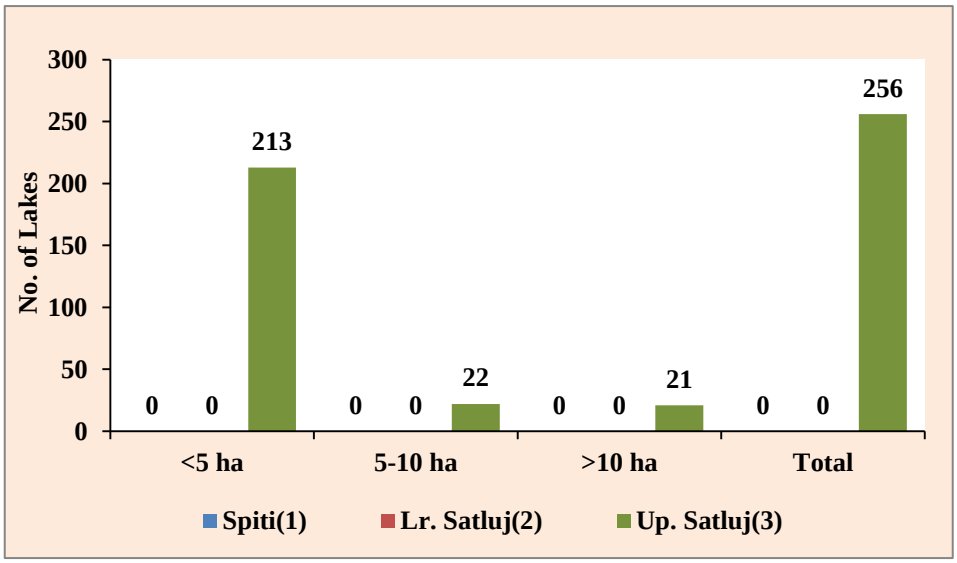


Fig.8.7 b: No. of lakes based on Resourcesat-2 LISS III image 99-49, 05 September 2020

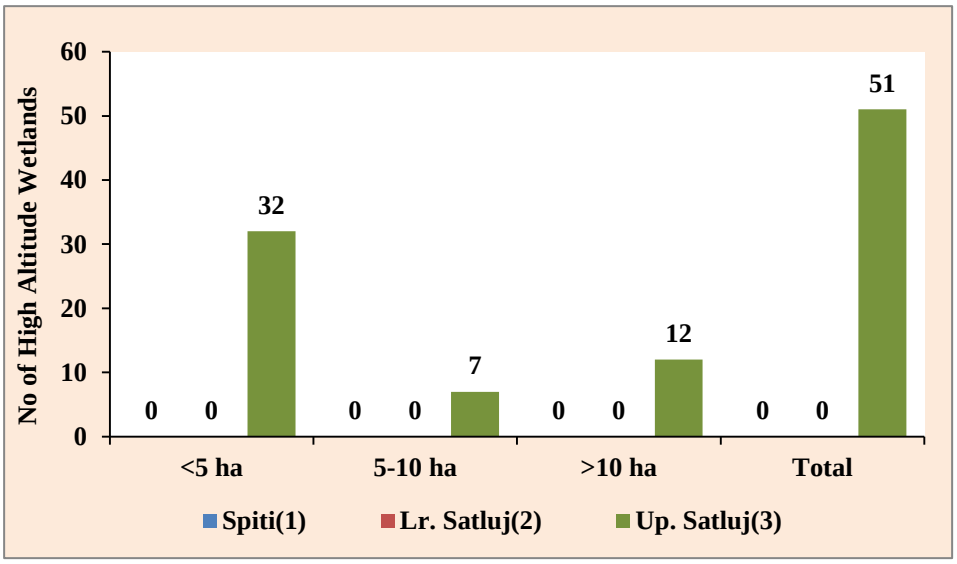


Fig.8.7 c: Resourcesat-2 LISS III image 99-49, 05 September 2020& the Interpreted layer

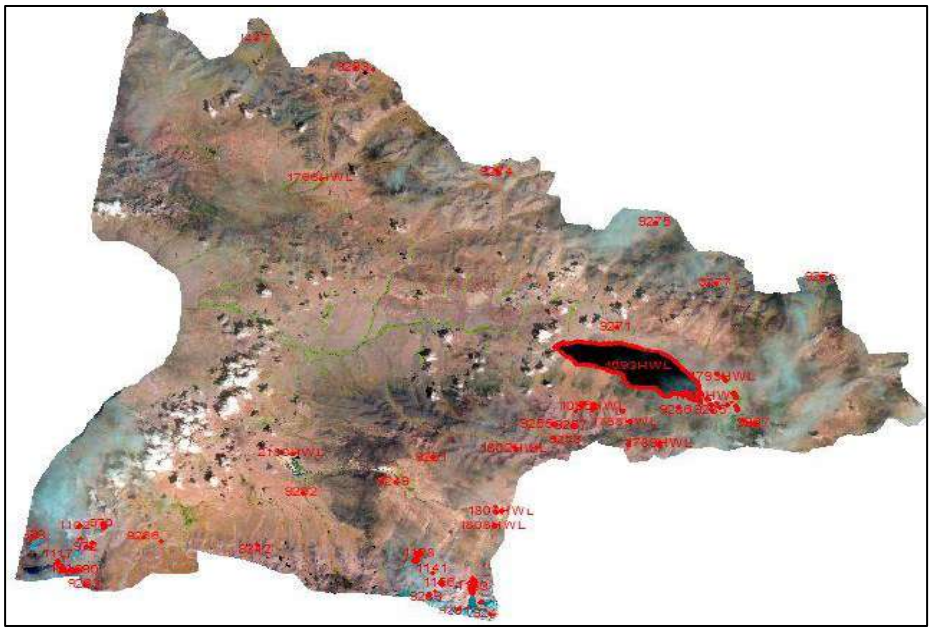


Fig.8.8a: Resourcesat-2 LISS III image100-49, 10 September 2020& the Interpreted layer

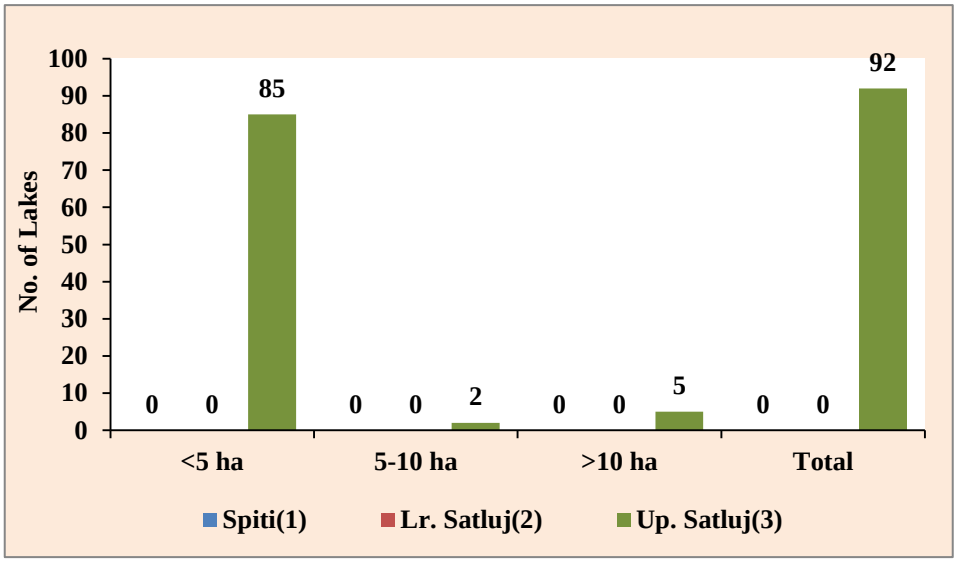


Fig.8.8 b: No. of lakes based on Resourcesat-2 LISS III image 100-49, 10 September 2020

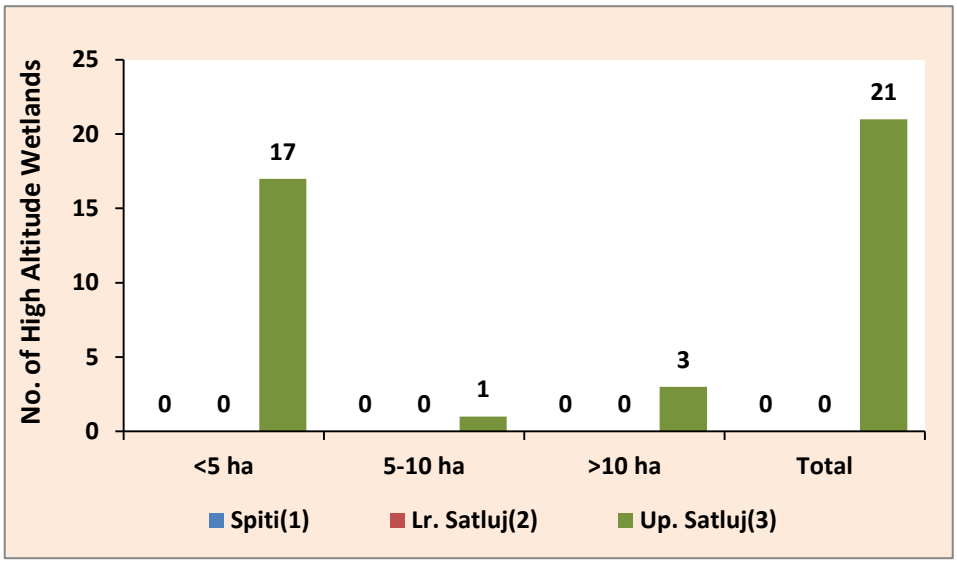


Fig.8.8 c: Resourcesat-2 LISS III image 100-49, 10 September 2020& the Interpreted layer

9.0: Basin wise comparative Analysis

The comparative analysis based on the results obtained from the analysis of AWIFS and LISS III data products during 2020 have been done with that of results obtained from 2019 for all 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 (Basin3). Based on the AWIFS satellite data analysis from April to October 2020 **(Table 9.1)** and **(Fig. 9.1)** suggest that maximum number of lakes/wetlands that could be delineated in 2020 using AWIFS satellite data having spatial resolution of 56 mts are 361 on 12 September 2020 in comparison to 229 as that of 09 September 2019 and were compared with that of 2019 indicating an overall increase of about 57% in total number of lakes mapped in 2020 in comparison to the maximum number of lakes mapped in 2019, and the variation is mainly due to the fact that the area covered on 09 September 2019 satellite data does not have the full coverage of the study area and the some part in basin 1&2 is missing as a result of which complete information could not be derived, where as in 2020 , the area coverage in the AWIFS satellite data on 12 September 2020 is complete, free from any cloud cover and snow cover impact, as a result of which the maximum information has been derived. The comparative analysis of the two dates reveals that the Spiti basin shows an increase of 44 lakes i.e 18 (2019) increased to 62(2020) comprising 43 lakes with area less 5ha, 13 lakes with area between 5-10ha and 7 lakes with more than 10ha, or in other words we can say that an enhancement of about 244% could be seen in the Spiti basin as a whole between 2019 and 2020 and 106%

enhancement w.r.t 2018(30). Likewise in Lower Satluj basin, an increase of about 185% w.r.t 2019 and about 3% w.r.t 2018 is observed i.e the number of lakes varies from 15(2018) to 7 (2019) to 20(2020) comprising 13 lakes having area less than 5ha, 5 lakes within the areal range of 5-10ha and 2 lakes having area more than 10ha. In Upper Satluj basin, a reduction of about 11% w.r.t 2018 and an increase of about 36% w.r.t 2019 could be seen in the total number of lakes mapped in 22 8(2018) to 204 (2019) to 279 (2020) comprising 163 lakes with area <5ha, 63 lakes with area between 5-10ha and 53 lakes with area >10ha. Thus from the analysis we can say about 77% of the total lakes falls in the Upper Satluj basin, 5% that from the Lower Satluj basin and 17% from the Spiti basin. Further comparative analysis of the bigger lakes with area >10ha reflects that 55% reduction could be seen in total number of lakes falling in this category total number of lakes with area more than 10ha varies from 69 (2018) to 31(2019) to 62 (2020) out of which 13 are the high-altitude wetlands. Further it is found that the Spiti basin the number of lakes with area >10ha that could be mapped varies from 4 (2018) to 1 (2019) to 7 (2020), in Lower Satluj basin the number of such lakes varies from 0 (2018) to 0 (2019) to 2 (2020), whereas in Upper Satluj basin the number varies from 60 (2018) to 30 (2019) to 53 (2020), and the variation is mainly due to the fact the coverage of the study area is not complete in 2019 during this month where maximum lakes have been mapped. Further analysis of **(Table -7.8)** reveals that total number of big lakes /wetlands with area more than 10ha mapped during 2020 is 70 (10 September 2020) out of 355 lakes mapped and likewise the number increase to 71 (16 October 2020) out of which 14 lakes are the high altitude wetlands, whereas the total number of lakes in October delineated as 288 (16 October),Further analysis of the **(Table-9.1)** and **(Fig. 9.4)** suggest that the lakes with area more than 10ha during 2017, 2018 and 2019 varies from 67 (2017) to 69 (2018) to 31(2019) to 62 (2020) in the month of September in the entire catchment. When the total number of lakes based on AWIFS data is seen w.r.t. 2007(196) onwards, it is found that a gradual increase has been observed in their number with some abnormalities in the beginning, whereas a gradual increasing trend could be seen from 2012 onwards **(Fig.9.5).** and then further reducing trend in 2018 and 2019. Out of 361 lakes mapped in 2020, 40 lakes are classified as high altitude wetlands in comparison to 38 (2019) and the remaining 321(2020) are from the glacial origin in comparison to 191(2019). Further these 40 wetlands when seen based on their areal size, it is found that 19 wetlands are of small dimensions i.e. less than 5ha, 8 are of the area between 5-10ha and 13 are of the area more than 10 ha respectively.

Based on the LISS-III satellite data analysis (96-48, 97-48, 97-49, 99-49 and 100-49) for 2020 a total of 993 have been delineated comprising 878 lakes as the small one with area less 5ha, 63 lakes with area 5-10ha and 52 lakes with area more than 10ha. As far as the full data coverage is concerned, the LISS III data mainly covers (96-48, 96-49, 97-48, 97-49, 98-48, 98-49, 99-49, 100-49) and thus there was a data gap in 2020 for (96-49, 98-48, 98-49) but some information could be derived by virtue of the data overlap. Maximum number of lakes mapped in 2020 from LISS III data falls in the path-row 96-48 (362) **(Fig. 8.4 b and 8.4c)** and 99-49 (307) **(Fig 8.7b and 8.7c).** Further out of 993 lakes mapped, 81 are mainly the high-altitude wetlands comprising 6 from Spiti basin and 75 from the Upper Satluj basin. The comparative analysis based on LISS-III satellite data reveals that total number of lakes varies from 642 (2017) to 769 (2018) to 562 (2019) to 993 (2020) indicating an overall increase of about 19% between 2017-18 and reduction of about 26% between 2018-19 and further an enhancement by about 76% between 2019-20 respectively. As far as the big lakes with area more than 10ha are concerned, total number of big lakes varies from 55 (2017) to 49 (2018) to 51 (2019) to 62 (2020) indicating a fluctuating trend in the lakes/wetlands with area >10ha.The total variation in the number of lakes mapped in Upper Satluj basin based on LISSS III data varies from 450 (2017) to 495 (2018) to 437 (2019) to 707 (2020) (Fig 8.3), in Lower Satluj basin the number varies from 102 (2017) to 98 (2018) to 52 (2019) to 89 (2020) (Fig 8.2) and in case of Spiti sub basin it varies from 90 (2017) to 176 (2018) to 73 (2019) to 197 (2020) (Fig.8.1) indicating about 10% (2017-18) and a reduction of about 11% (2018-19) and about 61% (2019-20) in case of Upper Saltuj basin, about 2% reduction (2017-18) and a reduction of about 46% (2018-19) and 71% (2019-20) in case of Lower Satluj and about 95% increase between 2017-18 and a reduction of about 58% (2018-19) and about 169% (2019-20) in case of Spiti basin could be seen. Further in Spiti basin the lakes with ids 1682RS (0.51ha), 1683RS (0.58ha), 1684RS (1.75ha),1686RS (1.09ha) and 1687RS (1.17ha) 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. All these water bodies are although small but needs monitoring **(Fig.9.11a and 9.11b).** Thus from the above analysis, it is clear that although the maximum number of lakes (about 71%) are being formed in the Upper Satluj basin , about 8% in the Lower Satluj basin and about 19% in the Spiti basin of the study area and majority of the lakes delineated in the entire study area during 2020 are small with area less than 5ha (about 88%) , about 6% 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 indicates an overall increase of about 57% in total number of lakes mapped in 2020 in comparison to 2019 reflecting 244% enhancement in case of Spiti basin, 185% increase in Lower Satluj and 36% from the Upper Satluj basin and the maximum lakes (77%) of the total 361 lakes have been mapped from Upper Satluj, 5% and 17% from Lower Satluj and Spiti basins respectively. In case of the bigger lakes with area >10ha, a 100% increase could also be seen in 2020 (62) in comparison to 2019 (31with majority of the lakes (53) forming part of the Upper Satluj basin, 2 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. Besides this on 16 October 2020, where in total 288 lakes have been mapped, out of which 71 lakes are with area more than 10ha comprising 14 lakes as the high altitude wetlands and the remaining 57 are the lakes from glacial origin as a whole in the entire study area. Likewise, LISS-III data indicates an increase of about 76% in terms of the total number of lakes with about 21% increase in case of the lakes with area more than 10ha. The comparative analysis based on LISS-III satellite data reveals that total number of lakes varies from 642 (2017) to 769 (2018) to 562 (2019) and 993 (2020) indicating an overall increase of about 19% between 2017-18 and reduction of about 26% between 2018-19 and about 76% increase between 2019-20 respectively. Thus, the data base based on AWIFS data product is reflects a complete inventory of 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 on 12 September 2020, whereas the LISS-III data products reflect a more detailed inventory of the lakes with a set of fine resolution (23.5mts) reflecting more detailed information about the lakes with small dimensions.

Table 9.1:Basin wise distribution of total number of lakes in Satluj Catchment during the year 2020 based on AWIFS and LISS III 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 (2020)	Total No. of lakes with area>10ha
Number of lakes based on AWIFS Satellite data during 2020					
16April2020	0	0	18	18	5
02Sep 2020	58	8	96	162	16
05Sep 2020	14	1	32	47	4
10 Sep 2020	38	10	307	355	70
12 Sep 2020	62	20	279	361	62
21Sep 2020	83	35	20	138	20

29Sep 2020	171	47	38	259	40
01 Oct 2020	56	29	161	246	44
16 Oct 2020	36	28	224	288	71
30 Oct 2020	4	8	160	172	52
Number of Lakes based on LISS III satellite Data during 2020					
96-48 (07&14 Sep2020)	194	49	119	362	3
97-48 (12 Sep 2020)	5	1	109	115	2
97-49 (12 Sep 2020)	0	39	57	96	1
99-49 (22 Oct 2020)	0	0	307	307	33
100-49 (10 Oct 2020)	0	0	113	113	8

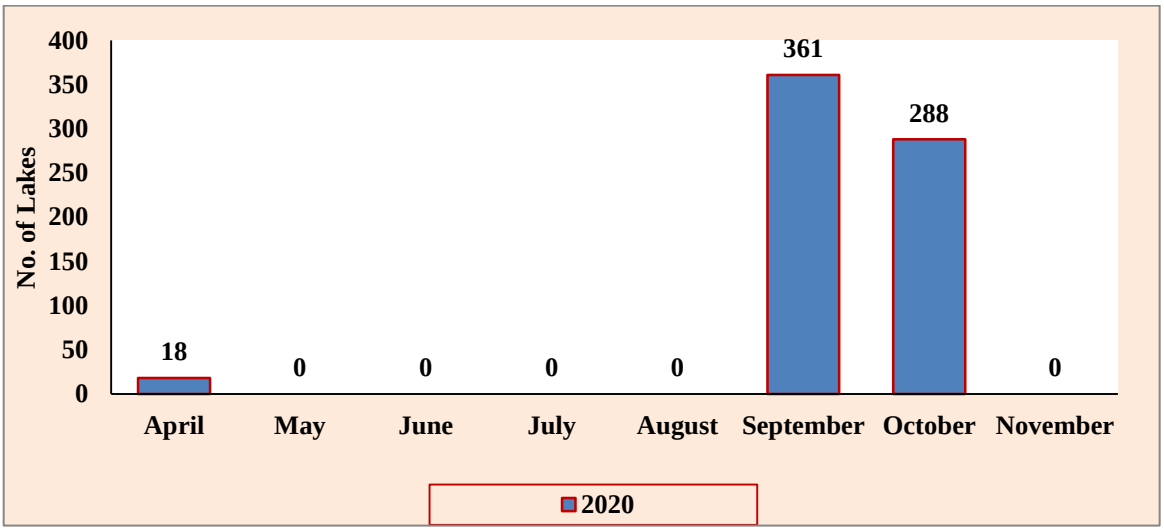


Fig. 9.1: Total No. of Lakes based on AWIFS satellite data 2020

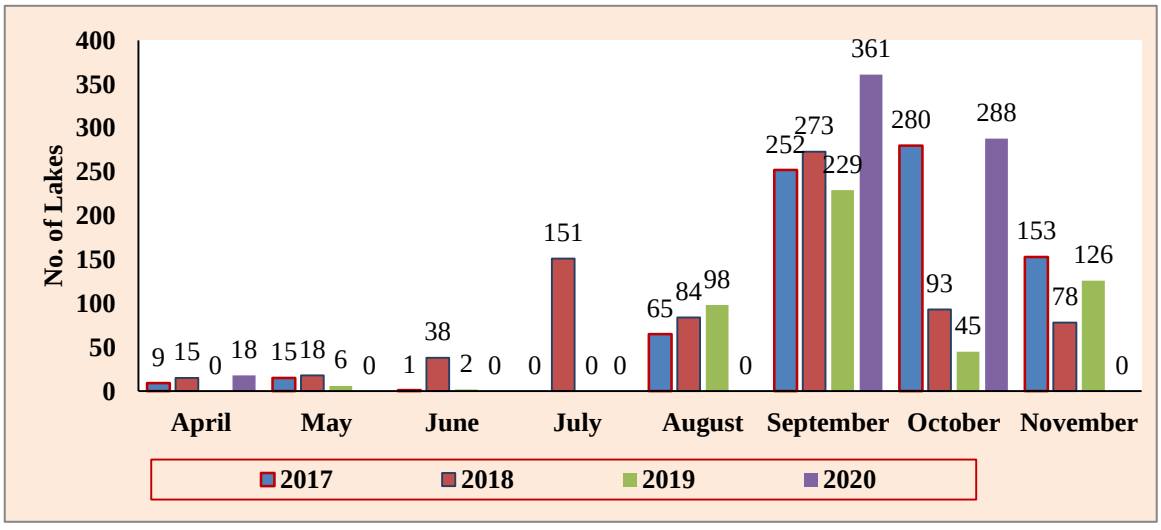


Fig. 9.2: Total No. of Lakes based on AWIFS satellite data 2017, 2018, 2019&2020

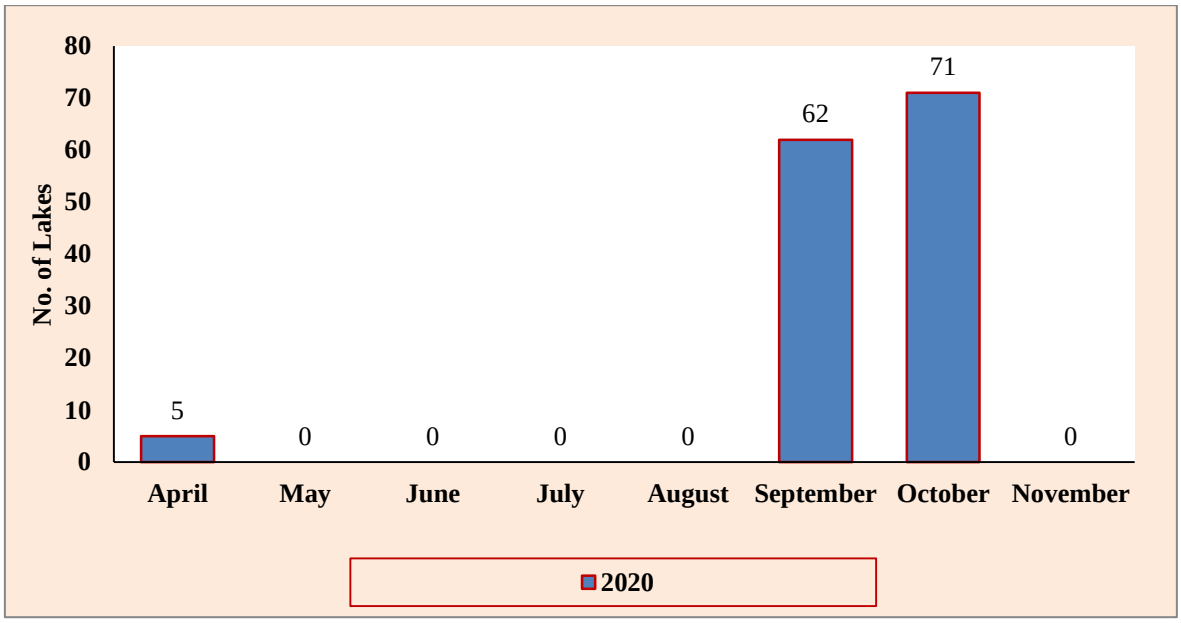


Fig. 9.3: Total No. of Lakes >10ha based on AWIFS satellite data 2020

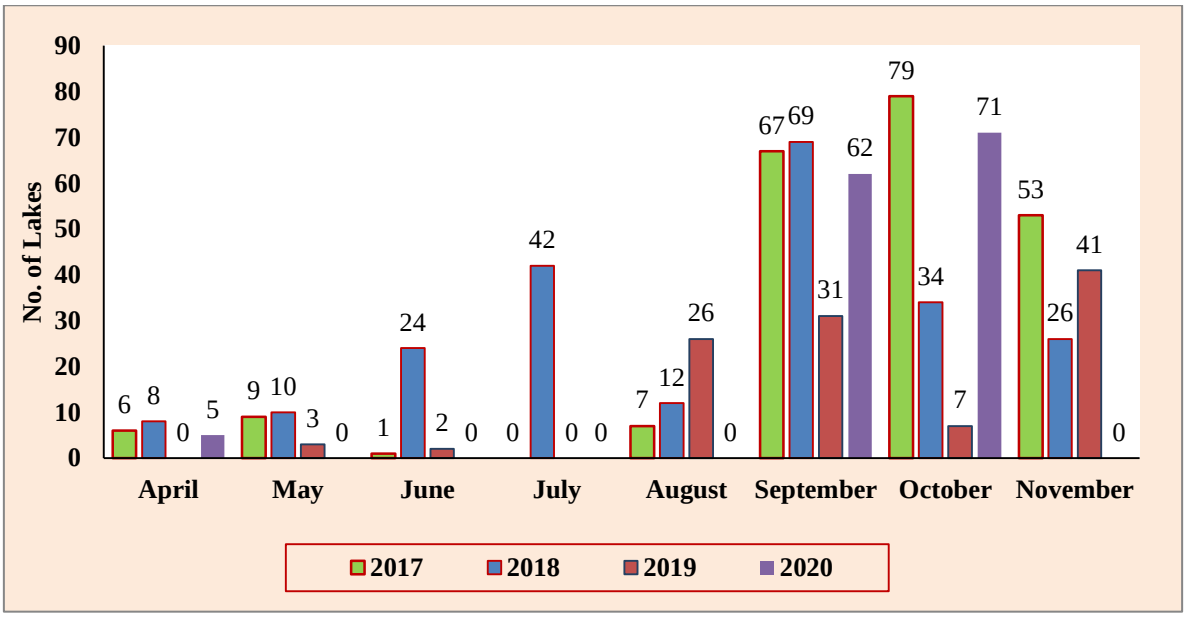


Fig. 9.4: Total No. of Lakes >10ha based on AWIFS satellite data 2017, 2018, 2019& 2020

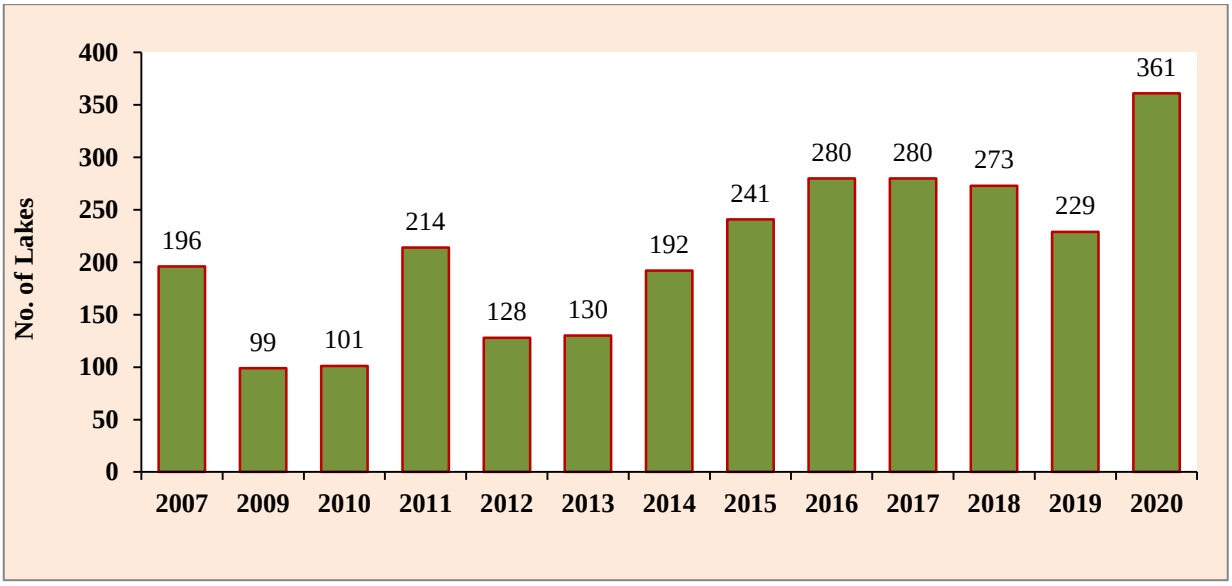


Fig. 9.5: Total Number of Lakes based on AWIFS Data

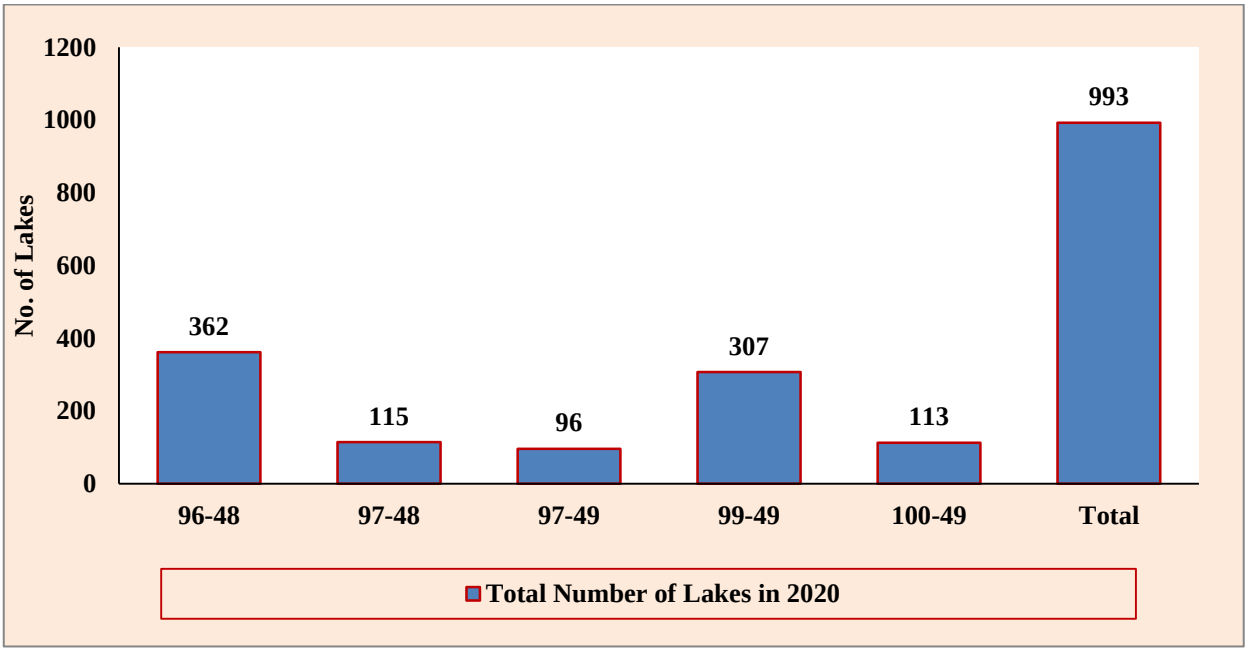


Fig. 9.6: Total No. of Lakes based on LISS III Satellite Data2020

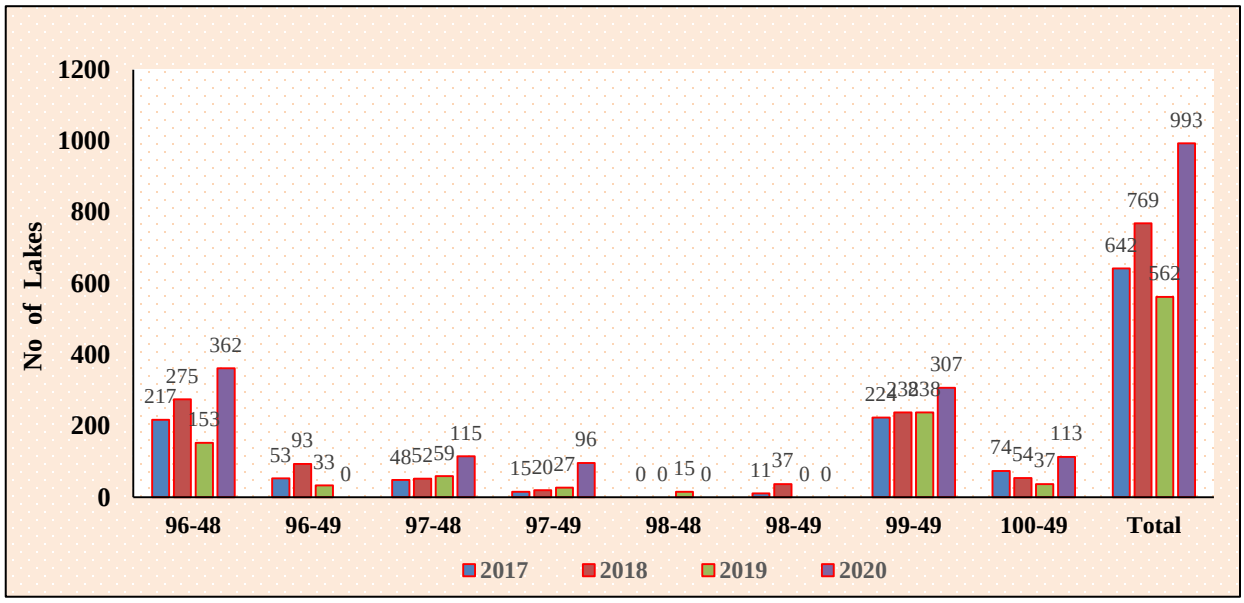


Fig. 9.7: Total No. of Lakes based on LISS III Satellite Data 2017, 2018, 2019, 2020

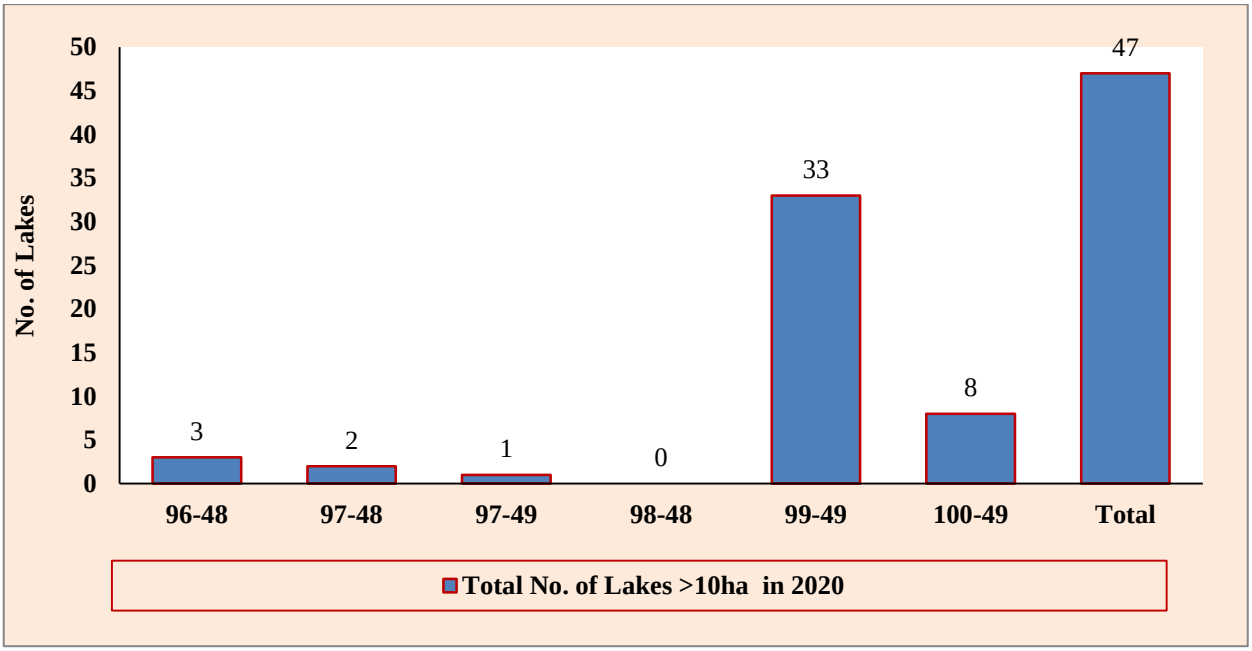


Fig. 9.8: Total No. of Lakes >10ha based on LISS III Satellite Data 2020

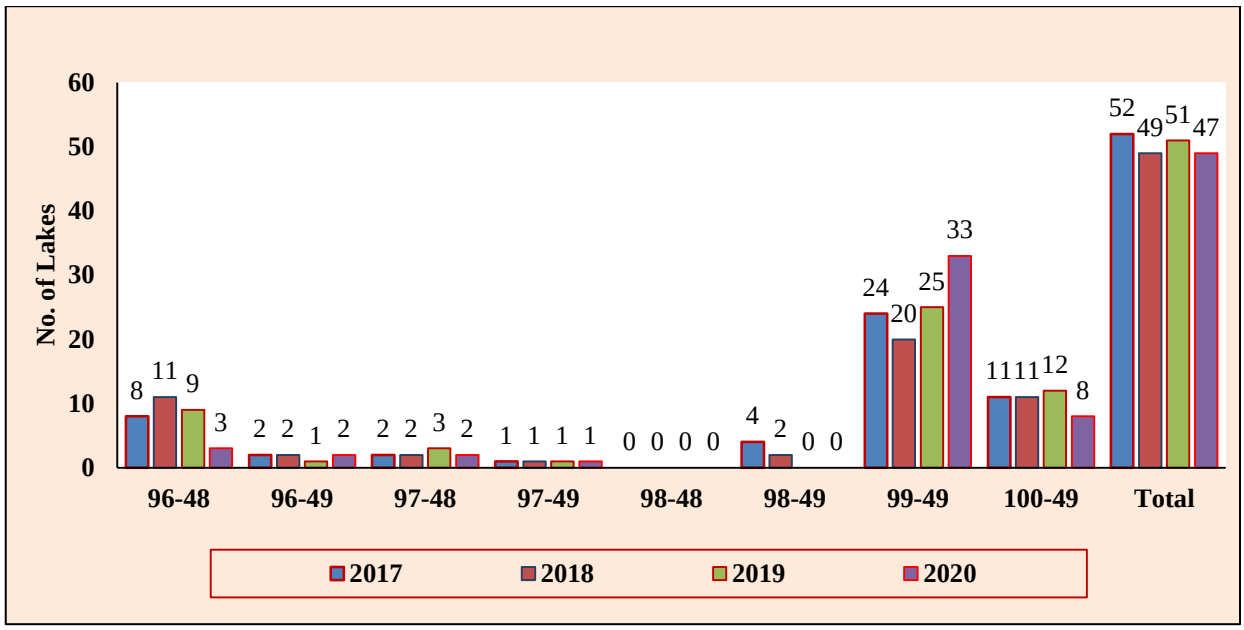


Fig. 9.9: Total No. of Lakes >10ha based on LISS III Satellite Data 2017, 20182019& 2020

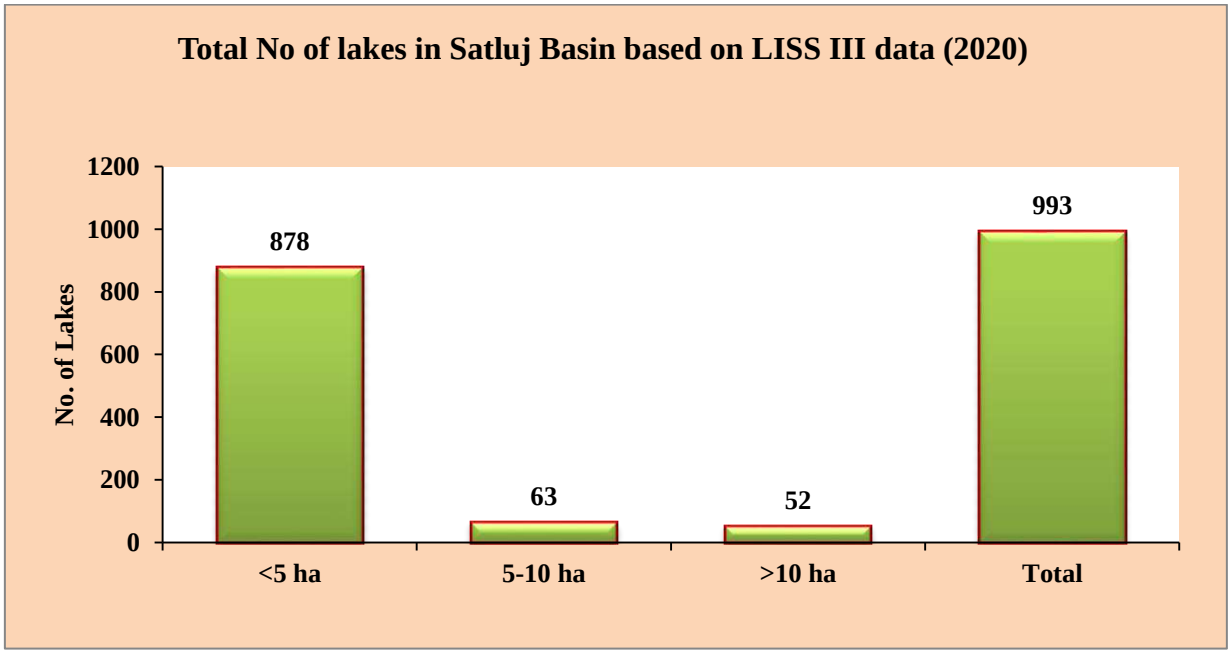


Fig. 9.10: Total No. of Lakes in Satluj Basin based on LISS III Satellite Data (2020)

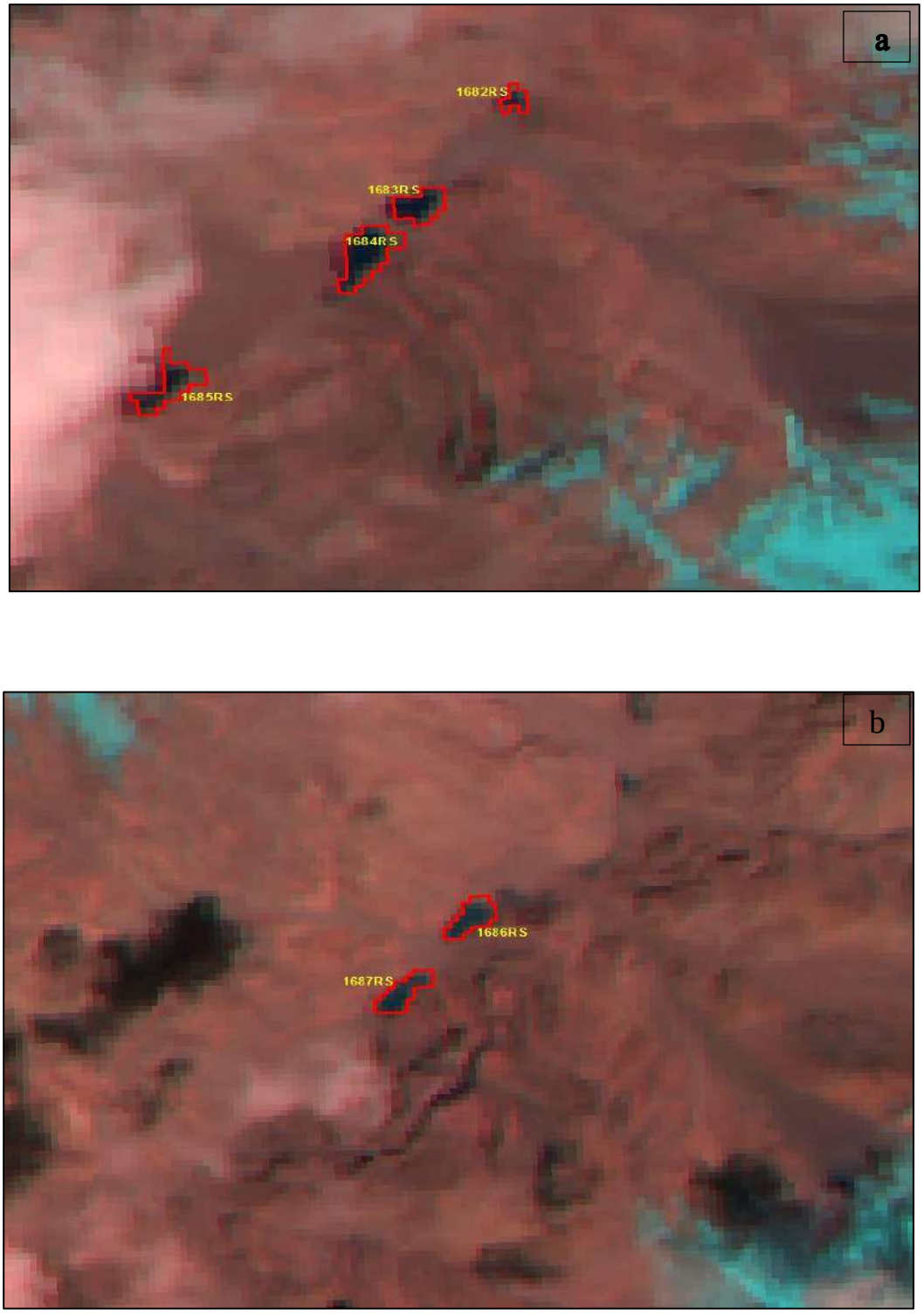


Fig. 9.11 (a-b): Satellite view of water bodies along the River Section in Spiti basin

10.0: Inventory of lakes based on LISS -IV satellite data for 2020

Besides the two datasets generated during 2020 using AWiFS (56mts) and LISS-III (23.5mts), a new set of data has been created for the entire Satluj catchment for 2020 using LISS-IV sensor having spatial resolution of 5.8mts, which provided a more precise and detailed information of the catchment. 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 2020 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, 96-48b, 96-48c, 96-48d, 97-48a, 97-48b, 97-49b, 99-49b path-row, besides some data gap within 98-48/49 and 100-49 path -row. Based on the above mentioned LISS-IV satellite data, a total of 1359 lakes/high altitude wetlands could be delineated comprising 225 from Spiti basin i.e basin1, 542 from the Lower Satluj basin i.e basin 2 and 592 from the Upper Satluj basin i.e. basin3, which may enhance further if the available satellite data would have covered the complete area **(Fig.10.1a-h) & (Table 10.1and 10.2).** Further out of these 1359 lakes/wetlands, 55 lakes have been classified as high-altitude wetlands and the remaining 1304 as from the glacial origin. Further analysis of the data reveals that out of 1359 lakes/wetlands delineated, 1278 are the small one with area less than 5ha, 36 are within the area range of 5-10 ha and 25 are the one which have the aera more than 10ha respectively. In other words, we can say that based on the LISS IV data, majority of the lakes /wetlands i.e.1298 (94%) are the small one with area less than 5ha, 36(2%) are within the areal range of 5-10ha and 25 (about 2%) are the big one with area more than 10ha.

As far as basin wise analysis based on LISS-IV data is concerned, it is observed that Spiti basin comprises of 225 lakes/wetlands out of which 9 lakes are mainly the high altitude wetlands, and the remaining 216 are from the glacial origin (Fig.10.5 &10.6). Further analysis based on the areal distribution reveals that out 225 lakes/wetlands, 212 lakes/wetlands are with area less than 5ha, 8 are within the areal range of 5-10ha and 5 lakes/wetlands are with area more than 10ha.Likewise, the Lower Satluj basin, a total of 542 lakes could be delineated comprising 539 lakes with area less than 5ha, 1 lake with are 5-10ha and 2 lakes with area more than 10ha. No high altitude wetland could be seen in this basin **(Fig.10.7**). Similarly in Upper Satluj basin i.e basin 3, a total of 592 lakes/wetlands could be delineated comprising 547 lakes/wetlands with are less than 5ha, 27 with area between 5-10ha and 18 with are more than 10ha **(Fig.10.8)** and out of these 592 lakes, 46 are mainly the high altitude wetlands and the remaining from the glacial origin.

The comparative analysis of the information retrieved from the visual interpretation, from the three different sensors reveals the following results

Table: 10.1: Comparative analysis of three different sensors

Sr. No.	**Basin Name**	**AWiFS (56mts)**	**LISS -III (23.5mts)**	**LISS-IV (5.8mts)**
1	Spiti Basin (1)	62	197	225
2	Lower Satluj (2)	20	89	542
3	Upper Satluj (3)	279	707	592
4	**Total Satluj Basin**	**361**	**993**	**1359**

From the above Table it is clear that, as the spatial resolution has increased, the level of information ahs also been increased, which is very much evident from the figures obtained that in Spiti basin, the number of lakes delineated has been enhanced from 62 with AWiFS sensor has increased to 197 with LISS III sensor and 225 with LISS IV sensor. Likewise in Lower Satluj basin, the 20 lakes delineated from AWiFS sensor has increased to 89 in LISS III and 542 with LISS IV sensor. Similarly in Upper Satluj basin, the 279 lakes as delineated from AWiFS sensor has increased to 707 with LISS III and 592 with LISS IV and the variation is mainly due to the data gap in LISS IV which mainly covers the areas falling in Upper Satluj basin. Thus from the above analysis base don 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.

10.1 Interpreted layer of LISS-IV data in Satluj Basin in 2020

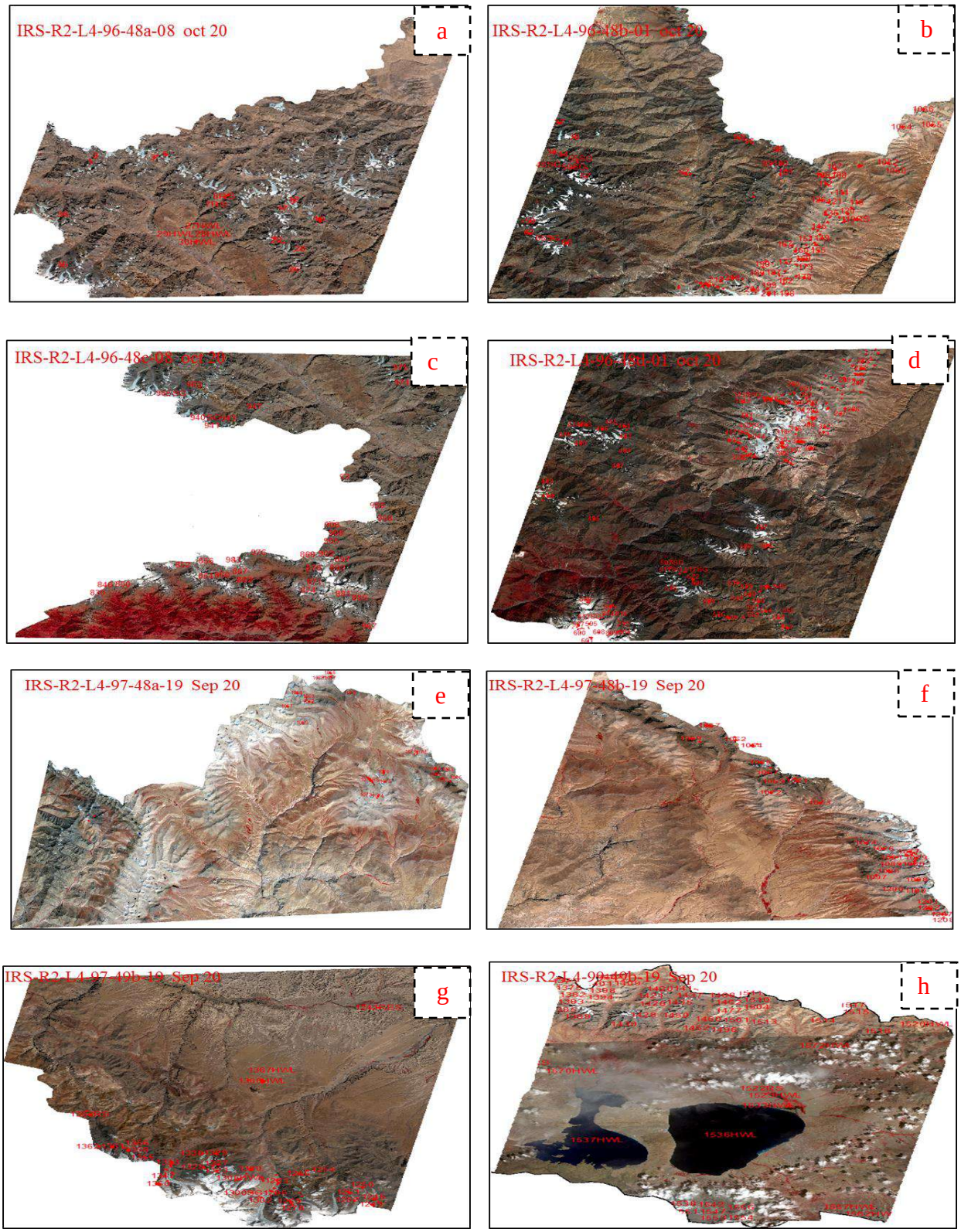


Fig: 10.1 (a-h) Interpreted layer of LISS-IV data in Satluj Basin in 2020

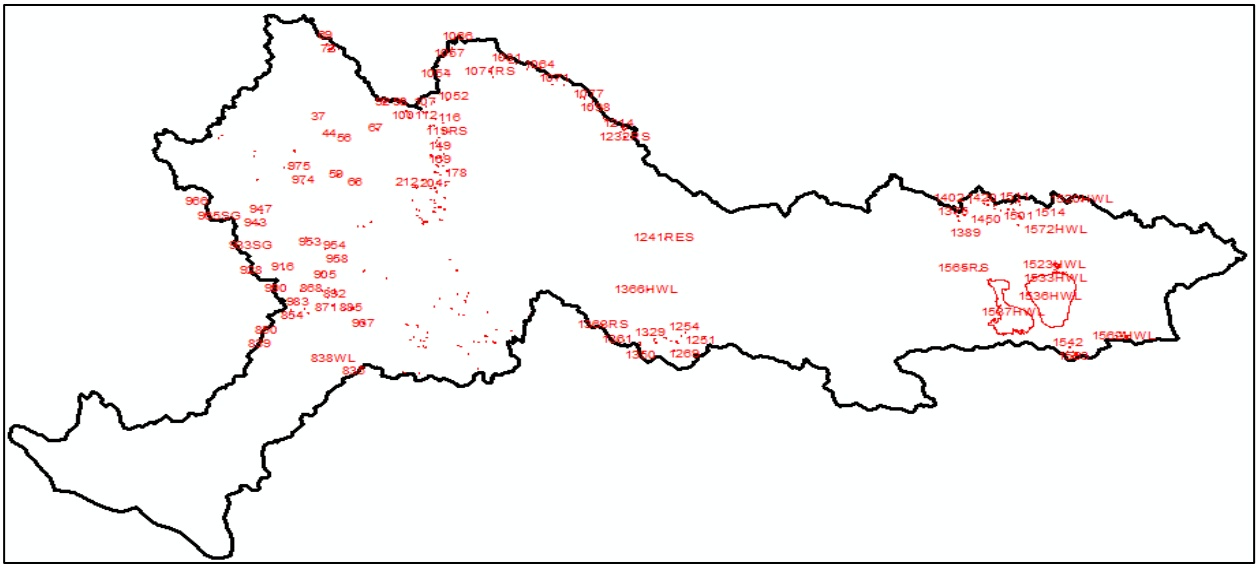


Fig 10.2 Interpreted layer of LISS-IV data in Satluj Basin in 2020

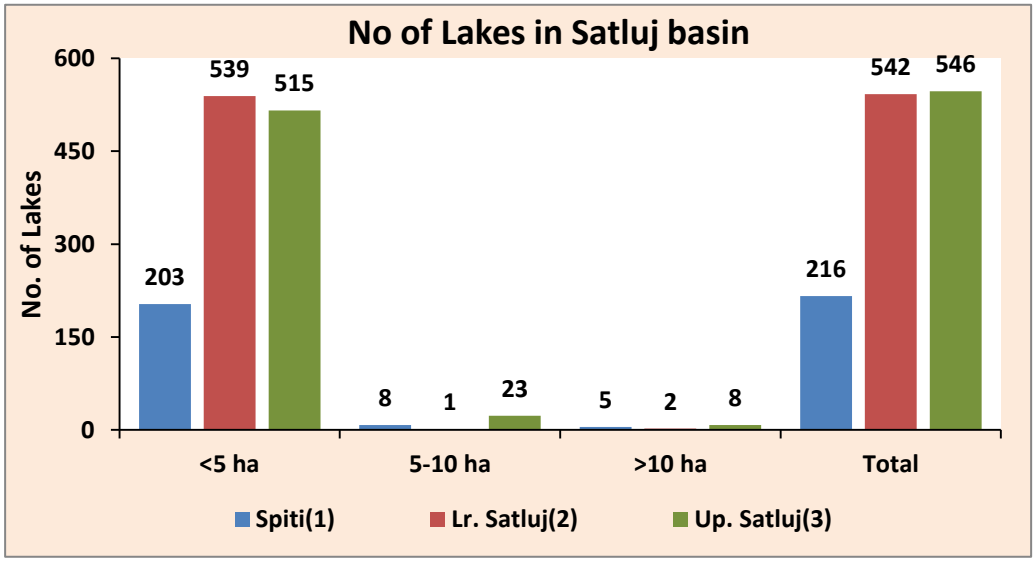


Fig: 10.3 : No. of Lakes in Satluj basin Based on LISS-IV Data

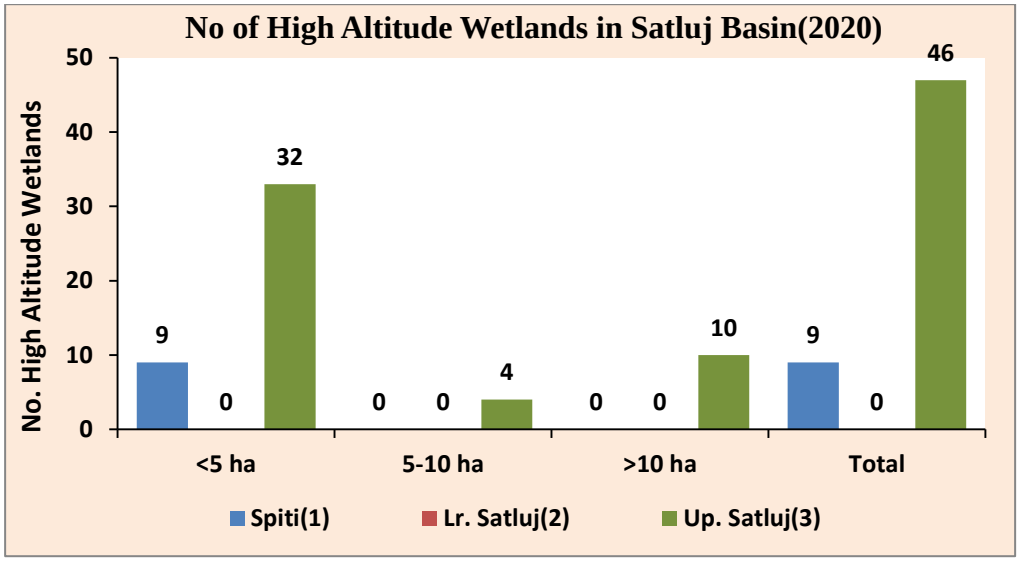


Fig: 10.4 No. of High Altitude Wetlands in Satluj basin Based on LISS-IV Data

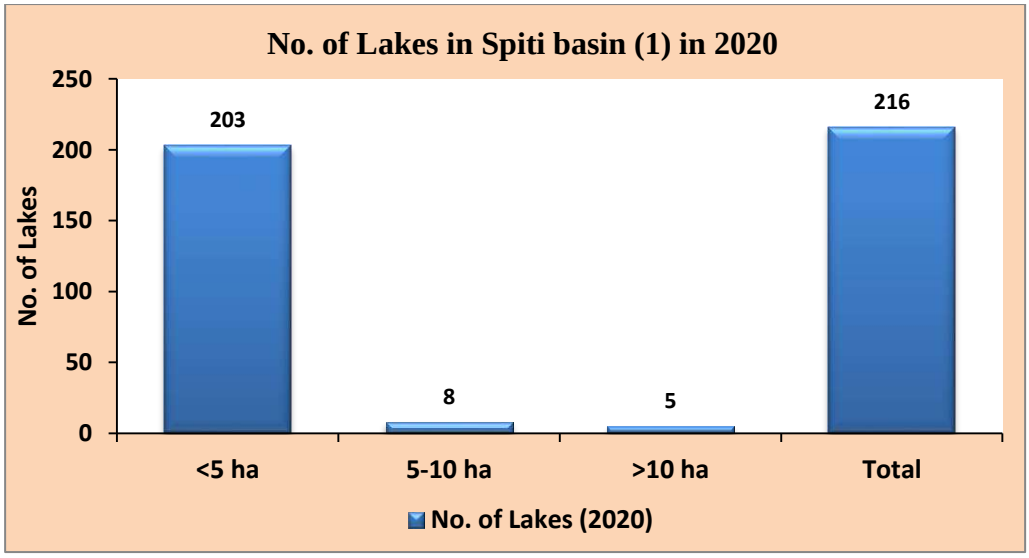


Fig: 10.5 No. of Lakes in Spiti basin (1) Based on LISS-IV Data

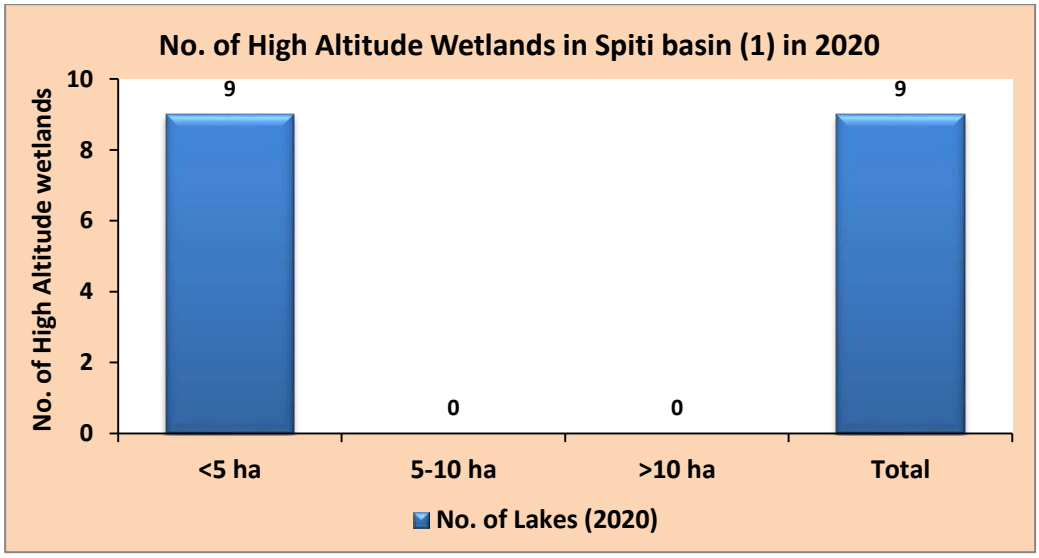


Fig: 10.6 No. of High Altitude Wetlands in Spiti basin (1) Based on LISS-IV Data

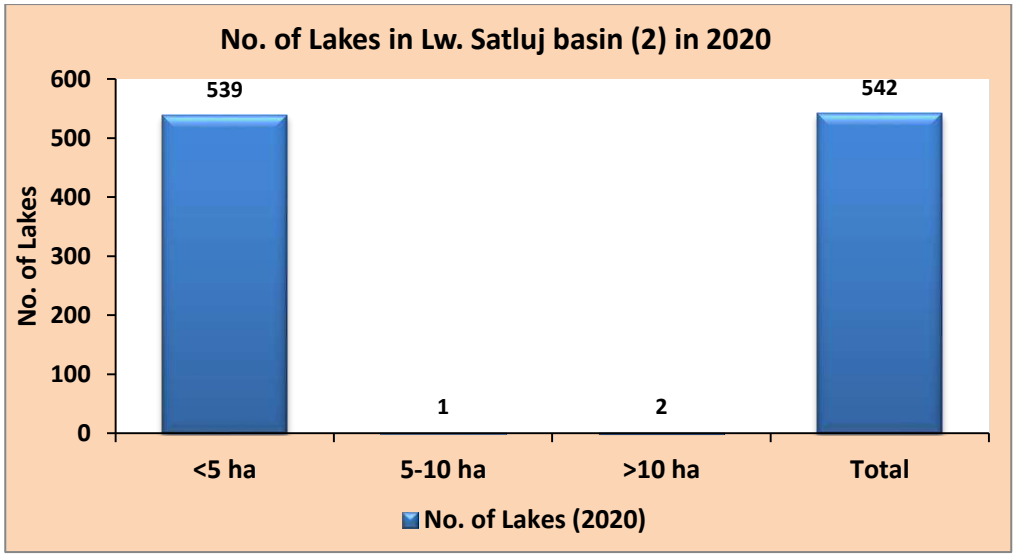


Fig: 10.7 No. of High Altitude Wetlands in Lw Satluj basin (2) Based on LISS-IV Data

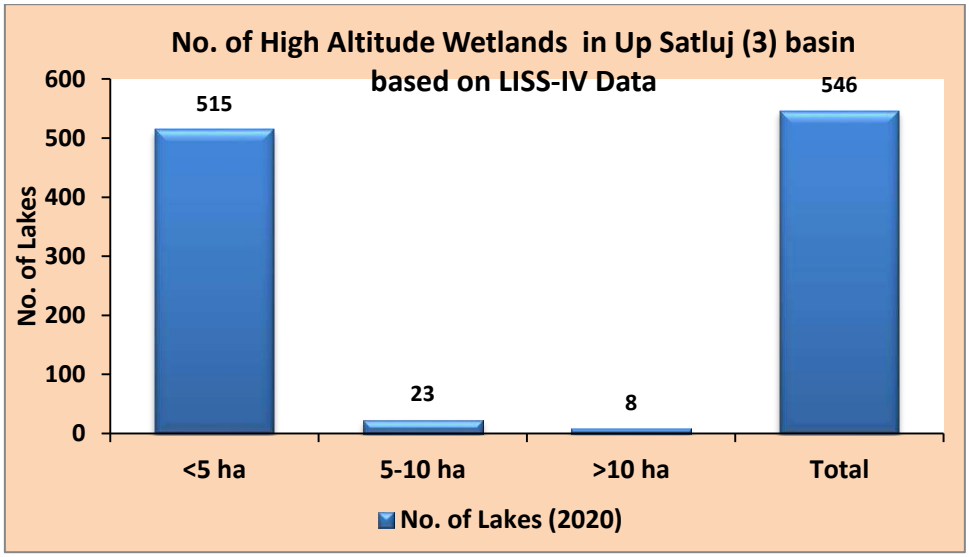


Fig: 10.8 No. of Lakes in Up Satluj basin (3) Based on LISS-IV Data

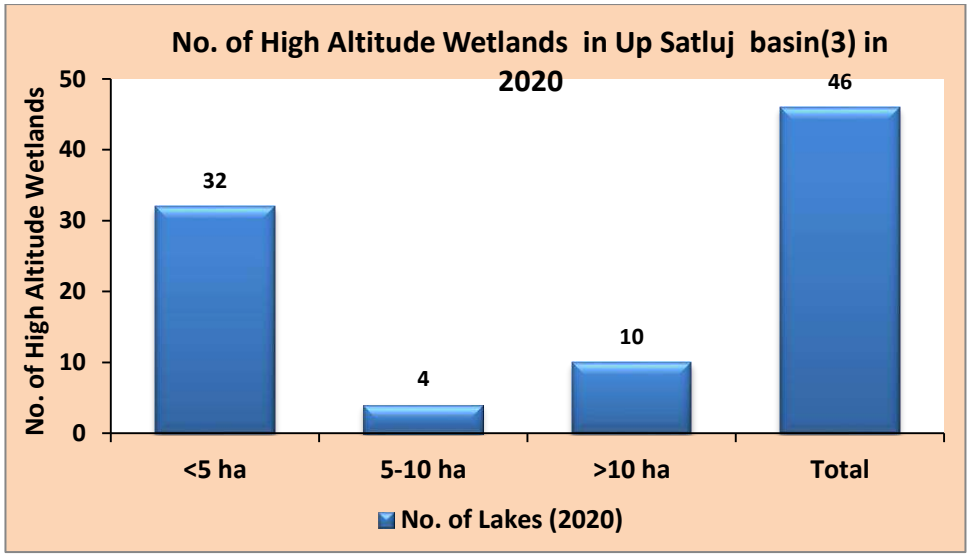


Fig: 10.9 No. of High Altitude Wetlands in Up Satluj basin (3) Based on LISS-IV Data

Table: 10.2 Distribution of Lakes and High Altitude Wetlands as per satellite data interpretation for the year 2020 using LISS-IV sensor

Sr.No.	Path-row	Lake Id. Number	Basin Number	Longitude	Latitude	Area (ha)
1.	96-48a	1	1	77.7149	32.5342	0.13
2.	96-48a	2	1	77.8168	32.5121	0.36
3.	96-48a	3	1	77.8269	32.5280	2.06
4.	96-48a	4	1	77.9423	32.5249	0.10
5.	96-48a	5	1	77.9487	32.5301	0.80
6.	96-48a	6	1	77.9658	32.5332	0.18
7.	96-48a	12	1	77.9651	32.5297	1.69
8.	96-48a	13	1	78.0671	32.4019	0.06
9.	96-48a	14	1	78.0823	32.4224	0.13
10.	96-48a	15	1	78.0884	32.4262	0.23
11.	96-48a	16	1	78.0898	32.4276	0.16
12.	96-48a	17	1	78.0923	32.4307	0.23
13.	96-48a	18	1	78.2199	32.4153	0.19
14.	96-48a	19	1	78.2214	32.4143	**13.16**
15.	96-48a	20	1	78.2207	32.4087	0.11
16.	96-48a	21	1	78.2171	32.4053	0.11
17.	96-48a	22	1	78.2056	32.3986	0.35
18.	96-48a	23	1	78.1990	32.3915	0.03
19.	96-48a	24	1	78.2705	32.3672	0.25
20.	96-48a	25	1	78.2722	32.3630	0.39
21.	96-48a	26	1	78.1836	32.3178	0.38
22.	96-48a	35	1	78.1812	32.3134	1.22
23.	96-48a	36	1	78.1872	32.3094	0.13
24.	96-48a	37	1	78.1938	32.3052	0.02
25.	96-48a	10RS	1	78.2014	32.3022	0.91
26.	96-48a	11RS	1	78.2342	32.2853	0.30
27.	96-48a	27HWL	1	78.0414	32.3451	0.44
28.	96-48a	28HWL	1	78.0620	32.3237	0.13
29.	96-48a	29HWL	1	78.0175	32.3194	0.03
30.	96-48a	30HWL	1	78.0279	32.3068	0.13
31.	96-48a	31HWL	1	78.0265	32.3061	0.10
32.	96-48a	32HWL	1	78.0236	32.3045	0.07
33.	96-48a	33HWL	1	78.0241	32.3040	0.07
34.	96-48a	34HWL	1	78.0239	32.3036	0.03
35.	96-48a	7RS	1	78.2224	32.2328	0.85
36.	96-48a	8RS	1	77.7612	32.2424	3.03

37.	96-48a	9RS	1	77.7617	32.3750	1.14
38.	96-48b	37	1	78.4736	32.4572	7.99
39.	96-48b	38	1	78.5019	32.4203	0.22
40.	96-48b	39	1	78.4606	32.3811	0.38
41.	96-48b	40	1	78.4613	32.3812	0.36
42.	96-48b	41	1	78.4620	32.3814	0.30
43.	96-48b	42	1	78.4636	32.3819	0.09
44.	96-48b	44	1	78.4807	32.3762	1.03
45.	96-48b	56	1	78.5265	32.3404	0.13
46.	96-48b	57	1	78.5242	32.3191	0.06
47.	96-48b	59	1	78.4180	32.2042	4.32
48.	96-48b	60	1	78.4119	32.1766	0.12
49.	96-48b	61	1	78.4114	32.1755	0.70
50.	96-48b	62	1	78.4145	32.1741	0.75
51.	96-48b	63	1	78.4182	32.1731	0.06
52.	96-48b	66	1	78.4879	32.1488	6.96
53.	96-48b	67	1	78.7135	32.3285	3.00
54.	96-48b	92	1	78.8161	32.4191	6.92
55.	96-48b	93	1	78.8276	32.4215	0.97
56.	96-48b	94	1	78.8247	32.4132	0.02
57.	96-48b	95	1	78.8270	32.4138	0.30
58.	96-48b	96	1	78.8346	32.4080	0.21
59.	96-48b	97	1	78.8925	32.3966	0.55
60.	96-48b	98	1	78.8915	32.3880	1.82
61.	96-48b	99	1	78.8805	32.3521	1.17
62.	96-48b	100	1	78.8979	32.3512	2.85
63.	96-48b	101	1	78.9080	32.3341	2.77
64.	96-48b	102	1	78.8963	32.3252	1.31
65.	96-48b	103	1	78.8974	32.3230	0.04
66.	96-48b	107	3	79.0023	32.3380	5.62
67.	96-48b	108	3	79.0017	32.3288	2.27
68.	96-48b	110	3	78.9941	32.3168	0.27
69.	96-48b	111	3	78.9932	32.3161	1.02
70.	96-48b	112	1	78.9854	32.2999	**13.54**
71.	96-48b	114	3	79.0172	32.2767	1.87
72.	96-48b	115	3	79.0483	32.2557	0.27
73.	96-48b	116	3	79.0440	32.2516	1.28
74.	96-48b	117	3	79.0337	32.2376	1.13
75.	96-48b	118	3	79.0323	32.2391	0.13
76.	96-48b	120	1	79.0260	32.2241	6.96

77.	96-48b	121	1	78.9913	32.2550	1.42
78.	96-48b	122	1	78.9869	32.2528	0.19
79.	96-48b	123	1	78.9863	32.2532	0.15
80.	96-48b	124	1	78.9890	32.2512	0.04
81.	96-48b	125	1	78.9777	32.2584	2.57
82.	96-48b	126	1	78.9711	32.2589	8.96
83.	96-48b	127	1	78.9871	32.2350	0.06
84.	96-48b	128	1	78.9830	32.2259	1.03
85.	96-48b	129	1	78.9831	32.2209	0.74
86.	96-48b	130	1	78.9851	32.2218	0.44
87.	96-48b	131	1	78.9867	32.2206	0.49
88.	96-48b	133	1	78.9872	32.2212	0.10
89.	96-48b	135	3	79.0051	32.2249	2.65
90.	96-48b	136	3	79.0089	32.2147	1.73
91.	96-48b	137	3	79.0106	32.2145	0.26
92.	96-48b	138	3	79.0191	32.2085	3.11
93.	96-48b	139	3	78.9933	32.2158	0.04
94.	96-48b	140	3	78.9903	32.2147	0.11
95.	96-48b	142	3	79.0169	32.2028	0.69
96.	96-48b	143	3	78.9875	32.2013	1.01
97.	96-48b	145	1	78.9728	32.1907	4.62
98.	96-48b	146	1	78.9601	32.1849	2.76
99.	96-48b	147	1	78.9684	32.1801	0.63
100.	96-48b	148	3	78.9725	32.1703	1.58
101.	96-48b	149	3	78.9769	32.1609	8.53
102.	96-48b	150	1	78.9535	32.1671	0.05
103.	96-48b	151	1	78.9531	32.1588	0.08
104.	96-48b	152	3	78.9626	32.1493	1.41
105.	96-48b	153	3	78.9638	32.1433	0.53
106.	96-48b	154	3	78.9676	32.1447	0.14
107.	96-48b	155	3	78.9701	32.1288	3.42
108.	96-48b	156	3	78.9593	32.1370	0.30
109.	96-48b	157	1	78.9478	32.1444	0.05
110.	96-48b	159	1	78.9462	32.1434	0.02
111.	96-48b	160	3	78.9473	32.1221	1.63
112.	96-48b	161	3	78.9507	32.1193	1.62
113.	96-48b	162	1	78.9268	32.1292	1.09
114.	96-48b	163	1	78.9252	32.1257	0.12
115.	96-48b	164	1	78.9241	32.1284	0.10
116.	96-48b	165	1	78.9203	32.1433	0.23

117.	96-48b	167	1	78.9064	32.1442	1.60
118.	96-48b	168	3	78.9319	32.1073	**11.62**
119.	96-48b	169	3	78.9413	32.1072	**11.77**
120.	96-48b	170	3	78.9470	32.1067	0.39
121.	96-48b	172	1	78.9378	32.1042	0.23
122.	96-48b	173	3	78.9468	32.0926	4.09
123.	96-48b	174	3	78.9292	32.0921	0.78
124.	96-48b	177	1	78.9078	32.0984	0.56
125.	96-48b	178	3	78.9432	32.0596	7.84
126.	96-48b	179	3	78.9275	32.0629	1.18
127.	96-48b	180	1	78.9056	32.0762	0.16
128.	96-48b	181	3	78.9098	32.0584	0.05
129.	96-48b	182	3	78.9040	32.0542	0.89
130.	96-48b	183	3	78.9007	32.0638	0.05
131.	96-48b	184	3	78.8949	32.0692	0.08
132.	96-48b	185	3	78.8947	32.0648	0.26
133.	96-48b	186	1	78.8858	32.0740	0.08
134.	96-48b	187	1	78.8850	32.0719	2.67
135.	96-48b	188	1	78.8832	32.0728	0.37
136.	96-48b	189	1	78.8631	32.0705	1.23
137.	96-48b	190	1	78.8634	32.0857	1.42
138.	96-48b	191	1	78.8824	32.0970	0.15
139.	96-48b	192	1	78.8719	32.1007	0.21
140.	96-48b	194	1	78.8691	32.1051	0.02
141.	96-48b	195	1	78.8696	32.1052	0.02
142.	96-48b	196	1	78.8673	32.1008	0.11
143.	96-48b	198	3	78.9097	32.0178	5.91
144.	96-48b	199	1	78.8723	32.0313	4.97
145.	96-48b	200	1	78.8763	32.0196	2.64
146.	96-48b	201	1	78.8748	32.0169	9.43
147.	96-48b	202	1	78.8494	32.0229	0.11
148.	96-48b	204	1	78.8454	32.0304	**20.15**
149.	96-48b	205	1	78.8245	32.0560	0.87
150.	96-48b	206	1	78.8069	32.0584	**10.24**
151.	96-48b	207	1	78.7989	32.0557	0.06
152.	96-48b	208	1	78.7991	32.0554	0.06
153.	96-48b	209	1	78.7983	32.0551	0.01
154.	96-48b	210	1	78.7978	32.0551	0.07
155.	96-48b	211	1	78.7981	32.0559	0.15
156.	96-48b	212	1	78.7822	32.0529	1.53

157.	96-48b	1050	3	79.1193	32.3339	0.59
158.	96-48b	1051	3	79.1173	32.3463	0.31
159.	96-48b	1052	3	79.1035	32.3538	3.43
160.	96-48b	1054	3	79.1310	32.4459	4.26
161.	96-48b	1055	3	79.1871	32.4516	3.50
162.	96-48b	1056	3	79.1714	32.4919	1.82
163.	96-48b	1046HWL	3	79.0469	32.3479	0.07
164.	96-48b	1047HWL	3	79.0478	32.3481	0.03
165.	96-48b	1048HWL	3	79.0474	32.3447	0.10
166.	96-48b	1049RS	3	79.0516	32.3469	5.55
167.	96-48b	119RS	1	79.0429	32.2099	**28.48**
168.	96-48b	193SG	1	78.8702	32.1017	0.06
169.	96-48b	45SG	1	78.4647	32.3492	0.16
170.	96-48b	46SG	1	78.4655	32.3491	0.06
171.	96-48b	47SG	1	78.4955	32.3414	0.26
172.	96-48b	48SG	1	78.4990	32.3410	0.05
173.	96-48b	49SG	1	78.5005	32.3425	0.04
174.	96-48b	50SG	1	78.5023	32.3436	0.57
175.	96-48b	51SG	1	78.5030	32.3447	0.05
176.	96-48b	52SG	1	78.5025	32.3456	0.32
177.	96-48b	53AG	1	78.5086	32.3553	0.19
178.	96-48b	55SG	1	78.5073	32.3605	0.05
179.	96-48b	64SG	1	78.4567	32.1635	0.05
180.	96-48b	65SG	1	78.4619	32.1609	1.00
181.	96-48b	67A	1	78.7175	32.3238	1.15
182.	96-48b	67B	1	78.7245	32.3256	3.89
183.	96-48c	0	2	78.0636	31.6856	0.09
184.	96-48c	832	1	78.0773	31.4277	0.48
185.	96-48c	833	1	78.0685	31.4226	1.33
186.	96-48c	834	1	78.0684	31.4192	1.01
187.	96-48c	835	1	78.0272	31.4086	5.09
188.	96-48c	836	1	78.0135	31.4055	0.17
189.	96-48c	837	1	78.0120	31.4064	5.08
190.	96-48c	839	2	77.6626	31.6735	2.49
191.	96-48c	840	2	77.6650	31.6755	0.33
192.	96-48c	841	2	77.6670	31.6741	0.21
193.	96-48c	842	2	77.6681	31.6777	0.25
194.	96-48c	843	2	77.6689	31.6769	0.42
195.	96-48c	844	2	77.6714	31.6789	0.42
196.	96-48c	845	2	77.6723	31.6786	0.22

197.	96-48c	846	2	77.6744	31.6770	1.11
198.	96-48c	847	2	77.6794	31.6867	0.12
199.	96-48c	848	2	77.6769	31.6908	0.64
200.	96-48c	849	2	77.6863	31.6962	0.26
201.	96-48c	850	2	77.7111	31.6961	2.63
202.	96-48c	851	2	77.8253	31.7485	0.03
203.	96-48c	852	2	77.8266	31.7484	0.33
204.	96-48c	853	2	77.8809	31.7116	0.41
205.	96-48c	854	2	77.8713	31.7182	1.85
206.	96-48c	855	2	77.8720	31.7448	0.15
207.	96-48c	856	2	77.8709	31.7570	0.21
208.	96-48c	857	2	77.8661	31.7590	0.20
209.	96-48c	858	2	77.8966	31.7248	0.15
210.	96-48c	859	2	77.9000	31.7198	0.03
211.	96-48c	860	2	77.9009	31.7207	0.93
212.	96-48c	861	2	77.9031	31.7213	0.51
213.	96-48c	862	2	77.9449	31.7075	0.63
214.	96-48c	863	2	77.9458	31.7076	0.35
215.	96-48c	864	2	77.9457	31.7068	0.02
216.	96-48c	865	2	77.9460	31.7065	0.17
217.	96-48c	866	2	77.9477	31.7060	0.04
218.	96-48c	867	2	77.9372	31.7308	0.60
219.	96-48c	868	2	78.0666	31.7748	0.52
220.	96-48c	869	2	78.0663	31.7737	0.21
221.	96-48c	870	2	78.0787	31.7396	0.09
222.	96-48c	871	2	78.0792	31.7019	0.81
223.	96-48c	872	2	78.0805	31.6877	0.02
224.	96-48c	873	2	78.0696	31.6810	0.12
225.	96-48c	874	2	78.0675	31.6860	0.18
226.	96-48c	875	2	78.0636	31.6850	0.03
227.	96-48c	878	2	78.0617	31.6866	0.10
228.	96-48c	879	2	78.1247	31.6673	0.09
229.	96-48c	880	2	78.1387	31.6695	0.04
230.	96-48c	881	2	78.1394	31.6704	0.43
231.	96-48c	882	2	78.1485	31.6623	0.12
232.	96-48c	883	2	78.1598	31.6620	0.34
233.	96-48c	884	2	78.1672	31.6629	0.24
234.	96-48c	885	2	78.1684	31.6609	**30.12**
235.	96-48c	886	2	78.1623	31.6579	0.51
236.	96-48c	887	2	78.1631	31.6576	0.04

237.	96-48c	888	2	78.1628	31.6574	0.03
238.	96-48c	889	2	78.1627	31.6571	0.01
239.	96-48c	890	2	78.1622	31.6565	0.13
240.	96-48c	891	2	78.1263	31.7371	0.26
241.	96-48c	892	2	78.1242	31.7398	2.82
242.	96-48c	893	2	78.1151	31.7402	0.04
243.	96-48c	894	2	78.1173	31.7486	0.34
244.	96-48c	895	2	78.1254	31.7536	0.18
245.	96-48c	896	2	78.1254	31.7596	0.22
246.	96-48c	897	2	78.1270	31.7615	0.23
247.	96-48c	898	2	78.1277	31.7617	0.03
248.	96-48c	899	2	78.1284	31.7619	0.03
249.	96-48c	901	2	78.1013	31.7775	0.06
250.	96-48c	902	2	78.1018	31.7780	0.53
251.	96-48c	903	2	78.1036	31.7781	0.34
252.	96-48c	904	2	78.1140	31.7912	0.17
253.	96-48c	905	2	78.1130	31.8108	0.21
254.	96-48c	906	2	78.1212	31.8276	0.11
255.	96-48c	907	2	78.1083	31.8461	0.05
256.	96-48c	908	2	78.1130	31.8466	0.07
257.	96-48c	909	1	78.1086	31.8624	0.03
258.	96-48c	910	1	78.1019	31.8641	0.04
259.	96-48c	911	1	77.9713	31.8801	0.02
260.	96-48c	912	1	77.9709	31.8800	0.04
261.	96-48c	913	1	77.9581	31.8890	0.09
262.	96-48c	914	1	77.9370	31.9107	0.02
263.	96-48c	915	1	77.9365	31.9147	0.07
264.	96-48c	916	1	77.9401	31.9194	0.10
265.	96-48c	917	1	77.9216	31.9620	0.03
266.	96-48c	918	1	77.9134	31.9722	0.06
267.	96-48c	919	1	77.8567	31.9298	0.07
268.	96-48c	920	1	77.7976	31.9510	0.15
269.	96-48c	921	1	77.7972	31.9515	0.15
270.	96-48c	922	1	77.8091	31.9596	0.07
271.	96-48c	923	1	77.8081	31.9605	0.03
272.	96-48c	924	1	77.8087	31.9610	0.01
273.	96-48c	925	1	77.8107	31.9620	0.17
274.	96-48c	926	1	77.8001	31.9698	0.21
275.	96-48c	927	1	77.7874	31.9632	0.17
276.	96-48c	928	1	77.7821	31.9528	0.74

277.	96-48c	941	1	77.8906	32.1246	0.04
278.	96-48c	943	1	77.9144	32.1368	1.65
279.	96-48c	944	1	77.9155	32.1371	0.04
280.	96-48c	945	1	77.9254	32.1292	1.42
281.	96-48c	946	1	77.9642	32.1663	0.07
282.	96-48c	947	1	77.9644	32.1672	0.50
283.	96-48c	948	1	77.9640	32.1681	0.05
284.	96-48c	949	1	78.1152	31.9977	0.15
285.	96-48c	950	1	78.1188	31.9984	0.03
286.	96-48c	951	1	78.1139	32.0057	0.05
287.	96-48c	952	1	78.1148	32.0068	0.44
288.	96-48c	953	1	78.1325	31.9796	1.90
289.	96-48c	954	1	78.1827	31.9270	0.21
290.	96-48c	955	1	78.1805	31.9340	0.09
291.	96-48c	956	2	78.2012	31.9051	0.19
292.	96-48c	957	2	78.2133	31.8698	0.04
293.	96-48c	958	2	78.2156	31.8710	0.28
294.	96-48c	959	2	78.2141	31.8687	0.12
295.	96-48c	960	2	78.2085	31.8660	0.04
296.	96-48c	961	1	78.1580	31.8706	0.02
297.	96-48c	962	1	78.1586	31.8712	0.13
298.	96-48c	963	1	77.8484	32.2245	0.12
299.	96-48c	966	1	77.6871	32.3041	0.10
300.	96-48c	971	1	78.2337	32.2220	0.04
301.	96-48c	972	1	78.2336	32.2231	0.04
302.	96-48c	973	1	78.2341	32.2238	0.05
303.	96-48c	974	1	78.2477	32.2304	0.26
304.	96-48c	975	1	78.2447	32.2700	0.08
305.	96-48c	976	1	77.9720	31.7810	0.12
306.	96-48c	977	1	77.9650	31.8024	0.12
307.	96-48c	978	1	77.9657	31.8024	0.02
308.	96-48c	979	1	77.9675	31.8030	0.06
309.	96-48c	980	1	77.9656	31.8037	0.28
310.	96-48c	981	1	77.9648	31.8037	0.05
311.	96-48c	982	1	77.9650	31.8056	0.23
312.	96-48c	985	1	77.8496	31.8250	0.09
313.	96-48c	986	1	77.8554	31.8305	0.03
314.	96-48c	987	1	77.8554	31.8310	0.10
315.	96-48c	989	1	77.8512	31.8422	0.04
316.	96-48c	990	1	77.8544	31.8432	0.42

317.	96-48c	991	1	77.8514	31.8613	0.04
318.	96-48c	992	1	77.8522	31.8618	0.07
319.	96-48c	993	1	77.8565	31.8637	0.41
320.	96-48c	838WL	1	77.9590	31.4812	1.58
321.	96-48c	929SG	1	77.8153	32.0032	0.03
322.	96-48c	930SG	1	77.8336	32.0456	0.04
323.	96-48c	932SG	1	77.8425	32.0506	0.03
324.	96-48c	933SG	1	77.8429	32.0524	0.19
325.	96-48c	935SG	1	77.8155	32.0746	0.03
326.	96-48c	936SG	1	77.8158	32.0771	0.07
327.	96-48c	937SG	1	77.8230	32.0783	0.06
328.	96-48c	938SG	1	77.8825	32.1344	0.03
329.	96-48c	939SG	1	77.8844	32.1375	0.01
330.	96-48c	940SG	1	77.8865	32.1377	0.08
331.	96-48c	942SG	1	77.9111	32.1300	0.04
332.	96-48c	964SG	1	77.8037	32.2048	0.15
333.	96-48c	965SG	1	77.8039	32.2015	0.37
334.	96-48d	273	2	78.9479	32.1386	0.59
335.	96-48d	274	2	78.9457	32.1400	0.10
336.	96-48d	275	2	78.9456	32.1377	0.06
337.	96-48d	276	2	78.9431	32.1385	0.07
338.	96-48d	277	3	78.9425	32.1225	3.79
339.	96-48d	277	3	78.9457	32.1216	0.14
340.	96-48d	278	3	78.9469	32.1199	3.20
341.	96-48d	279	3	78.9409	32.1184	0.39
342.	96-48d	280	3	78.9322	32.1216	0.11
343.	96-48d	281	3	78.9315	32.1185	0.21
344.	96-48d	282	3	78.9371	32.0831	0.09
345.	96-48d	283	3	78.9367	32.0847	0.04
346.	96-48d	284	3	78.9365	32.0862	0.03
347.	96-48d	285	2	78.9113	32.0910	2.02
348.	96-48d	286	3	78.9259	32.0145	1.35
349.	96-48d	287	3	78.9018	32.0039	1.47
350.	96-48d	288	2	78.8025	32.0812	0.41
351.	96-48d	289	2	78.8064	32.0801	0.44
352.	96-48d	291	2	78.8304	32.0642	0.06
353.	96-48d	292	2	78.8319	32.0435	1.80
354.	96-48d	293	2	78.8344	32.0361	0.34
355.	96-48d	294	3	78.8453	32.0114	1.60
356.	96-48d	295	3	78.8473	32.0111	0.13

357.	96-48d	296	3	78.8465	32.0111	0.05
358.	96-48d	297	3	78.8490	32.0086	0.82
359.	96-48d	298	3	78.8506	32.0081	0.06
360.	96-48d	299	3	78.8515	32.0075	0.31
361.	96-48d	300	2	78.8159	32.0324	2.45
362.	96-48d	301	2	78.8139	32.0327	0.19
363.	96-48d	302	2	78.8133	32.0322	0.04
364.	96-48d	303	2	78.8151	32.0323	0.16
365.	96-48d	304	2	78.8232	32.0135	1.13
366.	96-48d	305	3	78.8443	31.9929	**21.25**
367.	96-48d	306	3	78.8481	31.9947	1.42
368.	96-48d	307	3	78.8434	31.9877	0.30
369.	96-48d	308	3	78.8374	31.9806	4.82
370.	96-48d	309	3	78.8356	31.9802	0.37
371.	96-48d	310	3	78.8364	31.9787	1.47
372.	96-48d	311	3	78.8379	31.9772	1.53
373.	96-48d	312	3	78.8692	31.9696	6.37
374.	96-48d	313	3	78.8671	31.9569	3.68
375.	96-48d	314	3	78.7977	31.9715	0.81
376.	96-48d	315	3	78.8120	31.9649	3.90
377.	96-48d	316	3	78.8109	31.9604	0.05
378.	96-48d	317	3	78.7952	31.9573	0.18
379.	96-48d	318	3	78.7823	31.9564	0.38
380.	96-48d	319	3	78.8084	31.9520	0.27
381.	96-48d	320	3	78.8097	31.9508	0.53
382.	96-48d	321	3	78.8097	31.9528	0.09
383.	96-48d	322	3	78.8102	31.9526	0.11
384.	96-48d	323	2	78.7830	32.0307	0.19
385.	96-48d	324	2	78.7834	32.0327	0.02
386.	96-48d	325	2	78.7822	32.0316	0.02
387.	96-48d	326	2	78.7795	32.0330	0.56
388.	96-48d	327	2	78.7782	32.0341	0.49
389.	96-48d	328	2	78.7549	32.0423	0.16
390.	96-48d	329	2	78.7546	32.0446	0.72
391.	96-48d	331	3	78.7840	31.9311	0.47
392.	96-48d	333	3	78.7959	31.9333	0.30
393.	96-48d	335	3	78.8138	31.9341	3.83
394.	96-48d	336	3	78.8123	31.9330	0.06
395.	96-48d	337	3	78.8167	31.9318	0.28
396.	96-48d	338	3	78.8201	31.9327	1.39

397.	96-48d	339	3	78.8213	31.9317	0.18
398.	96-48d	340	3	78.8223	31.9329	0.99
399.	96-48d	341	3	78.8262	31.9323	0.15
400.	96-48d	342	3	78.8247	31.9314	0.06
401.	96-48d	343	3	78.8258	31.9315	0.07
402.	96-48d	344	3	78.8282	31.9309	0.20
403.	96-48d	345	3	78.8275	31.9303	0.16
404.	96-48d	346	3	78.8266	31.9299	0.25
405.	96-48d	347	3	78.8243	31.9294	0.05
406.	96-48d	348	3	78.8228	31.9307	0.08
407.	96-48d	349	3	78.8230	31.9300	0.20
408.	96-48d	350	3	78.8228	31.9293	0.03
409.	96-48d	351	3	78.8215	31.9304	0.71
410.	96-48d	353	3	78.8202	31.9297	0.07
411.	96-48d	354	3	78.8197	31.9299	0.03
412.	96-48d	355	3	78.8197	31.9305	0.23
413.	96-48d	356	3	78.8187	31.9304	0.05
414.	96-48d	357	3	78.8184	31.9294	1.38
415.	96-48d	358	3	78.8173	31.9294	0.13
416.	96-48d	359	3	78.8166	31.9301	0.02
417.	96-48d	360	3	78.8159	31.9302	0.03
418.	96-48d	361	3	78.8153	31.9297	0.04
419.	96-48d	362	3	78.8150	31.9294	0.07
420.	96-48d	363	3	78.8134	31.9305	0.07
421.	96-48d	364	3	78.8127	31.9299	0.04
422.	96-48d	365	3	78.8272	31.9274	0.02
423.	96-48d	366	3	78.8398	31.9138	**20.79**
424.	96-48d	367	3	78.8018	31.9085	0.75
425.	96-48d	368	3	78.7861	31.9050	0.40
426.	96-48d	369	3	78.7860	31.9061	0.29
427.	96-48d	370	3	78.7852	31.9058	0.14
428.	96-48d	371	3	78.7848	31.9069	0.21
429.	96-48d	372	3	78.7827	31.9193	**16.44**
430.	96-48d	373	3	78.7736	31.9148	0.22
431.	96-48d	374	3	78.7900	31.8831	0.32
432.	96-48d	375	3	78.7905	31.8826	0.13
433.	96-48d	376	3	78.7890	31.8820	0.03
434.	96-48d	377	3	78.7936	31.8823	0.66
435.	96-48d	378	3	78.7934	31.8804	0.34
436.	96-48d	379	3	78.7948	31.8802	0.07

437.	96-48d	380	3	78.7947	31.8788	0.02
438.	96-48d	381	3	78.7954	31.8793	0.04
439.	96-48d	382	3	78.7993	31.8758	0.09
440.	96-48d	383	3	78.8003	31.8762	0.49
441.	96-48d	385	3	78.8015	31.8728	0.02
442.	96-48d	386	3	78.8023	31.8735	0.29
443.	96-48d	387	3	78.8033	31.8726	0.03
444.	96-48d	388	3	78.8044	31.8727	0.06
445.	96-48d	389	2	78.7047	31.8871	0.63
446.	96-48d	390	2	78.7042	31.8876	0.10
447.	96-48d	391	2	78.7042	31.8888	0.07
448.	96-48d	392	2	78.6997	31.8894	0.28
449.	96-48d	414	2	78.7185	31.9008	1.03
450.	96-48d	415	2	78.7173	31.9002	0.38
451.	96-48d	416	2	78.7138	31.8981	0.55
452.	96-48d	417	2	78.7089	31.9065	0.63
453.	96-48d	418	2	78.7036	31.9103	0.20
454.	96-48d	419	2	78.7003	31.9127	4.47
455.	96-48d	420	2	78.7021	31.9177	0.50
456.	96-48d	421	2	78.6977	31.9273	0.18
457.	96-48d	422	2	78.6952	31.9288	0.01
458.	96-48d	423	2	78.6954	31.9292	0.21
459.	96-48d	424	2	78.6943	31.9302	0.18
460.	96-48d	425	2	78.6934	31.9300	0.25
461.	96-48d	426	2	78.6930	31.9306	0.19
462.	96-48d	427	2	78.6924	31.9306	0.07
463.	96-48d	429	2	78.6933	31.9278	0.16
464.	96-48d	430	2	78.6919	31.9284	0.06
465.	96-48d	432	2	78.6850	31.9337	0.77
466.	96-48d	433	2	78.6856	31.9344	0.02
467.	96-48d	434	2	78.6858	31.9347	0.05
468.	96-48d	435	2	78.6765	31.9355	0.17
469.	96-48d	437	2	78.6712	31.9376	0.06
470.	96-48d	461	2	78.7202	31.9913	0.28
471.	96-48d	462	2	78.7106	31.9954	0.09
472.	96-48d	463	2	78.7106	31.9994	0.34
473.	96-48d	464	1	78.4617	31.9718	7.67
474.	96-48d	465	1	78.4446	31.9766	0.29
475.	96-48d	466	1	78.4155	31.9640	6.52
476.	96-48d	479	1	78.3408	31.9494	0.29

477.	96-48d	480	2	78.3720	31.9263	0.21
478.	96-48d	483	2	78.4637	31.9449	0.46
479.	96-48d	484	2	78.4627	31.9081	0.33
480.	96-48d	485	2	78.4497	31.8721	0.13
481.	96-48d	486	2	78.4478	31.8698	0.03
482.	96-48d	487	2	78.4480	31.8681	0.13
483.	96-48d	488	2	78.4514	31.8652	0.04
484.	96-48d	489	2	78.3038	31.8291	0.04
485.	96-48d	490	2	78.3055	31.7894	1.59
486.	96-48d	491	2	78.3046	31.7907	0.05
487.	96-48d	492	2	78.3091	31.7916	0.05
488.	96-48d	493	2	78.3164	31.7924	0.12
489.	96-48d	494	2	78.2935	31.7797	1.20
490.	96-48d	495	2	78.3994	31.7319	2.22
491.	96-48d	496	2	78.4006	31.7296	0.31
492.	96-48d	497	2	78.7410	31.7091	1.98
493.	96-48d	498	2	78.7529	31.6631	0.03
494.	96-48d	499	2	78.7545	31.6624	0.17
495.	96-48d	500	2	78.7506	31.6613	0.53
496.	96-48d	501	2	78.7527	31.6658	0.21
497.	96-48d	502	2	78.7479	31.6567	0.16
498.	96-48d	503	2	78.7468	31.6569	0.24
499.	96-48d	504	2	78.7616	31.6584	0.06
500.	96-48d	505	2	78.7071	31.6533	0.03
501.	96-48d	506	2	78.7087	31.6599	0.07
502.	96-48d	519	2	78.6001	31.5736	0.37
503.	96-48d	520	2	78.6009	31.5745	0.02
504.	96-48d	521	2	78.6005	31.5751	0.42
505.	96-48d	522	2	78.6023	31.5750	0.79
506.	96-48d	523	2	78.6010	31.5765	0.19
507.	96-48d	524	2	78.6033	31.5654	0.20
508.	96-48d	525	2	78.6100	31.5647	0.97
509.	96-48d	526	2	78.6302	31.5237	0.03
510.	96-48d	527	2	78.6339	31.5204	0.14
511.	96-48d	528	2	78.6329	31.5189	0.02
512.	96-48d	529	2	78.6338	31.5180	0.39
513.	96-48d	530	2	78.6346	31.5182	0.03
514.	96-48d	531	2	78.6349	31.5175	0.04
515.	96-48d	532	2	78.6326	31.5165	0.03
516.	96-48d	533	2	78.6928	31.5247	0.18

517.	96-48d	534	2	78.6935	31.5250	0.05
518.	96-48d	535	2	78.6935	31.5253	0.04
519.	96-48d	536	2	78.6939	31.5256	0.06
520.	96-48d	537	2	78.6905	31.5651	0.04
521.	96-48d	538	2	78.6931	31.5656	0.16
522.	96-48d	539	2	78.7102	31.5557	0.29
523.	96-48d	540	2	78.7170	31.5311	0.91
524.	96-48d	541	2	78.7142	31.5225	0.07
525.	96-48d	542	2	78.7466	31.5587	0.44
526.	96-48d	543	2	78.7530	31.5600	0.05
527.	96-48d	544	2	78.7519	31.5569	0.27
528.	96-48d	545	2	78.7506	31.5543	4.75
529.	96-48d	546	2	78.7709	31.5558	0.03
530.	96-48d	547	2	78.7388	31.5457	0.21
531.	96-48d	548	2	78.7379	31.5447	0.23
532.	96-48d	549	2	78.7358	31.5425	0.56
533.	96-48d	550	2	78.7346	31.5187	2.98
534.	96-48d	551	2	78.7317	31.5074	0.95
535.	96-48d	552	2	78.7324	31.4966	0.04
536.	96-48d	554	2	78.7499	31.4934	1.23
537.	96-48d	555	2	78.7953	31.4934	0.09
538.	96-48d	556	2	78.7969	31.4489	0.09
539.	96-48d	557	2	78.7927	31.4500	7.75
540.	96-48d	558	2	78.7842	31.4577	0.02
541.	96-48d	559	2	78.7844	31.4570	0.40
542.	96-48d	560	2	78.7838	31.4547	0.09
543.	96-48d	561	2	78.7840	31.4543	0.01
544.	96-48d	562	2	78.7762	31.4765	0.17
545.	96-48d	563	2	78.7759	31.4738	0.03
546.	96-48d	564	2	78.7041	31.4783	0.07
547.	96-48d	565	2	78.7028	31.4759	0.02
548.	96-48d	566	2	78.7046	31.4753	0.01
549.	96-48d	567	2	78.6718	31.4793	0.07
550.	96-48d	568	2	78.6730	31.4764	0.05
551.	96-48d	569	2	78.6717	31.4750	0.34
552.	96-48d	570	2	78.6744	31.4754	0.03
553.	96-48d	571	2	78.6744	31.4746	0.01
554.	96-48d	572	2	78.6740	31.4741	0.02
555.	96-48d	573	2	78.6746	31.4738	0.03
556.	96-48d	574	2	78.6752	31.4736	0.33

557.	96-48d	575	2	78.6535	31.4839	0.03
558.	96-48d	576	2	78.6537	31.4835	0.45
559.	96-48d	577	2	78.6529	31.4814	0.38
560.	96-48d	578	2	78.5567	31.5503	0.14
561.	96-48d	579	2	78.3830	31.5220	5.08
562.	96-48d	580	2	78.3856	31.5205	0.04
563.	96-48d	581	2	78.3859	31.5156	1.84
564.	96-48d	582	2	78.3897	31.5143	0.04
565.	96-48d	583	2	78.3553	31.4493	0.05
566.	96-48d	584	2	78.3642	31.4514	0.05
567.	96-48d	585	2	78.3654	31.4565	0.13
568.	96-48d	586	2	78.3677	31.4541	0.02
569.	96-48d	587	2	78.3685	31.4584	1.04
570.	96-48d	588	2	78.3657	31.4441	0.03
571.	96-48d	589	2	78.3662	31.4450	0.02
572.	96-48d	590	2	78.3672	31.4467	0.05
573.	96-48d	591	2	78.3709	31.4467	0.09
574.	96-48d	592	2	78.3742	31.4484	0.14
575.	96-48d	593	2	78.3778	31.4468	0.04
576.	96-48d	594	2	78.3885	31.4604	0.11
577.	96-48d	595	2	78.3888	31.4592	0.37
578.	96-48d	596	2	78.3870	31.4521	0.03
579.	96-48d	597	2	78.3881	31.4480	0.02
580.	96-48d	598	2	78.3721	31.4381	0.12
581.	96-48d	599	2	78.3715	31.4380	0.03
582.	96-48d	600	2	78.3709	31.4358	0.21
583.	96-48d	601	2	78.3864	31.4152	0.36
584.	96-48d	602	2	78.3896	31.4244	0.35
585.	96-48d	603	2	78.3896	31.4250	0.06
586.	96-48d	604	2	78.3927	31.4235	0.02
587.	96-48d	605	2	78.3934	31.4248	0.15
588.	96-48d	606	2	78.3950	31.4239	0.05
589.	96-48d	607	2	78.4064	31.4370	0.24
590.	96-48d	608	2	78.4096	31.4379	1.57
591.	96-48d	610	2	78.4098	31.4119	0.84
592.	96-48d	611	2	78.4093	31.4137	0.11
593.	96-48d	612	2	78.4124	31.4182	0.35
594.	96-48d	613	2	78.4248	31.4040	0.48
595.	96-48d	614	2	78.4239	31.4047	0.19
596.	96-48d	615	2	78.4205	31.4038	2.45

597.	96-48d	616	2	78.4218	31.3991	0.73
598.	96-48d	617	2	78.4158	31.4014	0.08
599.	96-48d	618	2	78.4160	31.4005	0.30
600.	96-48d	619	2	78.4335	31.3910	0.48
601.	96-48d	621	2	78.6040	31.3160	0.04
602.	96-48d	622	2	78.6058	31.3156	0.10
603.	96-48d	623	2	78.6045	31.3087	0.05
604.	96-48d	624	2	78.6242	31.3104	0.03
605.	96-48d	625	2	78.6245	31.3137	0.17
606.	96-48d	626	2	78.6250	31.3142	0.01
607.	96-48d	627	2	78.6263	31.3152	0.22
608.	96-48d	628	2	78.6396	31.3184	0.07
609.	96-48d	629	2	78.6578	31.3285	0.04
610.	96-48d	630	2	78.6614	31.3311	0.83
611.	96-48d	631	2	78.6625	31.3334	0.96
612.	96-48d	632	2	78.6967	31.3255	1.37
613.	96-48d	633	2	78.7017	31.3264	1.18
614.	96-48d	634	2	78.7178	31.3361	0.47
615.	96-48d	635	2	78.7171	31.3384	0.13
616.	96-48d	636	2	78.7171	31.3398	2.25
617.	96-48d	637	2	78.7510	31.3284	0.09
618.	96-48d	638	2	78.7516	31.3278	0.02
619.	96-48d	639	2	78.7542	31.3261	0.07
620.	96-48d	640	2	78.7546	31.3258	0.10
621.	96-48d	641	2	78.7542	31.3240	0.47
622.	96-48d	642	2	78.7544	31.3231	0.05
623.	96-48d	643	2	78.7553	31.3218	1.02
624.	96-48d	644	2	78.7563	31.3229	0.12
625.	96-48d	645	2	78.7567	31.3223	0.03
626.	96-48d	646	2	78.7564	31.3221	0.07
627.	96-48d	648	2	78.7612	31.3207	0.05
628.	96-48d	649	2	78.7607	31.3202	0.05
629.	96-48d	650	2	78.7974	31.2996	0.19
630.	96-48d	651	2	78.8023	31.2945	0.39
631.	96-48d	652	2	78.7184	31.2890	0.08
632.	96-48d	653	2	78.7219	31.2785	0.04
633.	96-48d	654	2	78.7195	31.2409	0.06
634.	96-48d	672	2	78.7860	31.2166	0.31
635.	96-48d	673	2	78.7859	31.2171	0.06
636.	96-48d	674	2	78.7924	31.2109	0.09

637.	96-48d	689	2	78.5036	31.2351	0.15
638.	96-48d	690	2	78.4856	31.2494	0.17
639.	96-48d	699	2	78.3264	31.3066	0.41
640.	96-48d	700	2	78.3265	31.3076	0.06
641.	96-48d	701	2	78.3270	31.3089	0.12
642.	96-48d	702	2	78.3276	31.3089	0.04
643.	96-48d	703	2	78.3273	31.3093	0.03
644.	96-48d	704	2	78.3282	31.3095	0.07
645.	96-48d	705	2	78.3268	31.3103	0.04
646.	96-48d	706	2	78.3265	31.3105	0.08
647.	96-48d	707	2	78.3258	31.3101	0.04
648.	96-48d	708	2	78.3256	31.3103	0.06
649.	96-48d	709	2	78.3259	31.3108	0.34
650.	96-48d	710	2	78.3296	31.3106	0.23
651.	96-48d	711	2	78.3298	31.3111	0.12
652.	96-48d	712	2	78.3286	31.3109	0.10
653.	96-48d	713	2	78.3286	31.3115	0.14
654.	96-48d	714	2	78.3283	31.3119	0.14
655.	96-48d	715	2	78.3291	31.3121	0.22
656.	96-48d	716	2	78.3298	31.3122	0.89
657.	96-48d	717	2	78.3300	31.3134	0.11
658.	96-48d	718	2	78.3293	31.3127	0.11
659.	96-48d	719	2	78.3293	31.3133	0.17
660.	96-48d	720	2	78.3286	31.3128	0.06
661.	96-48d	721	2	78.3288	31.3137	0.06
662.	96-48d	722	2	78.3278	31.3132	0.03
663.	96-48d	723	2	78.3276	31.3136	0.03
664.	96-48d	724	2	78.3282	31.3143	0.56
665.	96-48d	725	2	78.3299	31.3154	0.48
666.	96-48d	727	2	78.2932	31.3496	0.16
667.	96-48d	728	2	78.2604	31.3320	0.49
668.	96-48d	729	2	78.2546	31.3399	**11.33**
669.	96-48d	730	2	78.1852	31.3505	0.46
670.	96-48d	731	2	79.0069	31.3584	0.14
671.	96-48d	732	2	79.0056	31.3598	0.03
672.	96-48d	733	2	79.0049	31.3597	0.01
673.	96-48d	734	2	78.9904	31.3799	0.05
674.	96-48d	735	2	78.9893	31.3773	0.04
675.	96-48d	736	2	78.9864	31.3766	0.33
676.	96-48d	737	2	78.8618	31.3437	0.03

677.	96-48d	738	2	78.8616	31.3440	0.06
678.	96-48d	739	2	78.8620	31.3443	0.06
679.	96-48d	740	2	78.8652	31.3484	0.02
680.	96-48d	741	2	78.8637	31.3490	0.07
681.	96-48d	742	2	78.8654	31.3498	0.06
682.	96-48d	744	2	78.7695	31.3613	0.37
683.	96-48d	745	2	78.7563	31.3644	0.55
684.	96-48d	747	2	78.7448	31.3755	0.11
685.	96-48d	748	2	78.7332	31.3613	0.16
686.	96-48d	749	2	78.7318	31.3604	0.04
687.	96-48d	750	2	78.7333	31.3586	1.64
688.	96-48d	751	2	78.7238	31.3624	0.95
689.	96-48d	752	2	78.7224	31.3664	0.30
690.	96-48d	767	2	78.6775	31.3647	0.17
691.	96-48d	768	2	78.6818	31.3689	0.09
692.	96-48d	769	2	78.6670	31.3599	0.07
693.	96-48d	770	2	78.6653	31.3581	0.05
694.	96-48d	771	2	78.6643	31.3543	0.15
695.	96-48d	774	2	78.6190	31.3782	0.03
696.	96-48d	775	2	78.6174	31.3796	0.06
697.	96-48d	776	2	78.6168	31.3812	0.01
698.	96-48d	777	2	78.6150	31.3818	0.02
699.	96-48d	778	2	78.6084	31.3841	0.05
700.	96-48d	779	2	78.6080	31.3847	0.07
701.	96-48d	781	2	78.6049	31.3880	0.27
702.	96-48d	782	2	78.5862	31.3541	0.05
703.	96-48d	783	2	78.5860	31.3544	0.06
704.	96-48d	785	2	78.5814	31.3615	0.46
705.	96-48d	786	2	78.5806	31.3654	0.23
706.	96-48d	788	2	78.5765	31.3638	0.03
707.	96-48d	789	2	78.5768	31.3708	0.19
708.	96-48d	790	2	78.5810	31.3731	0.52
709.	96-48d	791	2	78.5800	31.3750	0.42
710.	96-48d	792	2	78.5152	31.3841	0.05
711.	96-48d	793	2	78.4892	31.4010	2.19
712.	96-48d	794	2	78.4757	31.3951	0.04
713.	96-48d	800	2	78.4506	31.4403	0.08
714.	96-48d	804	2	78.4509	31.4384	0.04
715.	96-48d	806	2	78.4252	31.4288	0.15
716.	96-48d	807	2	78.4307	31.4340	0.02

717.	96-48d	808	2	78.4311	31.4346	0.02
718.	96-48d	809	2	78.4303	31.4351	0.16
719.	96-48d	810	2	78.4443	31.4871	0.23
720.	96-48d	814	2	78.4285	31.4910	0.70
721.	96-48d	815	2	78.4286	31.4918	0.09
722.	96-48d	816	2	78.4296	31.4939	0.12
723.	96-48d	817	2	78.4301	31.4953	0.29
724.	96-48d	819	2	78.4326	31.5037	1.31
725.	96-48d	820	2	78.4303	31.5047	0.04
726.	96-48d	821	2	78.4345	31.5047	0.06
727.	96-48d	822	2	78.4348	31.5051	0.04
728.	96-48d	823	2	78.4331	31.5063	0.46
729.	96-48d	824	2	78.4337	31.5070	0.49
730.	96-48d	825	2	78.4335	31.5078	0.04
731.	96-48d	826	2	78.4355	31.5075	0.10
732.	96-48d	830	2	78.7758	32.0386	0.06
733.	96-48d	1000	2	78.7617	32.0429	0.06
734.	96-48d	1001	2	78.7615	32.0408	0.64
735.	96-48d	1003	2	78.7600	32.0412	0.07
736.	96-48d	1004	2	78.7601	32.0389	0.10
737.	96-48d	1005	2	78.7599	32.0396	0.14
738.	96-48d	1006	2	78.7593	32.0379	0.02
739.	96-48d	1007	2	78.7588	32.0367	0.21
740.	96-48d	1008	2	78.7583	32.0369	0.14
741.	96-48d	1009	2	78.7584	32.0376	0.09
742.	96-48d	1010	2	78.7584	32.0383	0.05
743.	96-48d	1011	2	78.7578	32.0385	0.06
744.	96-48d	1012	2	78.7587	32.0391	0.46
745.	96-48d	1013	2	78.7582	32.0393	0.09
746.	96-48d	1014	2	78.7579	32.0398	0.23
747.	96-48d	1015	2	78.7576	32.0394	0.04
748.	96-48d	1016	2	78.7582	32.0415	1.85
749.	96-48d	1017	2	78.7568	32.0413	0.03
750.	96-48d	1018	2	78.7580	32.0433	0.04
751.	96-48d	1019	2	78.7584	32.0439	0.02
752.	96-48d	1020	2	78.7563	32.0433	0.02
753.	96-48d	1021	2	78.7554	32.0438	0.10
754.	96-48d	1022	2	78.7560	32.0446	0.50
755.	96-48d	1023	2	78.7539	32.0453	0.07
756.	96-48d	1024	2	78.7540	32.0456	0.02

757.	96-48d	1025	2	78.7529	32.0459	0.05
758.	96-48d	1026	2	78.7531	32.0451	0.06
759.	96-48d	1027	2	78.7519	32.0446	0.27
760.	96-48d	1028	2	78.7529	32.0429	0.22
761.	96-48d	1029	2	78.7518	32.0427	0.63
762.	96-48d	1030	2	78.7506	32.0427	0.08
763.	96-48d	1031	2	78.7444	32.0473	0.76
764.	96-48d	1032	2	78.7451	32.0459	0.25
765.	96-48d	1033	2	78.7446	32.0451	0.22
766.	96-48d	1034	2	78.7433	32.0451	0.01
767.	96-48d	1040	2	78.7022	32.0329	0.08
768.	96-48d	1041	2	78.7033	32.0340	0.01
769.	96-48d	1035SG	2	78.7472	32.0402	0.03
770.	96-48d	1036SG	2	78.7464	32.0364	0.03
771.	96-48d	1037SG	2	78.7490	32.0362	0.03
772.	96-48d	1038SG	2	78.7367	32.0488	0.11
773.	96-48d	1039SG	2	78.7372	32.0484	0.01
774.	96-48d	393SG	2	78.6982	31.8970	0.01
775.	96-48d	394SG	2	78.7003	31.8962	0.01
776.	96-48d	395SG	2	78.7008	31.8958	0.04
777.	96-48d	396SG	2	78.7027	31.8961	0.11
778.	96-48d	397SG	2	78.7039	31.8951	0.02
779.	96-48d	398SG	2	78.7072	31.8966	0.03
780.	96-48d	399SG	2	78.7124	31.8949	0.14
781.	96-48d	401SG	2	78.7134	31.8961	0.01
782.	96-48d	402SG	2	78.7134	31.8955	0.02
783.	96-48d	403SG	2	78.7138	31.8954	0.03
784.	96-48d	404SG	2	78.7141	31.8946	0.04
785.	96-48d	405SG	2	78.7142	31.8937	0.10
786.	96-48d	406SG	2	78.7218	31.8928	0.06
787.	96-48d	407SG	2	78.7221	31.8921	0.07
788.	96-48d	408SG	2	78.7261	31.8907	0.06
789.	96-48d	409SG	2	78.7286	31.8913	0.05
790.	96-48d	410SG	2	78.7291	31.8914	0.08
791.	96-48d	411SG	2	78.7282	31.8928	0.12
792.	96-48d	412SG	2	78.7250	31.8964	0.02
793.	96-48d	413SG	2	78.7256	31.8965	0.05
794.	96-48d	438SG	2	78.7147	31.9414	0.01
795.	96-48d	439SG	2	78.7145	31.9429	0.01
796.	96-48d	440SG	2	78.7156	31.9430	0.03

797.	96-48d	441SG	2	78.7153	31.9446	0.02
798.	96-48d	442SG	2	78.7148	31.9448	0.02
799.	96-48d	443SG	2	78.7151	31.9452	0.01
800.	96-48d	444SG	2	78.7152	31.9453	0.02
801.	96-48d	445SG	2	78.7152	31.9456	0.02
802.	96-48d	446SG	2	78.7149	31.9463	0.01
803.	96-48d	447SG	2	78.7152	31.9465	0.03
804.	96-48d	448SG	2	78.7147	31.9495	0.03
805.	96-48d	449SG	2	78.7154	31.9503	0.02
806.	96-48d	450SG	2	78.7139	31.9512	0.04
807.	96-48d	451SG	2	78.7143	31.9519	0.04
808.	96-48d	452SG	2	78.7106	31.9530	0.06
809.	96-48d	453SG	2	78.7103	31.9532	0.02
810.	96-48d	454SG	2	78.7108	31.9534	0.01
811.	96-48d	455SG	2	78.7061	31.9546	0.08
812.	96-48d	456SG	2	78.7009	31.9559	0.03
813.	96-48d	457SG	2	78.7011	31.9576	0.13
814.	96-48d	458SG	2	78.7002	31.9585	0.01
815.	96-48d	459SG	2	78.7206	31.9724	0.03
816.	96-48d	460SG	2	78.7197	31.9729	0.16
817.	96-48d	467SG	1	78.3837	31.9722	0.02
818.	96-48d	469SG	1	78.3827	31.9747	0.09
819.	96-48d	470SG	1	78.3861	31.9754	0.14
820.	96-48d	471SG	1	78.3830	31.9769	0.03
821.	96-48d	472SG	1	78.3828	31.9773	0.10
822.	96-48d	473SG	1	78.3719	31.9719	0.19
823.	96-48d	474SG	1	78.3709	31.9757	0.36
824.	96-48d	476SG	1	78.3737	31.9768	0.02
825.	96-48d	477SG	1	78.3734	31.9791	0.05
826.	96-48d	478SG	1	78.3760	31.9783	0.02
827.	96-48d	507SG	2	78.5585	31.6174	0.09
828.	96-48d	508SG	2	78.5555	31.6072	0.04
829.	96-48d	509SG	2	78.5558	31.6070	0.03
830.	96-48d	510SG	2	78.5549	31.6058	0.04
831.	96-48d	511SG	2	78.5552	31.6035	0.07
832.	96-48d	512SG	2	78.5732	31.5902	0.05
833.	96-48d	513SG	2	78.5755	31.5897	0.02
834.	96-48d	514SG	2	78.5830	31.5930	0.02
835.	96-48d	515SG	2	78.5838	31.5929	0.02
836.	96-48d	516SG	2	78.5846	31.5933	0.02

837.	96-48d	517SG	2	78.5866	31.5947	0.01
838.	96-48d	518SG	2	78.5879	31.5810	0.04
839.	96-48d	655SG	2	78.7061	31.2165	0.01
840.	96-48d	656SG	2	78.7107	31.2132	0.11
841.	96-48d	657SG	2	78.7117	31.2117	0.15
842.	96-48d	658SG	2	78.7144	31.2134	0.01
843.	96-48d	659SG	2	78.7156	31.2107	0.20
844.	96-48d	660SG	2	78.7177	31.2117	0.05
845.	96-48d	661SG	2	78.7178	31.2098	0.03
846.	96-48d	662SG	2	78.7226	31.2049	0.44
847.	96-48d	663SG	2	78.7242	31.2054	0.02
848.	96-48d	664SG	2	78.7230	31.2040	0.07
849.	96-48d	665SG	2	78.7260	31.2041	0.03
850.	96-48d	666SG	2	78.7282	31.2036	0.14
851.	96-48d	667SG	2	78.7307	31.2031	0.01
852.	96-48d	668SG	2	78.7307	31.2018	0.43
853.	96-48d	669SG	2	78.7324	31.2022	0.04
854.	96-48d	670SG	2	78.7409	31.2002	0.23
855.	96-48d	671SG	2	78.7421	31.1996	0.01
856.	96-48d	675SG	2	78.6122	31.2451	0.04
857.	96-48d	676SG	2	78.6128	31.2454	0.02
858.	96-48d	677SG	2	78.6141	31.2463	0.04
859.	96-48d	678SG	2	78.6138	31.2469	0.01
860.	96-48d	679SG	2	78.6144	31.2488	0.16
861.	96-48d	680SG	2	78.6155	31.2506	0.04
862.	96-48d	681SG	2	78.6153	31.2510	0.02
863.	96-48d	682SG	2	78.6159	31.2516	0.06
864.	96-48d	683SG	2	78.6141	31.2511	0.18
865.	96-48d	684SG	2	78.6152	31.2544	0.03
866.	96-48d	685SG	2	78.5556	31.2502	0.31
867.	96-48d	686SG	2	78.5546	31.2481	0.02
868.	96-48d	687SG	2	78.5560	31.2465	0.04
869.	96-48d	688SG	2	78.5555	31.2463	0.04
870.	96-48d	691SG	2	78.4851	31.2337	0.03
871.	96-48d	692SG	2	78.4810	31.2326	0.07
872.	96-48d	693SG	2	78.4800	31.2364	0.03
873.	96-48d	694SG	2	78.4762	31.2386	0.02
874.	96-48d	695SG	2	78.4769	31.2432	0.04
875.	96-48d	696SG	2	78.4742	31.2469	0.02
876.	96-48d	697SG	2	78.4775	31.2613	0.17

877.	96-48d	698SG	2	78.4759	31.2627	0.10
878.	96-48d	743RS	2	78.7945	31.3697	1.53
879.	96-48d	753SG	2	78.6813	31.3459	0.01
880.	96-48d	754SG	2	78.6810	31.3457	0.04
881.	96-48d	755SG	2	78.6787	31.3457	0.01
882.	96-48d	756SG	2	78.6802	31.3468	0.17
883.	96-48d	757SG	2	78.6788	31.3471	0.04
884.	96-48d	758SG	2	78.6794	31.3478	0.17
885.	96-48d	759SG	2	78.6808	31.3496	0.12
886.	96-48d	760SG	2	78.6805	31.3514	0.05
887.	96-48d	761SG	2	78.6787	31.3538	0.08
888.	96-48d	762SG	2	78.6762	31.3549	0.22
889.	96-48d	763SG	2	78.6778	31.3568	0.02
890.	96-48d	764SG	2	78.6777	31.3573	0.04
891.	96-48d	765SG	2	78.6768	31.3598	0.01
892.	96-48d	766SG	2	78.6782	31.3604	0.07
893.	96-48d	772SG	2	78.6627	31.3550	0.02
894.	96-48d	773SG	2	78.6622	31.3559	0.12
895.	96-48d	787SG	2	78.5804	31.3696	0.08
896.	96-48d	797SG	2	78.4479	31.4552	0.04
897.	96-48d	798SG	2	78.4479	31.4409	0.02
898.	96-48d	799SG	2	78.4485	31.4410	0.12
899.	96-48d	801SG	2	78.4470	31.4392	0.02
900.	96-48d	802SG	2	78.4476	31.4390	0.02
901.	96-48d	803SG	2	78.4480	31.4384	0.09
902.	96-48d	805SG	2	78.4459	31.4354	0.11
903.	96-48d	811SG	2	78.4178	31.4769	0.04
904.	96-48d	812SG	2	78.4128	31.4764	0.19
905.	96-48d	813SG	2	78.4190	31.4837	0.25
96-49 c data not available						
96-49 d data not available						
906.	97-48a	1057	3	79.2537	32.5065	3.92
907.	97-48a	1058	3	79.2717	32.5285	1.56
908.	97-48a	1059	3	79.2790	32.4771	1.16
909.	97-48a	1060	3	79.2877	32.5197	0.71
910.	97-48a	1061	3	79.2861	32.5159	0.62
911.	97-48a	1062	3	79.2920	32.5130	1.48
912.	97-48a	1063	3	79.2973	32.5120	1.00
913.	97-48a	1064	3	79.2729	32.5270	0.10
914.	97-48a	1065	3	79.3197	32.5537	0.43

915.	97-48a	1066	3	79.3312	32.5599	2.75
916.	97-48a	1067	3	79.3317	32.5538	1.48
917.	97-48a	1068	3	79.3329	32.5541	0.90
918.	97-48a	1069	3	79.3337	32.5546	0.36
919.	97-48a	1070	3	79.3651	32.5250	0.53
920.	97-48a	1072	3	79.3937	32.3516	0.36
921.	97-48a	1073	3	79.4032	32.3459	0.55
922.	97-48a	1074	3	79.4057	32.3494	3.76
923.	97-48a	1075	3	79.4179	32.3734	1.90
924.	97-48a	1076	3	79.4172	32.3902	9.71
925.	97-48a	1080	3	79.5081	32.3920	1.84
926.	97-48a	1081	3	79.5085	32.3824	2.26
927.	97-48a	1082	3	79.5203	32.3762	0.73
928.	97-48a	1083	3	79.5297	32.3896	0.56
929.	97-48a	1085	3	79.5435	32.3757	0.19
930.	97-48a	1086	3	79.5443	32.3766	0.14
931.	97-48a	1071RS	3	79.3933	32.3763	**23.48**
932.	97-48a	1077HWL	3	79.4717	32.4176	0.39
933.	97-48a	1078HWL	3	79.4775	32.4184	0.75
934.	97-48a	1079HWL	3	79.4776	32.4215	0.90
935.	97-49b	1087	3	79.5939	32.3525	4.88
936.	97-49b	1088	3	79.5897	32.3535	1.41
937.	97-49b	1089	3	79.5727	32.3316	1.20
938.	97-49b	1090	3	79.5814	32.3258	0.88
939.	97-49b	1091	3	79.6192	32.3325	0.87
940.	97-49b	1092	3	79.6201	32.3267	1.91
941.	97-49b	1093	3	79.6431	32.3197	1.15
942.	97-49b	1094	3	79.6375	32.3169	5.39
943.	97-49b	1095	3	79.6455	32.2874	1.56
944.	97-49b	1096	3	79.6552	32.2776	0.16
945.	97-49b	1097	3	79.6519	32.2694	0.18
946.	97-49b	1098	3	79.6723	32.2600	0.10
947.	97-49b	1099	3	79.6682	32.2540	0.08
948.	97-49b	1100	3	79.6806	32.2586	1.42
949.	97-49b	1101	3	79.6829	32.2539	5.52
950.	97-49b	1102	3	79.6533	32.2351	1.02
951.	97-49b	1103	3	79.7052	32.2153	2.69
952.	97-49b	1104	3	79.7511	32.1446	1.23
953.	97-49b	1105	3	79.7627	32.1339	0.32
954.	97-49b	1106	3	79.7693	32.1333	1.88

955.	97-49b	1107	3	79.7966	32.1275	3.54
956.	97-49b	1108	3	79.8007	32.1253	2.08
957.	97-49b	1109	3	79.8036	32.1166	2.37
958.	97-49b	1110	3	79.8020	32.1126	0.66
959.	97-49b	1111	3	79.8032	32.1230	0.14
960.	97-49b	1112	3	79.7984	32.1222	0.04
961.	97-49b	1113	3	79.8016	32.1109	0.11
962.	97-49b	1114	3	79.8008	32.1111	0.02
963.	97-49b	1115	3	79.8007	32.1097	0.34
964.	97-49b	1116	3	79.8007	32.1066	1.64
965.	97-49b	1117	3	79.7982	32.1060	0.03
966.	97-48B	1118	3	79.7974	32.1056	0.78
967.	97-48B	1119	3	79.7848	32.1065	0.23
968.	97-48B	1120	3	79.7739	32.1199	0.26
969.	97-48B	1121	3	79.7773	32.1192	0.68
970.	97-48B	1122	3	79.7787	32.1190	0.10
971.	97-48B	1123	3	79.7831	32.1184	0.21
972.	97-48B	1124	3	79.7728	32.0960	0.21
973.	97-48B	1125	3	79.7728	32.0943	2.07
974.	97-48B	1126	3	79.7743	32.0938	0.17
975.	97-48B	1127	3	79.7589	32.0887	0.11
976.	97-48B	1128	3	79.8022	32.0782	3.76
977.	97-48B	1129	3	79.8024	32.0613	0.27
978.	97-48B	1130	3	79.7999	32.0590	0.91
979.	97-48B	1131	3	79.7784	32.0626	0.22
980.	97-48B	1132	3	79.8117	32.0401	0.26
981.	97-48B	1133	3	79.8123	32.0294	1.49
982.	97-48B	1134	3	79.8102	32.0281	0.62
983.	97-48B	1135	3	79.8148	32.0274	0.76
984.	97-48B	1136	3	79.8144	32.0267	0.20
985.	97-48B	1137	3	79.8175	32.0209	0.52
986.	97-48B	1138	3	79.8262	32.0178	3.02
987.	97-48B	1139	3	79.8271	32.0115	0.39
988.	97-48B	1140	3	79.8304	32.0170	0.25
989.	97-48B	1141	3	79.8545	32.0007	1.30
990.	97-48B	1142	3	79.8452	31.9919	3.45
991.	97-48B	1143	3	79.8360	31.9881	2.39
992.	97-48B	1144	3	79.8716	31.9770	7.58
993.	97-48B	1145	3	79.8661	31.9670	0.31
994.	97-48B	1146	3	79.8814	31.9696	3.19

995.	97-48B	1147	3	79.8816	31.9657	0.51
996.	97-48B	1148	3	79.8891	31.9673	3.42
997.	97-48B	1149	3	79.8787	31.9629	2.10
998.	97-48B	1150	3	79.8735	31.9593	0.33
999.	97-48B	1151	3	79.8740	31.9582	0.74
1000.	97-48B	1152	3	79.8769	31.9559	3.28
1001.	97-48B	1153	3	79.8800	31.9516	0.44
1002.	97-48B	1154	3	79.8922	31.9599	0.44
1003.	97-48B	1155	3	79.8943	31.9584	3.29
1004.	97-48B	1156	3	79.8982	31.9642	4.99
1005.	97-48B	1157	3	79.8754	31.9397	0.63
1006.	97-48B	1158HWL	3	79.8560	31.9498	1.50
1007.	97-48B	1159	3	79.8817	31.9321	2.42
1008.	97-48B	1160	3	79.8896	31.9349	0.41
1009.	97-48B	1161RS	3	79.8644	31.9247	**33.22**
1010.	97-48B	1162HWL	3	79.9012	31.9271	1.15
1011.	97-48B	1163	3	79.9263	31.9399	0.57
1012.	97-48B	1164	3	79.9188	31.9337	1.13
1013.	97-48B	1165	3	79.9072	31.9169	0.12
1014.	97-48B	1166	3	79.9055	31.9173	0.54
1015.	97-48B	1167	3	79.9045	31.9172	0.20
1016.	97-48B	1168	3	79.8951	31.9111	0.09
1017.	97-48B	1169	3	79.8969	31.9101	0.22
1018.	97-48B	1170	3	79.7934	32.1214	4.23
1019.	97-48B	1171	3	79.8753	31.9679	3.64
1020.	97-48B	1172	3	79.8903	31.9553	0.37
97-48c Data not available						
1021.	97-49b	1243	3	79.7706	31.0106	0.10
1022.	97-49b	1244	3	79.7747	31.0099	0.02
1023.	97-49b	1245	3	79.7750	31.0099	0.04
1024.	97-49b	1246	3	79.7706	31.0094	0.20
1025.	97-49b	1247	3	79.7776	31.0031	0.03
1026.	97-49b	1248	3	79.7774	31.0028	0.19
1027.	97-49b	1249	3	79.7670	30.9980	1.10
1028.	97-49b	1250	3	79.7536	31.0398	4.19
1029.	97-49b	1251	3	79.7296	31.0285	6.55
1030.	97-49b	1252	3	79.7372	31.0099	0.07
1031.	97-49b	1253	3	79.7375	31.0081	0.07
1032.	97-49b	1254	3	79.6745	31.0850	0.12
1033.	97-49b	1255	3	79.6633	31.0846	0.16

1034.	97-49b	1256	3	79.6488	31.0773	0.87
1035.	97-49b	1257	3	79.6488	31.0757	0.03
1036.	97-49b	1258	3	79.6549	31.0739	0.70
1037.	97-49b	1262	3	79.6292	31.0124	0.02
1038.	97-49b	1263	3	79.6307	31.0116	0.05
1039.	97-49b	1264	3	79.6307	31.0112	0.01
1040.	97-49b	1265	3	79.6311	31.0110	0.01
1041.	97-49b	1266	3	79.6313	31.0106	0.04
1042.	97-49b	1267	3	79.6311	31.0099	0.01
1043.	97-49b	1268	3	79.6317	31.0098	0.03
1044.	97-49b	1269	3	79.6302	31.0101	0.15
1045.	97-49b	1270	3	79.6321	31.0083	0.02
1046.	97-49b	1271	3	79.6315	31.0080	0.05
1047.	97-49b	1272	3	79.6318	31.0078	0.01
1048.	97-49b	1273	3	79.6318	31.0073	0.02
1049.	97-49b	1274	3	79.6329	31.0047	0.05
1050.	97-49b	1275	3	79.6337	31.0031	0.01
1051.	97-49b	1276	3	79.6340	31.0030	0.04
1052.	97-49b	1277	3	79.6340	31.0024	0.03
1053.	97-49b	1278	3	79.6346	30.9990	0.03
1054.	97-49b	1280	3	79.6110	31.0749	0.06
1055.	97-49b	1281	3	79.6122	31.0650	0.05
1056.	97-49b	1282	3	79.6108	31.0635	0.07
1057.	97-49b	1283	3	79.6119	31.0629	0.17
1058.	97-49b	1284	3	79.6125	31.0629	0.06
1059.	97-49b	1285	3	79.6114	31.0616	0.05
1060.	97-49b	1286	3	79.6099	31.0612	0.04
1061.	97-49b	1287	3	79.6135	31.0575	0.05
1062.	97-49b	1294	3	79.5986	31.0382	0.02
1063.	97-49b	1295	3	79.5914	31.0351	0.07
1064.	97-49b	1296	3	79.6076	31.0307	1.31
1065.	97-49b	1301	3	79.5796	31.0238	0.06
1066.	97-49b	1302	3	79.5827	31.0213	0.07
1067.	97-49b	1309	3	79.5858	31.0717	0.04
1068.	97-49b	1310	3	79.5618	31.0802	0.04
1069.	97-49b	1311	3	79.5687	31.0883	0.03
1070.	97-49b	1312	3	79.5679	31.0883	0.10
1071.	97-49b	1313	3	79.5683	31.0888	0.05
1072.	97-49b	1314	3	79.5698	31.0898	0.09
1073.	97-49b	1315	3	79.5712	31.0893	0.04

1074.	97-49b	1316	3	79.5710	31.0922	0.05
1075.	97-49b	1317	3	79.5709	31.0925	0.02
1076.	97-49b	1319	3	79.5699	31.0923	0.02
1077.	97-49b	1320	3	79.5691	31.0922	1.71
1078.	97-49b	1321	3	79.5687	31.0936	0.73
1079.	97-49b	1322	3	79.5623	31.0949	0.18
1080.	97-49b	1323	3	79.5127	31.0887	2.93
1081.	97-49b	1324	3	79.5158	31.1030	0.03
1082.	97-49b	1325	3	79.5147	31.1040	0.77
1083.	97-49b	1326	3	79.5156	31.1046	0.51
1084.	97-49b	1327	3	79.5066	31.1016	1.72
1085.	97-49b	1328	3	79.4904	31.0974	2.93
1086.	97-49b	1329	3	79.5135	31.1311	5.15
1087.	97-49b	1330	3	79.4917	31.1310	1.52
1088.	97-49b	1331	3	79.4375	31.1146	0.33
1089.	97-49b	1332	3	79.4349	31.1139	0.15
1090.	97-49b	1333	3	79.4366	31.1117	0.92
1091.	97-49b	1334	3	79.4395	31.1123	0.03
1092.	97-49b	1335	3	79.4390	31.1109	0.02
1093.	97-49b	1336	3	79.4389	31.1081	0.20
1094.	97-49b	1337	3	79.4359	31.1061	0.03
1095.	97-49b	1338	3	79.4356	31.1059	0.05
1096.	97-49b	1339	3	79.4363	31.1057	0.01
1097.	97-49b	1340	3	79.4361	31.1026	0.10
1098.	97-49b	1341	3	79.4351	31.1023	0.08
1099.	97-49b	1342	3	79.4354	31.1018	0.09
1100.	97-49b	1343	3	79.4250	31.0957	0.04
1101.	97-49b	1344	3	79.4285	31.0943	0.03
1102.	97-49b	1345	3	79.4382	31.0889	0.13
1103.	97-49b	1346	3	79.4372	31.0863	0.03
1104.	97-49b	1347	3	79.4234	31.0788	0.25
1105.	97-49b	1349	3	79.4154	31.0618	0.37
1106.	97-49b	1350	3	79.4138	31.0603	6.07
1107.	97-49b	1351	3	79.4109	31.0604	3.59
1108.	97-49b	1352	3	79.4024	31.1260	0.03
1109.	97-49b	1353	3	79.4030	31.1263	0.03
1110.	97-49b	1354	3	79.4029	31.1275	0.03
1111.	97-49b	1355	3	79.3950	31.1253	0.11
1112.	97-49b	1356	3	79.3795	31.1595	0.46
1113.	97-49b	1357	3	79.3696	31.1459	0.09

1114.	97-49b	1358	3	79.3655	31.1434	3.54
1115.	97-49b	1359	3	79.3618	31.1496	0.32
1116.	97-49b	1360	3	79.3575	31.1501	1.21
1117.	97-49b	1361	3	79.3413	31.1530	3.56
1118.	97-49b	1362	3	79.3187	31.1543	0.47
1119.	97-49b	1241RES	3	79.8023	31.4758	0.27
1120.	97-49b	1242RES	3	79.7926	31.4724	0.11
1121.	97-49b	1260HWL	3	79.6501	31.0216	0.05
1122.	97-49b	1261HWL	3	79.6515	31.0215	0.06
1123.	97-49b	1288SG	3	79.6133	31.0545	0.12
1124.	97-49b	1289SG	3	79.6115	31.0538	0.07
1125.	97-49b	1290SG	3	79.6111	31.0512	0.06
1126.	97-49b	1291SG	3	79.6059	31.0428	0.14
1127.	97-49b	1292SG	3	79.6004	31.0362	0.02
1128.	97-49b	1293SG	3	79.6001	31.0357	0.01
1129.	97-49b	1299SG	3	79.5663	31.0336	0.02
1130.	97-49b	1300SG	3	79.5771	31.0320	0.03
1131.	97-49b	1303HWL	3	79.5884	31.0609	0.17
1132.	97-49b	1304HWL	3	79.5883	31.0620	0.06
1133.	97-49b	1305HWL	3	79.5888	31.0634	0.10
1134.	97-49b	1306HWL	3	79.5884	31.0682	0.25
1135.	97-49b	1307HWL	3	79.5879	31.0694	0.20
1136.	97-49b	1363RS	3	79.3060	31.2329	4.22
1137.	97-49b	1364RS	3	79.3015	31.2398	0.25
1138.	97-49b	1365RS	3	79.3020	31.2416	0.06
1139.	97-49b	1366HWL	3	79.5997	31.3042	**32.84**
1140.	97-49b	1367HWL	3	79.6181	31.3296	0.30
1141.	97-49b	1368HWL	3	79.5755	31.3075	0.23
97-49c Data Not available						
97-49d Data not available						
98-49b Data not available						
98-49d Data not available						
99-49a Data not available						
1142.	99-49b	68	3	78.6965	32.7498	0.45
1143.	99-49b	69	3	78.6980	32.7497	1.05
1144.	99-49b	70	3	78.6892	32.7305	0.65
1145.	99-49b	71	3	78.6815	32.7065	0.75
1146.	99-49b	72	3	78.6883	32.7077	5.04
1147.	99-49b	73	3	78.6980	32.7044	3.86
1148.	99-49b	74	3	78.7011	32.7049	0.81

1149.	99-49b	76	3	78.7034	32.7062	0.27
1150.	99-49b	77	3	78.7017	32.7075	0.25
1151.	99-49b	78	3	78.7028	32.7075	0.32
1152.	99-49b	79	3	78.7058	32.7069	0.67
1153.	99-49b	80	3	78.7067	32.7078	0.52
1154.	99-49b	81	3	78.7120	32.7087	0.28
1155.	99-49b	82	3	78.7093	32.7096	0.06
1156.	99-49b	83	3	78.7074	32.7107	2.80
1157.	99-49b	84	3	78.7108	32.6950	3.06
1158.	99-49b	85	3	78.7193	32.6982	0.77
1159.	99-49b	86	3	78.7304	32.6952	0.19
1160.	99-49b	87	3	78.7336	32.6981	1.94
1161.	99-49b	88	3	78.7357	32.6983	0.09
1162.	99-49b	89	3	78.7366	32.6998	0.43
1163.	99-49b	90	3	78.7388	32.7047	0.22
1164.	99-49b	91	3	78.7396	32.7065	1.79
1165.	99-49b	1369	3	81.1952	31.1609	0.11
1166.	99-49b	1370	3	81.1996	31.1656	0.70
1167.	99-49b	1371	3	81.2152	31.1640	2.15
1168.	99-49b	1372	3	81.2249	31.1610	1.15
1169.	99-49b	1373	3	81.2068	31.1558	0.06
1170.	99-49b	1374	3	81.2055	31.1556	0.36
1171.	99-49b	1375	3	81.2212	31.1483	8.20
1172.	99-49b	1376	3	81.2245	31.1493	1.74
1173.	99-49b	1377	3	81.2323	31.1490	0.35
1174.	99-49b	1378	3	81.2346	31.1485	0.30
1175.	99-49b	1379	3	81.2346	31.1474	0.09
1176.	99-49b	1381	3	81.2310	31.1430	0.31
1177.	99-49b	1382	3	81.2273	31.1294	4.52
1178.	99-49b	1386	3	81.2277	31.0614	0.09
1179.	99-49b	1387	3	81.2281	31.0612	0.03
1180.	99-49b	1388	3	81.2288	31.0606	0.05
1181.	99-49b	1390	3	81.2496	31.1056	0.31
1182.	99-49b	1391	3	81.2478	31.1068	0.47
1183.	99-49b	1392	3	81.2514	31.1160	0.95
1184.	99-49b	1394	3	81.2621	31.1232	1.04
1185.	99-49b	1395	3	81.2619	31.1240	0.05
1186.	99-49b	1396	3	81.2631	31.1243	0.13
1187.	99-49b	1397	3	81.2582	31.1393	1.05
1188.	99-49b	1398	3	81.2789	31.1374	7.11

1189.	99-49b	1399	3	81.2761	31.1504	0.01
1190.	99-49b	1400	3	81.2754	31.1516	0.12
1191.	99-49b	1401	3	81.2761	31.1528	0.58
1192.	99-49b	1402	3	81.2974	31.1812	1.33
1193.	99-49b	1403	3	81.3105	31.1614	0.05
1194.	99-49b	1404	3	81.3096	31.1606	0.02
1195.	99-49b	1405	3	81.3091	31.1591	0.06
1196.	99-49b	1406	3	81.3077	31.1601	0.05
1197.	99-49b	1407	3	81.3120	31.1495	0.20
1198.	99-49b	1409	3	81.3217	31.1604	0.25
1199.	99-49b	1410	3	81.3224	31.1611	0.09
1200.	99-49b	1411	3	81.3208	31.1727	0.76
1201.	99-49b	1412	3	81.4003	31.1449	0.09
1202.	99-49b	1413	3	81.4071	31.1442	1.29
1203.	99-49b	1414	3	81.4232	31.1374	5.38
1204.	99-49b	1415	3	81.4128	31.1342	1.41
1205.	99-49b	1416	3	81.4061	31.1253	0.97
1206.	99-49b	1417	3	81.4014	31.1277	4.10
1207.	99-49b	1418	3	81.3945	31.1279	0.01
1208.	99-49b	1419	3	81.3936	31.1286	0.72
1209.	99-49b	1420	3	81.3819	31.1389	7.99
1210.	99-49b	1421	3	81.3664	31.1256	0.43
1211.	99-49b	1423	3	81.3682	31.1238	0.13
1212.	99-49b	1424	3	81.3913	31.1116	0.04
1213.	99-49b	1425	3	81.3717	31.0928	0.10
1214.	99-49b	1426	3	81.3709	31.0928	0.84
1215.	99-49b	1427	3	81.3498	31.0850	0.08
1216.	99-49b	1429	3	81.3450	31.0562	0.07
1217.	99-49b	1430	3	81.3112	31.0320	0.19
1218.	99-49b	1431	3	81.4106	31.0784	0.12
1219.	99-49b	1432	3	81.4118	31.0962	0.08
1220.	99-49b	1433	3	81.4119	31.1041	1.21
1221.	99-49b	1434	3	81.4146	31.1031	0.07
1222.	99-49b	1435	3	81.4159	31.1025	2.41
1223.	99-49b	1436	3	81.4223	31.1135	1.25
1224.	99-49b	1437	3	81.4341	31.1142	4.01
1225.	99-49b	1438	3	81.4476	31.1094	0.06
1226.	99-49b	1439	3	81.4486	31.1100	0.08
1227.	99-49b	1440	3	81.4494	31.1097	0.03
1228.	99-49b	1441	3	81.4742	31.1185	0.50

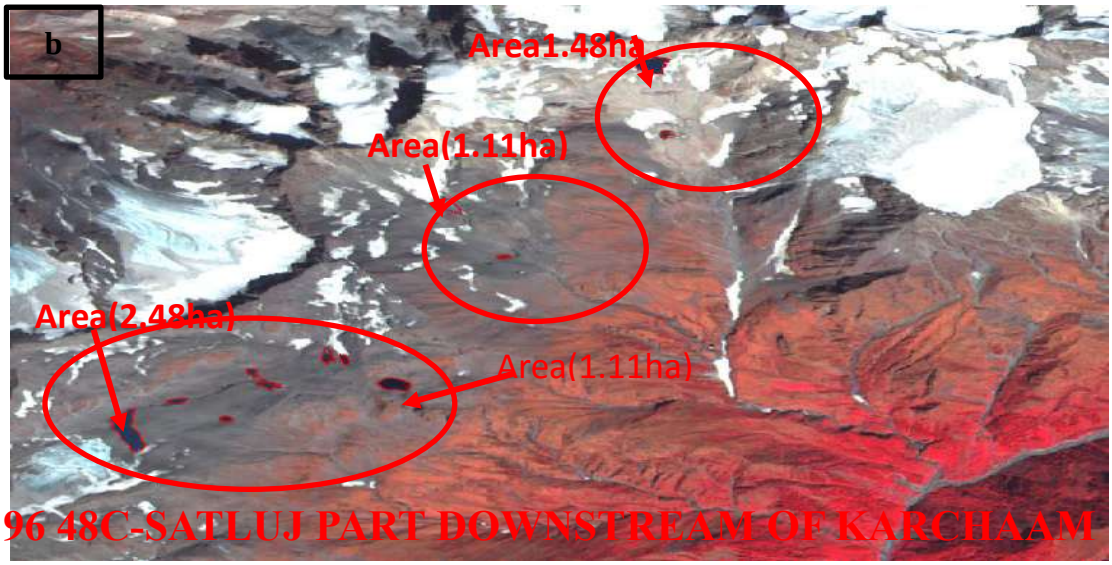
1229.	99-49b	1442	3	81.4443	31.0866	0.06
1230.	99-49b	1443	3	81.4439	31.0883	0.28
1231.	99-49b	1444	3	81.4324	31.0921	0.20
1232.	99-49b	1445	3	81.4250	31.0842	2.13
1233.	99-49b	1446	3	81.4271	31.0802	0.11
1234.	99-49b	1447	3	81.4257	31.0794	0.08
1235.	99-49b	1448	3	81.4240	31.0799	1.16
1236.	99-49b	1449	3	81.4160	31.0657	0.09
1237.	99-49b	1450	3	81.4064	31.0552	2.86
1238.	99-49b	1451	3	81.4585	31.0130	0.03
1239.	99-49b	1452	3	81.4574	31.0141	0.34
1240.	99-49b	1453	3	81.4654	31.0187	0.05
1241.	99-49b	1454	3	81.4654	31.0195	0.03
1242.	99-49b	1455	3	81.4681	31.0195	0.07
1243.	99-49b	1456	3	81.4723	31.0158	0.03
1244.	99-49b	1457	3	81.4689	31.0366	0.02
1245.	99-49b	1458	3	81.4694	31.0369	0.19
1246.	99-49b	1459	3	81.4824	31.0366	0.03
1247.	99-49b	1460	3	81.4819	31.0393	0.36
1248.	99-49b	1461	3	81.4808	31.0808	2.35
1249.	99-49b	1462	3	81.5033	31.0945	4.53
1250.	99-49b	1463	3	81.5132	31.0987	3.20
1251.	99-49b	1464	3	81.4820	31.1086	0.02
1252.	99-49b	1465	3	81.4820	31.1091	0.06
1253.	99-49b	1466	3	81.4815	31.1092	0.01
1254.	99-49b	1467	3	81.4810	31.1097	0.02
1255.	99-49b	1468	3	81.5019	31.1124	7.39
1256.	99-49b	1469	3	81.5240	31.1057	0.28
1257.	99-49b	1470	3	81.5301	31.0954	1.30
1258.	99-49b	1471	3	81.5307	31.0942	0.22
1259.	99-49b	1472	3	81.5291	31.0923	2.03
1260.	99-49b	1473	3	81.5312	31.0916	0.04
1261.	99-49b	1474	3	81.5184	31.0828	1.79
1262.	99-49b	1475	3	81.5204	31.0758	0.16
1263.	99-49b	1476	3	81.5048	31.0722	0.70
1264.	99-49b	1477	3	81.5033	31.0641	0.82
1265.	99-49b	1478	3	81.5143	31.0515	0.81
1266.	99-49b	1479	3	81.5153	31.0520	0.02
1267.	99-49b	1480	3	81.5156	31.0524	0.04
1268.	99-49b	1481	3	81.5180	31.0511	0.03

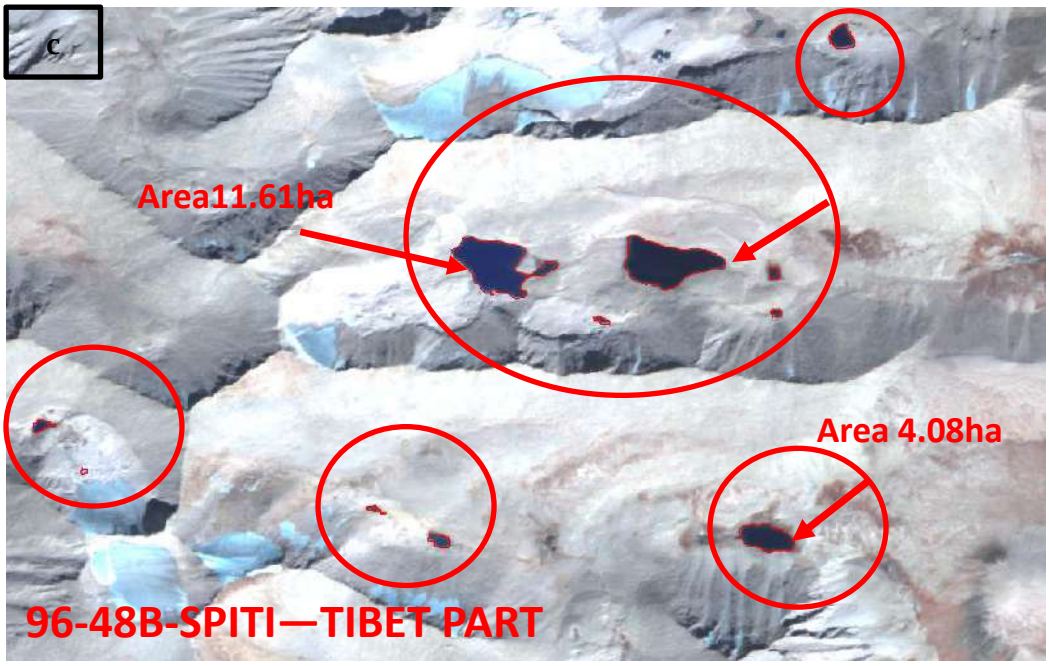
1269.	99-49b	1482	3	81.5043	31.0444	1.94
1270.	99-49b	1483	3	81.4963	31.0365	0.07
1271.	99-49b	1484	3	81.4982	31.0360	0.33
1272.	99-49b	1485	3	81.4950	31.0283	0.06
1273.	99-49b	1486	3	81.4963	31.0275	0.04
1274.	99-49b	1487	3	81.4968	31.0275	0.03
1275.	99-49b	1488	3	81.4992	31.0260	0.05
1276.	99-49b	1489	3	81.4892	31.0213	0.04
1277.	99-49b	1490	3	81.4895	31.0212	0.03
1278.	99-49b	1491	3	81.4830	31.0096	0.38
1279.	99-49b	1492	3	81.4839	31.0089	0.04
1280.	99-49b	1493	3	81.4841	31.0086	0.05
1281.	99-49b	1494	3	81.4855	31.0073	0.18
1282.	99-49b	1495	3	81.4861	31.0066	0.40
1283.	99-49b	1496	3	81.4888	31.0061	0.94
1284.	99-49b	1497	3	81.4887	31.0045	0.16
1285.	99-49b	1498	3	81.5174	31.0290	0.14
1286.	99-49b	1499	3	81.5181	31.0307	0.39
1287.	99-49b	1500	3	81.5185	31.0317	0.58
1288.	99-49b	1501	3	81.5131	31.0351	2.97
1289.	99-49b	1502	3	81.5138	31.0389	1.26
1290.	99-49b	1503	3	81.5440	31.0756	0.08
1291.	99-49b	1504	3	81.5469	31.0794	1.78
1292.	99-49b	1505	3	81.5402	31.0898	0.06
1293.	99-49b	1506	3	81.5467	31.0919	0.24
1294.	99-49b	1507	3	81.5499	31.0938	1.01
1295.	99-49b	1508	3	81.5539	31.0910	0.98
1296.	99-49b	1509	3	81.5602	31.0940	1.49
1297.	99-49b	1510	3	81.5454	31.1035	3.73
1298.	99-49b	1511	3	81.5423	31.1165	8.86
1299.	99-49b	1512	3	81.5547	31.0289	0.09
1300.	99-49b	1513	3	81.5543	31.0271	0.17
1301.	99-49b	1514	3	81.6662	31.0262	1.86
1302.	99-49b	1515	3	81.7269	31.0517	0.72
1303.	99-49b	1516	3	81.7235	31.0568	0.58
1304.	99-49b	1517	3	81.7223	31.0706	7.81
1305.	99-49b	1518	3	81.7616	30.9887	1.59
1306.	99-49b	1519	3	81.8390	31.0112	0.23
1307.	99-49b	1538	3	81.4007	30.4769	0.91
1308.	99-49b	1539	3	81.4126	30.4602	1.79

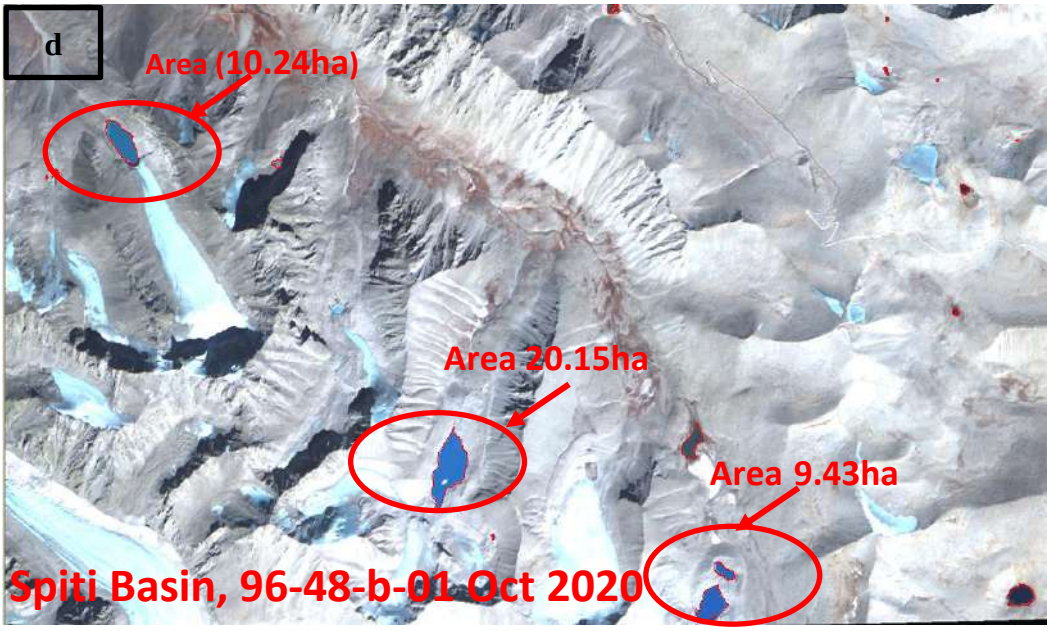
1309.	99-49b	1540	3	81.4102	30.4566	1.16
1310.	99-49b	1541	3	81.4141	30.4533	0.72
1311.	99-49b	1542	3	81.4292	30.4715	5.73
1312.	99-49b	1543	3	81.4330	30.4707	1.19
1313.	99-49b	1544	3	81.4463	30.4695	0.08
1314.	99-49b	1546	3	81.4371	30.4507	0.04
1315.	99-49b	1547	3	81.4321	30.4489	7.74
1316.	99-49b	1548	3	81.3924	30.4563	0.13
1317.	99-49b	1549	3	81.3935	30.4562	0.22
1318.	99-49b	1550	3	81.3959	30.4558	0.03
1319.	99-49b	1551	3	81.3921	30.4542	2.92
1320.	99-49b	1552	3	81.3945	30.4511	0.09
1321.	99-49b	1553	3	81.4297	30.4299	**188.30**
1322.	99-49b	1554	3	81.4625	30.4313	7.84
1323.	99-49b	1555	3	81.4813	30.4628	0.22
1324.	99-49b	1556	3	81.4818	30.4615	2.49
1325.	99-49b	1422RS	3	81.3645	31.1247	0.03
1326.	99-49b	1520HWL	3	81.8512	31.0060	**24.87**
1327.	99-49b	1521HWL	3	81.8592	31.0087	0.09
1328.	99-49b	1522RS	3	81.5421	30.8184	1.27
1329.	99-49b	1523HWL	3	81.5638	30.8031	**288.21**
1330.	99-49b	1524HWL	3	81.5687	30.7890	1.23
1331.	99-49b	1525HWL	3	81.5652	30.7876	5.07
1332.	99-49b	1526HWL	3	81.5526	30.7840	1.29
1333.	99-49b	1527HWL	3	81.5485	30.7842	4.25
1334.	99-49b	1528HWL	3	81.5376	30.7780	5.76
1335.	99-49b	1529HWL	3	81.5355	30.7764	0.16
1336.	99-49b	1530HWL	3	81.5325	30.7761	0.15
1337.	99-49b	1531HWL	3	81.5243	30.7764	1.44
1338.	99-49b	1532HWL	3	81.5455	30.7726	4.25
1339.	99-49b	1533HWL	3	81.5526	30.7717	**60.42**
1340.	99-49b	1534HWL	3	81.5651	30.7670	**12.14**
1341.	99-49b	1535HWL	3	81.5770	30.7614	**55.00**
1342.	99-49b	1536HWL	3	81.4620	30.6829	**41479.40**
1343.	99-49b	1537HWL	3	81.2404	30.6907	**25772.40**
1344.	99-49b	1557HWL	3	81.6755	30.4478	8.31
1345.	99-49b	1558HWL	3	81.6978	30.4547	2.77
1346.	99-49b	1559HWL	3	81.6980	30.4392	0.81
1347.	99-49b	1560HWL	3	81.6965	30.4306	5.64
1348.	99-49b	1561HWL	3	81.7195	30.4485	6.27

1349.	99-49b	1562HWL	3	81.7128	30.4283	**24.62**
1350.	99-49b	1563HWL	3	81.7210	30.4276	3.19
1351.	99-49b	1564HWL	3	81.7223	30.4206	**19.92**
1352.	99-49b	1565RS	3	81.1314	30.9222	2.21
1353.	99-49b	1566RS	3	81.1380	30.9204	0.23
1354.	99-49b	1567HWL	3	81.1971	30.8922	0.22
1355.	99-49b	1569HWL	3	81.2032	30.8930	0.94
1356.	99-49b	1570HWL	3	81.2110	30.8937	1.86
1357.	99-49b	1571HWL	3	81.2295	30.8919	1.20
1358.	99-49b	1573HWL	3	81.5376	30.7780	5.76
1359.	99-49b	1572HWL	3	81.6673	30.9491	2.29
100-49 a-b Data not available						

11.0 Satellite view of Lakes in Satluj Basin



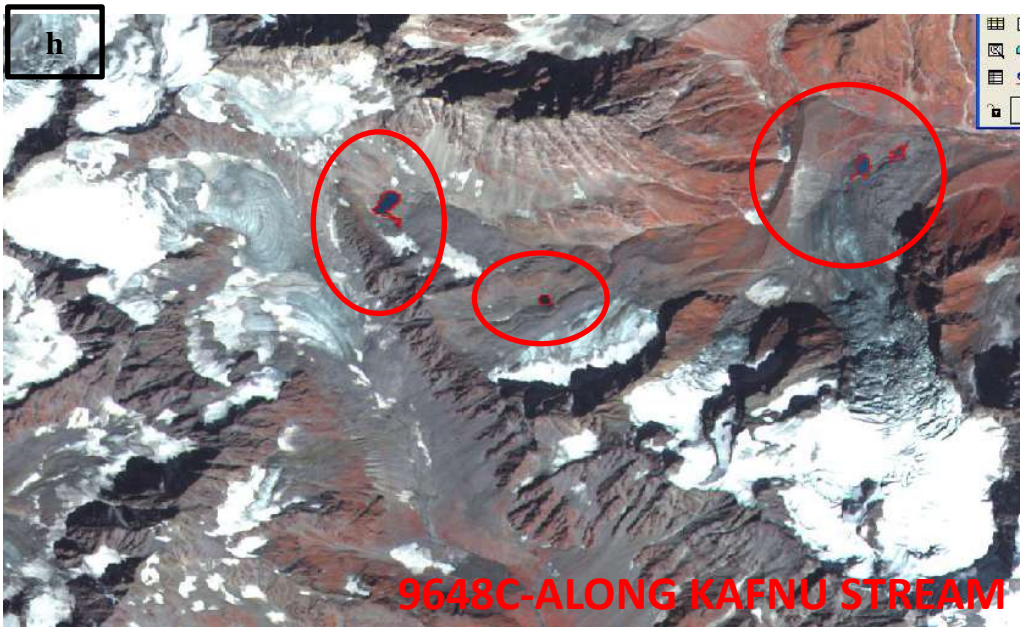

c
Area11.61ha
Area 4.08ha
96-48B-SPITI—TIBET PART

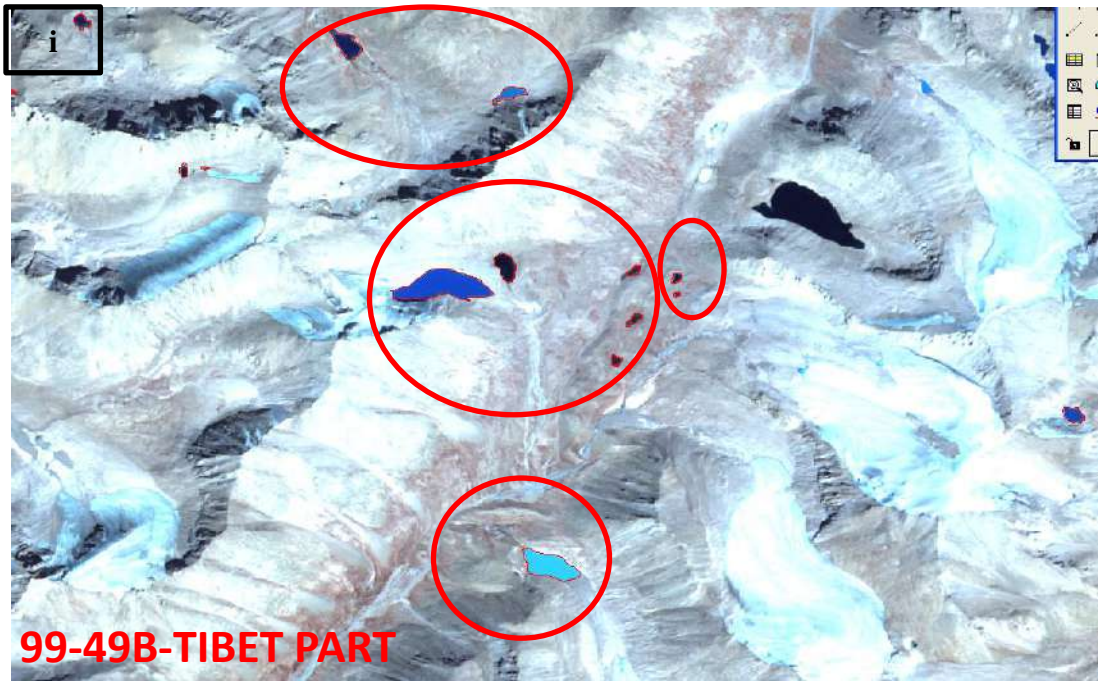

d
Area (10.24ha)
Area 20.15ha
Area 9.43ha
Spiti Basin, 96-48-b-01 Oct 2020


e
6.36ha
21.24ha
3.67ha
20.78


f
Area(30.11ha)
96-48-c-08 Oct 20 (Lower Satluj Basin on northwest of Kalpa


g
Area7.57ha
Area 3.63ha
Area 4.99ha
Area(33.21ha)
UPPER SATLUJ TIBET PART


h
9648C-ALONG KAFNU STREAM


i
99-49B-TIBET PART


j
9648C-ALONG KAFNU STREAM

Fig: 11(a-l) Satellite view of Lakes in Satluj Basin

12.0. Conclusion:

- The present study 'Monitoring of Glacial lakes/water bodies (2020)" 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.
- Monitoring has been carried out using IRS RS2&RS2A AWIFS data product 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 satellite data product having spatial resolution of 23.5mts for the year 2020.
- During 2020 another dataset using LISS-IV data having spatial resolution of 5.8 mts have been generated for the entire Satluj catchment but a few data gaps were there due to the non-availability of good quality cloud free satellite data in 2020 for LISS IV.
- Parechhu Lake which is basically a Landslide Induced Lake (LLOFs) formed within a geomorphic depression along the Parechhu River course and has a 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 2020, there was again satellite data limitation because of the cloud and snow cover impacts as a result of which only 03 scenes i.e. 10 June 2020, 27 June 2020 and 14 August 2020 were procured based on which the analysis 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 27 June 2020, landslide impact could also be seen from the right bank of the Parechhu River which was nor so prominent earlier.
- During 2020, the analysis was done using AWIFS, LISS III and LISS IV satellite data. A total of 10 AWIFS scenes were browsed and procured form April to October and a total of 10 AWIFS data products 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. No good quality data could be

Procured during November 2020 for AWiFS so, the interpretation has been done up to October 30, 2020 only. As far as LISS III and LISS IV satellite is concerned, the cloud free and good quality data products from August to September /October have been used in the analysis.

- During the month of April 2020, when most of the area is under the influence of the seasonal snow cover as a result of which the surface area is not fully exposed. But during 2020, on 16 April from AWiFS data product, a total of 18 lakes/wetlands could be delineated that too from the Upper Satluj basin, whereas the other basins were under the snow cover impact, and thus no information could be derived.
- No information could be derived during May, June 2020 due to non-availability of cloud free and snow free AWiFS satellite data product.
- Although July-August is the ideal period for carrying glaciological studies, but due to the predominance of the cloud cover, the availability of the good quality data due to monsoon season is very difficult. During July-August 2020, no information could be derived due to the non-availability of good quality satellite data products.
- During September which is considered as the end of the ablation season in the glaciated regions, most of the area is completely exposed and the glacier features are fully developed as result of which 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 in general.
- During September 2020, 06 AWIFS satellite data products were browsed and analyzed for 2nd September, 5th September, 10 September, 12 September, 21st September and 29 September respectively. Based on the analysis of the data, it is found that the data product for 2nd, 5th, 10th, 21st and 29th September data products are partially covering the study area, whereas on 12th September 2020, the data coverage is complete for all the basins and is clear from any cloud and snow cover impact.
- From the analysis of the 06 data products in September 2020, a total of 162, 47, 355, 361,138 and 259 lakes were mapped on 2nd, 5th,10th,12th,21st and 29th September 2020 respectably. Also in October 2020, data shows the presence of 246,288 and 172 lakes as on 1st, 16th and 30th October 2020 respectively.
- From the above analysis, it is found that 12th September 2020 shows the maximum number of lakes that could be mapped and thus 361 lakes/wetlands mapped during 2020 has been considered as the maximum input in terms of the lakes/wetlands based on AWIFS data product. Further analysis of

361 lakes reveals that 218 lakes are the small one with area less than 5ha, 81 lakes are within the aerial range of 5-10 ha and 62 lakes are the big one with are more than 10ha.The analysis based on classification suggest that out of 361 lakes, 40 are the high-altitude wetlands comprising 13 with area more than 10ha and thus 49 lakes are from glacial origin from the total 62 lakes mapped with area more than 10ha. Temporal analysis of 361 lakes/wetlands further reveals that 64 lakes/wetlands could be seen temporally with reference to 2019 out of which 39 lakes/wetlands are showing an increasing trend and 25 are showing reducing trend in their water spread w.r.t 2019. As far as the contribution of each basin is concerned, Spiti basin is characterized by 63 lakes/wetlands, Lower Satluj by 20 and Upper Saltuj basin by 278 lakes/wetlands reflecting that maximum (77%) of the total (361) are observed in Upper Satluj basin, 5% from lower Satluj and 17% from the Spiti basin as on 12 September 2020.

- From the comparative analysis of the maximum number of lakes/wetlands that have been delineated during 2020 are in the month of September i.e on 12 September 2020 wherein 361 lakes/wetlands have been delineated in comparison to 229 lakes/wetlands as mapped on 09 September 2019 reveals that the Spiti basin shows an increase of 44 lakes i.e 18 (2019) increased to 62(2020) comprising 43 lakes with area less 5ha, 13 lakes with area between 5-10ha and 7 lakes with more than 10ha, or in other words we can say that an enhancement of about 244% could be seen in the Spiti basin as a whole between 2019 and 2020 and 106% enhancement w.r.t 2018(30). Likewise, in Lower Satluj basin, an increase of about 185% w.r.t 2019 and about 3% w.r.t 2018 is observed i.e the number of lakes varies from 15(2018) to 7 (2019) to 20(2020) comprising 13 lakes having area less than 5ha, 5 lakes within the areal range of 5-10ha and 2 lakes having area more than 10ha. In Upper Satluj basin, a reduction of about 11% w.r.t 2018 and an increase of about 36% w.r.t 2019 could be seen in the total number of lakes mapped in 228(2018) to 204(2019) to 278(2020) comprising 162 lakes with area <5ha, 63 lakes with area between 5-10ha and 53 lakes with area >10ha.
- Thus from the analysis we can say about 77% of the total lakes falls in the Upper Satluj basin, 5% that from the Lower Satluj basin and 17% from the Spiti basin. Further comparative analysis of the bigger lakes with area >10ha reflects that total number of lakes falling in this category varies from 69(2018) to 31(2019) to 62(2020) out of which 13 are the high-altitude wetlands. Further it is found that in Spiti basin, the number of lakes with area >10ha that could be mapped varies from 4(2018) to 1 (2019) to 7 (2020), in Lower Satluj basin, the number of such lakes varies from 0(2018) to 0(2019) to 2(2020), whereas in Upper Satluj basin, the number varies from 60(2018) to 30(2019)

to 53(2020), and the variation is mainly due to the fact that the coverage of the study area was not complete in 2019 during this month where maximum lakes have been mapped.

- Thus percentage increase/decrease in terms of the lakes with area more than 10ha is reflected by about 200 % (6lakes/wetlands) increase in basin 1 i.e. Spiti basin, Lower Satluj basin i..e basin 2 does not show any lake in 2019 whereas, there are 2 lakes/wetlands in 2020 and about 47% (23 lakes) increase in basin 3 as far as the lakes/wetlands with area more than 10ha as mapped on 12 September 2020 are concerned.
- Likewise the total number of lakes in 2020 with area between 5-10 ha constitutes about 22% of the total number of the lakes i.e 81(2020) and shows an increase by about 138% in comparison to 2019 i.e. 34 (2019) and by about 30% in comparison to 2018 i.e. 62(2018) .The lakes with area <5ha varies from 142(2018) to 164(2019) to 218(2020) reflecting an increase of about 53% (76) w.r.t. 2018 and 32% (54)with reference to 2019.
- The lakes with abbreviation RS in their ids are mainly formed due to the accumulation of water along the main river course i.e the Satluj River and seem to be the common feature in the preceding years as well.
- 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. Thus, considering the AWIFS data availability on 01, 16 and 30 October 2020 have also been used for undertaking analysis for the mapping of various lakes/wetlands in the study area
- On 01, 16 and 30 October 2020, a total of 246,288 and 172 lakes have mapped from the satellite data respectively. Further analysis of 246 lakes mapped on 1st October comprises of 56 lakes from Spiti basin, 29 lakes from Lower Satluj and 161 from the Upper Satluj basin with 44 lakes as the big one with area more than 10ha. Likewise, on 16th October 2020, the total 288 lakes mapped comprises of 35 lakes from Spiti basin, 28 from Lower Satluj and 225 from the Upper Satluj and out of 288 lakes 71 lakes are with area more than 10ha. A total of 172 lakes which were mapped on 30th October 2020 comprises of 4 from Spiti, 8 from Lower Satluj and 160 from Upper Satluj basin with 52 as the big lakes. The analysis carried out during the month of October also reveals that the maximum lakes are being delineated from Upper Satluj basin and the number of big lakes that could be mapped has also increased to 71 which may indicate that there are 71 lakes which have the area more than 10ha.
- During the month of November, no data product could be procured by virtue of the data quality and thus analysis could not be done during November 2020.

- 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.
- Out of 361 lakes mapped on 12 September 2020, 40 lakes were classified as high-altitude wetlands and the remaining 321 lakes are from the glacial origin. Further these 40 wetlands when seen based on their areal size, it is found that 19 wetlands are of small dimensions i.e. less than 5ha, 8 are of the area between 5-10ha and 13 are of the area more than 10 ha respectively
- The total high-altitude wetlands (HWL) comprise about 11% (40) in 2020 reflecting a reduction of about 5% in comparison to 2019 (38 lakes) out of the total number lakes mapped in 2020 and 2019.
- As a whole the analysis of AWIFS data revels the presence of total maximum number of lakes that could be mapped during 2020 varies from April (18), September (361), October (288) and the variation in the numbers is mainly due to the availability of good quality satellite data and its coverage and the exposed area available **(Fig. 9.1)**
- Further analysis using AWIFS data based on total number of lakes mapped from April onwards during 2018, 2019 and 2020 suggest that the number varies from 15, --,18 (April), 18,6,---(May), 38,2,---(June),151,0,---(July), 84,98,----(August), 273,229,361(Sept), 93,45,288(Oct) reflects that the total number of lakes in Satluj catchment based on AWIFS data generally falls between 229-361 during 2018-2020 **(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 62(2020) in comparison to 31(Sept 2019) and out of these 62 lakes, 25 lakes could be compared with that of 2019 data which shows an increase/ decrease in their spatial extent w.r.t 2019 and 2 lakes/in comparison to 69 (Sept 2018) and 51 (November 2019) (**Fig.9.3)** and the variation in number is mainly due to the fact 02 wetlands which were in the areal range category of 5-10 ha in 2019 have shown an increase in their water spread in 2020 and thus have been counted in next category of area i.e more than 10ha.w.r.t 2019 ha. In general the number of such lakes(>10ha) varies over the years as in the lakes with area 2017(79) to 2018(69) to 2019(31&51) and 2020(62 & 71) **(Fig.9.4)**
- As far the lakes with area less than 5ha and between 5-10ha are concerned during 2020, 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.

- 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 2020, total number of lakes /wetlands mapped varies from 769 (2018) to 562(2019) to 993(2020) and the variation is mainly due to the fact that the satellite data during 2019 is by and large does have the impact of snow and cloud cover as a result of which complete information could not be derived.
- Out of the 993 lakes/wetlands mapped in 2020 using LISS III satellite data, basin 1 i.e Spiti basin constitutes about 19% (197) of the total lakes mapped (993) which is about 169% more in comparison to 2019(73) and about 11% more than 2018 (176). Likewise, basin 2 i.e the Lower Satluj basin constitutes 8% (89) of the total lakes mapped which is about 71% more than 2019 (52) and 7% less than 2018(98) and likewise, the Upper Satluj basin i.e the basin 3 constitutes of 71% (707) of the total lakes mapped in 2020 which is about 61% more than 2019 (437) and about 42% more than 2018 (495).
- Out of 993 lakes mapped in 2020 from LISS II data, about 88% (878) lakes are the small one with area less than 5ha, about 6% (63) falls within the aerial range of 5-10ha and about 5% (52) are the big one with area more than 10ha.
- The comparative analysis based on LISS-III satellite data reveals that total number of lakes varies from 642(2017) to 769(2018) to 562 (2019) to 993(2020) indicating an overall increase of about 19% between 2017-18 and reduction of about 26% between 2018-19 and further an enhancement by about 76% between 2019-20 respectively, which is mainly due to the non-availability of good quality LISS III data products in 2019.
- The total variation in the number of lakes mapped in Upper Satluj basin based on LISSS III data varies from 450(2017) to 495(2018) to 437(2019) to 707(2020), in Lower Satluj basin the number varies from 102 (2017) to 98(2018) to 52(2019) to 89(2020) and in case of Spiti sub basin it varies from 90(2017) to 176(2018) to 73(2019) to 197(2020) indicating about 10% increase between (2017-18) and a reduction of about 11% (2018-19)) and increase of about 61% (2019-20) in case of Upper Satluj basin, about 2% reduction (2017-18) and a reduction of about 46% (2018-19) and 71%(2019-20) in case of Lower Satluj and about 95% increase between 2017-18 and a reduction of about 58% (2018-19) and about 169%(2019-20) in case of Spiti basin could be seen
- As far as the big lakes with area more than 10ha are concerned, total number of big lakes varies from 55 (2017) to 49(2018) to 51(2019) to 52(2020) indicating a fluctuating trend in the lakes/wetlands with area >10ha, but are very close to each other.

- Further distribution of lakes based on the LISS III data based on their areal size, the number of lakes with area between 5-10ha shows an increase of 6 lakes/wetland w.r.t 2018(57) and 10 lakes/wetlands w.r.t 2019(53) indicting an overall increase of about 10% and 18% w.r.t 2018 and 2019 respectively.
- Likewise, the small category lakes i.e the lakes with area less than 5ha based on LISS III data varies from 663(2018) to 458(2019) to 878 (2020) indicating an overall increase of about 32% w.r.t 2018 and about 91% w.r.t 2019.
- Thus from the above analysis, it is clear that although the maximum number of lakes (about 71%) are being formed in the Upper Satluj basin , about 8% in the Lower Satluj basin and about 19% in the Spiti basin of the study area and majority of the lakes delineated in the entire study area during 2020 are small with area less than 5ha (about 88%) , about 6% 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 indicates an overall increase of about 57% in total number of lakes mapped in 2020 in comparison to 2019 reflecting 244% enhancement in case of Spiti basin, 185% increase in Lower Satluj and 36% from the Upper Satluj basin.
- Further the maximum lakes based on AWiFS data (77%) of the total 361 lakes have been mapped from Upper Satluj, 5% and 17% from Lower Satluj and Spiti basins respectively. In case of the bigger lakes with area >10ha, a 100% increase could also be seen in 2020(62) in comparison to 2019(31) with majority of the lakes (53) forming part of the Upper Satluj basin, 2 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 increase of about 76% in terms of the total number of lakes with about 2% increase in case of the lakes with area more than 10ha. The comparative analysis based on LISS-III satellite data reveals that total number of lakes varies from 642(2017) to 769 (2018) to 562 (2019) and 993(2020) indicating an overall increase of about 19% between 2017-18 and reduction of about 26% between 2018-19 and about 76% increase between 2019-20 respectively and the maximum number of lakes (about 71%) are being formed in the Upper Satluj basin , about 8% in the Lower Satluj basin and about 19% in the Spiti basin of the study area

- Classification of the lakes based on their origin suggest that, about 11%(40) of the total maximum lakes mapped on 12 September 2020 are the high altitude wetlands out of 361 lakes mapped from AWIFS satellite data and 8% (81) from the LISS III satellite data out of 993 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.

- Further in Spiti basin the lakes with ids 1682RS(0.51ha), 1683RS(0.58ha), 1684RS(1.75ha),1686RS(1.09ha) and 1687RS(1.17ha) 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. All these water bodies are although small but needs monitoring.
- Further based on the analysis carried out using LISS-IV(5.8mts) data , a very precise and more detailed information about the glacial lakes and the wetlands has been generated for the Satluj basin.
- The data which was available mainly falls within 96-48a, 96-48b, 96-48c, 96-48d, 97-48a, 97-48b, 97-49b, 99-49b path-row, besides some data gap within 98-48/49 and 100-49 path -row.
- Based on the above mentioned LISS-IV satellite data, a total of 1359 lakes/high altitude wetlands could be delineated comprising 225 (16%) from Spiti basin i.e basin1, 542 (39%) from the Lower Satluj basin i.e basin2 and 592 (43%) from the Upper Satluj basin i.e. basin3, out of which 55 lakes have been classified as high-altitude wetlands and the remaining 1304 as from the glacial origin.
- Further analysis of the data reveals that out of 1359 lakes/wetlands delineated, 1278 are the small one with area less than 5ha, 36 are within the area range of 5-10 ha and 25 are the one which have the aera more than 10ha respectively in other words we can say that (94%) are the small one with area less than 5ha, (2%) are within the areal range of 5-10ha and (about 2%) are the big one with area more than 10ha.
- The comparative analysis based on three different sets of data reflects that in Spiti basin, the number of lakes delineated has been enhanced from 62 with AWiFS sensor to 197 with LISS III sensor and 225 with LISS IV sensor. Likewise, in Lower Satluj basin, the 20 lakes delineated from AWiFS sensor increased to 89 in LISS III and 542 with LISS IV sensor. Similarly, in Upper Satluj basin, the 279 lakes as delineated from AWiFS sensor has increased to 707 with LISS III and 592 with LISS IV and the variation is mainly due to the data gap in LISS IV which mainly covers the areas falling in Upper Satluj basin. 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.

- Further based on the basin wise analysis and distribution of the lakes, it is found that the basin 3 i.e the Upper Satluj basin, the number of lakes is quite high in all the cases either in AWIFS (77%) or LISS III (71%) or LISS IV (43%) followed by Lower Satluj basin (5%, 8% and 39%) and Spiti basin (17% ,19% and 16%) 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, the data base based on AWIFS data product is reflects a complete inventory of 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 on 12 September 2020, whereas the LISS-III data products reflect a more detailed inventory of the lakes with a set of fine resolution(23.5mts) reflecting more detailed information about the lakes with small dimensions, besides a more precise and detailed database by using LISS IV data product (5.8mts). 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 has been carried out using IRS–RS2, AWIFS, IRS RS2 & RS2A LISS-III and IRS RS2A LISS -IV satellite data products having spatial resolution of 56mts, 23.5mts and 5.8mts for the year 2020 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 (SJVNL) to assess the threat from the moraine dammed glacial lakes/water during the year 2020. This study is being carried out regularly since 2009 during the ablation season (April to October) 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 and from LISSS 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 10 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, 96-48b,96-48c, 96-48d, 97-48a, 97-48b,97-49b,99-49b using LISS IV data products. During April 2020, which is generally considered as the start of ablation season, very limited information could be obtained as most of the catchment area was under the snow cover impact, so no information could be derived. Due to non-availability of good quality cloud free and snow free AWiFS data products during May to August, no information of the catchment could be derived.

During September 2020, the study area was investigated using data for six different dates i.e.2,5,10,12,21 and 29 September, which reveals the presence of 162,47,355,361,138,259 lakes/wetlands in the entire study area, whereas in October 03 data sets were used mainly for 1st, 16 and 30th October 2020 and a total of 248,288 and 172 lakes/wetlands were mapped. Based on the satellite data quality, cloud free and snow free coverage, the data procured on 12 September 2020 seems to be the best one and the information derived from this data has been considered as the maximum number of lakes during 2020 from AWIFS data. Based on the results obtained for 12 September 2020, maximum of 361 lakes could be mapped in the study area comprising 278 from the Upper Satluj basin i.e. sub basin 3, 63 from the Spiti basin i.e. sub basin1 and 20 form the Lower Satluj basin i.e. sub basin2. Further out of 361 lakes, 218 lakes are the small one with area less than 5ha, 81 lakes are within the aerial range of 5-10 ha and 62 lakes are the big one with are more than 10ha.The analysis based on classification suggest that out of 361 lakes, 40 are the high-altitude wetlands comprising 13 with area more than 10ha and thus 49 lakes are from glacial origin from the total 62 lakes mapped with area more than 10ha.Temporally 39 lakes/wetlands show a positive trend whereas 25 lakes/wetlands shows a negative trend in their spatial distribution out of 64 lakes which were compared with reference to 2019 for spatial distribution.

The comparative analysis of the maximum number of lakes/wetlands that have been delineated from 12 September 2020 wherein 361 lakes/wetlands have been delineated in comparison to 229 lakes/wetlands as mapped on 09 September 2019 reveals that the Spiti basin shows an increase of 44 lakes i.e 18 (2019) increased to 62(2020) indicating an overall increase of about 244% in the Spiti basin as a whole between 2019 and 2020. Likewise, in Lower Satluj basin, an increase of about 185% w.r.t 2019 and in Upper Satluj basin, an increase of about 36% w.r.t 2019 could be seen in the total number of lakes mapped in 204(2019) to 278(2020). Thus from the analysis we can say about 77% of the total lakes falls in the Upper Satluj basin, 5% that from the Lower Satluj basin and 17%

from the Spiti basin. Thus we can say that basin number 3 i.e. Upper Satluj basin of the study area within Tibetan Himalayan Region is more susceptible for such changes due to climatic variations as a result of which the basin 3 has more number of moraine dammed/supra glacial lakes in the area under investigation. Based on the areal distribution of lakes/wetlands on 12 September 2020, the bigger lakes with area >10ha, number of lakes falling in this category varies from 69(2018) to 31(2019) to 62(2020) out of which 13 are the high-altitude wetlands. The percentage increase/decrease in terms of the lakes with area more than 10ha is reflected by about 200 % (6 lakes/wetlands) increase in basin 1 i.e. Spiti basin, Lower Satluj basin i..e basin 2 does not show any lake in 2019 whereas, there are 2 lakes/wetlands in 2020 and about 47% (23 lakes) increase in basin 3 as far as the lakes/wetlands with area more than 10ha as mapped on 12 September 2020 are concerned. Likewise the total number of lakes in 2020 with area between 5-10 ha constitutes about 22% of the total number of the lakes i.e 81(2020) and shows an increase by about 138% in comparison to 2019 i.e. 34 (2019) and by about 30% in comparison to 2018 i.e. 62(2018) .The lakes with area <5ha varies from 142(2018) to 164(2019) to 218(2020) reflecting an increase of about 53% (76) w.r.t. 2018 and 32% (54)with reference to 2019.

Further , the increase in the total number of lakes with area more than 10ha with respect to the base line data of 2007(NRSC Hyderabad, 2007), it is found that this number has increased from 40(2007) to 85(2016) to 79(2017) to 69(2018) to 51(2019) to 62(2020) based on AWIFS data reflecting an overall increase of about 112% between 2007-2016 and about 97% increase between 2007-2017 and 72% between 2007-18 and about 27% between 2007-19 and about 55% between 2007-20 and about 16% between 2019-20 and 71% between 2007-2020 and 39% between 2019-20 and in case when the number of lakes mapped is 51 on 16 October 2020 . Thus we can say that the formation of the lakes with area more than 10ha reflects an increasing trend with respect to the base line data of 2007 i.e. 40 lakes with area more than 10ha.Likewise there is an increasing trend in the total number of lakes with reference to the base year i.e 196(2007) based on AWIFS data have been observed which indicates an increase of about 42% w.r.t the base year i.e. 2007(196) to 2017(280), 39% in 2018(273) about 16% in 2019(229) and about 84% in 2020(361). Thus we can say the total number of lakes in Satluj catchment is on the increasing side. Further Classification of lakes based on their origin suggest that 40 lakes i.e. about 11% lakes are mainly the high altitude wetlands and 321 lakes i.e.88% lakes are from the glacial origin i.e. the lakes which are either formed at or near the glacier snouts known as Moraine Dammed Glacier Lakes or more commonly known as (GLOFs) or within the glacier body in the ablation zone known as Supra glacier lakes (SG).

Further based on the LISS-III satellite data analysis for *2020* , a total of 993 lakes have been delineated out of which about 88% (878) lakes are the small one with area less than 5ha, about 6% (63) falls within the aerial range of 5-10ha and about 5% (52) are the big one with area more than 10ha. The comparative analysis based on LISS-III satellite data reveals that total number of lakes varies from 642(2017) to 769(2018) to 562 (2019) to 993(2020) indicating an overall increase of about 19% between 2017-18 and reduction of about 26% between 2018-19 and further an enhancement by about 76% between 2019-20 respectively, which is mainly due to the non-availability of good quality LISS III data products in 2019. From the analysis, it is clear that the maximum number of lakes (about 71%) are being formed in the Upper Satluj basin, about 8% in the Lower Satluj basin and about 19% in the Spiti basin of the study area 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. As far as the big lakes with area more than 10ha are concerned, total number of big lakes varies from 55 (2017) to 49(2018) to 51(2019) to 52(2020) indicating a fluctuating trend in the lakes/wetlands with area >10ha, but are very close to each other.

The Parechhu Lake in the Tibetan Himalayan Region was also monitored separately during the ablation period of 2020 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 2020 for June and August. 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. On 27 June 2020, another landslide from the right bank of Parechhu River encroaching the river course could be seen, by virtue of which slight accumulation was noticed, but the outflow was normal

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(0.51ha), 1683RS(0.58ha), 1684RS(1.75ha),1686RS(1.09ha) and 1687RS(1.17ha) 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. 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.

Further based on the analysis carried out using LISS-IV(5.8mts) data, a very precise and more detailed information about the glacial lakes and the wetlands has been generated for the Satluj basin for 2020.Based on the above mentioned LISS-IV satellite data, a total of 1359 lakes/high altitude wetlands could be delineated comprising 225 (16%) from Spiti basin i.e basin1, 542 (39%) from the Lower Satluj basin i.e basin2 and 592 (43%) from the Upper Satluj basin i.e. basin3, out of which 55 lakes have been classified as high-altitude wetlands and the remaining 1304 as from the glacial origin. The comparative analysis based on three different sets of data reflects that in Spiti basin, the number of lakes delineated has been enhanced from 62 with AWiFS sensor to 197 with LISS III sensor and 225 with LISS IV sensor. Likewise, in Lower Satluj basin, the 20 lakes delineated from AWiFS sensor increased to 89 in LISS III and 542 with LISS IV sensor. Similarly, in Upper Satluj basin, the 279 lakes as delineated from AWiFS sensor has increased to 707 with LISS III and 592 with LISS IV and the variation is mainly due to the data gap in LISS IV which mainly covers the areas falling in Upper Satluj basin. 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. Further based on the basin wise analysis and distribution of the lakes, it is found that the basin 3 i.e the Upper Satluj basin, the number of lakes is quite high in all the cases either in AWIFS (77%) or LISS III (71%) or LISS IV (43%) followed by Lower Satluj basin (5%, 8% and 39%) and Spiti basin (17% ,19% and 16%) and thus basin 3 i.e Upper Satluj basin seems to be more susceptible than the Spiti and the Lower Satluj basin as far as moraine dammed lakes/water bodies are concerned in the study area.

Thus based on the analysis carried out using AWIFS , LISS III and LISS IV data products in the catchment area of Satluj Jal Vidyut Nigam Ltd. on 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 basins identified in the Satluj catchment, especially the Tibetan Himalayan Region i.e the Upper Satluj basin(basin 3) wherein the number of lakes is comparatively very high, which may be due to the more pronounced effect of climatic variations in this region, as a result the small category lakes are coming at a very fast pace. 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. The recent tragedy of 2013 in the Uttrakhand 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 2020. 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. 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 Parechhu and other instances of GLOFs (Glacier lake Outbursts Floods) in the Himalayan Region of Nepal and Bhutan and the recent tragedy of Uttrakhand Himalaya, which will not only save the precious human lives but also the public and the Govt. property.

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