

Boundary Delineation of Khunjerab National Park

Boundary Delineation and Renotification
of Protected Areas Project



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LIST OF ABBREVIATIONS

ASC	Area Specific Committee
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
CCHA	Community Controlled Hunting Area
DEM	Digital Elevation Model
DIP	Digital Image Processing
DRG	Digital Raster Graphic
ERDAS	Earth Resources Data Analysis System
FCC	False Color Composite
GIS	Geographical Information System
GPS	Global Positioning System
GR	Game Reserve
ha	Hectare
IUCN	International Union for Conservation of Nature
Km	Kilometer
LCLU	Land Cover Land Use
KNP	Khunjerab National Park
KVO	Khunjerab Villager Organization
MoE	Ministry of Environment
OBIA	Object Based Image Analysis
PA	Protected Area
PPEPCA	Pakistan Petroleum Exploration & Production Companies Association
RS	Remote Sensing
SNT	Shimshal Nature Trust
TIN	Triangulated Irregular Network
WWF - P	World Wide Fund for Nature – Pakistan
WS	Wildlife Sanctuary

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SUMMARY

The study deals with the boundary delineation of Khunjerab National Park (KNP) by using GIS/RS techniques. WWF – Pakistan has conducted this study in collaboration with the Ministry of Environment (MoE), Pakistan Petroleum Exploration and Production Companies Association (PPEPCA) under the “Boundary Demarcation and Renotification of Protected Areas” Project.

Khunjerab National Park (KNP) lies in Tibetan Plateau steppes of G200 Ecoregions. It hosts a highly diverse ecosystem with beautiful landscape.

For the accurate boundary delineation of KNP, an Area Specific Committee (ASC) was formulated. The Committee had representatives from the directorate of Khunjerab National Park, Revenue department and WWF – Pakistan.

Terra (ASTER) satellite images and topographic layers were used to delineate the KNP extent. For this purpose references from existing notification of KNP, Shimshal Community Controlled Hunting Area (CCHA) and Soqhterabad CCHA were used to translate the boundary into a GIS format. Consultative sessions were arranged with the members of both CCHAs to delineate the exact extent of common boundary between KNP and CCHAs. A2 size maps on different scales were developed to conduct a field survey. These maps were very useful during the discussion session with the communities. During the surveys, Global Positioning System (GPS) coordinates were collected for the boundary references of CCHAs and Khunjerab National Park.

The Object Based Image Analysis (OBIA) technique was used for the landcover mapping. Twelve major land cover classes were identified from ASTER (15m) imagery. The output thematic map provides information about the spatial pattern and area coverage of the twelve land cover classes. The output thematic map contains snow (53%) and rocks (12%) as major land cover classes. Analysis revealed that the 3.64% area of the National Park contains vegetation classes. Topographic mapping and habitat mapping were also used to define the exact extent of boundary of Khunjerab National Park.

Delineated boundary significantly defines the KNP extent considering physical as well as geographical references. Water channels, ridges and hills are the main boundary references on the north, east, west and south directions.

The KNP boundary covers an area of 4,455 sq km, whereas the area given in the notification is 5,544 sq km. These values indicate a comparative less area of 1,089 sq km. It is the result of the exclusion of the overlapping area of CCHAs from the National Park’s boundary which were declared as CCHAS in November 2006.

Furthermore, a draft notification format was developed which contains three parts i.e. textual description, a GIS map and list of boundary coordinates.

1 INTRODUCTION

1.1 Background

A Protected Area (PA) is defined as “An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources and managed through legal or other effective means” [1]. PAs represent diverse ecological, terrestrial and aquatic ecosystem and are considerably important for their ecological and socio-economic services.

In Pakistan, there are more than 232 PAs of different categories such as National Parks (NPs), Wildlife Sanctuaries (WSs) and Game Reserves (GRs). These cover around 11% land (approximately 2,754,000 hectares) of the country. These PAs represent almost every ecological, terrestrial and aquatic ecosystem and are considerably important for their ecological and socio-economic services. In Pakistan very few organizations are working in the field of conservation. WWF - Pakistan has been involved in different conservation activities for more than three decades.

Currently available information about PAs' boundaries is only in the form of notifications and sketch maps. Most of the notifications are without any geographic reference whereas in some notifications localities, roads, water channel or any other landmark is considered as a reference. Such references are not reliable in the long run as the land conditions change with passage of time i.e. shift in water channel or migration of certain locality. These references are much generalized, hence cause inaccuracies in position as well as in areas. On the other hand, GIS provides an opportunity to define boundary of a certain region with geographic information. A need of PA notifications with proper geo-information of boundaries was therefore identified so that ambiguities and errors could be avoided.

WWF – Pakistan in collaboration with the Federal Ministry of Environment (MoE) and with the financial assistance of PPEPCA organized a three day Consultative National Workshop on Boundary Demarcation and Renotification of Protected Areas”. Participants of the workshop included government officials, representatives of relevant civil society organizations, petroleum exploration and production companies and independent consultants.

As an outcome of this workshop, “Boundary Delineation and Renotification of Protected Areas” Project was launched. Under this Project, WWF - P is delineating boundaries of seven selected PAs (Figure 1). So far, the boundaries, and notifications of Ayubia, Machiara, Hingol, Margallah and Khirthar National Parks have been finalized.

This report describes the procedures adopted for the GIS based boundary delineation of Khunjerab National Park (KNP).

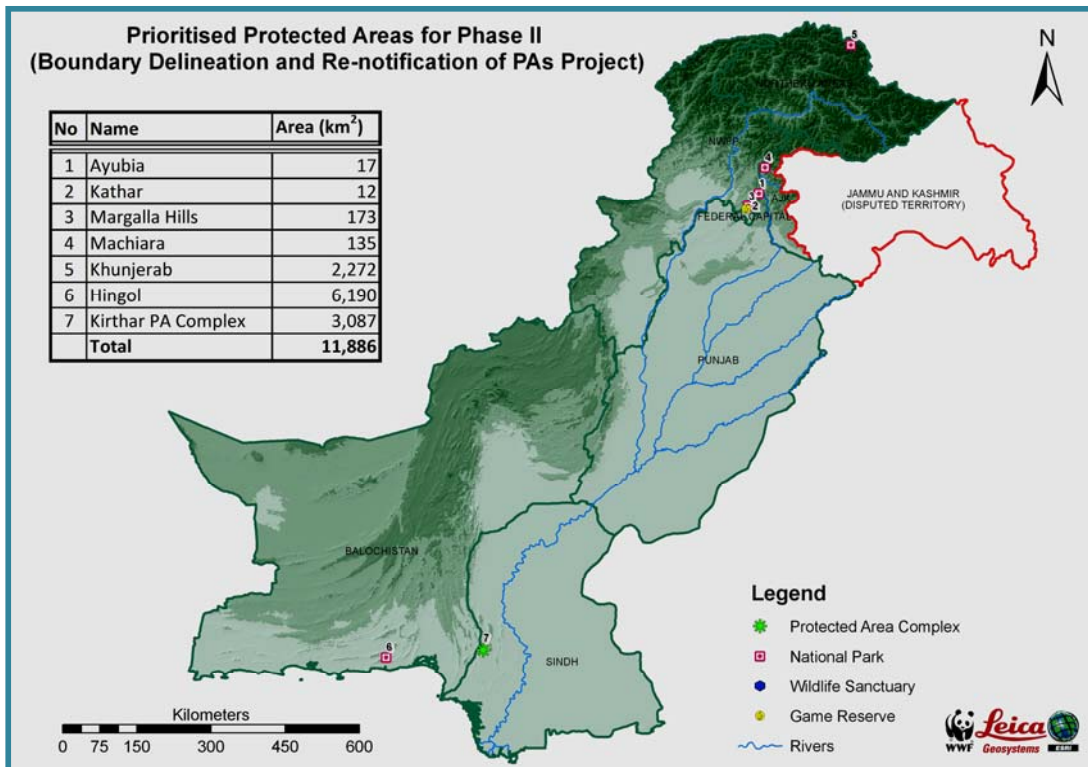


Figure 1: Seven prioritized Protected Areas

1.2 Study Area

Khunjerab National Park lies at the extreme northern part of Gojal. "Khunjerab" is actually a combination of two words "Khoon" and "Jerab" meaning "Valley of the Khan". However, according to the local interpretation, Khunjerab mean the "Valley of Blood" due to very tough terrain of the area [1]. The geographic coordinates of KNP are 75° 41' 03.81''E and 36° 26' 34.89''N.

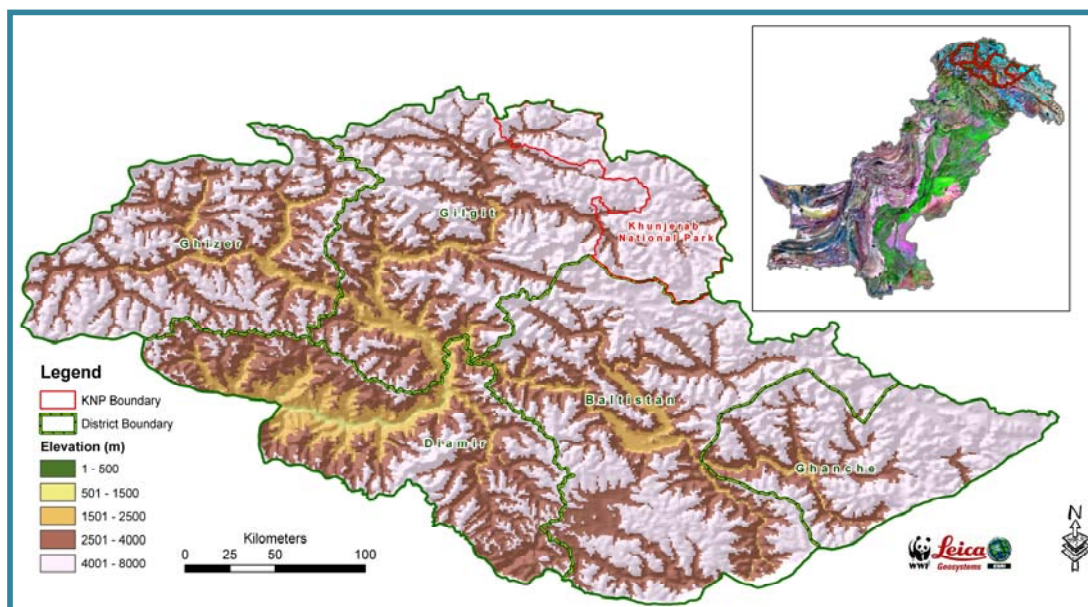


Figure 2: Location map of Khunjerab National Park

Khunjerab National Park is one of the highest altitude Parks in the world. Most of peaks of the Park are above 4,000 meters (13,000 ft) in elevation. Khunjerab National Park consists of three different valleys i.e. Khunjerab (through which the Karakoram Highway passes), Ghujerab and the remote Shimshal valley [2].

The Khunjerab, Gujerab and Shimshal rivers flow westwards and drain into Hunza river. All the waterways are perennial. There is a variety of sedimentary, metamorphic and igneous rocks. Soils are generally shallow and immature, containing fragments of rocky material, drifted sand and clay. They are formed mainly by the deposition of glacial material carried down in valley [3].

1.3 Climate

The nearest meteorological station is at Misgar Valley that is located 32 km from the Park entrance. The climatic conditions vary considerably with altitude. Winter is long and severe and summer is cold and dry. The minimum temperature during the winter (December and January) is -12°C . July and August are the hottest months, with a mean temperature of 14°C [3].

1.4 Biodiversity

The National Park is a biodiversity hotspot. It provides habitat to a large number of endangered fauna like Marco Polo sheep, Blue sheep, Himalayan Ibex, Tibetan wild ass, Brown bear, Snow leopard, Indian wolf etc. It is also one of the most important alpine biodiversity regions within Pakistan.

1.4.1 Flora

In the dry alpine scrub zone consists of the species like *Artemisea marina*, *Juniperus excelsa*, *Rosa webbiana* and *Polygonum* spp. on the dry slopes and *Myricaria germanica* and *Hippophae rhamnoides*, along the steam beds. *Populus nepalensis*, *Salix* spp. and *Beula utilis* are found in moist places [4].

1.4.2 Fauna

Khunjerab National Park was basically established to protect the Snow Leopard besides Brown Bear, Lynx, Tibetan wolf, Tibetan fox, Markhor, Blue sheep, Golden marmot and Himalayan ibex.

Himalayan Ibex, Brown Bear, Tibetan Red Fox, Tibetan Wolf, Blue Sheep, Tibetan Wild Donkey, Ermine, Alpine Weasel, Stone Martin, Golden Marmot, Large-eared Pika, Cape Hare and many other small mammals are also found in the Park [3].

The Park also hosts Golden Eagle, Lammegier, Himalayan Griffon and Eurasian Black Vultures, Marsh Harrier, Eurasian Sparrow Hawk, Eurasian and Lesser Kestrel, Saker and Peregrin Falcon, Himalayan Snow Cock, Snow Partridge, Grey Heron, Hill and Snow Pigeon, Northern Eagle Owl, Eurasian Cuckoo, Common Swallow, Magpie, Alpine Cough and Raven [5].

2 MATERIALS AND METHODS

Field data, habitat maps, topographic layers and land cover maps were used to delineate the draft KNP boundary. ASC meetings lead to rectification of the draft GIS boundary. The workflow diagram is shown in Figure 3.

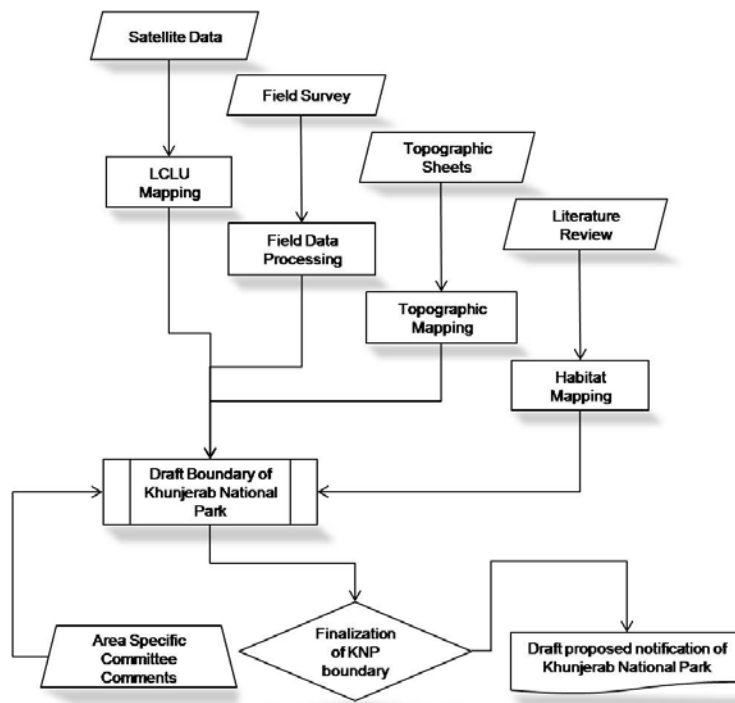


Figure 3: Flow chart

2.1 Satellite Data Procurement

For boundary delineation and land cover mapping KNP, cloud free and most recent available Terra (ASTER) image were procured from USGS. The characteristic details of the acquired satellite images are given in Table 1.

Table 1: SPOT Data Characteristics

Satellite	Sensor	Acquisition Date	Spatial Resolution (m)
Terra	ASTER	26-09-2008	15
Terra	ASTER	26-09-2008	15
Terra	ASTER	03-10-2008	15
Terra	ASTER	03-10-2008	15
Terra	ASTER	28-09-2006	15
Terra	ASTER	17-06-2006	15
Terra	ASTER	17-06-2006	15
Terra	ASTER	11-03-2006	15

2.2 Software Used

For boundary delineation and maps formulation, ArcGIS 9.0[®] was used. Whereas, for satellite images interpretation and processing Digital Image Processing (DIP) software ERDAS Imagine 8.7[®] and Definien Developer 7.0[®] were used. Microsoft Word and Microsoft Excel were used for documentation and graphical analysis. Field maps, Garmin GPS 76 CSX receiver and Canon PowerShot SX1 IS digital camera were used for field navigation and data recording.

2.3 Pre-processing

2.3.1 Import

The images were acquired in Hierarchical Data Format (*.hdf*). For easy handling and processing, the images were imported in ERDAS Imagine native image format (*.img*).

2.3.2 Satellite Image Enhancement

Image enhancement is a technique that improves a low contrast satellite image to enhance its interpretation level. For this study, Standard Deviation Stretch and Brightness Contrast Control utility were applied on the images [6].

2.4 Topographic Mapping

Spot heights, populated places, drainages, roads, catchments area and water marks were digitized from 1:250,000 and 1:100,000 topographic sheets (Figure 4). The attribute information was attached with each feature and output files were saved in GIS format.

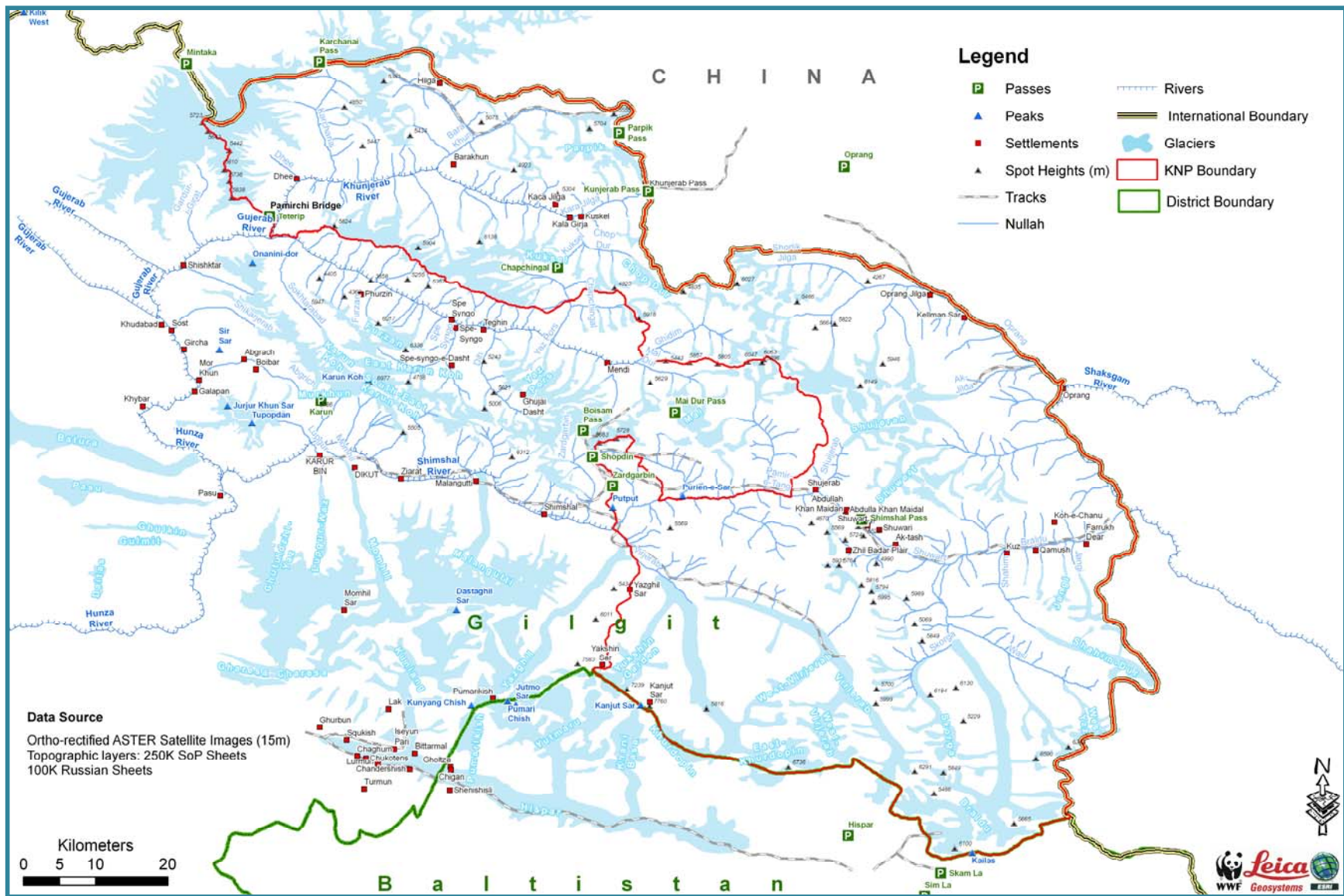


Figure 4: Topographic map of Khunjerab National Park

Boundary Delineation of Khunjerab National Park

2.5 Ground Truthing and Field Data Collection

Field visit of KNP was conducted from 29th June to 09th July, 2009. The main purpose of the visit was to have meetings with the local communities of hunting areas i.e. Soqhterabad and Shimshal to resolve and clarify the boundary conflicts between the boundaries of the CCHAs and Khunjerab National Park. Moreover, field data regarding the boundary references and hot spots for landcover mapping were also collected during the field visit. A2 size maps of ASTER satellite data were developed at a scale of 1: 100, 000 with one minute grid intervals for discussion with the communities and field data collection. The survey team comprised of representatives from following departments/organizations;

- Directorate of KNP
- Wildlife Department , Gilgit Baltistan
- WWF – Pakistan
- Shimshal CCHA
- Soqhterabad CCHA

During the discussion with the communities, the members from CCHAs, KNP and Wildlife Departments identified the common boundary between Khunjerab National Park and CCHAs. Moreover, they helped in GPS data collection and identification of different references, points for the boundary delineation of KNP

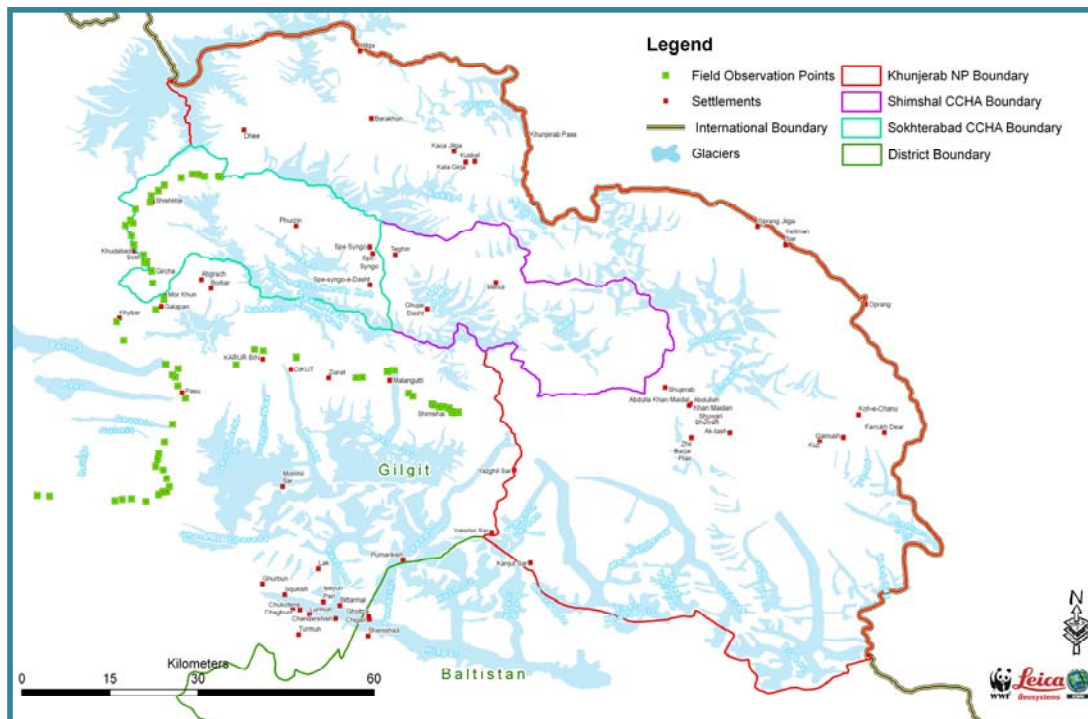


Figure 5: Field observation points of KNP

2.6 Field Observation Points

- The Park/area attracts the visitors due to its natural beauty and trekking activities. The main source to cross the water channels flowing under the high cliff mountains are small and dangerous bridges. Pamirchi Bridge is the western ending point of the Park.



Figure 6: Pamirchi bridge (a) GPS point on satellite image (b) Digital photograph

- Most of the area near the shimshal pass comprises of grasses/pastures that are being used for grazing livestock. The peat lands are also one of the main sources of livelihood.



Figure 7: Peat land (a) Satellite image and (b) Digital photograph

- *Junipers* spp. are needle leaved evergreen shrubs/trees ranges from 1 to 10 feet in height [8]. Sparse forest of *Juniper* spp. was observed at higher altitudes.



Figure 8: *Juniper Communis* (a) GPS point on satellite image (b) Digital photograph

- Shimshal village lies in the southern periphery of boundary of KNP. Shimshal is a large Wakhi speaking (local language) village supported by herds of sheep, goats and yaks that are moved up and down in the valley with the season. The Wakhi people of Shimshal village are mostly dependent on agriculture. The fields of hardy cereals (wheat and barley), potatoes, apricots and apple were observed in the area.

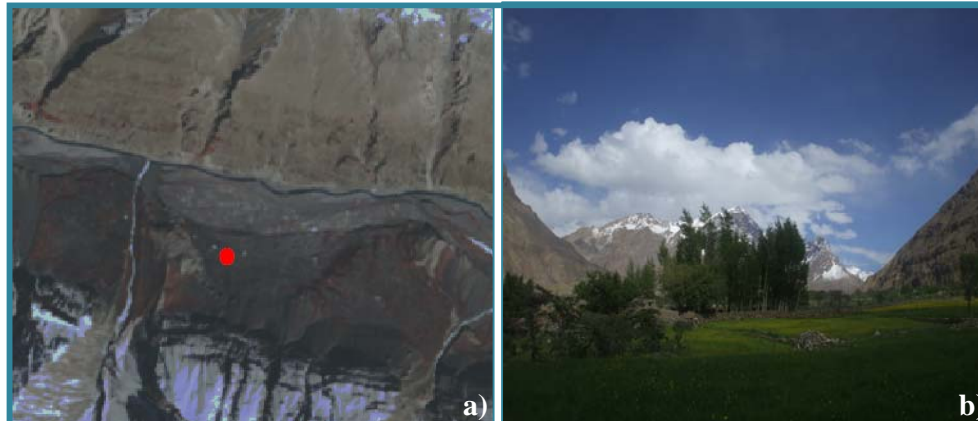


Figure 9: Shimshal village (a) GPS point on satellite image and (b) Digital photograph

- The Park consists of high rugged mountains of barren rocks. However, there are certain plane areas/pastures which are used for the grazing purposes by the local community.

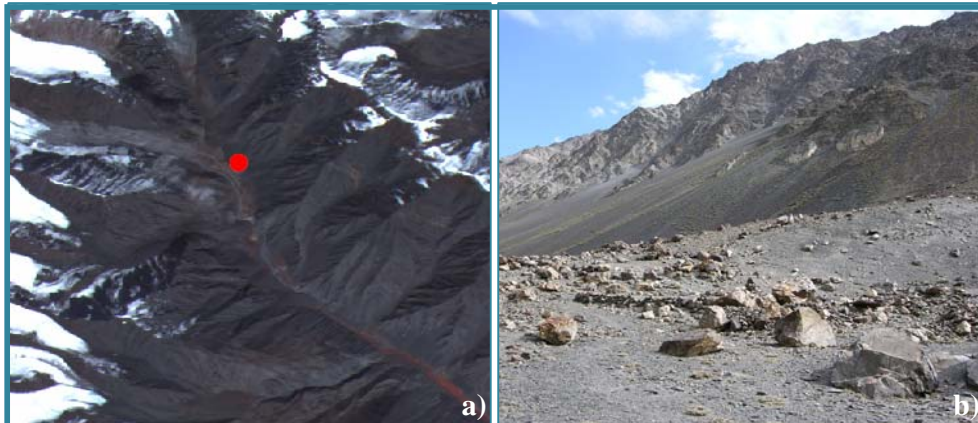


Figure 10: Bare Rocks in Dhee (a) GPS point and (b) Digital photograph

- During the survey, boundary reference points were collected and discussed with the community. Absence of boundary pillars in the area, makes it difficult to identify the exact extent of the Park. However, due to the terrain of the Park, certain ridges and junction point of rivers and water channels were taken as references. Junction point of the Khunjerab and Gujerab river is one of the boundary references of the boundary of the National Park.

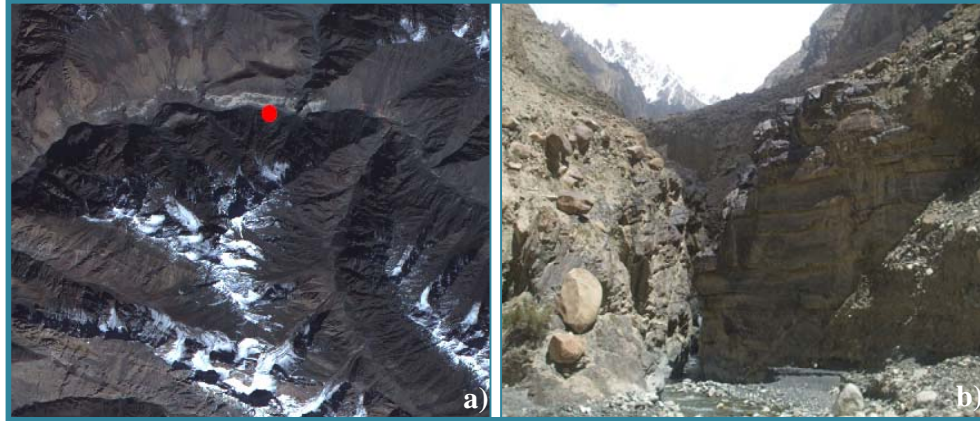


Figure 11: Digital photograph of (a) Confluence point between Khunjerab and Gujerab nullah (b) snow cover in upper Khunjerab River

3 LAND COVER MAPPING

3.1 Object Based Image Analysis

A Satellite sensor records electromagnetic radiations coming from the reflections of different ground features in the form of digital numbers. Each feature on earth has a specific uniqueness with respect to a brightness value.

Classification is the process of assigning pixels of a continuous raster image to predefined classes [6]. For the land cover mapping, different conventional classification techniques (unsupervised classification, supervised classification, hybrid classification etc.) are being used by the GIS professionals. In this study advanced and the most recent classification technique i.e. Object Based Classification was applied on the satellite images. In conventional classification techniques, a specific class is assigned to a particular group of pixels on the basis of spectral reflectance values. These techniques do not cater to shape, pattern, texture and other visual image interpretation elements. Whereas in Object Based Image Analysis (OBIA), classes are defined by using spectral values as well as image interpretation elements [9]. Following figure describes the fundamental steps of OBIA.

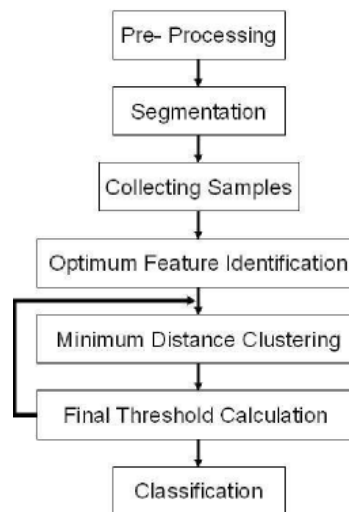


Figure 12: The Procedure for Object-based Classification

On the segmented layer, different training samples were collected by using ground truth data, objects shape, reflectance values and visual image interpretation elements. On the basis of these samples, a pre-classification was performed which was refined to get the final classified layers.

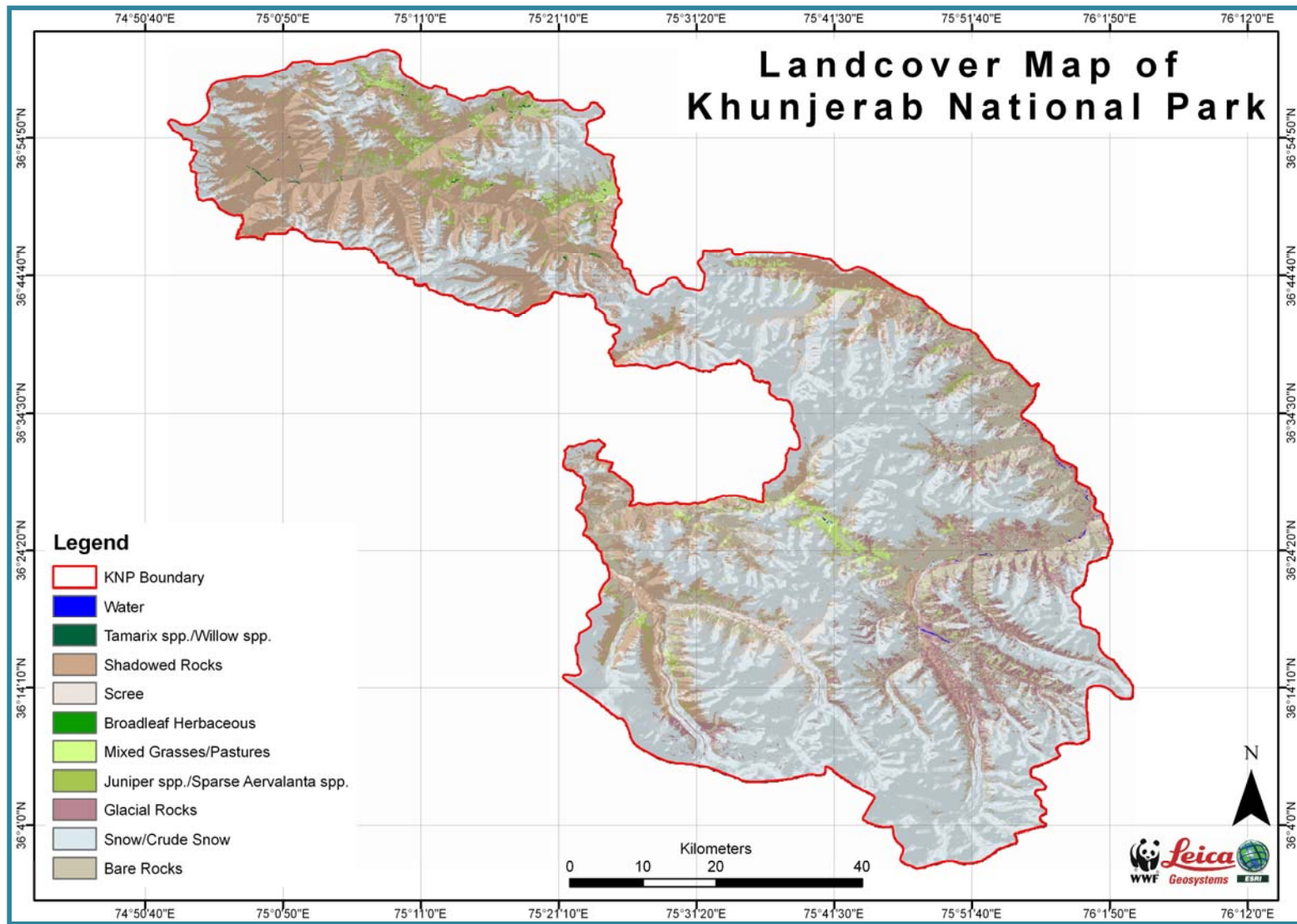


Figure 13: Landcover Map of Khunjerab National Park

Table 2: Area coverage of the land cover/land use classes

Class Names	Area (ha)
Snow/Crude Snow	2,35,355
Bare Rocks	54,632
Glacial Rocks	16,275
Water	242
Shadowed Rocks	99,851
Scree	22,915
<i>Juniper</i> spp./ <i>Sparse Aervalanta</i> spp.	8,198
Mixed Grasses/Pastures	7,769
Broadleaved Herbaceous Vegetation	51
<i>Tamarix</i> spp./ <i>Willow</i> spp.	219

Figure 14 shows the percentage cover of each class present in the National Park. The Park is composed of rugged bare rocks and more than 50% of the area is covered by snow.

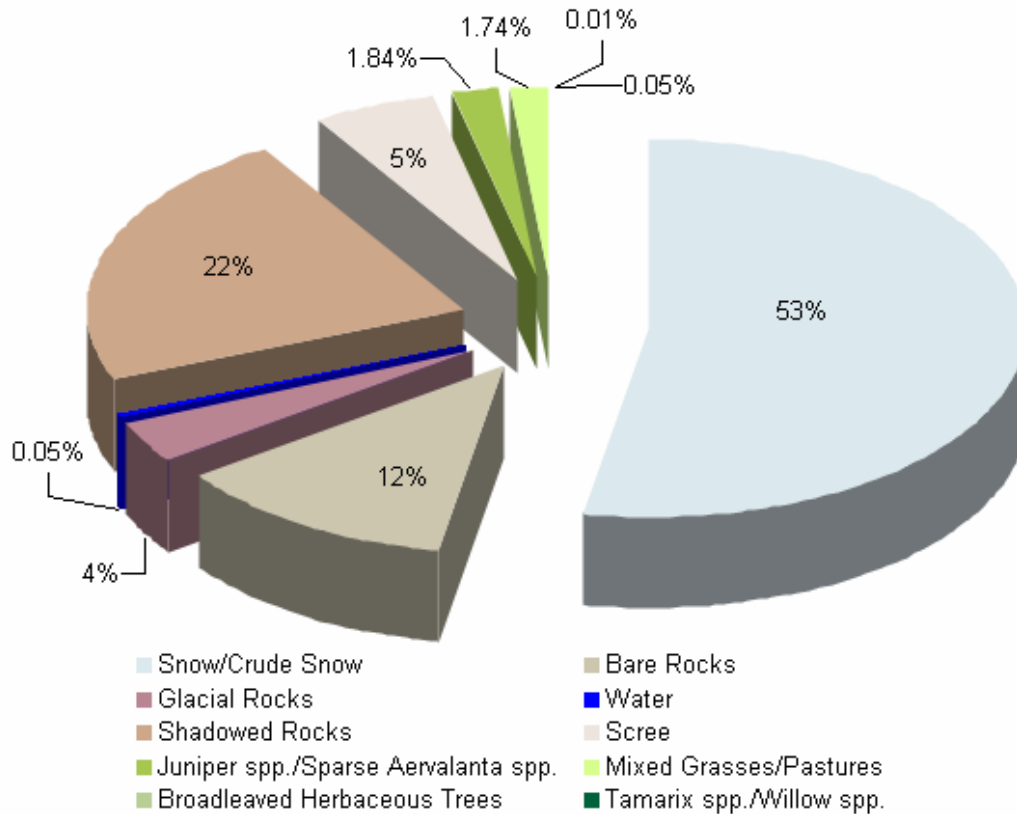


Figure 14: Percentage cover of each land cover class

3.2 Description of land cover classes

KNP consists of rugged high mountains of bare rocks. Twelve major output land cover/land use classes were defined on the bases of ground truthing, field observation points and satellite image interpretation.

Snow

KNP lies at an altitude from 3,200 m to 6,000 m and mostly consists of glaciers. Snow was classified in two major classes i.e. fresh and crud. Crud snow represents the heavy wet lumpy snow. Snow cover under the shadow of the certain high cliffs was classified as shadowed snow. However, the area of snow cover depends on the season at the time of acquisition of satellite imagery. These snow classes were merged to get a single output class covering an area of about 235,355 ha (52.83%).

Bare Rocks/Bare Soil

The area consists of large rugged bare rocks. There is variety of sedimentary, metamorphic and igneous rocks in the area. Soil is generally shallow and immature containing small fragments of rocky material, drifted sand and clay [3]. This class covers an area of 54,632 ha (12%).

Moraines/Glacial Rocks

Possibly due to the global climate change, continuous melting of glaciers is taking place leaving behind the rocks underneath. These rocks are classified as moraines/glacial rocks. This particular class covers about 16,275 ha (3.6%).

Water

Khunjerab, Gujerab and Shimshal rivers flow westwards and drain into the Hunza River. Most of the nullahs are seasonal and dependent on the density of melting of glaciers. There are small glacial lakes near the Shimshal meadows named as Shimshal Pamir lakes. This landcover class covers an area of about 242 ha (0.05%).

Shadowed Rocks

This is a class identified due to no reflectance from certain steep parts of the valley. Shadowed rocks are the Northern and North Western aspect of the high rocky hills. This class covers an area of about 99,851 ha (22%) of the total area of the Park.

Scree

Scree is a general term given to tiny small pebbles (broken rocks) present mostly in the gentle slope areas. It was clearly identified as a separate land cover class due to high reflectance values as compared to the bare rocks. This particular class covers an area of about 22,915 ha (5.41%).

Junipers spp. /Sparse Aervalanta

Junipers are evergreen shrubs and trees having needle-like leaves. Junipers varies in height from 5-10 m and mostly present in sparse condition at an altitude of about 3000 to 3500 m. *Aervalanta* spp. are the small shrubs present in sparse condition with the *Juniper* spp. This forest class covers an area of about 8,198 ha (1.84%).

Mixed Grasses/Meadows

Mixed grasses/meadows are being used by the communities for grazing purposes. In winter, these pastures are completely covered by the snow whereas in summer this area transforms in lush green biomass patches. This specific class covers about 7,769 ha (1.74%) of the total area of the Park.

Broad Leaved Herbaceous Vegetation

This class comprises of Popular spp., Apricot and Sea-buckthorn. Popular trees are tall trees mostly present at the low altitude area of KNP. Dense patches of Popular have been classified near the Shimshal and Soqhterabad villages. Apricot trees are generally present closer to the water channels.

Sea-buckthorn is a deciduous shrub ranging from 0.5–8 m in height. As these classes are mostly present in mixed form, these were merged to form a single class named as “Broad leaved herbaceous vegetation”. Such type of vegetation is mostly present on the south facing mountains as it demand full sunlight for good growth. This mixed class covers an area of 51 ha (0.01%) of the Park.

***Tamarix* spp. /*Willow* spp.**

Tamarix spp. mostly present in mixed form with *Willow* spp. near the water channels. This class covers an area of about 219 ha (0.05%).

3.3 Aspect Variation and elevation ranges

The elevation of the mountains of KNP varies from the Pamirchi bridge to the Khunjerab Park and then to the Yazghil Sar peak. The different aspects of the area are shown in figure 15 representing the aspects of the cliffs towards different angle. Moreover, vegetation cover varies with different aspects depending upon the sunlight and other biological factors.

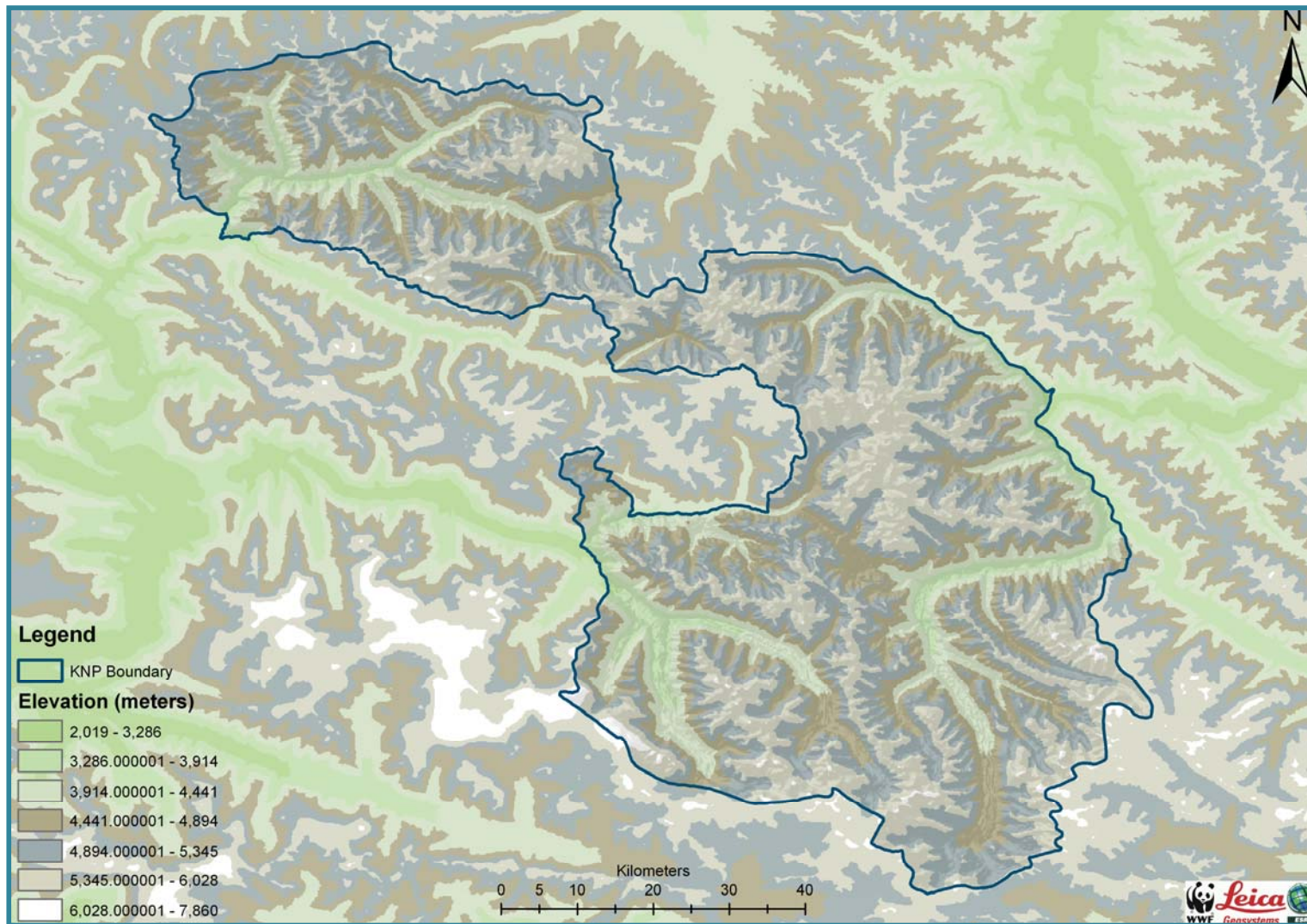


Figure 15: Aspects of KNP

4 DISTRIBUTION AND HABITAT MAPPING OF KEY FAUNA SPECIES

Zoogeographical aspect of KNP is pretty interesting. The great Himalayas form a boundary between the two major zoogeographical regions in the world namely; the Palearctic region and the Oriental region. But in the north-east, due to the geographical features, it is difficult to clearly define a boundary between the two regions. Similar is the case with the north-west where KNP is located in the Karakoram mountain ranges. Hence, these areas represent a transitional zone between the two regions and show a mixing of different animal species from Palearctic and Oriental regions [10].

The area under present KNP was known for several large mammals such as Marco Polo sheep, Blue sheep, Himalayan Ibex, Tibetan wild ass, Brown bear, Snow leopard, Indian wolf etc. However, it was primarily because of the drastic fall in the numbers of Marco Polo sheep that the American wildlife Biologist, Dr. George B. Schaller recommended that this area be made a National Park. Hence, on 29th April 1975, Khunjerab was declared a National Park by the Government of the Northern Areas under the directives of the late Prime Minister, Zulfikar Ali Bhutto.

Khunjerab National Park (KNP) lies in the permanent snow fields, alpine and sub-alpine scrub eco-zones [11]. In the permanent snow fields and cold deserts, as in the northern most regions, the vegetation is often xerophytic characterized by *Salix denticulate*, *Juniperus communis*, *Mertensia tibetica* and *Potentilla desertorum*. At Khunjerab top, Wologh Dor and Shetan Jerab, during summer season, different species of grasses attract a number of primary consumers like Himalayan Ibex, Marco Polo sheep, and Cape hare etc. Golden Marmots which hibernate during winter are frequently seen during summer season. All these primary consumers in turn attract the predators such as Snow Leopard and Indian wolf. Among birds, Snow Partridge and Snow cock also reach these heights to feed on soft grasses. These birds are attractive for raptors like Golden Eagle, and Eurasian Sparrow Hawk. Soft leaves, buds, flowers and the seeds attract a variety of insects, which in turn attract the birds like Wagtails and Redstarts.

Alpine zone where mountains extend above coniferous tree line is characterized with species like *Artemisia martina*, *Juniperus excelsa*, *Rosa webbiana* and *Polygonum sp* and moist alpine pastures with species like *Primula macrophylla*, *Potentilla desertorum*, *Gentiana sp*, *Anemone sp*, *Polygonum spp*, *Sedum sp*, *Plantago sp*, *Saxifraga sibirica*, *Poa bulbosa* and *Poa sinaica*. Such habitats in KNP are the home for Brown bear, Snow leopard and Himalayan ibex. Brown bear feeds on vegetation, roots and ground insects. It also feeds on Marmots and some times even digs them out of their burrows. Tibetan Red fox, Indian wolf and Weasels are also found feeding on rodents. Himalayan ibex, Cape hare and Pikas can easily be seen here. During warmer summer days, these areas become rich in insect fauna. Resultantly, insectivorous bird species arrive here for feeding as well as for nesting. Chukar partridge, Snow pigeon, Red billed chough, Yellow billed chough, Common Swift, Wagtails, Horned larks,

Wheatears, finches etc. forage and breed in these areas. Golden eagles, Sparrow hawks and Lammergeyers are also found here.

Sub alpine scrub and birch forests that exist along stream beds, and ravines consist mainly of *Salix* spp; *Betula utilis*, *Myricaria germanica*, *Hippophae rhamnoides* and *Poa bulbosa* and *Poa sinaica* among grass species. This type of habitat supports different rodents like field mouse, golden marmot and migratory hamster; Lagomorphs like Cape hare and Karakoram pika and also the Tibetan Red Fox. These plant species are also attractive for various birds like Pipits, Wheatears, Wagtails, Finches, Redstarts, Chiffchaffs, Doves, Choughs, and Thrushes.

In KNP there are 24 recorded mammal species and more than 80 recorded bird species including both migratory and resident while only 3 species of reptiles have been recorded so far [10, 11 & 12].

Wildlife survey reports and sighting data was obtained from the different sources. Geographical coordinates of the distribution of wildlife species were extracted from the reports, entered into MS Excel for further processing. These geographic points helped in delineating the areas within the Park where the species were observed. Most of the sighting points collected were in the geographical coordinates of Degrees Minutes Seconds (DMS) format, which were converted into Degrees Decimals (DD) using MS Excel. This geo-coded vantage point datasets were retrieved in the Arc-View GIS as event theme for displaying species existence to map their distribution. Relevant attributed information of wildlife species were added in the attribute tables.

Each wild animal has specific habitat requirements, and the possible distribution and numbers of any species of wild animal are limited in any given area by the quality and quantity of available habitat. For wildlife management, the ability to model spatial distribution and changes in distribution of wildlife is of considerable importance. Once spatial distribution can be adequately modeled, the distribution and abundance can be monitored efficiently over time, and future changes can be predicted.

4.1 Mammals Distribution Mapping

There are no concise and comprehensive data/maps available on the spatial distribution of the mammals within KNP. Nonetheless, there are a number of wildlife ecologists and biologists who have studied and surveyed KNP with more or less account of the spatial distribution.

The data for mapping the spatial information of small and large mammal species, out of the recorded mammals, were obtained from different data sources namely:

- “Baseline Studies on The Small Mammals of Khunjerab National Park, Northern Areas, Pakistan”. By Muhammad Rafique. (2006).
- “A Baseline Study of Khunjerab National Park, Pakistan” by Khan, W.A. (2006).
- “The Mammals of Pakistan” by Roberts, T.J. (1997).

The geo-coded sighting point datasets were retrieved in the Arc-View GIS as event theme for displaying species existence to map their distribution (Figure 16 Figure 17).

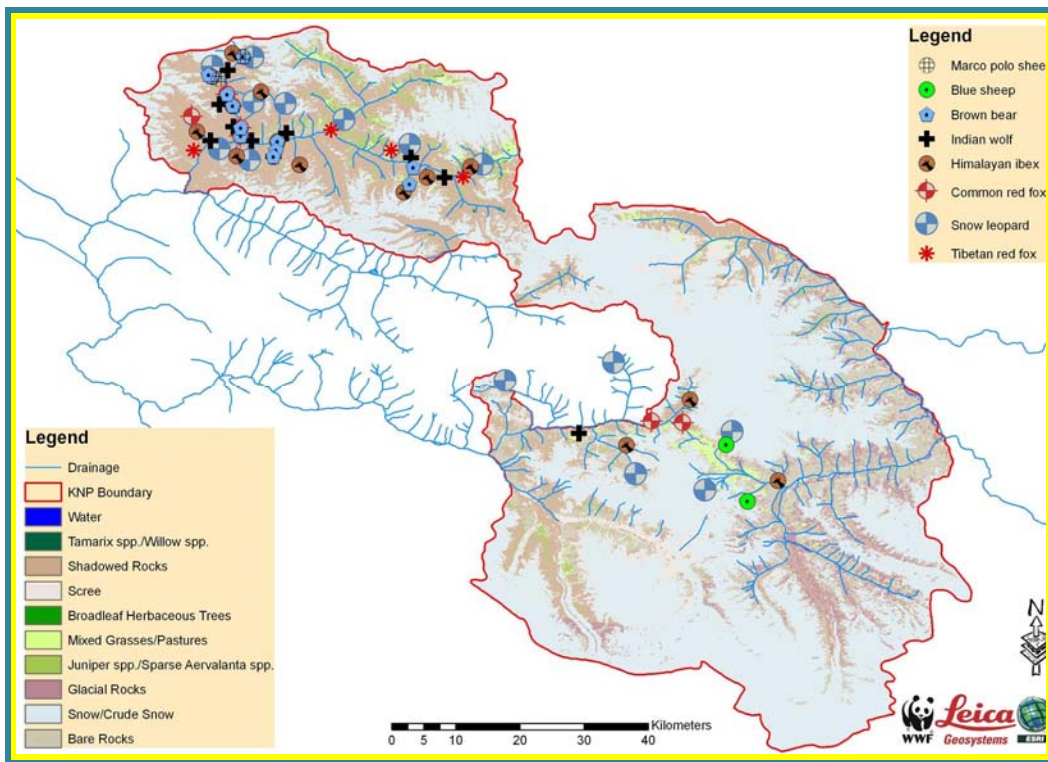


Figure 16: Large mammals distribution in KNP

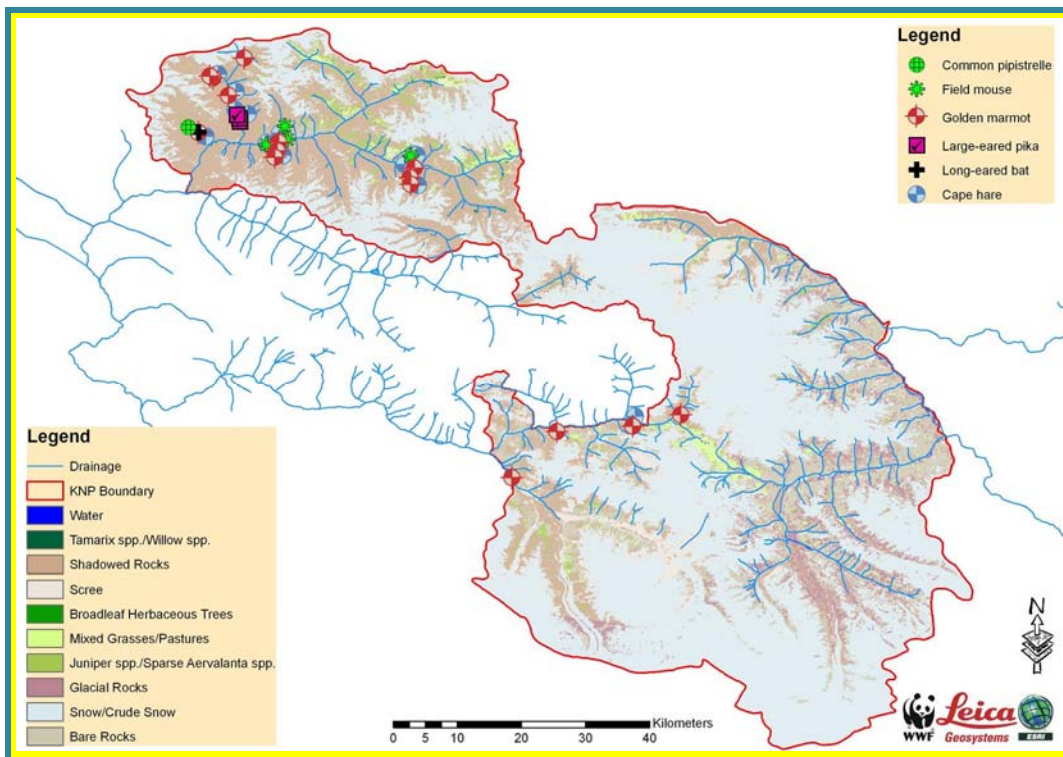


Figure 17: Small mammals distribution in KNP

4.2 Reptiles Mapping

There are only 3 species of reptiles recorded so far from Khunjerab National Park. The data for mapping the spatial information of these reptile species was obtained from different data sources namely:

- “A Baseline Study of Khunjerab National Park, Pakistan” by Khan, W.A. (2006).
- “Amphibians and Reptiles of Pakistan” by Khan, M.S. (2006).

Figure 18 represents the spatial distribution of the known reptiles within Khunjerab National Park.

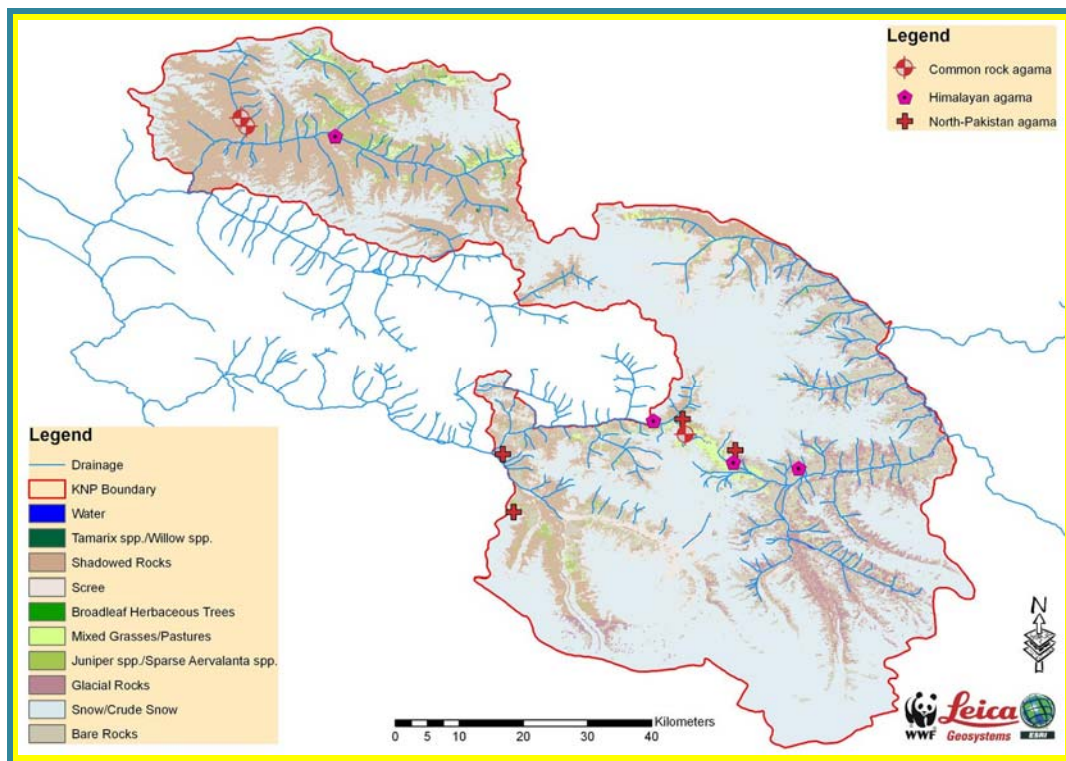


Figure 18: Reptiles distribution within KNP

5 BOUNDARY DELINEATION

KNP was declared as National Park under the section 5 of the Northern Area Wildlife Preservation Act, 1975. Later on 22nd November, 2005, it was re-notified with its changed boundaries with an increased area from 187 sq. kilometers to 5,544 sq. kilometers under notification No. F&A-8(4)/F/2001.

After that, Shimshal and Soqhterabad were notified as Community Controlled Hunting Areas (CCHAs) in November, 2006 under section 22 of Northern Areas Wildlife Act, 1975. Some of the area of the National Park was notified as CCHA. So there is certain overlap regions between National Park boundary and CCHAs boundaries.

5.1 Area Specific Committee (ASC) meetings

For the accurate boundary delineation of KNP, an Area Specific Committee (ASC) was formulated which comprised of following members;

- Mr. Babar Khan, Head Northern Areas, WWF – Pakistan
- Mr. Ghulam Muhammad, Divisional Forest Officer (Wildlife Division) Northern Areas Forest & Wildlife department, Sonikot, Gilgit
- Mr. Ghulam Murtaza, Revenue Officer/Executive Magistrate Sost Gujal, Hunza
- Mr. Muhammad Ismail Zafar, Director Khunjerab National Park, Jutial, Gilgit

In the first ASC meeting, it was highlighted that there are certain problems regarding interpretation of government notification (November, 2006) into GIS based maps. The draft boundary doesn't clearly translate the CCHAs notifications and some of the areas have been included into the KNP extent. The absence of boundary pillars is the leading to confusion about the common boundary of KNP and CCHAs.

To resolve the issue, meetings with the members of CCHAs were arranged in Shimshal and Sost for Shimshal CCHA and Soqhterabad CCHA respectively.

The draft boundary of Shimshal CCHA was marked on the maps through participatory GIS. Discussions with the community representatives helped to mark the CCHA boundary on the maps. Ridge lines and water channels were taken as reference landmarks for the boundary of the CCHAs and the National Park.

5.2 GIS based boundary of KNP

GPS field observations of boundary references were overlaid on the Terra (ASTER) satellite image, DEM, TIN, landcover maps, habitat map and bio-physical GIS layers. These layers were used as a base layer for the boundary delineation of KNP. GPS data significantly helped to delineate the boundary by using ArcGIS 9.0[®]. The boundary was delineated in Geographic Projection

System. To calculate the area of the National Park, GIS layer was re-projected in Zone 43 of Universal Transverse Mercator (UTM) Projection with Spheroid and Datum as WGS 84.

The proposed boundary of the Park covers an area of about 4, 45,506 ha (approx. 4,455.06 km²).

For better understanding of the Park boundary, it was classified into various sections (Figure 19) as discussed below:

International Boundary

Northern side of the KNP is international boundary line between Pakistan and China, which shares about 234 km border line with KNP.

Administrative Boundary

Eastern boundary of the Park is the district boundary between Gilgit and Baltistan that covers about 74 km boundary line.

Ridge Lines

Most of the part of the boundary of KNP follows the ridge lines passing through different peaks and passes. These include Shopdin Pass, Yazghil Sar, Yakshin Sar, Kanjut Sar, Kailas Peak and Khunjerab Pass etc. The ridge lines are taken as solid boundary references as there are certain issues of the community controlled hunting areas with the National Park boundary.

Water Channels

Primary water channels and nullahs are taken as boundary references at certain places. These water channels includes Khunjerab River, Gujerab River, Pamir - e - Tang nullah, Chupchingal nullah, Virjerab nullah, Ghidim nullah and other seasonal water channels.

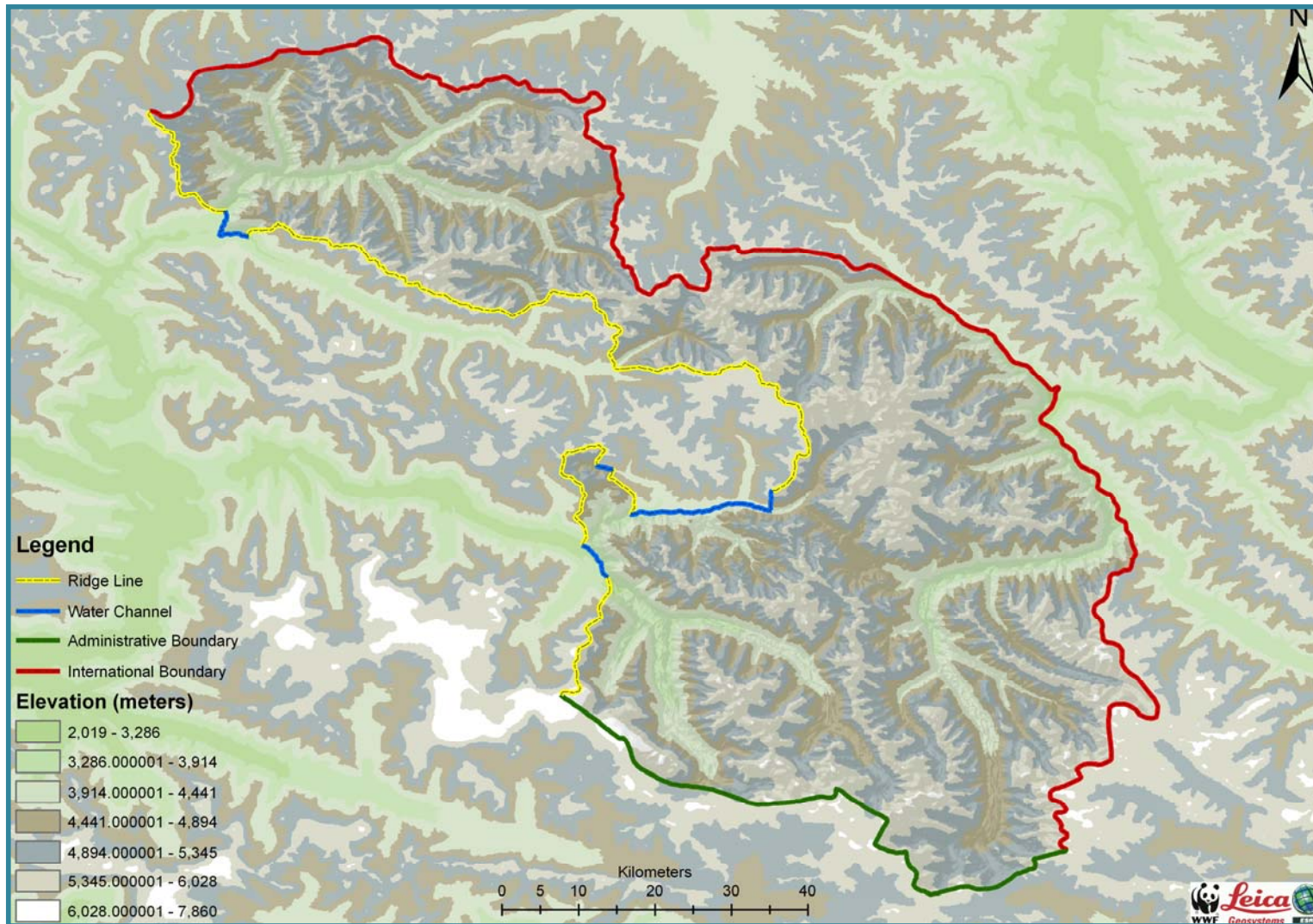


Figure 19: KNP boundary classification according to the boundary references

5.3 Formulation of Notification Format

The old notification of Khunjerab National Park contains vague references with limited details. On the basis of delineated boundary, a notification was developed. The proposed notification format has three parts;

- Textual description
- A comprehensive GIS based map
- List of the coordinate along the boundary

The proposed notification format of KNP is shown below;

GOVERNMENT OF PAKISTAN CHIEF SECRETARY NORTHERN AREAS GILGIT

Dated: 25-01-2010

NOTIFICATION

No. F&A-8 (4)/F/2001

In exercise of the powers conferred under section 22 of Northern Areas Wildlife preservation Act 1975, read with the section 1(2) (b) (iii), 28((1) & (2) and 80(1) (b) of Pakistan forest act 1927, the provincial government for the Northern Area is pleased to re-notify the Khunjerab National Park with its changed boundary specified in the schedule given below with immediate effect.

SCHEDULE

- | | |
|-----------------------|--|
| 1) District(s) | : Gilgit |
| 2) Tehsil(s) | : Hunza Sub-division |
| 3) Locality | : Khunjerab National Park (Khunjerab River, Pamirchi Bridge, Gujerab River, Pamir - e - Tang nullah, Shopdin Pass, Yazghil Sar, Yakshin Sar, Kanjut Sar, Kailas Peak and Khunjerab Pass) |
| 4) Area | : 4, 45,506 hectares (approx. 4,455.06 km ²) |
| 5) Coordinates | : 74° 52' 33.21"E, 36° 56' 11.63"N to 76° 03' 26.96" E, 36° 13' 24.24" N. |

BOUNDARIES

The boundary of the Khunjerab National Park follows the following references in all the directions.

North:

Northern side of the Khunjerab National Park follows the Pak – China border starting from the grid reference point N1/W24 (74° 52' 33.20"E, 36° 56' 11.65"N) to grid reference point E1/N6 (75° 31' 52.50"E, 36° 46' 30.04"N) {Grid reference points between N1/W24 and E1/N6 are; N2 (75° 09' 01.94"E, 37° 01' 11.03"N), N3 (75° 14' 07.62"E, 36° 57' 34.96"N), N4 (75° 23' 49.70"E, 36° 57' 25.34"N) and N5 (75° 27' 30.71"E, 36° 43' 20.50"N)}.

East:

Eastern side of the boundary starts from grid reference points E1/N6 (75° 31' 52.50"E, 36° 46' 30.04"N). From E1/N6 boundary follows the Pak - China border up to grid reference point E3/S1 (75° 57' 04.75"E, 36° 04' 05.41"N) {E2 (75° 56' 33.04"E, 36° 36' 38.34"N) is between the grid reference point E1/N6 and E3/S1.

South:

Southern boundary of Khunjerab National Park starts from the grid reference point E3/S1 (75° 57' 04.75"E, 36° 04' 05.41"N) and follows the common administrative boundary of Gilgit and Baltistan districts up to grid reference point W1/S4 (75° 21' 28.58"E, 36° 14' 54.82"N) at the Yakshin Sar (7,583 m) {Grid reference points between E3/S1 and W1/S4 are: S2 (75° 49' 44.76"E, 36° 01' 21.04"N) at Kailas Peak and S3 (75° 25' 01.67"E, 36° 12' 17.64"N) at Kanjut Sar.

West:

The western boundary of Khunjerab National Park starts from the grid reference point W1/S4 (75° 21' 28.58"E, 36° 14' 54.82"N) at the Yakshin Sar. From W1/S4, the boundary follows a ridge line in northern direction to the grid reference point W2 (75° 24' 09.09" E, 36° 21' 04.05" N) at Yazghil Sar. From W2, the boundary dips northward into Virjerab Nullah at W3 (75° 24' 45.62"E, 36° 23' 11.84" N). From W3, the boundary follows Virjerab Nullah and moves in north-west direction up to grid reference point W4 (75° 22' 58.07"E, 36° 25' 32.75" N). From this point boundary moves along the ridge line and reaches at grid reference point W5 (75° 22' 26.83" E, 36° 27' 26.42" N) at Putput Peak. The boundary further follows ridgeline in northern direction and crosses Zardgarbin Pass and reaches at grid reference point W6 (75° 21' 38.01" E, 36° 31' 10.42" N) at Shopdin Pass. Boundary further extends on the ridgeline in eastern direction up to grid reference point W7 (75° 24' 33.18" E, 36° 32' 11.89"N) tracing the elevation of 5,683 m and 5,728 m.

From W7 to W8 (75° 24' 01.02" E, 36° 31' 05.34" N), the boundary moves in south-west direction along the water channel (which is primary water channel of Pamir - e - Tang nullah). From grid reference point W8 to W9 (75° 25' 09.37" E, 36° 30' 49.87" N) the boundary further moves eastward and follows a water channel which is one of the primary water channel for the Pamir - e - Tang nullah.

From W9 boundary moves along the ridgeline including grid reference points W10 (75° 24' 52.18" E, 36° 30' 13.27" N) and W11 (75° 25' 45.21" E, 36° 29' 42.49" N). From W11 to W12 (75° 26' 23.55" E, 36° 27' 37.96" N), the boundary moves southwards following a water channel (Pass). Grid reference point W12 (75° 26' 23.55" E, 36° 27' 37.96" N) to W13 (75° 36' 16.35" E, 36° 27' 56.93" N) the boundary moves along the Pamir-e-Tang Nullah and follows a primary water channel of Pamir-e-Tang northwards up to the grid reference point W14 (75° 36' 18.02" E, 36° 29' 19.45" N). From the grid reference point W14 to W15 (75° 38' 12.87" E, 36° 35' 19.36" N), National Park's boundary moves along the ridge line on sub – watershed of Shujerab Nullah including the Shujerab glacier. From grid reference point W15 to W16 (75° 34' 27.54" E, 36° 38' 26.26" N) the boundary of the Park follows a ridgeline of Gujerab mountains (Historic Pak – China Border). From W16 the boundary moves in westward direction following the ridge line up to W17 (75° 25' 21.59" E, 36° 38' 00.15" N) at Ghidim Nullah. From W16 to W17,

boundary passes through the elevations of 6063 m, 5805 m, 5857 m and 5443 m. From W17 the boundary crosses the Ghidim Nullah in northern direction and reaches at W18 (75° 25' 35.07"E, 36° 40' 51.23" N) which is at the western watershed boundary of Ghidim Nullah. The boundary further passes through the elevations at 5,918 m and 4,925 m in north-western direction up to grid reference point W19 (75° 23' 11.35" E, 36° 43' 21.16" N). From grid reference point W19 to W20 (75° 17' 57.82" E, 36° 41' 42.62" N), the boundary moves along the ridge line in south-western direction which is the northern watershed boundary of Chupchingal nullah.

From W20 to W21 (74° 59' 21.58" E, 36° 47' 20.17" N), the boundary further moves westwards along the ridge line which is also northern watershed boundary of Gujerab river. From W21, the boundary moves along the Gujerab river in the western direction and reaches at the grid reference point W22 (74° 57' 22.46" E, 36° 47' 27.59" N) which is at the confluence of Khunjerab and Gujerab rivers. Boundary further extends northward along the Khunjerab river upto grid reference point W23 (74° 57' 47.61" E, 36° 49' 07.51" N) at Pamirchi Bridge. From W23, the boundary moves along the ridge line (which is the southern watershed boundary of Dhee nullah) up to grid reference point N1/W24 (74° 52' 33.21" E, 36° 56' 11.63" N) at Pak-China border. Elevations 5838 m, 5736 m, 5810 m, 5442 m, 5643 m exists between W23 and N1/W24.

REFERENCE

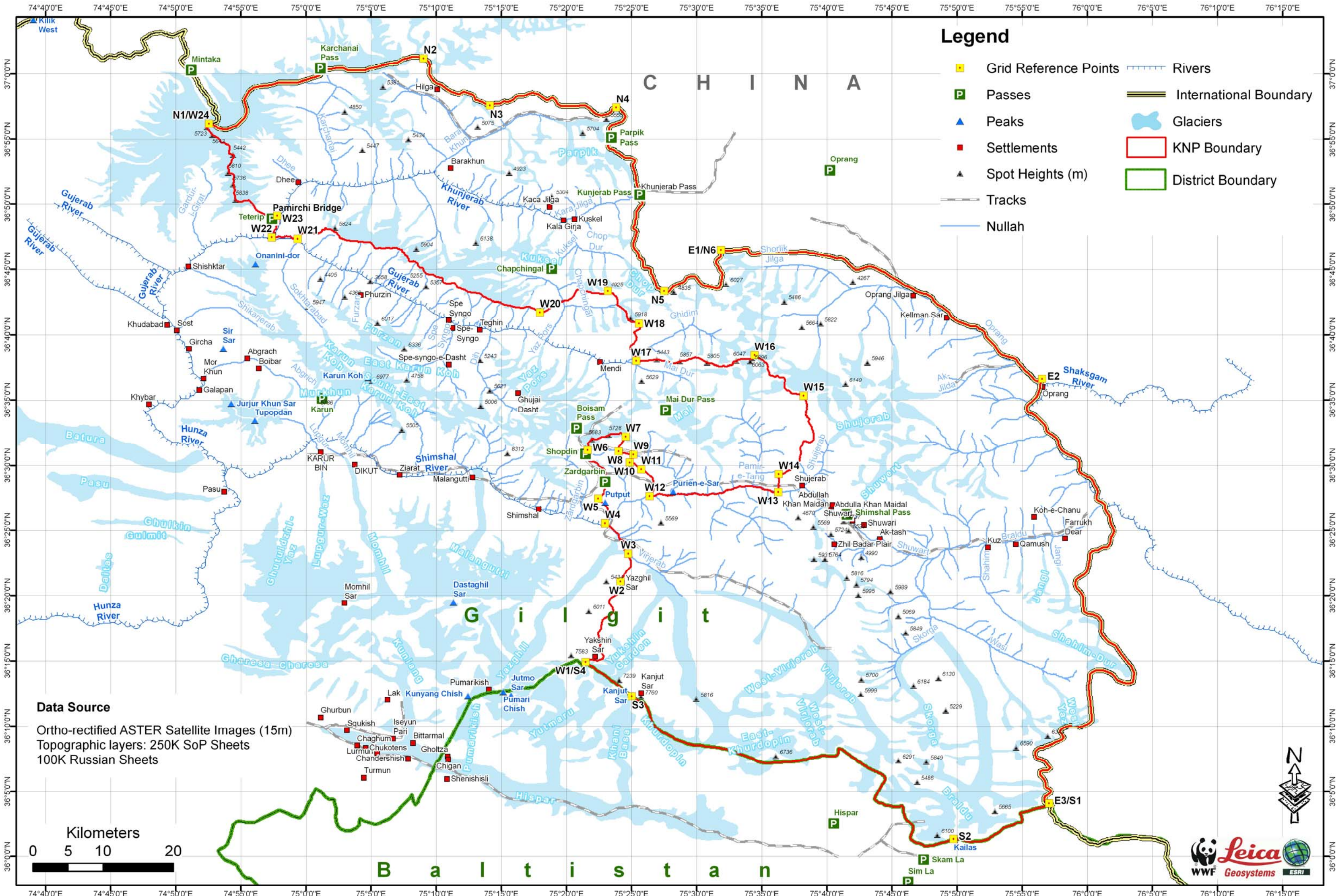
Geo-Rectified ASTER (15 m) Satellite Image
1: 2,50,000 Survey of Pakistan Maps
1: 1,00,000 Russian Maps
Projection: Geographic Coordinate System
Spheroid & Datum: World Geodetic System (WGS) 84
(Single frequency GPS receiver was used for the field data collection)

(Authority)

Chief Secretary, Northern Areas

A copy is forwarded to the:-

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GIS Map of Khunjerab National Park Boundary with Grid Reference Points

List of selected boundary coordinates

S. No	Longitude (E)	Latitude (N)	S. No	Longitude (E)	Latitude (N)
1	76° 01' 46.56"	36° 24' 29.20"	51	75° 59' 35.41"	36° 10' 00.66"
2	76° 01' 46.56"	36° 24' 29.20"	52	75° 59' 21.26"	36° 09' 58.75"
3	76° 01' 41.41"	36° 23' 59.60"	53	75° 59' 11.62"	36° 10' 03.25"
4	76° 01' 34.36"	36° 23' 45.46"	54	75° 58' 34.36"	36° 10' 03.90"
5	76° 01' 11.21"	36° 23' 42.90"	55	75° 57' 51.34"	36° 09' 41.40"
6	76° 00' 46.80"	36° 23' 29.40"	56	75° 57' 51.34"	36° 09' 36.25"
7	76° 00' 25.60"	36° 23' 27.46"	57	75° 58' 08.04"	36° 09' 09.94"
8	76° 00' 19.84"	36° 23' 24.90"	58	75° 58' 03.54"	36° 09' 02.84"
9	76° 00' 12.74"	36° 23' 16.55"	59	75° 56' 59.28"	36° 08' 32.03"
10	76° 00' 09.86"	36° 22' 50.20"	60	75° 56' 13.67"	36° 08' 18.53"
11	75° 59' 58.96"	36° 21' 59.44"	61	75° 56' 04.02"	36° 08' 12.08"
12	75° 59' 42.86"	36° 21' 38.23"	62	75° 55' 58.91"	36° 08' 03.73"
13	75° 59' 23.60"	36° 21' 28.62"	63	75° 56' 00.17"	36° 07' 40.62"
14	75° 59' 10.10"	36° 21' 17.68"	64	75° 56' 04.02"	36° 07' 35.47"
15	75° 59' 06.25"	36° 21' 11.92"	65	75° 56' 42.58"	36° 07' 20.06"
16	75° 59' 02.40"	36° 20' 52.01"	66	75° 57' 03.78"	36° 06' 56.30"
17	75° 59' 10.10"	36° 20' 34.01"	67	75° 57' 06.37"	36° 06' 49.86"
18	75° 59' 28.10"	36° 20' 17.30"	68	75° 56' 57.37"	36° 06' 40.21"
19	75° 59' 39.01"	36° 19' 56.10"	69	75° 56' 25.87"	36° 06' 37.01"
20	75° 59' 38.08"	36° 19' 20.75"	70	75° 56' 19.46"	36° 06' 25.45"
21	75° 59' 42.32"	36° 18' 50.22"	71	75° 56' 20.72"	36° 06' 16.45"
22	76° 00' 00.11"	36° 18' 37.76"	72	75° 56' 38.08"	36° 06' 00.40"
23	76° 00' 24.52"	36° 18' 33.91"	73	75° 56' 46.43"	36° 05' 43.04"
24	76° 00' 48.92"	36° 18' 23.65"	74	75° 56' 44.20"	36° 05' 26.99"
25	76° 01' 03.07"	36° 18' 03.10"	75	75° 57' 07.96"	36° 05' 08.99"
26	76° 01' 03.07"	36° 17' 30.95"	76	75° 57' 07.96"	36° 04' 54.88"
27	76° 01' 00.48"	36° 17' 19.39"	77	75° 56' 45.49"	36° 04' 40.73"
28	76° 01' 05.63"	36° 17' 03.98"	78	75° 56' 40.34"	36° 04' 31.73"
29	76° 01' 18.48"	36° 16' 44.69"	79	75° 56' 43.55"	36° 04' 20.82"
30	76° 01' 39.04"	36° 16' 26.72"	80	75° 56' 54.46"	36° 04' 10.52"
31	76° 02' 06.04"	36° 16' 11.28"	81	75° 57' 04.75"	36° 04' 05.41"
32	76° 03' 20.56"	36° 14' 37.50"	82	75° 57' 04.61"	36° 03' 59.65"
33	76° 03' 33.41"	36° 14' 07.94"	83	75° 56' 56.83"	36° 03' 55.08"
34	76° 03' 32.11"	36° 13' 44.80"	84	75° 56' 36.89"	36° 03' 52.02"
35	76° 03' 26.96"	36° 13' 24.24"	85	75° 54' 54.11"	36° 03' 25.67"
36	76° 03' 12.82"	36° 13' 19.13"	86	75° 54' 48.96"	36° 03' 20.56"
37	76° 02' 43.30"	36° 13' 21.68"	87	75° 54' 58.61"	36° 02' 54.85"
38	76° 02' 16.30"	36° 13' 33.24"	88	75° 54' 55.40"	36° 02' 41.35"
39	76° 02' 00.89"	36° 13' 52.54"	89	75° 54' 29.05"	36° 02' 36.20"
40	76° 01' 46.74"	36° 14' 02.80"	90	75° 54' 04.00"	36° 02' 24.00"
41	76° 01' 28.74"	36° 14' 11.80"	91	75° 53' 37.64"	36° 02' 16.30"
42	76° 01' 10.78"	36° 14' 16.94"	92	75° 53' 10.03"	36° 01' 53.18"
43	76° 00' 38.63"	36° 14' 16.94"	93	75° 52' 21.86"	36° 01' 22.98"
44	76° 00' 20.66"	36° 14' 10.50"	94	75° 51' 40.10"	36° 01' 12.04"
45	76° 00' 09.11"	36° 13' 58.94"	95	75° 51' 04.10"	36° 01' 10.13"
46	76° 00' 05.22"	36° 13' 08.83"	96	75° 50' 48.70"	36° 01' 11.42"
47	76° 00' 06.52"	36° 12' 32.87"	97	75° 50' 16.26"	36° 01' 21.68"
48	76° 00' 15.52"	36° 11' 10.61"	98	75° 49' 44.76"	36° 01' 21.04"
49	76° 00' 16.81"	36° 10' 24.38"	99	75° 48' 04.54"	36° 00' 53.42"
50	76° 00' 10.37"	36° 10' 16.64"	100	75° 47' 39.48"	36° 00' 48.92"

101	75° 47' 32.42"	36° 00' 48.92"	151	75° 28' 20.50"	36° 09' 02.34"
102	75° 47' 07.37"	36° 01' 02.42"	152	75° 27' 07.60"	36° 09' 42.80"
103	75° 46' 44.87"	36° 01' 08.18"	153	75° 26' 50.89"	36° 09' 55.66"
104	75° 46' 30.76"	36° 01' 17.18"	154	75° 26' 36.10"	36° 10' 14.27"
105	75° 46' 22.40"	36° 01' 28.74"	155	75° 26' 27.10"	36° 10' 34.21"
106	75° 46' 33.96"	36° 01' 59.59"	156	75° 26' 25.84"	36° 10' 45.12"
107	75° 46' 34.61"	36° 02' 22.09"	157	75° 26' 09.74"	36° 11' 30.08"
108	75° 46' 30.11"	36° 02' 29.15"	158	75° 25' 50.48"	36° 11' 54.49"
109	75° 46' 05.70"	36° 02' 51.65"	159	75° 25' 33.78"	36° 11' 55.14"
110	75° 45' 56.05"	36° 03' 08.35"	160	75° 25' 23.52"	36° 12' 02.23"
111	75° 45' 50.90"	36° 03' 26.96"	161	75° 24' 06.41"	36° 13' 03.25"
112	75° 45' 48.35"	36° 03' 50.72"	162	75° 22' 02.21"	36° 14' 30.55"
113	75° 45' 44.50"	36° 03' 55.22"	163	75° 21' 45.47"	36° 14' 39.70"
114	75° 45' 31.64"	36° 03' 50.11"	164	75° 21' 28.58"	36° 14' 54.82"
115	75° 45' 02.41"	36° 03' 50.11"	165	75° 21' 35.50"	36° 15' 07.60"
116	75° 44' 56.62"	36° 03' 53.32"	166	75° 21' 47.20"	36° 15' 08.68"
117	75° 44' 32.86"	36° 03' 57.82"	167	75° 22' 23.52"	36° 15' 03.28"
118	75° 43' 56.24"	36° 04' 11.93"	168	75° 22' 45.55"	36° 15' 12.17"
119	75° 43' 38.89"	36° 04' 23.52"	169	75° 22' 49.40"	36° 15' 24.37"
120	75° 43' 36.34"	36° 04' 27.98"	170	75° 22' 32.99"	36° 15' 59.80"
121	75° 44' 27.71"	36° 05' 57.95"	171	75° 22' 33.67"	36° 16' 36.55"
122	75° 44' 27.71"	36° 06' 06.30"	172	75° 22' 26.44"	36° 16' 52.28"
123	75° 44' 24.50"	36° 06' 12.10"	173	75° 22' 24.46"	36° 17' 11.98"
124	75° 43' 57.50"	36° 06' 28.15"	174	75° 22' 38.89"	36° 17' 29.69"
125	75° 43' 40.80"	36° 06' 33.91"	175	75° 22' 42.53"	36° 18' 09.72"
126	75° 43' 22.84"	36° 06' 45.50"	176	75° 23' 14.03"	36° 18' 27.43"
127	75° 43' 07.39"	36° 06' 51.26"	177	75° 23' 31.06"	36° 18' 40.54"
128	75° 42' 32.72"	36° 07' 16.32"	178	75° 23' 32.39"	36° 19' 05.48"
129	75° 41' 53.20"	36° 07' 40.08"	179	75° 23' 14.68"	36° 19' 29.75"
130	75° 41' 17.23"	36° 08' 09.64"	180	75° 23' 13.34"	36° 19' 36.98"
131	75° 41' 03.73"	36° 08' 17.34"	181	75° 23' 28.43"	36° 19' 54.05"
132	75° 40' 52.82"	36° 08' 19.28"	182	75° 24' 14.80"	36° 20' 22.42"
133	75° 40' 50.88"	36° 08' 00.02"	183	75° 24' 16.34"	36° 20' 32.35"
134	75° 40' 45.73"	36° 07' 49.08"	184	75° 24' 09.11"	36° 21' 04.07"
135	75° 40' 35.47"	36° 07' 43.93"	185	75° 24' 12.89"	36° 21' 17.89"
136	75° 40' 12.97"	36° 07' 43.32"	186	75° 24' 33.80"	36° 21' 50.83"
137	75° 39' 53.06"	36° 07' 46.52"	187	75° 24' 54.90"	36° 22' 15.31"
138	75° 39' 33.16"	36° 07' 45.23"	188	75° 24' 54.07"	36° 22' 42.35"
139	75° 38' 38.54"	36° 07' 34.32"	189	75° 24' 49.00"	36° 22' 53.29"
140	75° 38' 22.49"	36° 07' 26.62"	190	75° 24' 45.61"	36° 23' 11.83"
141	75° 36' 09.18"	36° 07' 14.41"	191	75° 24' 26.17"	36° 23' 27.42"
142	75° 35' 15.86"	36° 07' 13.76"	192	75° 24' 21.85"	36° 23' 50.75"
143	75° 34' 37.96"	36° 07' 21.47"	193	75° 24' 17.96"	36° 23' 58.96"
144	75° 34' 00.05"	36° 07' 38.82"	194	75° 24' 18.40"	36° 24' 12.78"
145	75° 32' 11.15"	36° 08' 16.73"	195	75° 24' 05.44"	36° 24' 20.56"
146	75° 30' 58.54"	36° 08' 28.93"	196	75° 23' 58.52"	36° 24' 42.59"
147	75° 30' 41.83"	36° 08' 28.93"	197	75° 23' 26.52"	36° 25' 12.43"
148	75° 30' 20.63"	36° 08' 33.43"	198	75° 23' 02.76"	36° 25' 27.98"
149	75° 29' 51.72"	36° 08' 33.43"	199	75° 22' 58.08"	36° 25' 32.74"
150	75° 29' 12.55"	36° 08' 41.14"	200	75° 23' 13.52"	36° 26' 03.34"

201	75° 23' 12.66"	36° 26' 21.73"	251	75° 27' 05.47"	36° 27' 50.58"
202	75° 23' 06.68"	36° 26' 47.44"	252	75° 27' 44.78"	36° 27' 41.33"
203	75° 22' 26.83"	36° 27' 26.42"	253	75° 27' 50.11"	36° 27' 45.14"
204	75° 22' 35.40"	36° 27' 38.84"	254	75° 28' 06.02"	36° 27' 43.88"
205	75° 22' 52.97"	36° 27' 54.68"	255	75° 28' 08.22"	36° 27' 47.34"
206	75° 22' 55.74"	36° 28' 26.83"	256	75° 28' 33.67"	36° 27' 50.98"
207	75° 23' 01.75"	36° 28' 47.78"	257	75° 29' 10.18"	36° 27' 46.44"
208	75° 23' 09.89"	36° 29' 04.09"	258	75° 29' 49.34"	36° 27' 54.07"
209	75° 23' 08.16"	36° 29' 08.77"	259	75° 30' 10.44"	36° 27' 45.90"
210	75° 22' 57.04"	36° 29' 19.50"	260	75° 30' 27.83"	36° 27' 48.24"
211	75° 22' 54.44"	36° 29' 44.34"	261	75° 30' 33.80"	36° 27' 45.25"
212	75° 22' 35.18"	36° 29' 54.20"	262	75° 30' 42.26"	36° 27' 47.05"
213	75° 22' 22.76"	36° 30' 04.90"	263	75° 30' 47.84"	36° 27' 44.06"
214	75° 22' 15.92"	36° 30' 15.59"	264	75° 31' 13.76"	36° 27' 52.27"
215	75° 21' 41.00"	36° 30' 24.16"	265	75° 31' 24.82"	36° 27' 47.99"
216	75° 21' 29.45"	36° 30' 34.45"	266	75° 31' 31.80"	36° 27' 52.09"
217	75° 21' 31.14"	36° 30' 55.87"	267	75° 31' 36.37"	36° 27' 50.98"
218	75° 21' 38.02"	36° 31' 10.42"	268	75° 31' 54.34"	36° 27' 53.32"
219	75° 21' 39.71"	36° 31' 36.12"	269	75° 32' 17.34"	36° 28' 06.96"
220	75° 21' 35.50"	36° 31' 43.21"	270	75° 32' 36.46"	36° 28' 07.46"
221	75° 21' 46.30"	36° 31' 50.48"	271	75° 32' 48.05"	36° 28' 15.17"
222	75° 21' 55.19"	36° 32' 02.47"	272	75° 33' 19.12"	36° 28' 24.96"
223	75° 22' 17.80"	36° 32' 02.11"	273	75° 33' 32.69"	36° 28' 22.12"
224	75° 22' 36.30"	36° 32' 10.32"	274	75° 33' 47.05"	36° 28' 25.10"
225	75° 23' 01.64"	36° 32' 13.74"	275	75° 34' 16.75"	36° 28' 24.53"
226	75° 23' 23.21"	36° 32' 26.09"	276	75° 34' 43.46"	36° 28' 20.71"
227	75° 23' 53.02"	36° 32' 25.40"	277	75° 34' 57.18"	36° 28' 17.40"
228	75° 24' 05.33"	36° 32' 33.04"	278	75° 35' 01.21"	36° 28' 12.47"
229	75° 24' 33.19"	36° 32' 11.90"	279	75° 35' 09.06"	36° 28' 09.19"
230	75° 24' 32.58"	36° 32' 05.24"	280	75° 35' 21.70"	36° 28' 09.73"
231	75° 24' 22.32"	36° 31' 56.82"	281	75° 35' 31.92"	36° 28' 04.98"
232	75° 24' 00.00"	36° 31' 27.88"	282	75° 35' 40.34"	36° 28' 04.26"
233	75° 23' 59.42"	36° 31' 07.36"	283	75° 35' 48.91"	36° 27' 58.21"
234	75° 24' 12.67"	36° 31' 01.34"	284	75° 36' 16.34"	36° 27' 56.92"
235	75° 25' 09.37"	36° 30' 49.86"	285	75° 36' 14.54"	36° 28' 33.89"
236	75° 25' 03.94"	36° 30' 39.60"	286	75° 36' 18.18"	36° 28' 43.93"
237	75° 25' 02.75"	36° 30' 31.18"	287	75° 36' 15.62"	36° 29' 05.14"
238	75° 24' 55.73"	36° 30' 24.48"	288	75° 36' 16.92"	36° 29' 18.13"
239	75° 24' 52.20"	36° 30' 13.28"	289	75° 36' 24.95"	36° 29' 23.24"
240	75° 25' 15.78"	36° 30' 08.03"	290	75° 36' 37.26"	36° 29' 22.78"
241	75° 25' 45.23"	36° 29' 42.50"	291	75° 37' 11.71"	36° 29' 42.11"
242	75° 26' 07.26"	36° 29' 30.26"	292	75° 37' 25.25"	36° 29' 52.51"
243	75° 26' 35.02"	36° 29' 04.31"	293	75° 37' 31.15"	36° 30' 03.24"
244	75° 26' 38.04"	36° 28' 47.42"	294	75° 37' 52.14"	36° 30' 23.08"
245	75° 26' 36.24"	36° 28' 19.70"	295	75° 37' 51.31"	36° 30' 30.42"
246	75° 26' 39.48"	36° 28' 04.58"	296	75° 37' 58.37"	36° 30' 56.05"
247	75° 26' 39.52"	36° 28' 04.58"	297	75° 37' 55.52"	36° 31' 22.26"
248	75° 26' 27.96"	36° 27' 52.99"	298	75° 38' 11.62"	36° 31' 53.26"
249	75° 26' 23.57"	36° 27' 37.94"	299	75° 38' 19.50"	36° 31' 53.26"
250	75° 26' 46.46"	36° 27' 40.46"	300	75° 38' 27.10"	36° 31' 48.76"

301	75° 38' 39.48"	36° 31' 46.78"	351	75° 30' 22.97"	36° 38' 07.51"
302	75° 38' 50.21"	36° 31' 51.85"	352	75° 29' 53.84"	36° 38' 17.56"
303	75° 38' 55.82"	36° 31' 57.47"	353	75° 29' 47.08"	36° 38' 17.09"
304	75° 38' 55.82"	36° 32' 28.46"	354	75° 29' 14.35"	36° 38' 03.59"
305	75° 38' 49.06"	36° 32' 58.63"	355	75° 28' 49.37"	36° 38' 01.82"
306	75° 38' 34.15"	36° 33' 18.61"	356	75° 28' 18.16"	36° 37' 49.37"
307	75° 38' 32.46"	36° 33' 26.24"	357	75° 27' 37.84"	36° 38' 02.08"
308	75° 38' 37.25"	36° 33' 33.55"	358	75° 27' 16.60"	36° 38' 02.58"
309	75° 38' 27.38"	36° 33' 44.28"	359	75° 26' 55.61"	36° 38' 08.59"
310	75° 38' 26.52"	36° 33' 49.07"	360	75° 25' 21.61"	36° 38' 00.13"
311	75° 38' 19.64"	36° 33' 54.25"	361	75° 25' 13.30"	36° 38' 11.87"
312	75° 38' 22.16"	36° 34' 01.02"	362	75° 25' 15.49"	36° 38' 23.57"
313	75° 38' 20.47"	36° 34' 06.67"	363	75° 25' 05.99"	36° 38' 34.94"
314	75° 38' 26.38"	36° 34' 18.52"	364	75° 24' 51.55"	36° 39' 01.76"
315	75° 38' 24.43"	36° 34' 26.69"	365	75° 24' 54.61"	36° 39' 11.09"
316	75° 38' 26.66"	36° 34' 43.57"	366	75° 25' 06.31"	36° 39' 18.72"
317	75° 38' 12.88"	36° 35' 19.36"	367	75° 25' 19.99"	36° 39' 37.73"
318	75° 38' 01.03"	36° 35' 25.84"	368	75° 25' 21.86"	36° 39' 52.16"
319	75° 37' 45.80"	36° 35' 26.95"	369	75° 25' 09.44"	36° 40' 14.05"
320	75° 37' 35.11"	36° 35' 30.91"	370	75° 25' 36.52"	36° 40' 28.81"
321	75° 37' 18.77"	36° 35' 30.62"	371	75° 25' 41.45"	36° 40' 41.99"
322	75° 37' 12.00"	36° 35' 34.30"	372	75° 25' 35.08"	36° 40' 51.24"
323	75° 37' 04.69"	36° 35' 43.87"	373	75° 25' 20.96"	36° 40' 59.92"
324	75° 36' 57.06"	36° 35' 45.96"	374	75° 24' 55.33"	36° 41' 02.90"
325	75° 36' 44.24"	36° 35' 57.12"	375	75° 24' 41.87"	36° 41' 14.10"
326	75° 36' 41.72"	36° 36' 16.27"	376	75° 24' 31.39"	36° 41' 49.99"
327	75° 36' 45.40"	36° 36' 33.48"	377	75° 24' 22.32"	36° 41' 58.96"
328	75° 36' 40.03"	36° 36' 46.98"	378	75° 23' 54.31"	36° 42' 17.82"
329	75° 36' 17.78"	36° 36' 48.42"	379	75° 23' 52.04"	36° 42' 22.50"
330	75° 36' 09.61"	36° 36' 53.75"	380	75° 23' 54.49"	36° 42' 36.14"
331	75° 36' 00.86"	36° 36' 48.67"	381	75° 23' 48.52"	36° 42' 55.94"
332	75° 35' 31.56"	36° 37' 02.21"	382	75° 23' 32.50"	36° 43' 11.28"
333	75° 35' 32.96"	36° 37' 10.67"	383	75° 23' 16.91"	36° 43' 20.14"
334	75° 35' 23.96"	36° 37' 28.70"	384	75° 23' 11.36"	36° 43' 21.18"
335	75° 35' 26.77"	36° 37' 35.72"	385	75° 23' 04.78"	36° 43' 13.19"
336	75° 35' 20.87"	36° 37' 50.95"	386	75° 22' 58.87"	36° 43' 10.42"
337	75° 35' 13.81"	36° 37' 54.62"	387	75° 22' 32.52"	36° 43' 10.06"
338	75° 34' 51.56"	36° 38' 09.56"	388	75° 22' 16.03"	36° 43' 13.01"
339	75° 34' 27.55"	36° 38' 26.27"	389	75° 22' 01.81"	36° 43' 12.32"
340	75° 34' 13.19"	36° 38' 11.15"	390	75° 21' 42.05"	36° 43' 19.27"
341	75° 33' 44.89"	36° 38' 08.81"	391	75° 21' 23.00"	36° 43' 19.96"
342	75° 33' 28.22"	36° 38' 10.39"	392	75° 20' 55.21"	36° 43' 28.92"
343	75° 33' 10.40"	36° 38' 06.11"	393	75° 20' 44.27"	36° 43' 23.45"
344	75° 32' 44.84"	36° 37' 54.48"	394	75° 20' 30.91"	36° 42' 57.35"
345	75° 32' 42.11"	36° 37' 43.64"	395	75° 20' 10.25"	36° 42' 40.93"
346	75° 32' 26.23"	36° 37' 40.55"	396	75° 19' 20.46"	36° 42' 30.60"
347	75° 32' 17.30"	36° 37' 35.51"	397	75° 19' 01.02"	36° 42' 14.22"
348	75° 31' 43.03"	36° 37' 37.52"	398	75° 18' 28.80"	36° 41' 54.17"
349	75° 31' 08.54"	36° 37' 49.69"	399	75° 18' 07.56"	36° 41' 43.22"
350	75° 30' 47.30"	36° 37' 52.39"	400	75° 17' 57.84"	36° 41' 42.61"

401	75° 17' 11.65"	36° 42' 09.97"	451	75° 02' 32.10"	36° 47' 31.45"
402	75° 16' 55.85"	36° 42' 10.55"	452	75° 02' 30.91"	36° 47' 37.43"
403	75° 16' 38.86"	36° 42' 06.30"	453	75° 02' 20.36"	36° 47' 48.37"
404	75° 15' 55.73"	36° 42' 09.97"	454	75° 01' 52.50"	36° 48' 05.47"
405	75° 15' 38.70"	36° 42' 17.86"	455	75° 01' 38.75"	36° 48' 06.88"
406	75° 15' 11.99"	36° 42' 19.08"	456	75° 01' 30.43"	36° 48' 12.64"
407	75° 14' 56.80"	36° 42' 31.21"	457	75° 01' 23.02"	36° 48' 03.31"
408	75° 14' 17.38"	36° 42' 35.46"	458	75° 01' 15.60"	36° 48' 03.02"
409	75° 13' 54.48"	36° 42' 47.02"	459	75° 01' 08.18"	36° 47' 53.16"
410	75° 13' 32.34"	36° 42' 59.15"	460	75° 00' 56.38"	36° 47' 46.82"
411	75° 13' 16.54"	36° 43' 13.15"	461	75° 00' 34.96"	36° 47' 47.90"
412	75° 12' 27.83"	36° 43' 18.12"	462	75° 00' 20.66"	36° 47' 45.17"
413	75° 11' 36.35"	36° 43' 39.58"	463	75° 00' 05.00"	36° 47' 48.48"
414	75° 11' 24.04"	36° 44' 00.64"	464	74° 59' 34.76"	36° 47' 44.34"
415	75° 11' 00.28"	36° 43' 57.18"	465	74° 59' 25.15"	36° 47' 33.90"
416	75° 10' 36.44"	36° 43' 59.88"	466	74° 59' 24.86"	36° 47' 22.38"
417	75° 10' 29.21"	36° 44' 07.66"	467	74° 59' 21.59"	36° 47' 20.18"
418	75° 10' 28.09"	36° 44' 21.34"	468	74° 59' 13.60"	36° 47' 23.46"
419	75° 10' 01.42"	36° 44' 27.92"	469	74° 58' 56.32"	36° 47' 25.12"
420	75° 09' 45.07"	36° 44' 38.08"	470	74° 58' 44.76"	36° 47' 33.36"
421	75° 09' 16.24"	36° 44' 41.24"	471	74° 58' 27.88"	36° 47' 34.48"
422	75° 09' 02.30"	36° 44' 55.00"	472	74° 58' 09.44"	36° 47' 29.51"
423	75° 08' 54.31"	36° 45' 10.30"	473	74° 57' 59.29"	36° 47' 32.53"
424	75° 08' 39.01"	36° 45' 13.10"	474	74° 57' 40.07"	36° 47' 29.80"
425	75° 08' 33.83"	36° 45' 21.24"	475	74° 57' 29.34"	36° 47' 23.75"
426	75° 08' 31.24"	36° 45' 31.82"	476	74° 57' 22.46"	36° 47' 27.60"
427	75° 08' 17.88"	36° 45' 39.17"	477	74° 57' 25.52"	36° 47' 40.99"
428	75° 08' 01.18"	36° 45' 37.58"	478	74° 57' 33.55"	36° 47' 48.34"
429	75° 07' 54.41"	36° 45' 39.56"	479	74° 57' 31.21"	36° 47' 54.38"
430	75° 07' 51.20"	36° 45' 45.76"	480	74° 57' 32.54"	36° 48' 00.90"
431	75° 07' 52.03"	36° 45' 50.11"	481	74° 57' 41.40"	36° 48' 07.74"
432	75° 07' 45.05"	36° 46' 01.67"	482	74° 57' 42.59"	36° 48' 21.60"
433	75° 07' 35.11"	36° 46' 08.04"	483	74° 57' 51.26"	36° 48' 28.30"
434	75° 07' 30.90"	36° 46' 19.20"	484	74° 57' 53.42"	36° 48' 40.00"
435	75° 07' 21.97"	36° 46' 25.97"	485	74° 57' 47.63"	36° 49' 07.50"
436	75° 07' 20.75"	36° 46' 33.53"	486	74° 57' 39.06"	36° 49' 05.16"
437	75° 07' 06.64"	36° 46' 36.30"	487	74° 57' 11.30"	36° 49' 04.73"
438	75° 06' 55.30"	36° 46' 42.49"	488	74° 56' 57.16"	36° 49' 09.01"
439	75° 06' 35.78"	36° 46' 40.30"	489	74° 56' 22.88"	36° 49' 27.01"
440	75° 06' 12.28"	36° 46' 42.28"	490	74° 56' 10.46"	36° 49' 36.84"
441	75° 05' 53.95"	36° 46' 38.50"	491	74° 55' 55.06"	36° 49' 59.12"
442	75° 05' 40.85"	36° 46' 42.49"	492	74° 55' 35.04"	36° 50' 20.51"
443	75° 05' 29.29"	36° 46' 38.28"	493	74° 54' 53.68"	36° 50' 10.82"
444	75° 05' 19.32"	36° 46' 39.29"	494	74° 54' 35.71"	36° 50' 20.65"
445	75° 05' 06.18"	36° 46' 57.22"	495	74° 54' 31.86"	36° 50' 26.23"
446	75° 04' 52.07"	36° 47' 07.55"	496	74° 54' 31.43"	36° 50' 40.38"
447	75° 04' 01.88"	36° 47' 08.56"	497	74° 54' 26.28"	36° 50' 49.78"
448	75° 03' 49.54"	36° 47' 13.74"	498	74° 54' 31.43"	36° 51' 09.07"
449	75° 03' 11.52"	36° 47' 14.53"	499	74° 54' 24.98"	36° 51' 24.05"
450	75° 02' 35.88"	36° 47' 27.85"	500	74° 54' 25.85"	36° 52' 17.58"

501	74° 54' 03.17"	36° 52' 25.72"	551	75° 10' 47.17"	36° 58' 52.07"
502	74° 54' 03.17"	36° 52' 43.28"	552	75° 11' 08.38"	36° 58' 40.51"
503	74° 53' 56.94"	36° 52' 55.70"	553	75° 11' 37.93"	36° 58' 29.57"
504	74° 54' 12.78"	36° 53' 11.58"	554	75° 11' 47.58"	36° 58' 29.57"
505	74° 54' 13.64"	36° 53' 22.70"	555	75° 11' 59.78"	36° 58' 39.22"
506	74° 54' 25.20"	36° 53' 39.84"	556	75° 12' 06.19"	36° 58' 39.86"
507	74° 54' 26.93"	36° 53' 50.10"	557	75° 12' 51.80"	36° 58' 25.07"
508	74° 54' 03.78"	36° 53' 58.24"	558	75° 12' 57.60"	36° 58' 03.86"
509	74° 54' 06.37"	36° 54' 15.80"	559	75° 13' 00.80"	36° 58' 01.31"
510	74° 54' 03.78"	36° 54' 35.93"	560	75° 13' 31.01"	36° 57' 52.31"
511	74° 53' 42.40"	36° 54' 45.36"	561	75° 14' 02.47"	36° 57' 35.60"
512	74° 53' 27.17"	36° 54' 47.48"	562	75° 14' 13.42"	36° 57' 34.96"
513	74° 53' 19.46"	36° 55' 03.36"	563	75° 14' 29.47"	36° 57' 44.60"
514	74° 52' 46.92"	36° 55' 20.89"	564	75° 14' 50.03"	36° 57' 45.25"
515	74° 52' 20.35"	36° 55' 56.21"	565	75° 15' 12.53"	36° 57' 56.16"
516	74° 52' 33.20"	36° 56' 11.65"	566	75° 15' 31.14"	36° 57' 54.90"
517	74° 52' 51.20"	36° 56' 07.76"	567	75° 15' 39.49"	36° 57' 56.81"
518	74° 53' 14.32"	36° 55' 52.36"	568	75° 15' 49.14"	36° 58' 01.31"
519	74° 53' 38.76"	36° 55' 48.50"	569	75° 16' 08.40"	36° 58' 19.96"
520	74° 53' 55.46"	36° 55' 48.50"	570	75° 16' 40.55"	36° 58' 21.86"
521	74° 54' 39.13"	36° 56' 03.91"	571	75° 17' 21.66"	36° 58' 34.72"
522	74° 55' 13.84"	36° 56' 37.32"	572	75° 17' 33.22"	36° 58' 34.07"
523	74° 55' 24.10"	36° 57' 03.02"	573	75° 17' 47.98"	36° 58' 28.92"
524	74° 55' 24.10"	36° 57' 22.32"	574	75° 18' 25.88"	36° 58' 02.60"
525	74° 55' 12.54"	36° 58' 00.84"	575	75° 18' 37.48"	36° 58' 04.51"
526	74° 55' 35.69"	36° 58' 44.54"	576	75° 18' 54.79"	36° 58' 13.51"
527	74° 55' 58.80"	36° 58' 59.95"	577	75° 19' 07.97"	36° 58' 01.96"
528	74° 57' 17.17"	36° 59' 12.80"	578	75° 19' 15.67"	36° 57' 45.25"
529	74° 57' 51.88"	36° 59' 21.80"	579	75° 19' 37.52"	36° 57' 34.96"
530	74° 58' 48.40"	36° 59' 21.80"	580	75° 21' 26.10"	36° 57' 35.60"
531	74° 59' 20.54"	36° 59' 24.36"	581	75° 21' 46.66"	36° 57' 22.75"
532	75° 01' 00.77"	36° 59' 55.21"	582	75° 22' 15.56"	36° 56' 57.70"
533	75° 01' 31.58"	37° 00' 24.77"	583	75° 22' 40.62"	36° 56' 52.55"
534	75° 02' 21.70"	37° 00' 29.92"	584	75° 22' 56.06"	36° 56' 54.49"
535	75° 02' 49.96"	37° 00' 29.92"	585	75° 23' 17.23"	36° 57' 02.84"
536	75° 03' 10.55"	37° 00' 18.32"	586	75° 23' 23.68"	36° 57' 06.70"
537	75° 04' 30.18"	37° 00' 18.32"	587	75° 23' 29.47"	36° 57' 20.84"
538	75° 04' 49.48"	37° 00' 28.62"	588	75° 23' 33.94"	36° 57' 24.05"
539	75° 05' 20.29"	37° 00' 32.47"	589	75° 23' 41.03"	36° 57' 25.96"
540	75° 06' 25.85"	37° 00' 49.18"	590	75° 23' 59.96"	36° 57' 23.40"
541	75° 06' 57.96"	37° 00' 51.73"	591	75° 24' 21.82"	36° 57' 02.20"
542	75° 07' 25.57"	37° 01' 08.44"	592	75° 24' 28.22"	36° 56' 53.20"
543	75° 08' 04.13"	37° 01' 20.03"	593	75° 24' 28.87"	36° 56' 46.14"
544	75° 08' 36.24"	37° 01' 20.03"	594	75° 24' 25.67"	36° 56' 36.49"
545	75° 09' 01.94"	37° 01' 11.03"	595	75° 24' 16.67"	36° 56' 24.94"
546	75° 09' 25.09"	37° 00' 56.88"	596	75° 23' 54.82"	36° 56' 14.68"
547	75° 09' 28.94"	37° 00' 40.18"	597	75° 23' 26.56"	36° 56' 06.32"
548	75° 09' 27.40"	36° 59' 59.89"	598	75° 23' 13.06"	36° 55' 52.18"
549	75° 09' 42.30"	36° 59' 33.83"	599	75° 23' 18.85"	36° 55' 08.47"
550	75° 10' 24.06"	36° 59' 10.68"	600	75° 23' 09.85"	36° 54' 31.21"

601	75° 23' 15.00"	36° 54' 21.60"	651	75° 29' 45.60"	36° 44' 31.16"
602	75° 23' 38.76"	36° 54' 11.30"	652	75° 29' 54.60"	36° 44' 26.66"
603	75° 23' 45.20"	36° 54' 04.25"	653	75° 30' 08.75"	36° 44' 08.05"
604	75° 24' 12.82"	36° 53' 48.19"	654	75° 30' 30.60"	36° 43' 48.14"
605	75° 24' 24.05"	36° 53' 37.90"	655	75° 31' 32.59"	36° 43' 35.94"
606	75° 25' 00.05"	36° 53' 34.04"	656	75° 31' 42.20"	36° 43' 37.85"
607	75° 25' 12.25"	36° 53' 26.99"	657	75° 31' 48.65"	36° 43' 48.76"
608	75° 25' 12.25"	36° 53' 17.99"	658	75° 31' 53.15"	36° 44' 09.96"
609	75° 25' 04.55"	36° 53' 06.43"	659	75° 31' 55.06"	36° 44' 49.16"
610	75° 25' 03.90"	36° 52' 59.34"	660	75° 31' 44.80"	36° 45' 01.37"
611	75° 25' 18.66"	36° 52' 00.88"	661	75° 31' 26.15"	36° 45' 34.13"
612	75° 25' 21.90"	36° 51' 30.71"	662	75° 31' 30.00"	36° 45' 44.42"
613	75° 25' 34.72"	36° 51' 06.30"	663	75° 31' 46.06"	36° 45' 57.28"
614	75° 25' 32.16"	36° 50' 53.45"	664	75° 31' 48.65"	36° 46' 03.68"
615	75° 25' 34.72"	36° 50' 23.24"	665	75° 31' 49.30"	36° 46' 27.44"
616	75° 25' 47.24"	36° 50' 14.24"	666	75° 31' 52.50"	36° 46' 30.04"
617	75° 25' 47.24"	36° 50' 02.69"	667	75° 32' 13.70"	36° 46' 28.09"
618	75° 25' 31.19"	36° 49' 44.04"	668	75° 33' 17.32"	36° 46' 30.68"
619	75° 25' 21.58"	36° 49' 26.69"	669	75° 33' 35.28"	36° 46' 37.09"
620	75° 25' 21.58"	36° 49' 11.93"	670	75° 33' 54.58"	36° 46' 36.44"
621	75° 25' 15.78"	36° 48' 48.17"	671	75° 33' 57.78"	36° 46' 24.89"
622	75° 25' 15.78"	36° 48' 30.17"	672	75° 34' 02.93"	36° 46' 17.18"
623	75° 25' 06.13"	36° 48' 18.61"	673	75° 34' 11.89"	36° 46' 12.68"
624	75° 25' 06.78"	36° 48' 09.61"	674	75° 34' 45.95"	36° 46' 15.24"
625	75° 25' 20.28"	36° 47' 59.96"	675	75° 34' 55.60"	36° 46' 21.04"
626	75° 25' 23.48"	36° 47' 52.26"	676	75° 35' 05.24"	36° 46' 22.33"
627	75° 25' 06.78"	36° 47' 05.35"	677	75° 36' 35.50"	36° 46' 22.94"
628	75° 25' 05.81"	36° 46' 46.74"	678	75° 37' 07.00"	36° 46' 20.39"
629	75° 25' 27.01"	36° 46' 18.48"	679	75° 38' 11.22"	36° 46' 22.33"
630	75° 25' 33.46"	36° 45' 54.68"	680	75° 40' 12.00"	36° 46' 04.33"
631	75° 25' 48.22"	36° 45' 45.68"	681	75° 40' 44.44"	36° 45' 52.78"
632	75° 25' 50.81"	36° 45' 37.33"	682	75° 41' 04.99"	36° 45' 53.42"
633	75° 25' 51.42"	36° 45' 16.13"	683	75° 41' 16.58"	36° 45' 48.28"
634	75° 25' 57.22"	36° 45' 10.37"	684	75° 41' 51.90"	36° 45' 14.87"
635	75° 26' 10.07"	36° 45' 10.37"	685	75° 42' 11.20"	36° 45' 00.72"
636	75° 26' 19.72"	36° 45' 07.16"	686	75° 42' 27.90"	36° 45' 00.72"
637	75° 26' 26.77"	36° 45' 00.72"	687	75° 43' 08.36"	36° 45' 16.13"
638	75° 26' 28.07"	36° 44' 45.96"	688	75° 43' 21.22"	36° 45' 16.13"
639	75° 26' 44.12"	36° 44' 12.55"	689	75° 43' 40.48"	36° 45' 10.37"
640	75° 26' 52.15"	36° 43' 43.64"	690	75° 44' 26.09"	36° 44' 47.22"
641	75° 26' 56.00"	36° 43' 37.85"	691	75° 45' 35.82"	36° 44' 02.26"
642	75° 27' 17.32"	36° 43' 25.36"	692	75° 46' 45.84"	36° 43' 23.70"
643	75° 27' 39.06"	36° 43' 16.64"	693	75° 47' 25.01"	36° 43' 08.94"
644	75° 27' 46.12"	36° 43' 16.64"	694	75° 47' 34.01"	36° 43' 08.94"
645	75° 27' 51.91"	36° 43' 19.85"	695	75° 48' 04.21"	36° 42' 50.29"
646	75° 28' 09.23"	36° 43' 44.29"	696	75° 48' 08.71"	36° 42' 40.03"
647	75° 28' 56.14"	36° 44' 02.26"	697	75° 48' 31.18"	36° 42' 19.48"
648	75° 29' 03.19"	36° 44' 07.40"	698	75° 49' 20.35"	36° 41' 46.72"
649	75° 29' 10.28"	36° 44' 20.26"	699	75° 49' 29.35"	36° 41' 30.01"
650	75° 29' 30.19"	36° 44' 29.90"	700	75° 49' 50.52"	36° 41' 10.07"

701	75° 50' 16.87"	36° 40' 57.25"	731	75° 56' 50.06"	36° 32' 39.34"
702	75° 50' 57.98"	36° 40' 42.46"	732	75° 57' 32.80"	36° 32' 09.78"
703	75° 51' 32.69"	36° 40' 37.31"	733	75° 57' 43.06"	36° 31' 53.72"
704	75° 51' 37.19"	36° 40' 30.25"	734	75° 57' 50.11"	36° 31' 26.11"
705	75° 51' 51.30"	36° 40' 24.46"	735	75° 58' 01.70"	36° 31' 11.32"
706	75° 52' 01.60"	36° 40' 16.10"	736	75° 58' 22.26"	36° 30' 57.17"
707	75° 52' 12.50"	36° 39' 52.99"	737	75° 58' 56.32"	36° 30' 43.06"
708	75° 52' 49.15"	36° 39' 13.79"	738	75° 59' 16.87"	36° 30' 30.20"
709	75° 53' 11.29"	36° 38' 40.38"	739	75° 59' 22.63"	36° 30' 07.70"
710	75° 53' 24.79"	36° 38' 29.47"	740	75° 59' 18.46"	36° 29' 37.54"
711	75° 54' 12.96"	36° 38' 15.97"	741	75° 59' 23.60"	36° 29' 29.80"
712	75° 54' 33.55"	36° 38' 03.77"	742	75° 59' 58.96"	36° 29' 07.98"
713	75° 54' 49.61"	36° 37' 41.92"	743	76° 00' 09.86"	36° 29' 06.04"
714	75° 55' 57.07"	36° 36' 32.54"	744	76° 00' 17.57"	36° 29' 00.24"
715	75° 56' 09.28"	36° 36' 28.04"	745	76° 00' 27.86"	36° 28' 33.92"
716	75° 56' 29.18"	36° 36' 40.90"	746	76° 00' 41.33"	36° 28' 16.57"
717	75° 56' 33.04"	36° 36' 38.34"	747	76° 00' 46.48"	36° 28' 03.07"
718	75° 56' 33.68"	36° 36' 34.49"	748	76° 00' 40.07"	36° 27' 36.72"
719	75° 56' 24.04"	36° 36' 20.99"	749	76° 00' 40.72"	36° 27' 26.46"
720	75° 56' 20.18"	36° 36' 08.78"	750	76° 00' 49.07"	36° 27' 19.40"
721	75° 56' 18.56"	36° 35' 48.23"	751	76° 01' 12.18"	36° 27' 07.81"
722	75° 56' 06.36"	36° 35' 18.02"	752	76° 01' 18.91"	36° 26' 55.00"
723	75° 55' 20.10"	36° 34' 34.32"	753	76° 01' 21.50"	36° 26' 33.79"
724	75° 55' 17.54"	36° 34' 28.56"	754	76° 01' 38.86"	36° 26' 10.64"
725	75° 55' 18.19"	36° 34' 18.26"	755	76° 01' 42.06"	36° 25' 44.94"
726	75° 55' 25.25"	36° 34' 08.00"	756	76° 01' 49.76"	36° 25' 23.74"
727	75° 55' 47.75"	36° 33' 57.06"	757	76° 01' 58.76"	36° 25' 07.68"
728	75° 56' 18.56"	36° 33' 34.60"	758	76° 01' 59.41"	36° 24' 50.98"
729	75° 56' 39.12"	36° 33' 10.19"	759	76° 01' 46.56"	36° 24' 29.20"
730	75° 56' 47.47"	36° 32' 52.84"	760	76° 01' 46.56"	36° 24' 29.20"

6 CONCLUSION AND RECOMMENDATIONS

The GIS based boundary of Khunjerab National Park with permanent physical features or landmarks has been delineated by incorporating the topography, landcover maps, wildlife habitats as well as field data. The proposed boundary of KNP covers about 4, 45,506 hectares (approx. 4,455.06 km²).

On the basis of delineated boundary, a notification format was developed. The proposed notification format has three parts i.e. textual description, a comprehensive GIS map and list of boundary coordinates. The notification format significantly describes the boundary with dual references i.e. the land features/land marks and geographic coordinates. As the proposed notification format is an outcome of GIS based scientific study, it is recommended to renotify the KNP boundaries with geographical coordinates.

Common boundary between Shimshal and Soqhterabad hunting areas has always been a source of conflict between both the communities. Although the common boundary has been marked on map in consultation with both CCHA's, but there is a strong need for on ground boundary demarcation. It is highly recommended to demarcate the common boundary so that the conflicts can be resolved.

It is also recommended to organize a basic level GPS training for the Park management staff. It will help the staff to translate the boundary on ground with the help of GPS. It will help to introduce the emerging GIS/GPS technology to the Park management.

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ANNEXURE 1. ASTER Sensor of Terra Satellite

Aster obtains medium to low-resolution (ranging from 15 to 90 meter per pixel) images of the earth in 14 different wavelength bands of electromagnetic spectrum ranging from visible to thermal infrared. Aster data is utilized to create detailed maps of land surface, temperature, emissivity, reflectance and elevation models (as ASTER sensor has along track stereo capability). Accuracies obtained from these stereo data are in the range of 15m x, y and z with ideal conditions.

Fourteen bands of the ASTER data could be divided into three broad categories of electromagnetic spectrum, based on its spatial resolution as shown in the table 6.

Table 3: ASTER data specifications

Spectral Bands	Band Numbers	Spectral Range (μm)	Spatial Resolution (m)
VNIR	1	0.52-0.60	15 m
	2	0.63-0.69	
	3N (Nadir)	0.76-0.86	
	3B Backward)	Same as 3N	
SWIR	4	1.60-1.70	30 m
	5	2.145-2.185	
	6	2.185-2.225	
	7	2.235-2.285	
	8	2.295-2.365	
	9	2.36-2.43	
TIR	10	8.125-8.475	90 m
	11	8.475-8.85	
	12	8.925-9.275	
	13	10.25-10.95	
	14	10.95-11.65	

The swath width for the ASTER data is 60×60 km. It is capable of revisiting any place on the earth after every 16 days. Data are acquired in 14 spectral bands. In addition, nadir and backward-looking telescopes in the visible will provide stereo images used to produce digital elevation topography model. It provides data with radiometric resolution of 8-bit (for VNIR and SWIR) and 12-bit (for TIR).

ANNEXURE 2. Glossary of Terms

False Color Composite (FCC)

In satellite image processing, false-color Composites (FCC) images are used as they increase the interpretability of the data. False color composite of ASTER data in which bands 3N, 2, 1 are represented in red, green and blue spectral ranges respectively, enhance the interpretation of vegetative biomass by presenting it in varying tones of red.

Global Positioning System

The Global Positioning System, usually called GPS (the US military refers to it as NAVSTAR GPS - Navigation Signal Timing and Ranging Global Positioning System), is a satellite navigation system is used for determining precise locations and providing a highly accurate time reference almost anywhere on Earth.

Ortho-rectification

Ortho-rectification is the process of removing the geometric distortion inherent in imagery caused by the camera/sensor orientation, topographic relief displacement and systematic errors associated with imagery (ASTER User Handbook JPL).

WGS-84

A consistent set of parameters describing the size and shape of the earth, the positions of a network of points with respect to the center of mass of the earth, transformations from major geodetic datums, and the potential of the earth (usually in terms of harmonic coefficients).

