Application of Remote Sensing and GIS Technology for Disaster Management in Pakistan

UN / Germany Expert Meeting on Space Technologies for Flood and Drought Risk Reduction

05 - 06 June 2014, Bonn Germany

Wazir Khan, General Manager
SUPARCO, Pakistan

Outline

- Brief Introduction to SUPARCO
- Disaster Management Frame Work , Pakistan
- Role of SUPARCO in Disaster Management
- Application of Space Technology for Flood Monitoring and Management
- International Collaboration/Cooperation
- Conclusions

SUPARCO – National Space Agency

Mandate

- Enhance indigenous capabilities in space technology and promote peaceful applications of space sciences for socioeconomic development of the country
- Prepare and propose long term as well as short term space programs and plans to the government
- Advise government in all space related matters
- Liaise with national & international agencies


Proposed Space & Atmospheric Research Centre (SPARC)
CHINA
Gilgit
Space & Atmospheric Research Centre (SPARC)
AFGHANISTAN
Peshawar
Jammu & Kashmir
Islamabad
• Satellite Ground Station
• Space & Atmospheric Research Station
• Geomagnetic Observatory
Kalashah Kako
Lahore
Paksat Ground Control Station – L
Space Applications & Research Centre (SPARC)
Quetta
Multan
•Satellite Research & Development Center
•TT&C Station for LEO Satellite
IRAN
INDIA
Space & Atmospheric Research Facility, Multan
•SUPARCO HQs
•Space Application and Research Wing
•National Center for Remote Sensing and Geoinformatics
•COSPAS-SARSAT
•Geomagnetic Observatory
•Paksat Ground Control Station – K
•SUPARCO Plant
•Space Technology Wing
•Range & Instrumentation Wing
•Satellite Research & Development Center
•SUPARCO Institute of Technical Training
Gawadar
Sonmiani
Karachi
• Flight Test Range (FTR)
•Ionospheric Research Facility

Satellite Ground Stations

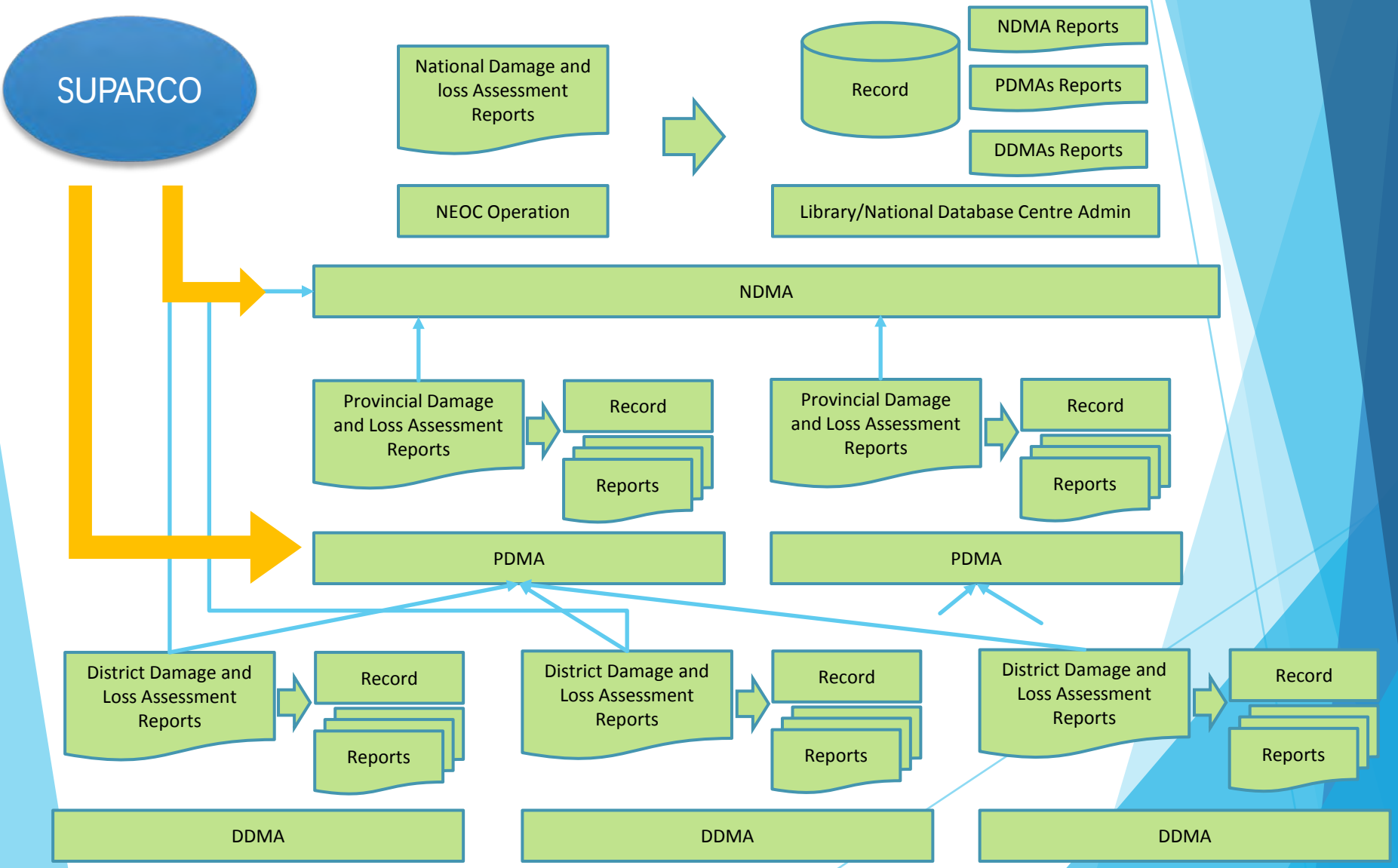
Atmosphere Data Processing & Receiving Centre (ADPRC) Karachi

Satellite Ground Station (SGS) Islamabad

Space Application Center for Response in Emergency and Disasters (SACRED)

- Serve as focal office for Emergency OPS & Response in case of Natural Disaster
- Coordinate with National/Provincial Disaster Management Authorities and other agencies during all phases of disasters
- Serve as Regional Support Office of UN-SPIDER

Disaster Management Framework, Pakistan



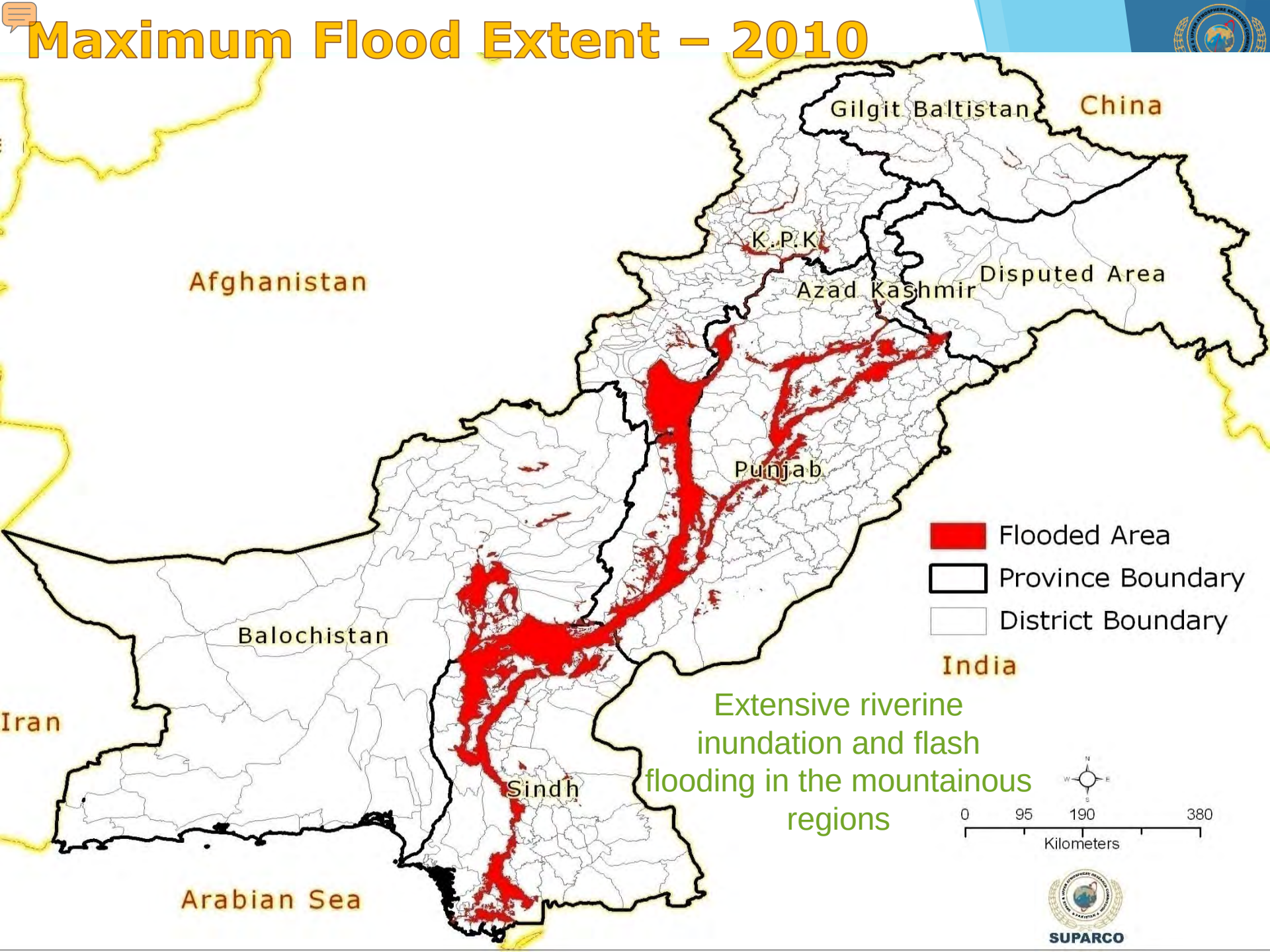
SUPARCO Role in Disaster Management

- Development of Early Warning System
- Hazard mapping
- Identification and mapping of evacuation/safe sites
- Inventory of population, property, infrastructure, agriculture etc in the hazard prone area
- Assist NDMA/PDMAs in Risk Assessment and Risk Reductions efforts/Projects
- Preparation of Initial rapid damage assessment reports
- Monitoring of breaches in embankments/bunds
- Assist NDMA and PDMAs in preparation of Post Disaster Need Assessment (PDNA)
- Monitoring of Rehabilitation and Reconstruction Activities
- Monitoring depletion of glaciers/snow cover/melt

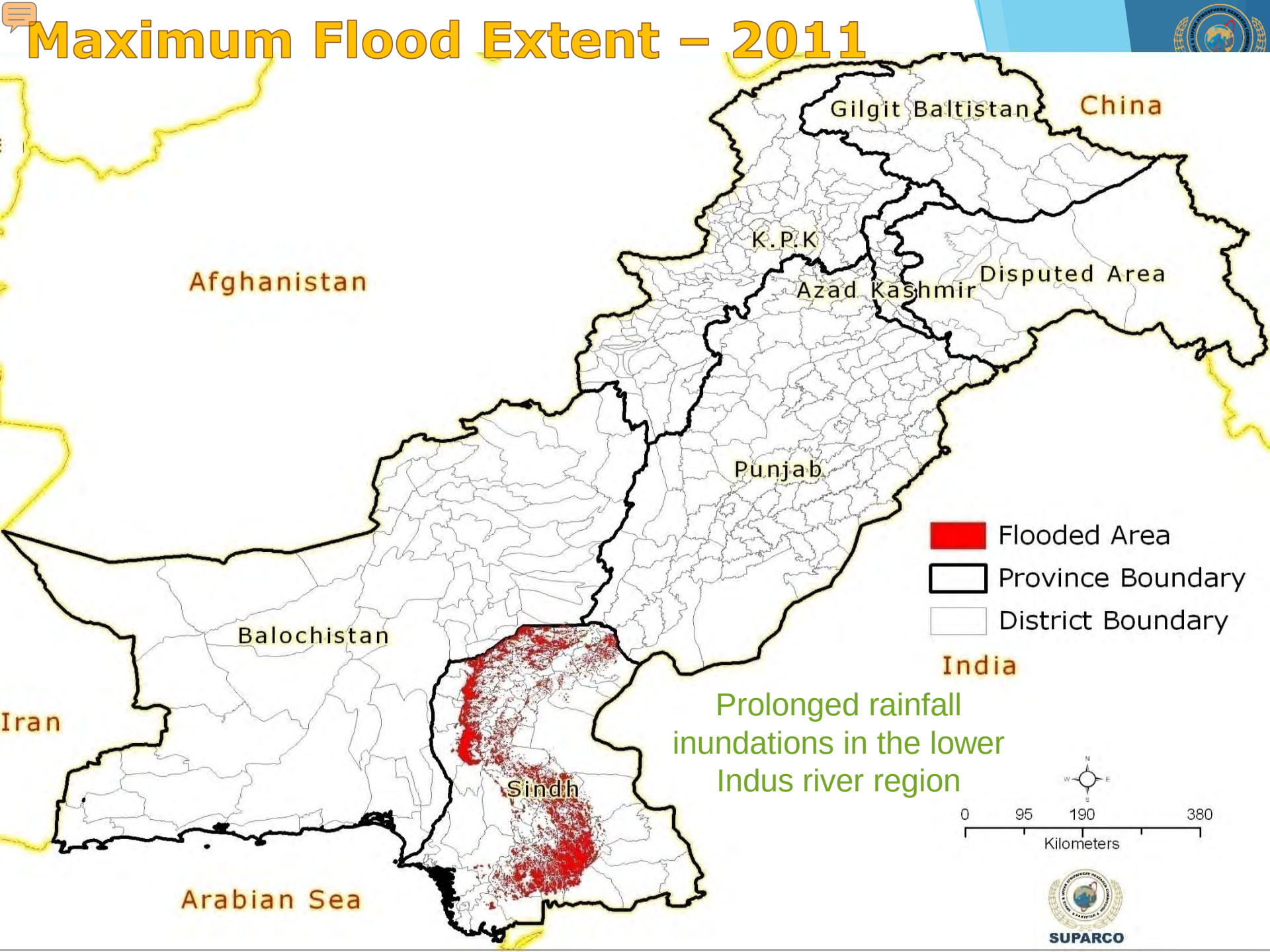
REMOTE SENSING AND GIS TECHNOLOGY APPLICATION FOR FLOOD MONITORING AND MANAGEMENT

Flood Prone Areas

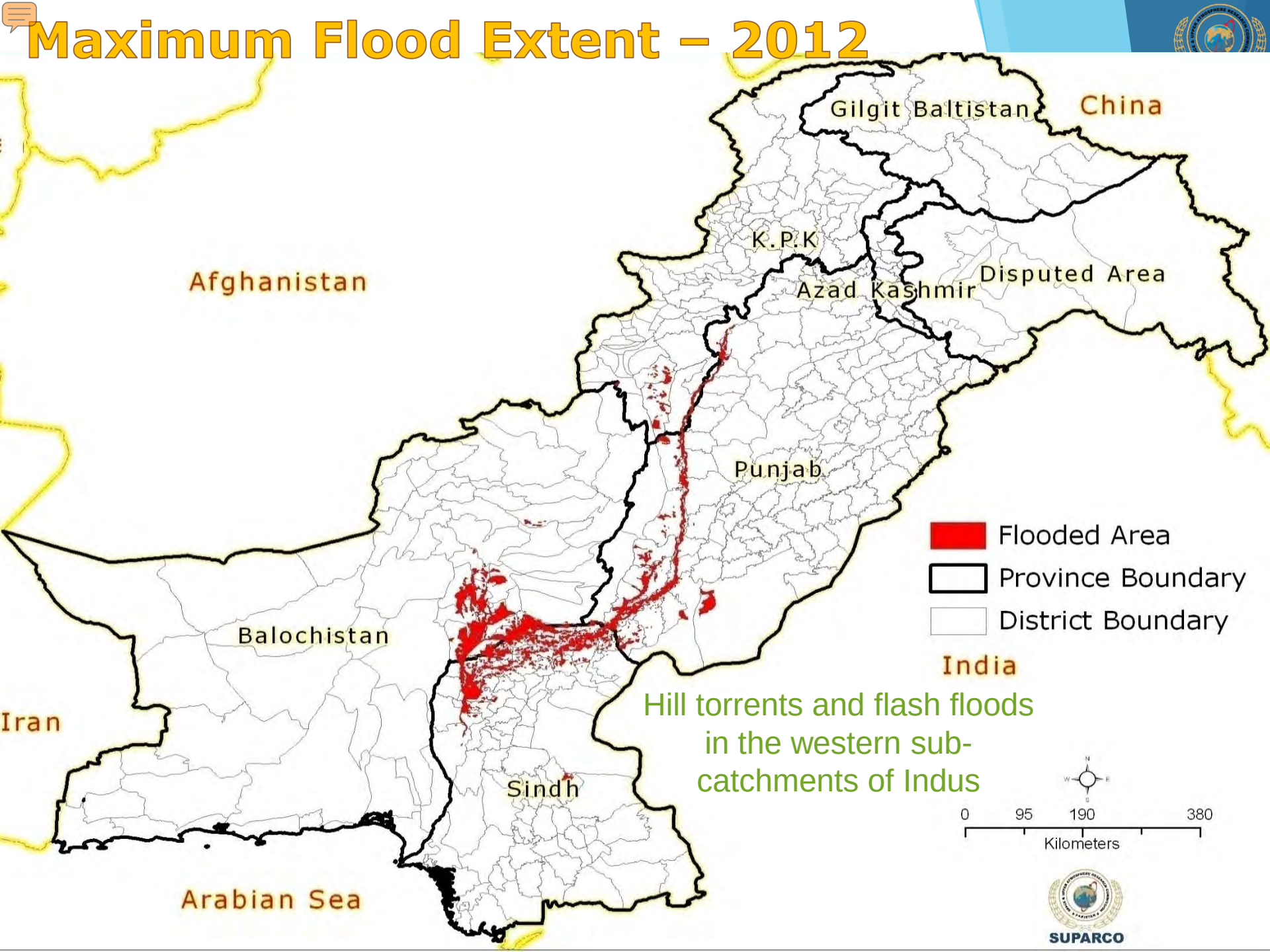
Maximum Flood Extent – 2010



Maximum Flood Extent – 2011

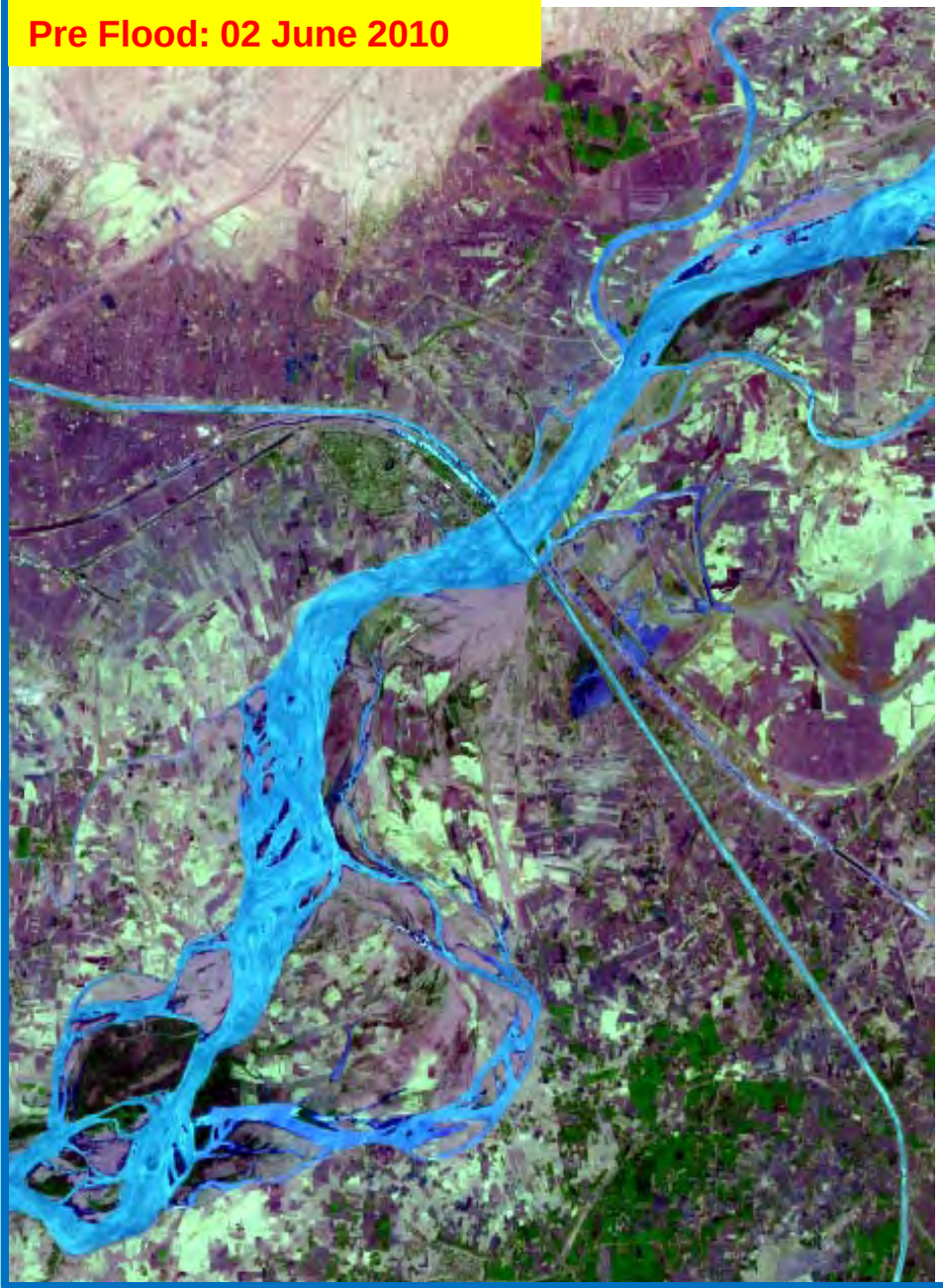


Maximum Flood Extent – 2012

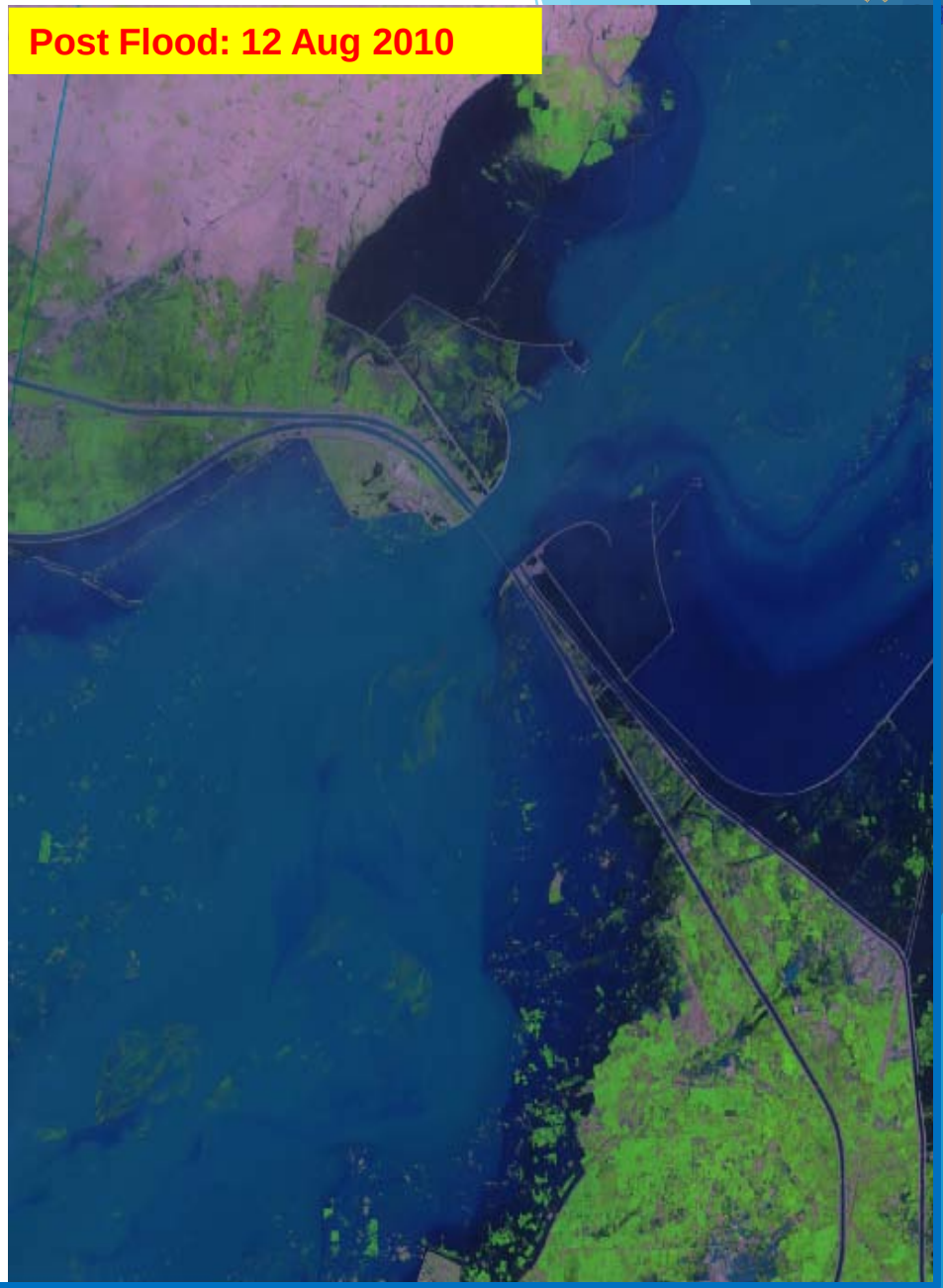


Guddu Barrage

Pre Flood: 02 June 2010

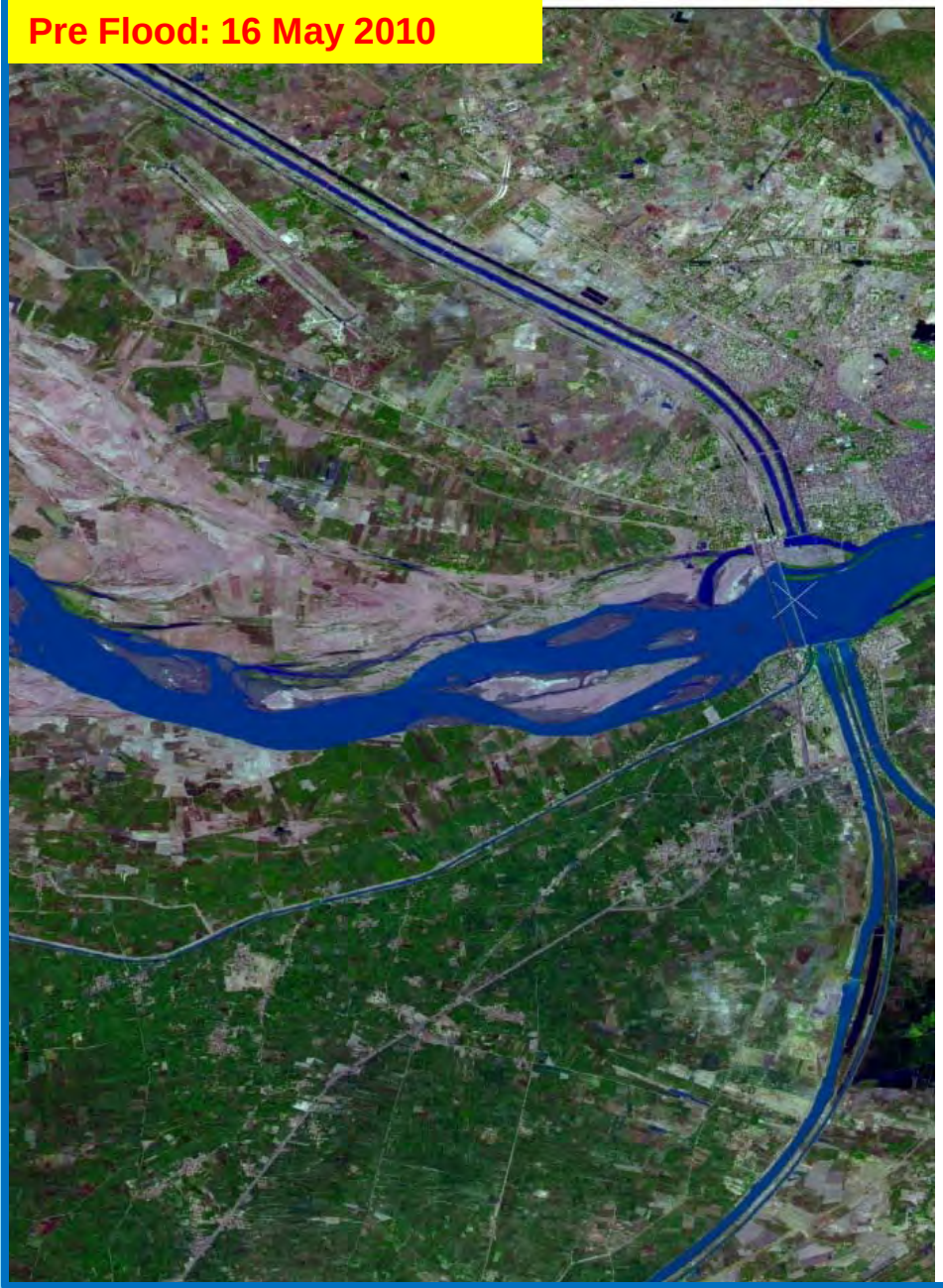


Post Flood: 12 Aug 2010

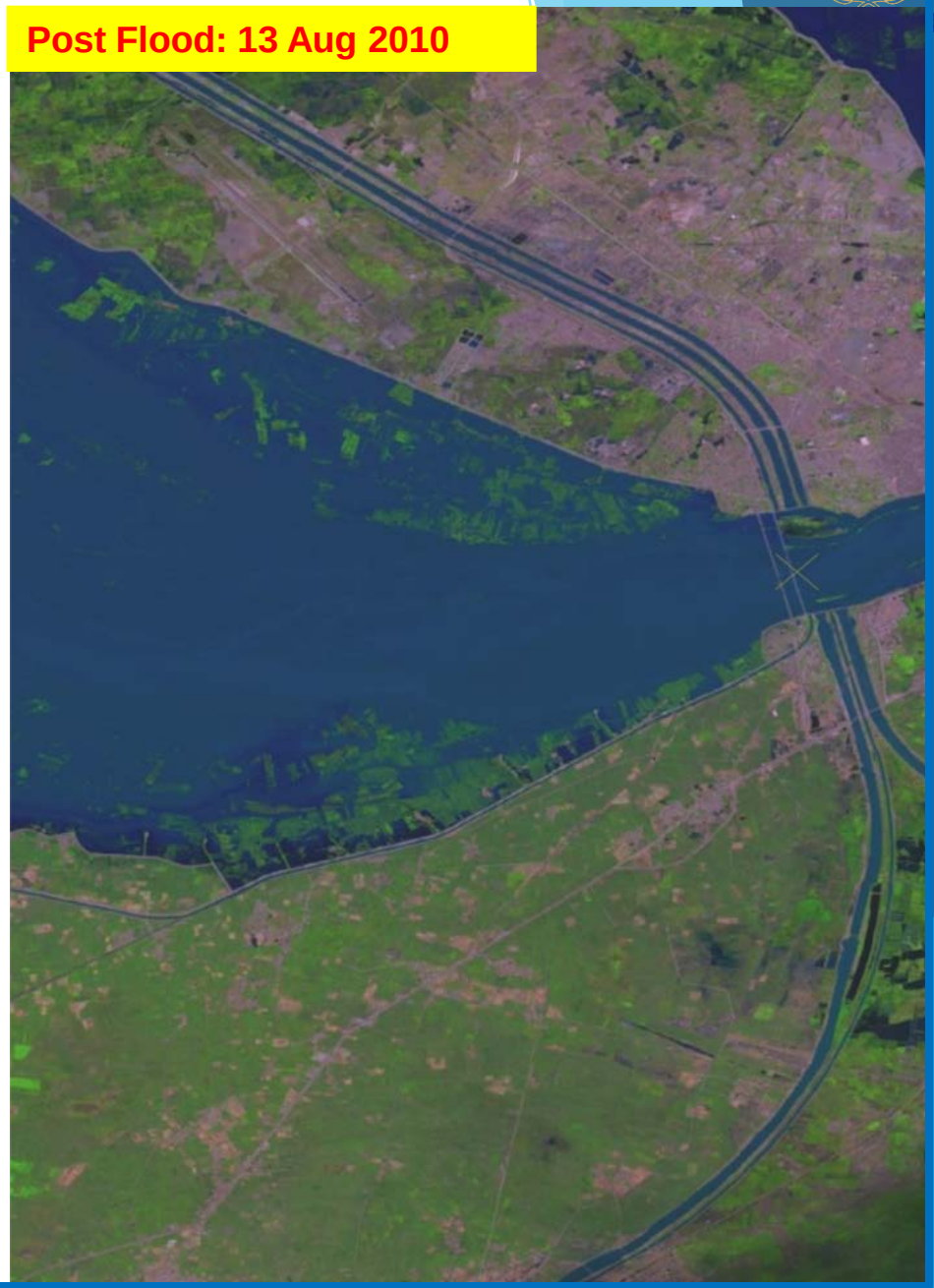


Sukkur Barrage

Pre Flood: 16 May 2010



Post Flood: 13 Aug 2010



Contribution of SUPARCO in:

Preparedness

- Nation-wide baseline data (LULC)
- Rapid mapping
- Development of Flood Early warning system (I-IFAS)
- Flood-prone area mapping
- River bank erosion
- Monitoring snow-melt

Rescue and Early Recovery

- Timely dissemination of information to line agencies
- Flood monitoring
- Rapid Damage assessment
- 2D, 3D visualization

Reconstruction & Rehabilitation

- Detailed damage assessment
- Monitoring of reconstruction and rehabilitation activities
- Studying & improving preparedness

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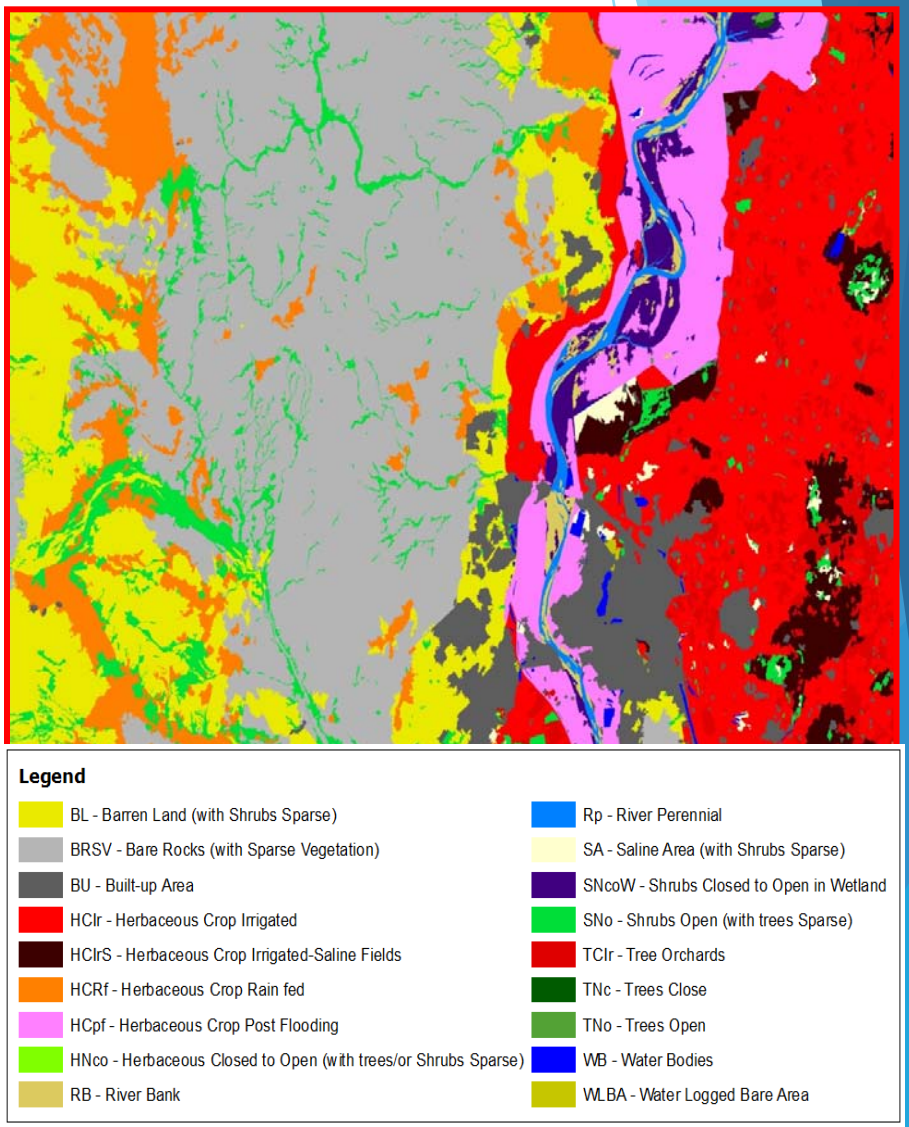
Preparation of Baseline Data

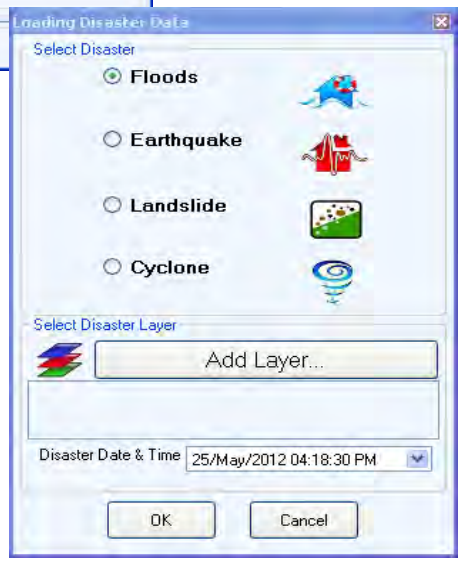
- District boundaries
- Road network
- Railroad network
- Settlements
- Population
- Irrigation network
- Water bodies (rivers, streams, canals, lakes)
- Dams/Barrages
- Agriculture Area

Land Cover Classification System

- Completed for Punjab and Sindh
- Land has been classified into 39 classes
- Very useful for damage assessment of a particular class such as agricultural land, settlements, woodlands



Damage Assessment (Rapid)



Historical/baseline Data Collection

Pre Flood SPOT-4 & 5

Post Flood SPOT – 4 & 5 Aqua & Terra

During Flood SPOT – 4 & 5 Aqua & Terra

Data conversion and standardization

GIS Layers

Precise Flood extent

Daily Flood extent

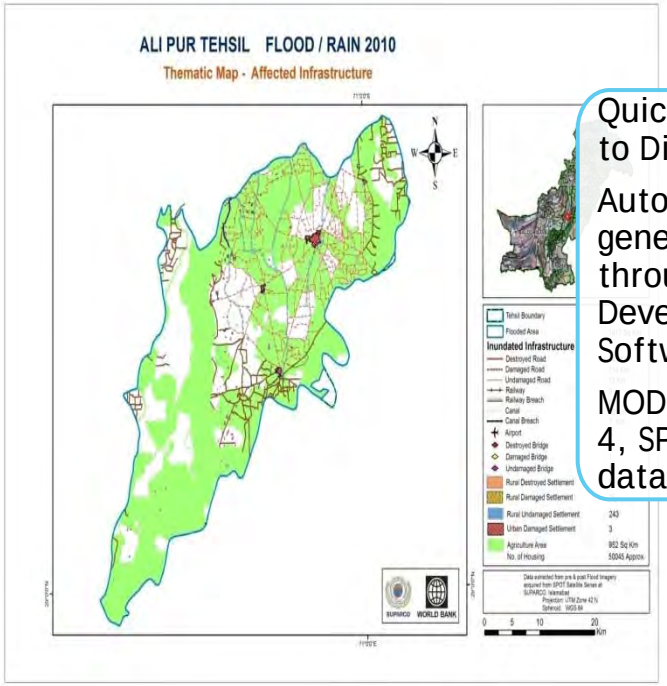
Detailed Damage Assessment

Rapid Damage Assessment

Templates for dissemination of maps

Damage Assessment (Rapid)

Rapid Mapping



Quick Response to Disaster

Automatic map generation through Custom Developed Software

MODIS, SPOT 4, SPOT 5, Vector data

Detailed Assessment

District	Total District Area (sq. km)	Total Affected Area (sq. km)	31-Jul	5-Aug	10-Aug	15-Aug	20-Aug	25-Aug	30-Aug
BOLAN	8646	3034			↑ 100%	↓ 19%		↓ 60%	↓
JAFARABAD	2487	1926			↑ 73%	↓ 58%	↑ 42%	↑ 1	↑ 3%
NASIRABAD	3222	1264			↑ 85%	↑ 58%	↑ 15%	↑ 1	↑ 3%
JHAL MAGSI	3859	929			↑ 60%	↑ 14%	↑ 6%	↓ 3	
LORALAI	9955	286			↑ 100%	↓ 100%			
SIBI	4963	250			↑ 100%	↓ 100%			
DERA BUGTI	10286	229			↑ 99%		↑ 1%		
QILLA SAIFULLAH	12446	229			↑ 100%	↓ 100%			
D. I. KHAN	9466	6014	↑ 66%	↓ 43%	↑ 69%	↓ 44%	↑ 2%	↓	
TANK	3167	1108	↑ 58%	↓ 15%	↑ 42%	↓ 20%	↓ 5%	↓ 2	
LAKKI MARWAT	3126	316		↑ 100%	↓ 100%				
NOWSHERA	1806	287	↑ 78%	↑ 22%			↓ 82%	↓	
SWABI	1474	241	↑ 75%	↑ 25%		↓ 37%		↓ 1	
HARIPUR	2113	220		↑ 100%		↓ 100%			
CHARSADDA	1091	215	↑ 57%	↑ 43%	↓ 100%				
LOWER DIR	1697	149		↑ 100%	↓ 100%				
KOHAT	3495	147	↑ 78%			↓ 47%	↑ 22%	↓ 9%	↓ 100%
MUZAFFARGARH	8412	4783	↑ 16%	↑ 11%	↑ 64%	↓ 31%	↑ 9%		↓ 15%
RAJANPUR	12372	3772	↑ 10%	↓ 3%	↑ 83%	↓ 32%	↑ 9%	↓ 7%	↓ 1%
JHANG	6189	3003	↑ 20%	↑ 31%	↑ 49%	↓ 54%	↓ 5%		↓ 5%

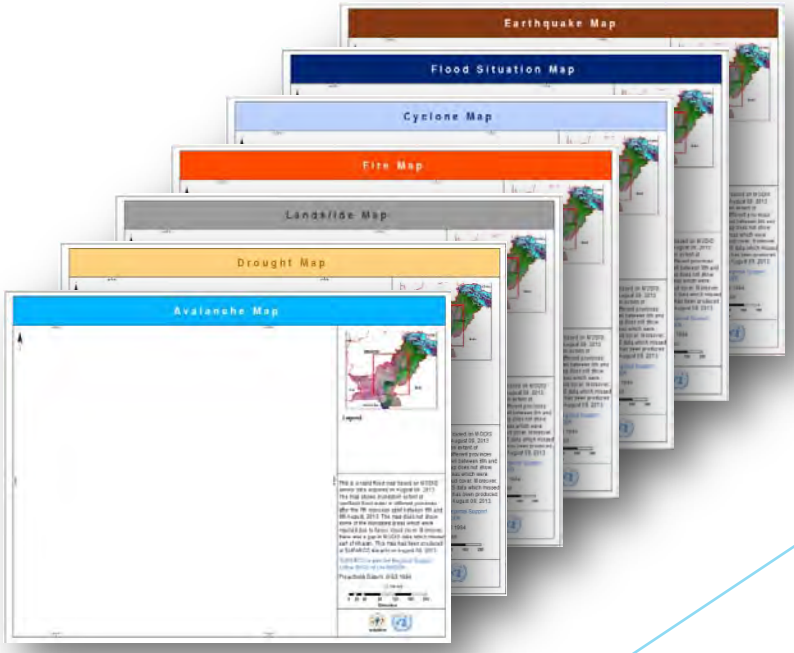
Ground surveys

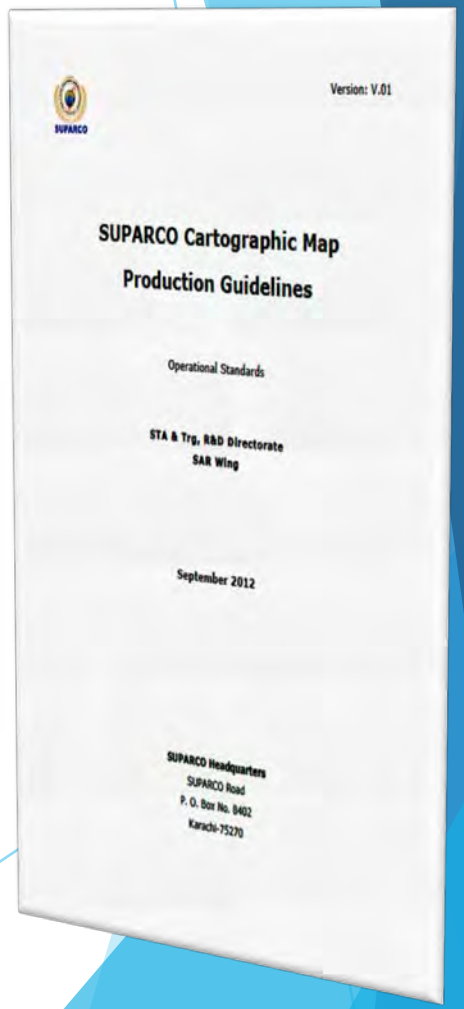
Damage Analysis for Infrastructure, Agriculture, Household etc.

Detailed Reports

Standards for Map Production

- Cartographic standards have been prepared for map production
- Colour-coded Templates for Disaster maps:
  - Earthquake
  - Flood
  - Cyclone
  - Fire
  - Landslide
  - Drought
  - Avalanche

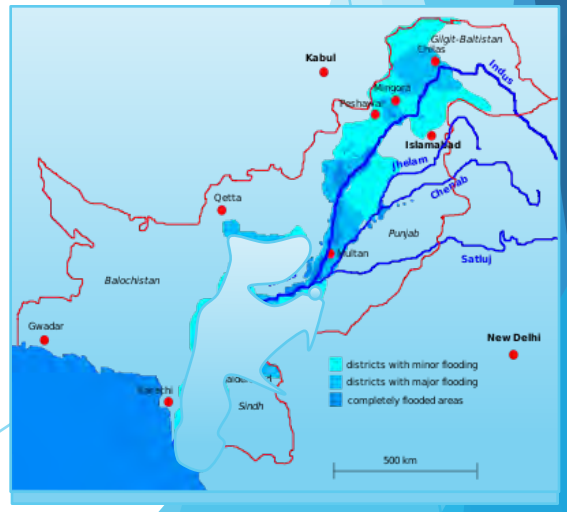




Strategic Strengthening of Flood Warning and Management Capacity of Pakistan

- **Project Associates**
  - SUPARCO/PMD/UNESCO/JAXA
- **Objectives**
  - Development of Indus-Integrated Flood Analysis System (IFAS)
  - Flood modelling & hazard mapping
  - Test operation in 2014

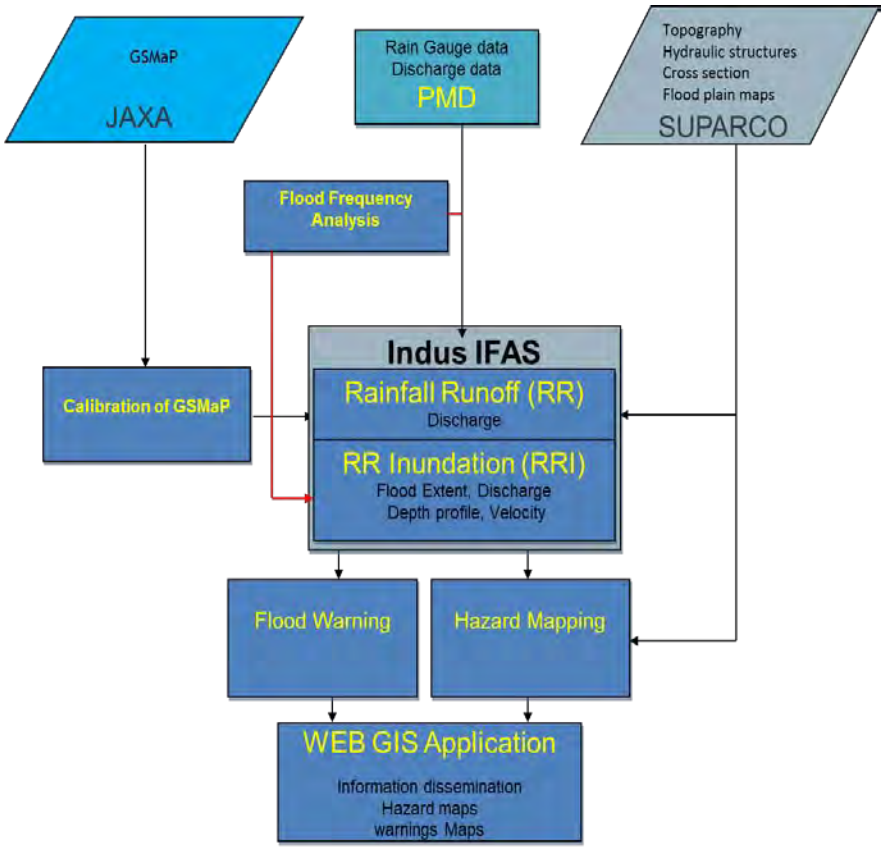
Geographic area to be covered by Indus-IFAS (enclosed by dotted lines)



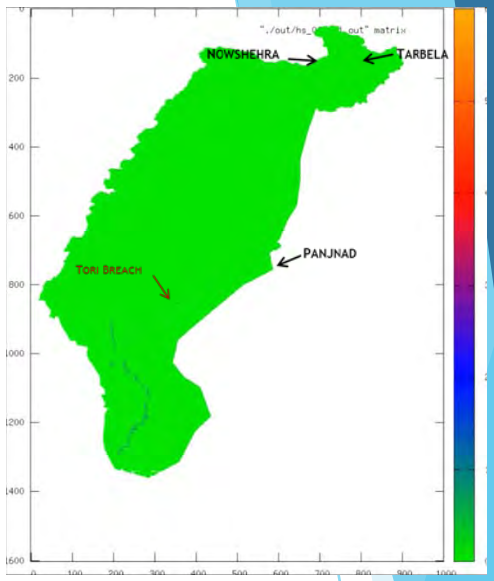
Proposed Flood Hazard Mapping Area

Strategic Strengthening of Flood Warning and Management Capacity of Pakistan

PROJECT FLOW CHART



INUNDATION SIMULATION FOR 2010 FLOODS



TRAININGS & CAPACITY BUILDING

04 nominated PMD officials have been enrolled in the 2-year Masters in Geoinformatics program at NCRG, SUPARCO HQ, Karachi.

120 officials from PMD, NDMA, WAPDA, IRSA, FFC, PDMAs, Provincial Irrigation departments and other local organizations were invited for the workshops **"Flood Risk Mapping using Spatial Technologies"** from 10 - 15 December, 2012 and "**Safe, Connected communities against floods through RS&GIS tools**" from 10-13 March, 2014.

06 Trainings for officers of stakeholder organizations.

"Safe, Connected communities against floods through RS&GIS tools" from 10-13 March, 2014

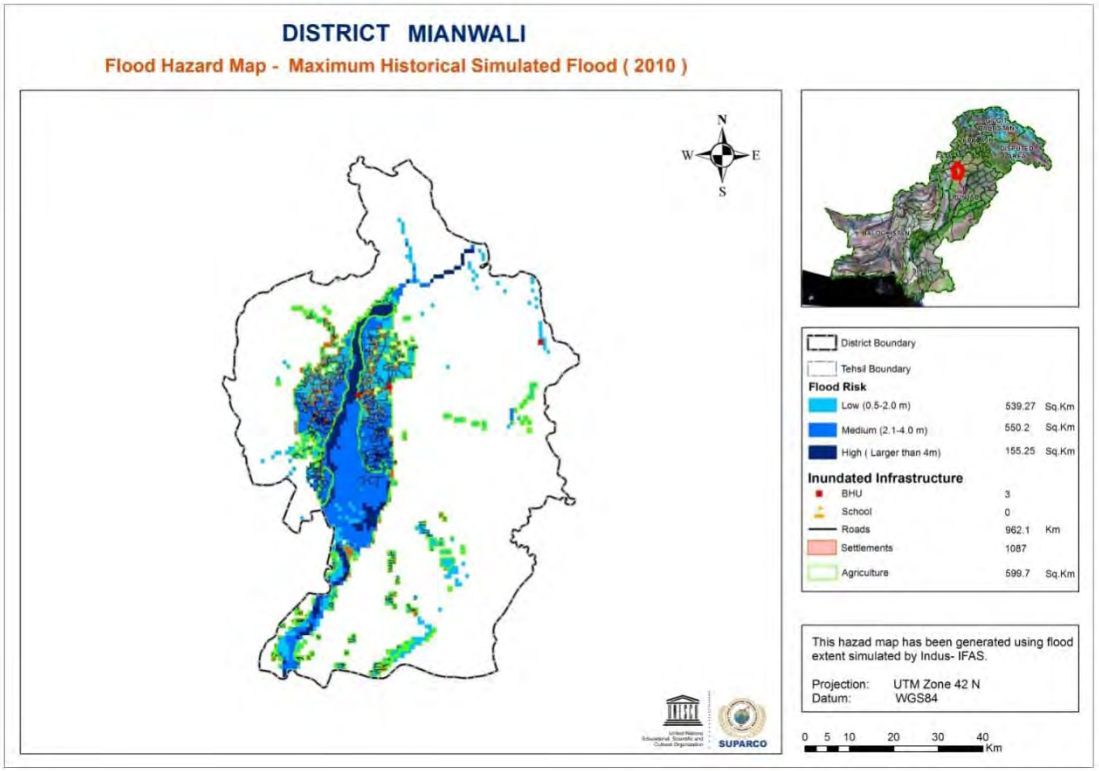
Opening Address during "Safe, Connected communities against floods through RS&GIS tools"

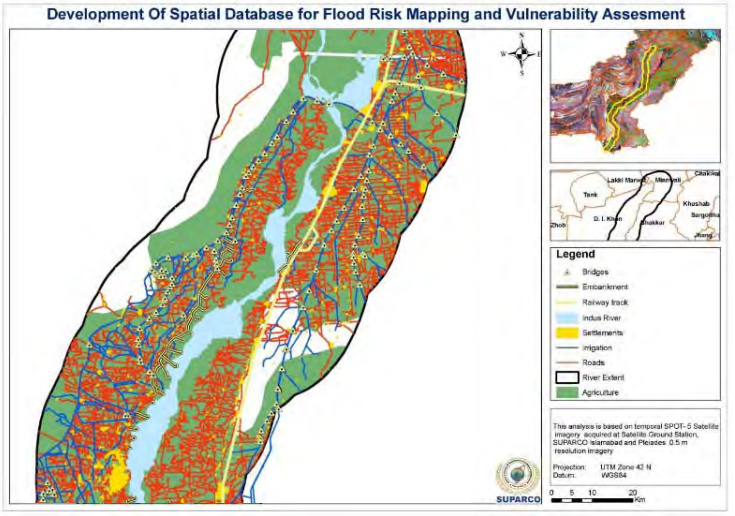
Chief Guest and speakers during workshop opening session. 14 Dec

A view of the participants during technical workshop sessions. 14 Dec

Use simulated flood model output for hazard mapping of floodplains. Disseminate maps to federal / provincial flood managers, local administrations and communities.

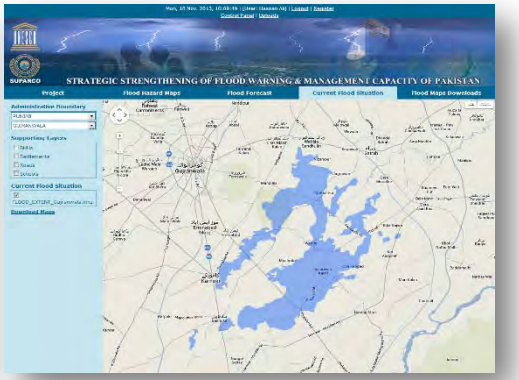
SPATIAL DATABASE FOR FLOOD HAZARD & RISK





- Following GIS layers were prepared in a buffer of 20km across the Indus River from Kalabagh to Indus River Delta.
- Settlements
- Roads
- Embankments
- Bridges
- Irrigation channels
- Agriculture land

FLOOD HAZARD MAPPING VISUALIZATION TOOL

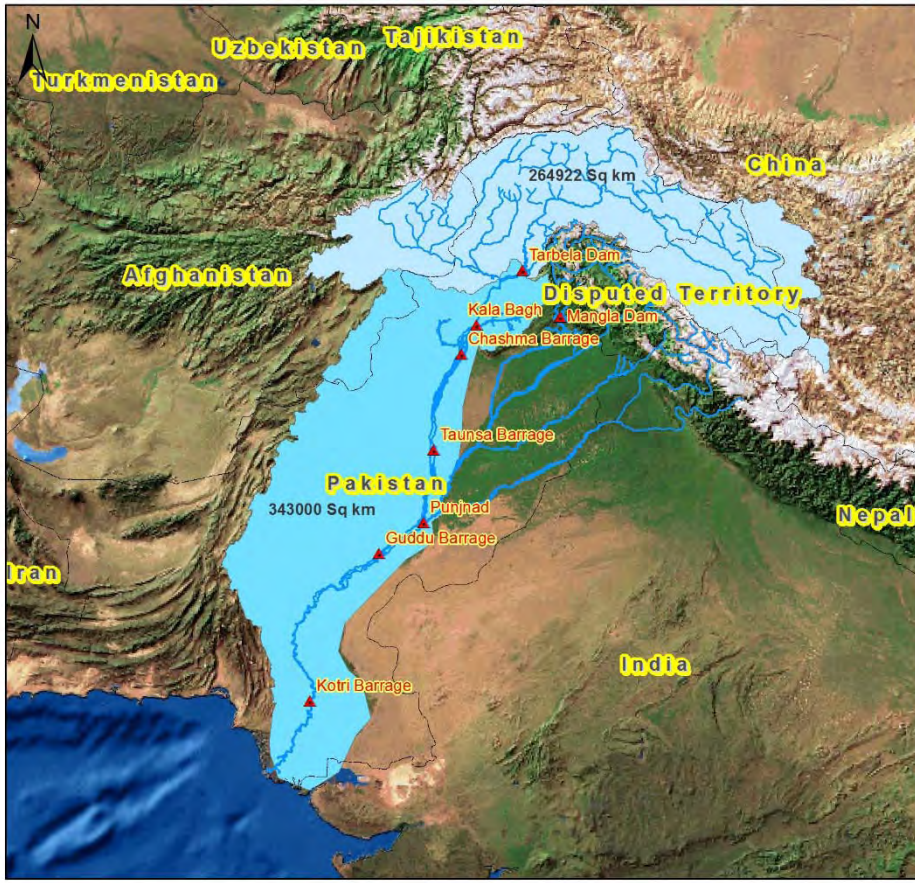


FIELD VALIDATION EXERCISES FOR FLOODPLAIN MAPPING

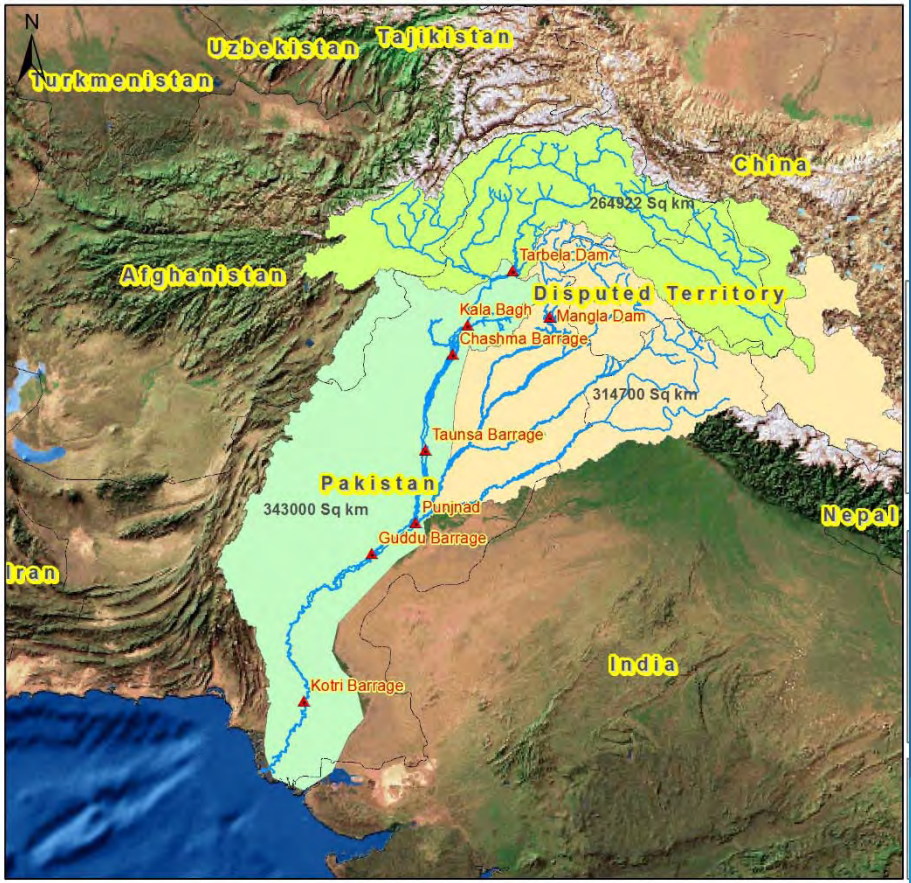
Phase II: Strategic Strengthening of Flood Warning and Management Capacity of Pakistan

SUPARCO

TARGET AREA – PHASE I

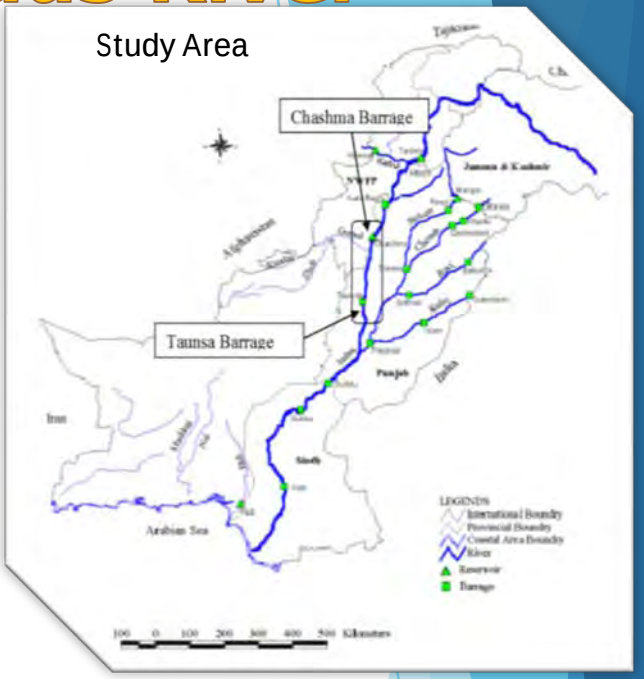


TARGET AREA – PHASE II



Flood/Erosion Modelling & Impacts on Agriculture on the Indus River

- **Project Associates**
  - FAO/SUPARCO/WAPDA/University of Southampton-UK
- **Objectives**
  - Bank erosion modeling of the Indus River(Chashma to Taunsa)
  - Impacts of Flood and bank erosion on agriculture on Indus River
  - Production of an atlas of the spatial and temporal impacts of flood and bank erosion on the River Indus
  - Capacity development of SUPARCO officials



Predition of Vulnerable Embankments along Indus River in Sindh

(Services to Sindh Irrigation Department & PDMA Sindh)

SUPARCO

Downstream of Sukkur Barrage (Sukkur-Khairpur)

Highly vulnerable	Moderately vulnerable	Less vulnerable
-	Ulra Jagir Bund	-
-	S M BUND	-

Downstream of Sukkur Barrage (Larkana)

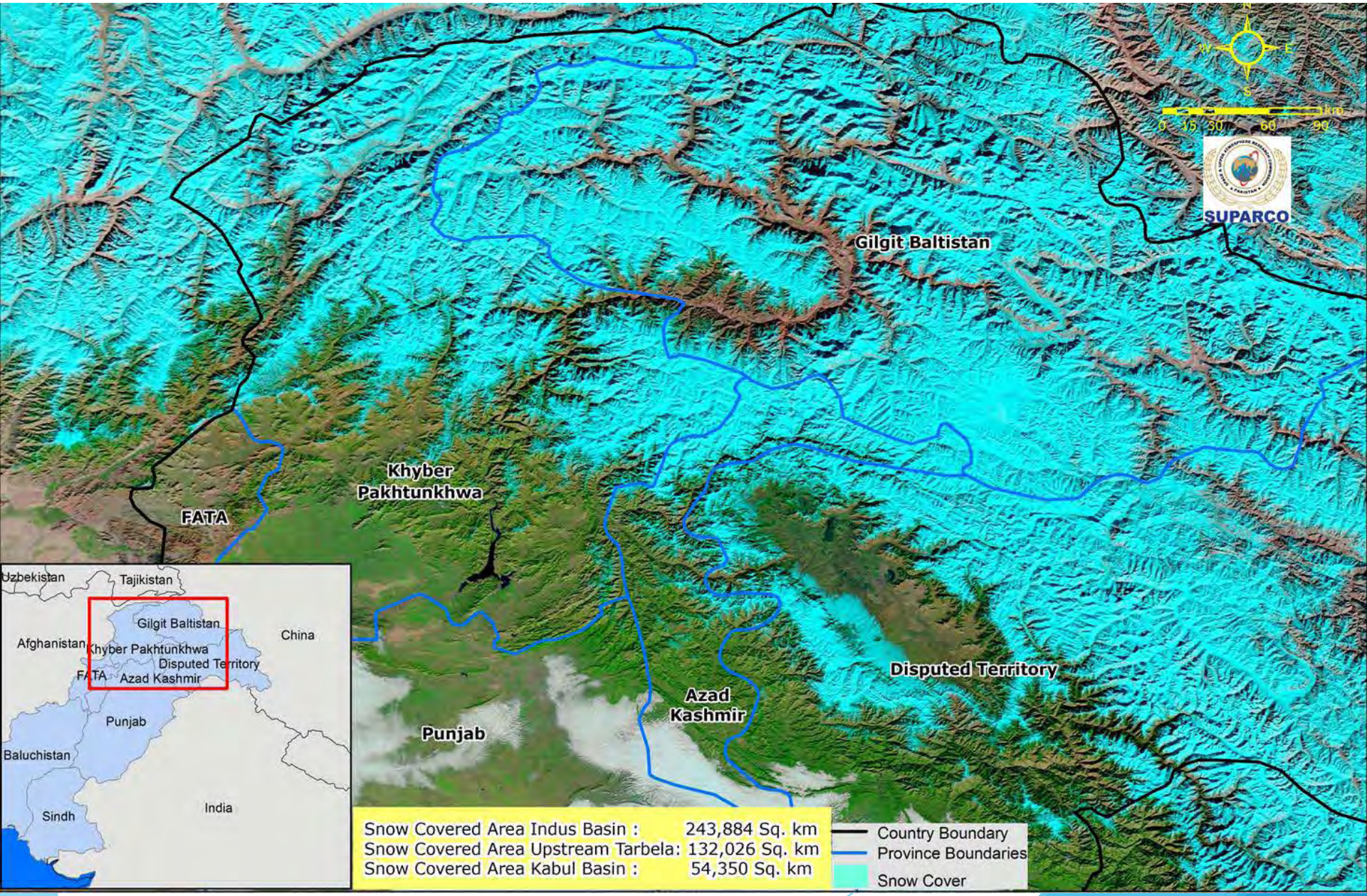
Highly vulnerable	Moderately vulnerable	Less vulnerable
-	Nusrat Loop Bund	-

Based on June 2013 and July 2013 images, river course mapping conducted for prediction of vulnerable bunds for forthcoming high flows

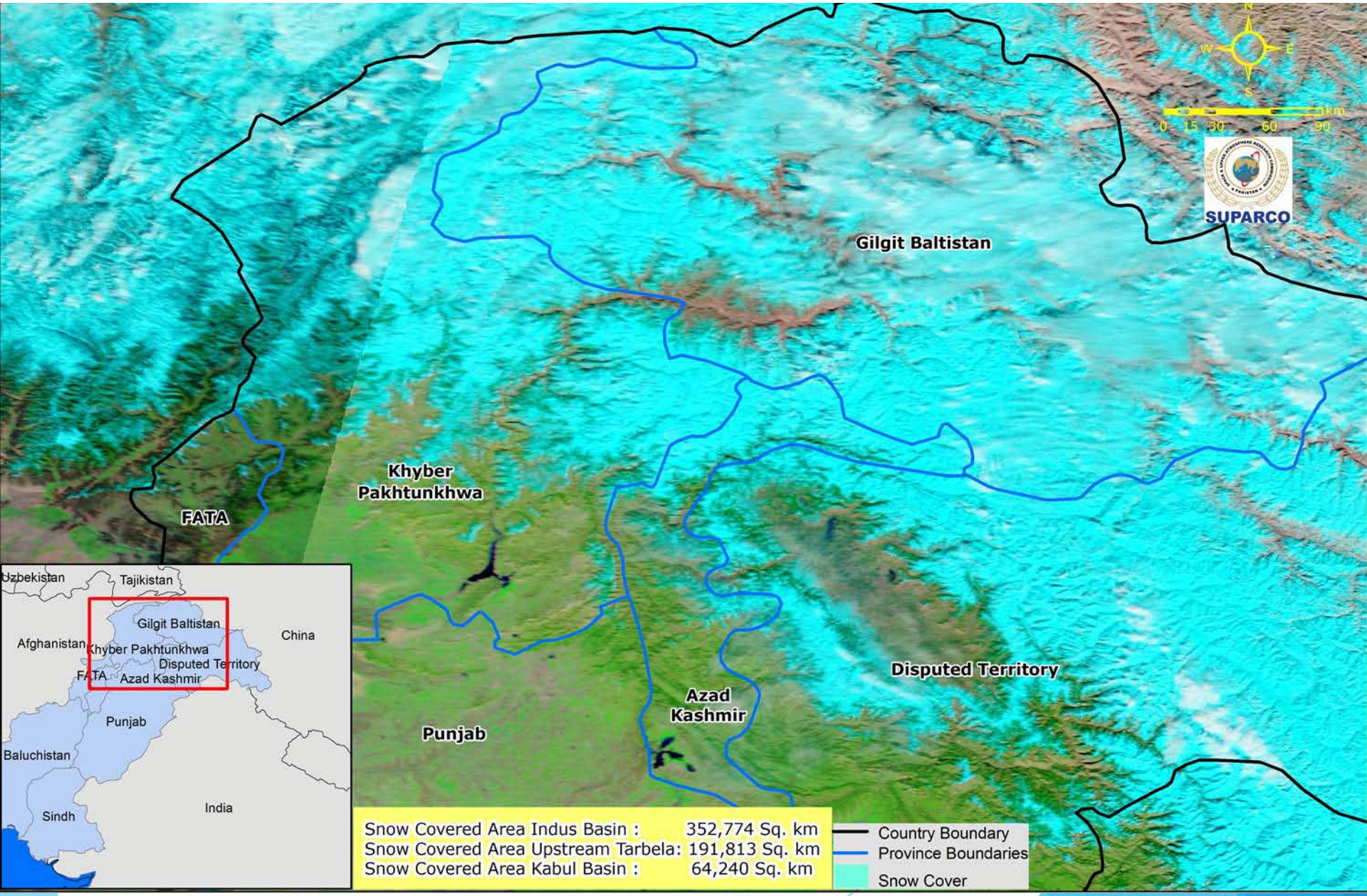
Image Acquisition: Jun 2013


Estimation of Snow Cover During
2008-2013
(Indus Basin)

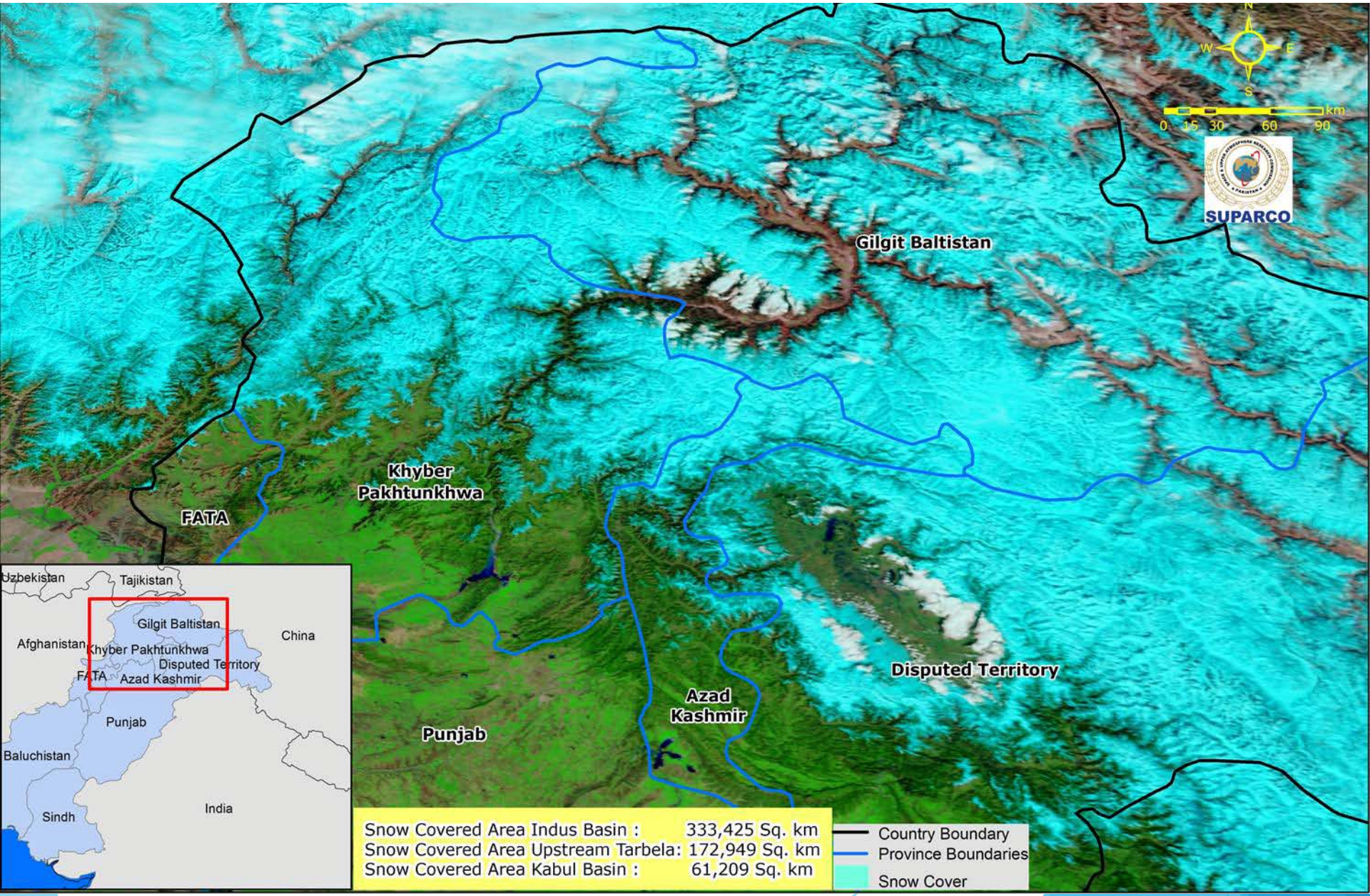
Snow Cover Extent – 02 Jan 2013



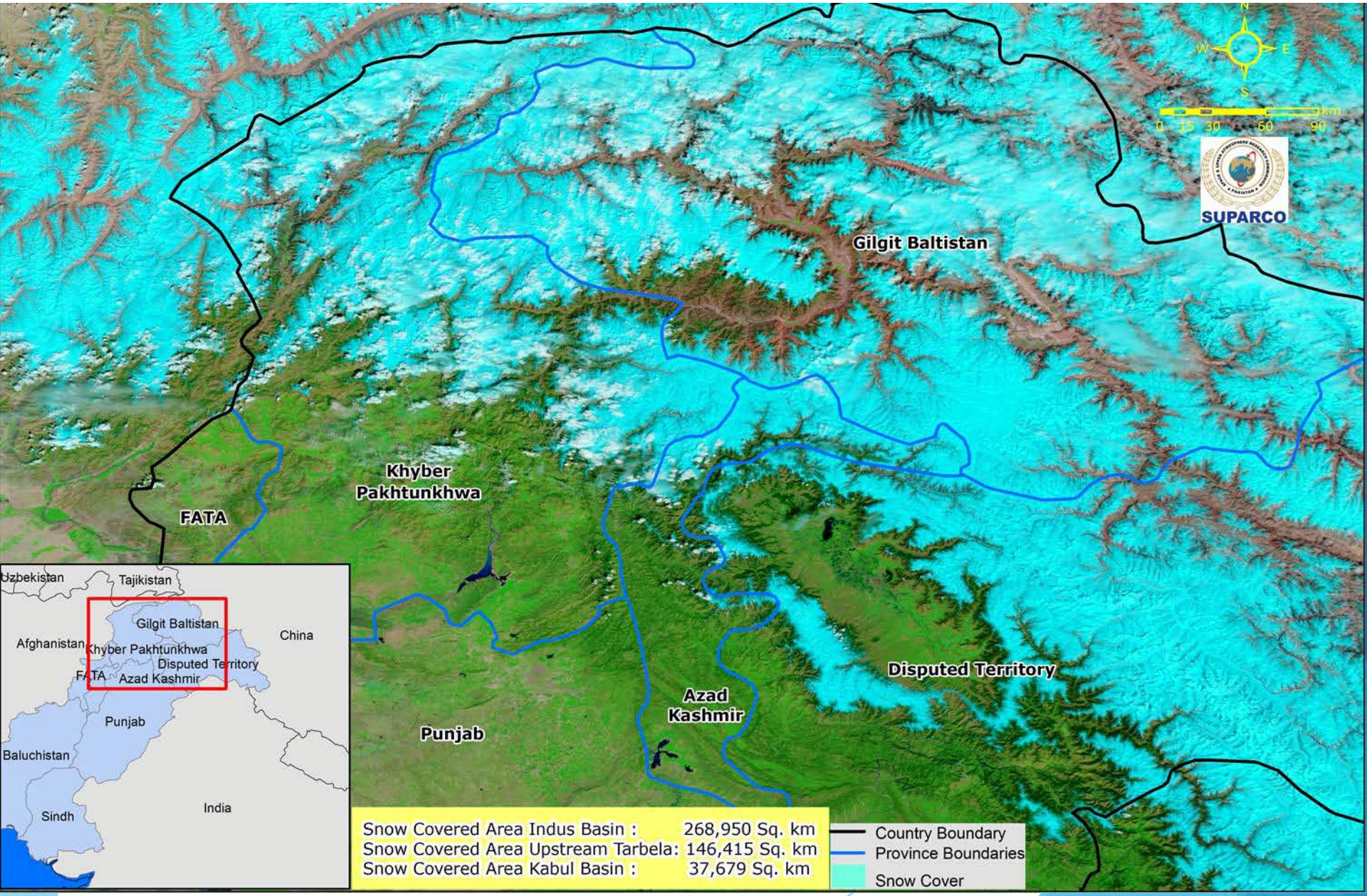
Snow Cover Extent – 09 Feb 2013



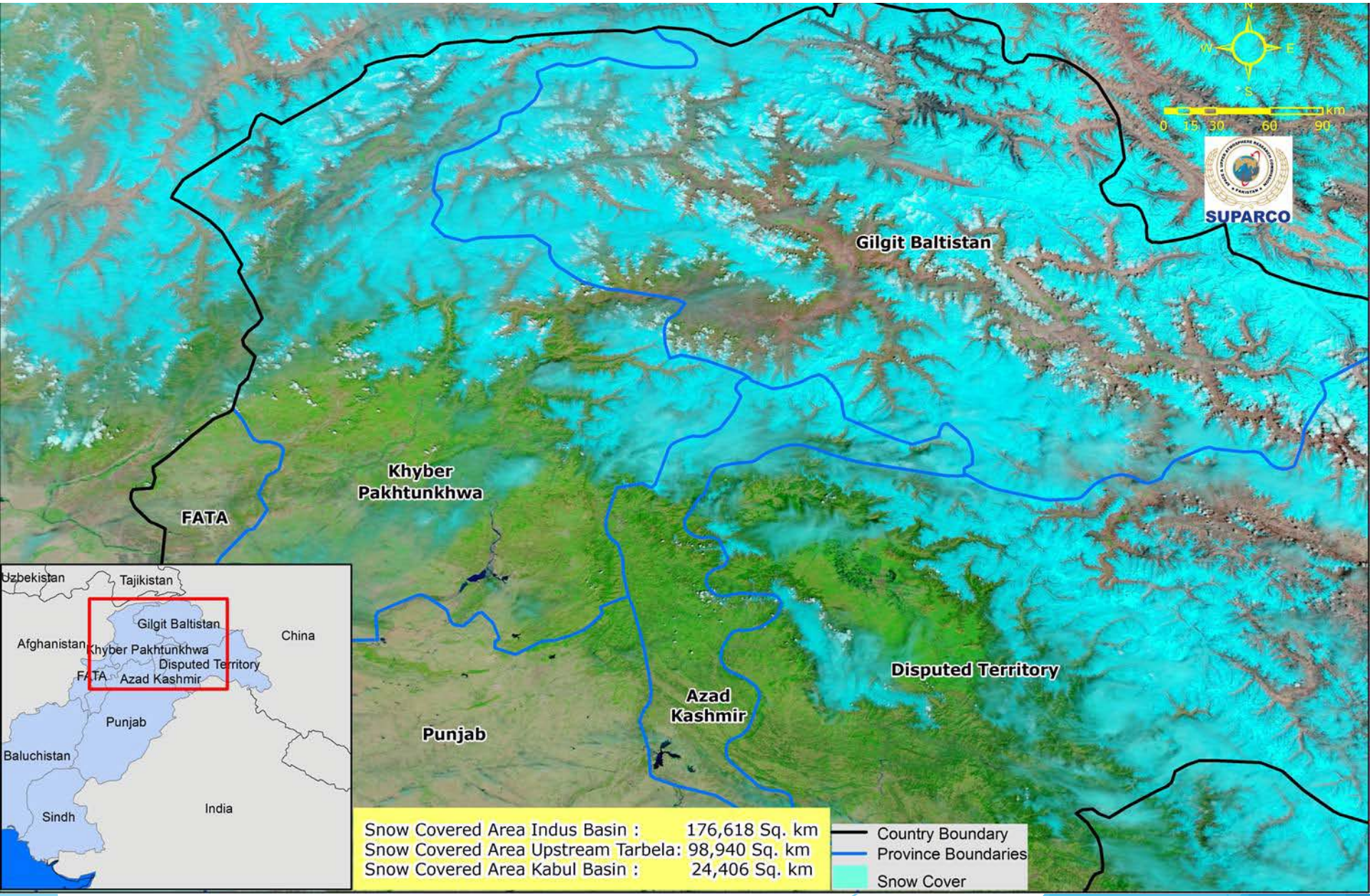
Snow Cover Extent – 01 Mar 2013



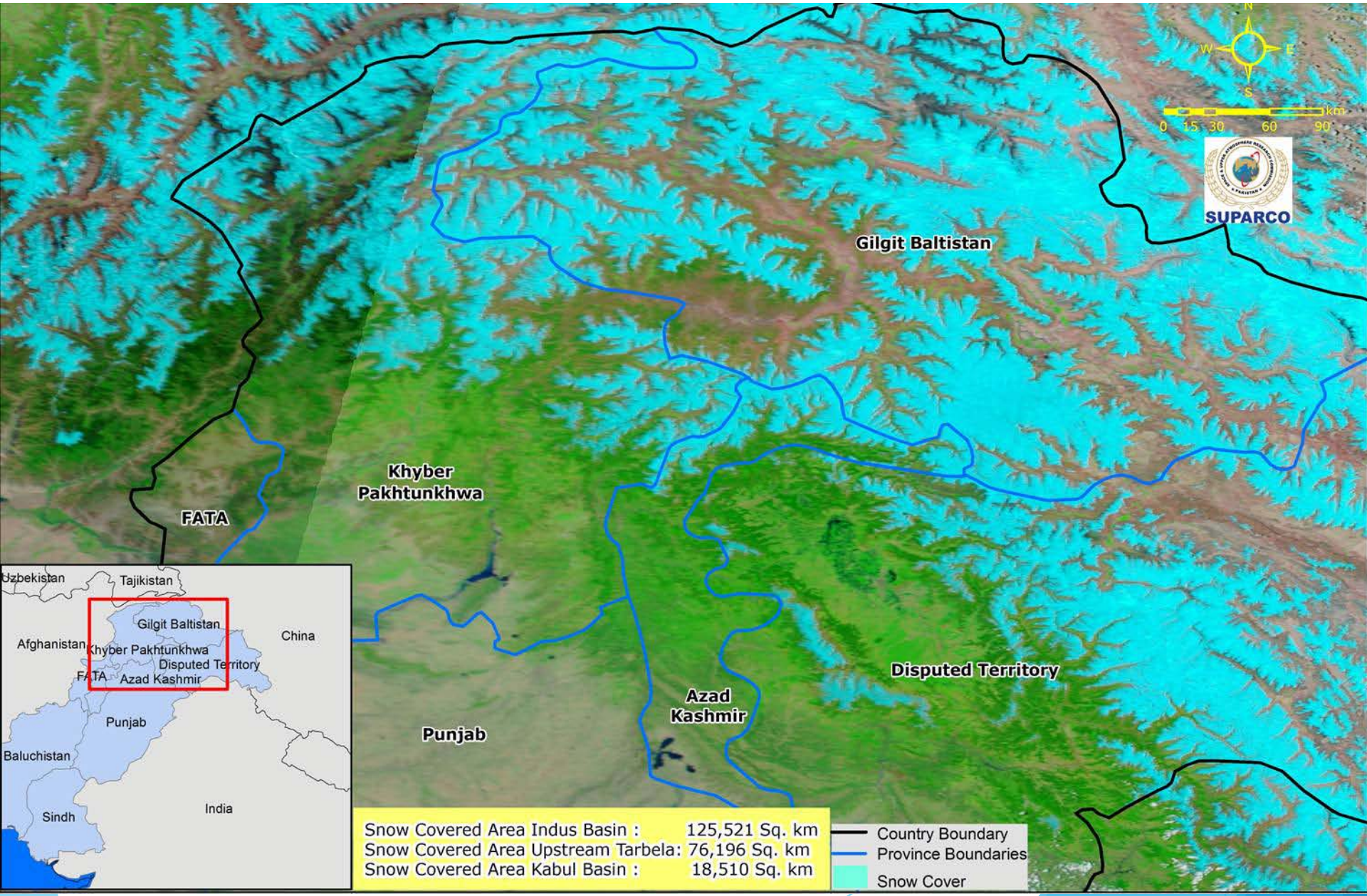
Snow Cover Extent – 06 Apr 2013



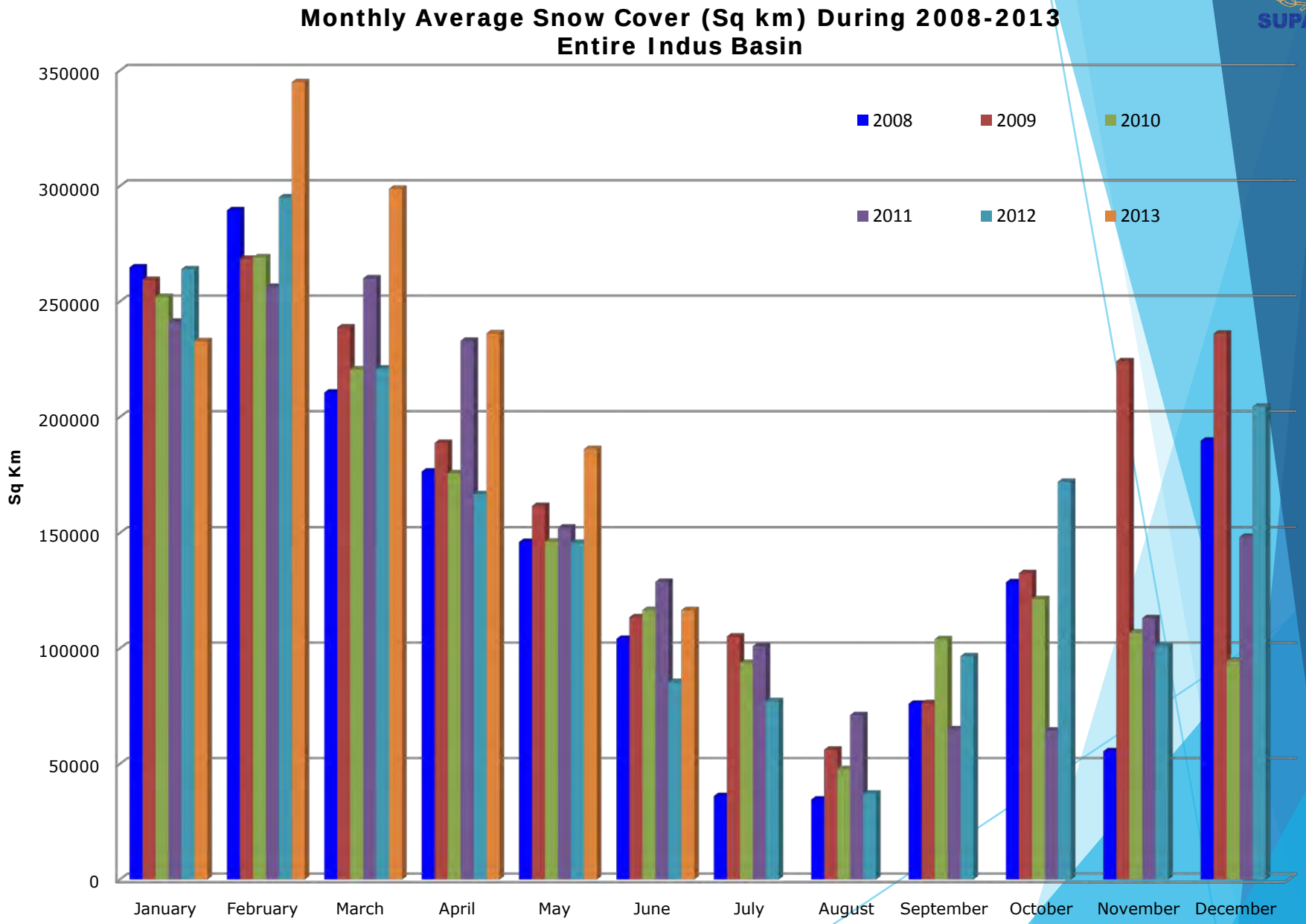
Snow Cover Extent – 10 May 2013



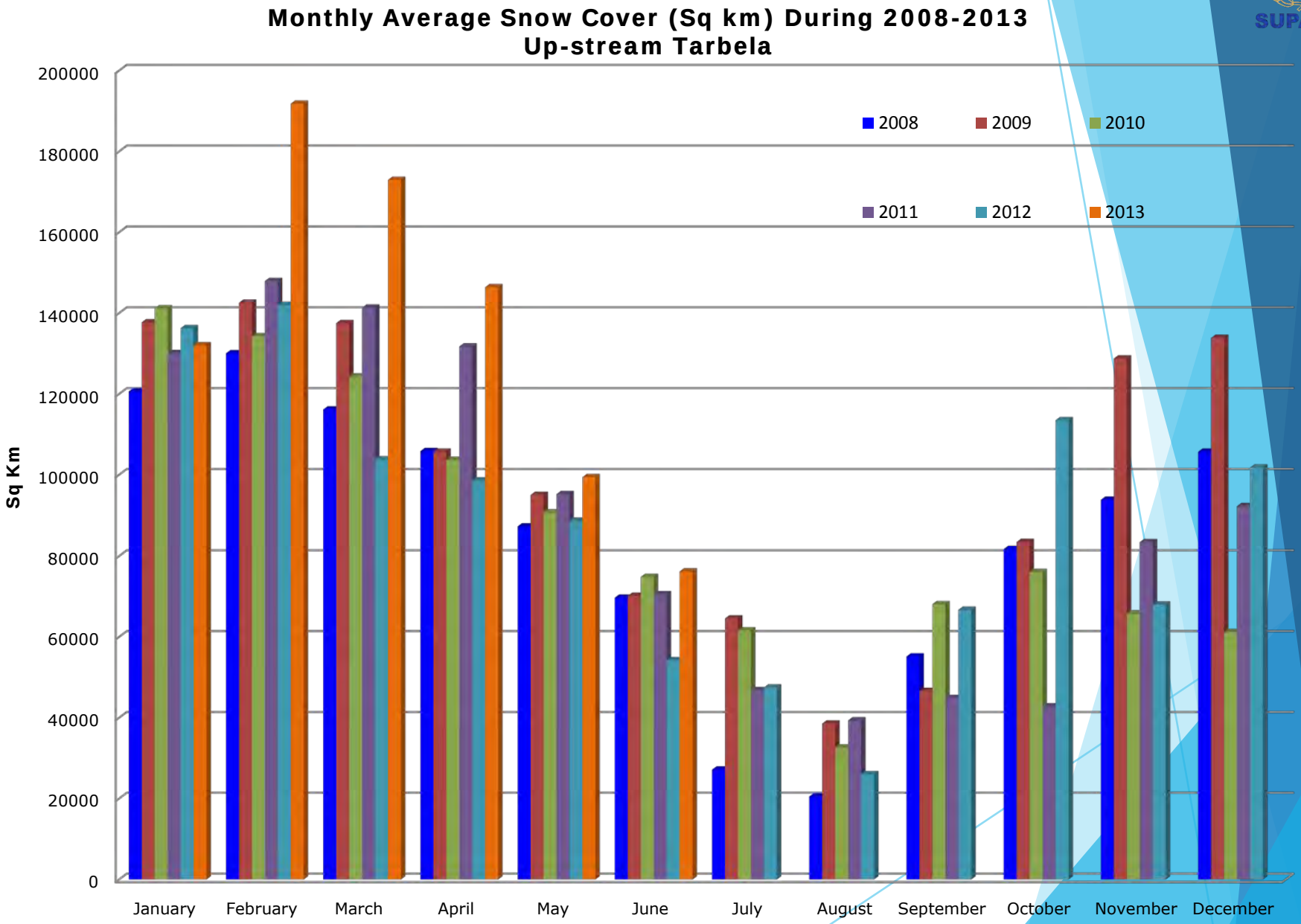
Snow Cover Extent – 01 Jun 2013



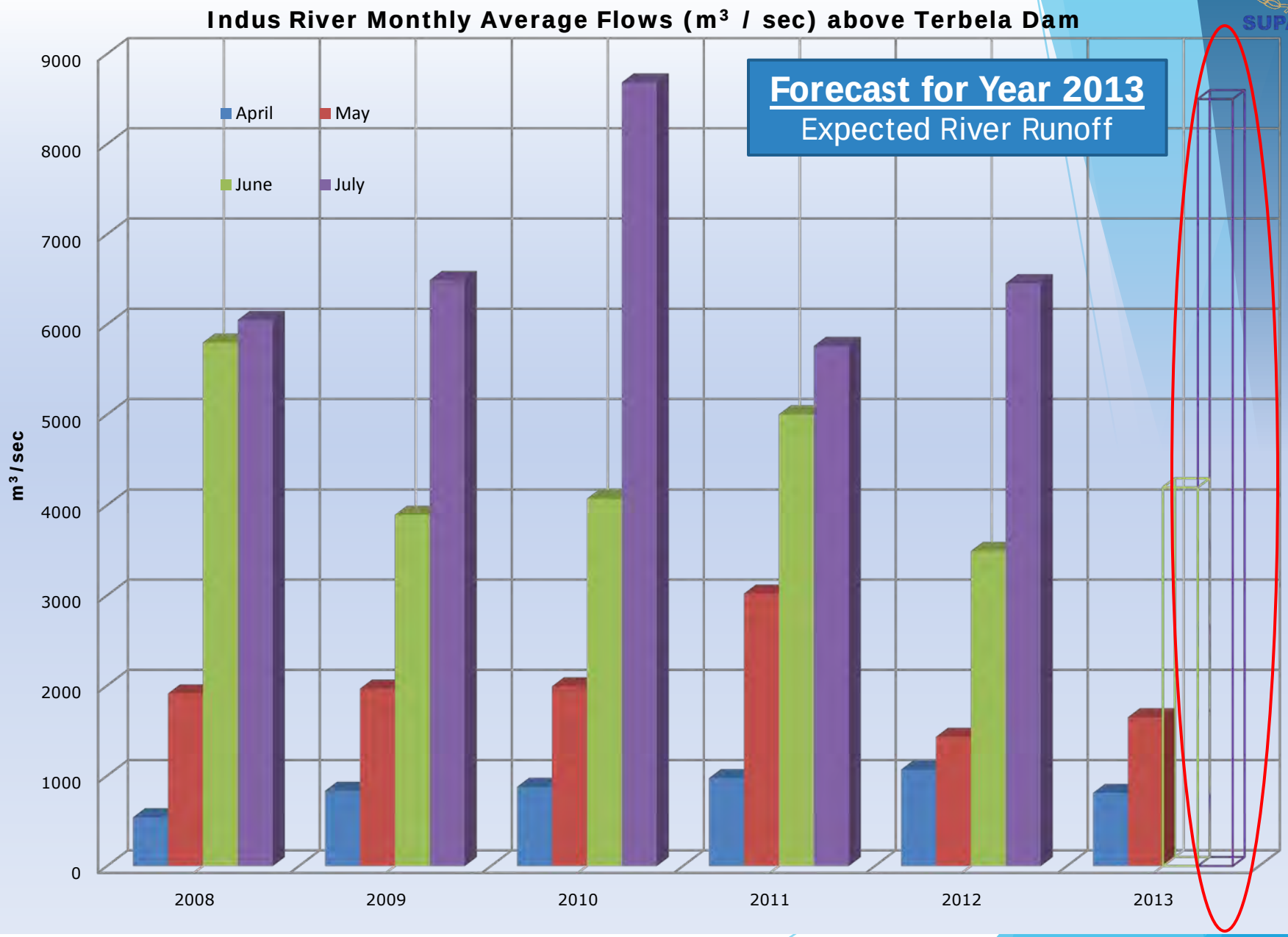
Snow Cover


Monthly Average Snow Cover (Sq km) During 2008-2013
Entire Indus Basin
Sq Km
350000
300000
250000
200000
150000
100000
50000
0
2008
2009
2010
2011
2012
2013
January
February
March
April
May
June
July
August
September
October
November
December

Snow Cover


Monthly Average Snow Cover (Sq km) During 2008-2013
Up-stream Tarbela
Sq Km
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
2008
2009
2010
2011
2012
2013
January
February
March
April
May
June
July
August
September
October
November
December

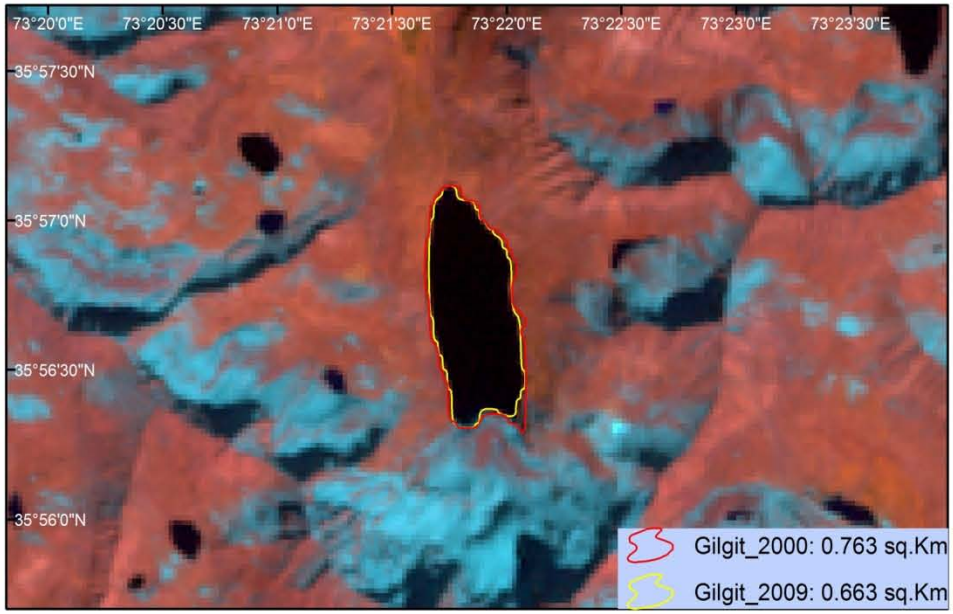
Snow Cover

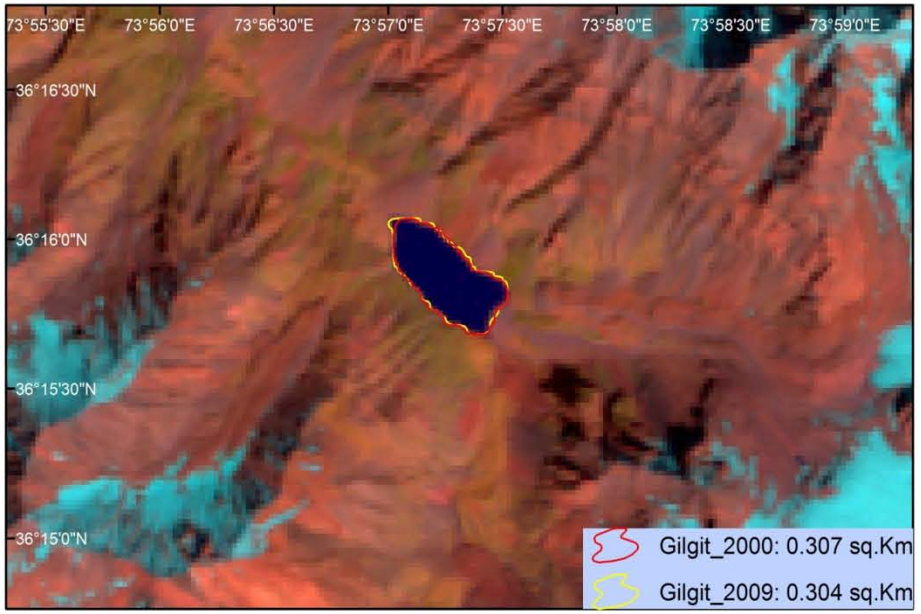

Indus River Monthly Average Flows (m³ / sec) above Terbela Dam
Forecast for Year 2013
Expected River Runoff
April
May
June
July
m³/sec
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2008
2009
2010
2011
2012
2013

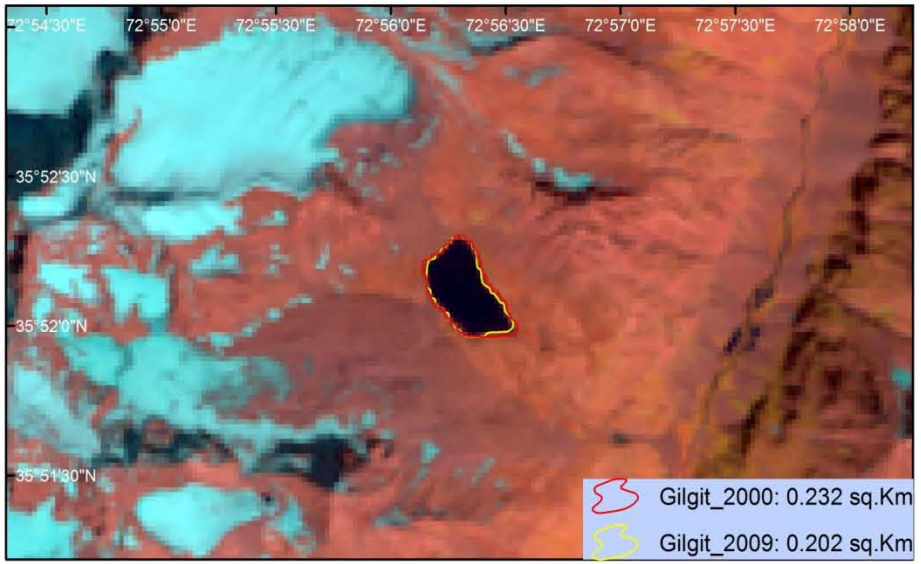
Glaciers and Glacial Lakes Study

- ✓ Development of a digital database/inventory of glacial lakes using the satellite data
- ✓ Inventory of Glacial Lakes
- ✓ There are more than 5218 Glaciers in HKH and 2400 *plus* Glacial Lakes
- ✓ Identification of existing hot spots and potentially vulnerable glacial lakes
- ✓ Identification of areas prone to glacial lake formation

Glacial Lakes of Gilgit River Basin (Sept 2000 & 2009)







Map Scale
1:30,000

N
W
E
S

SUPARCO

Pakistan Space & Upper Atmosphere Research Commission

0 5 10 20 30 40 50
Kilometers

Contribution of SUPARCO in:

Preparedness

- Nation-wide baseline data (LULC)
- Rapid mapping
- R&D in Flood Early warning system (I-IFAS)
- Flood-prone area mapping
- River bank erosion
- Monitoring snow-melt

Rescue and Early Recovery

- Timely dissemination of information to line agencies
- Flood monitoring
- Rapid Damage assessment
- 2D, 3D visualization

Reconstruction & Rehabilitation

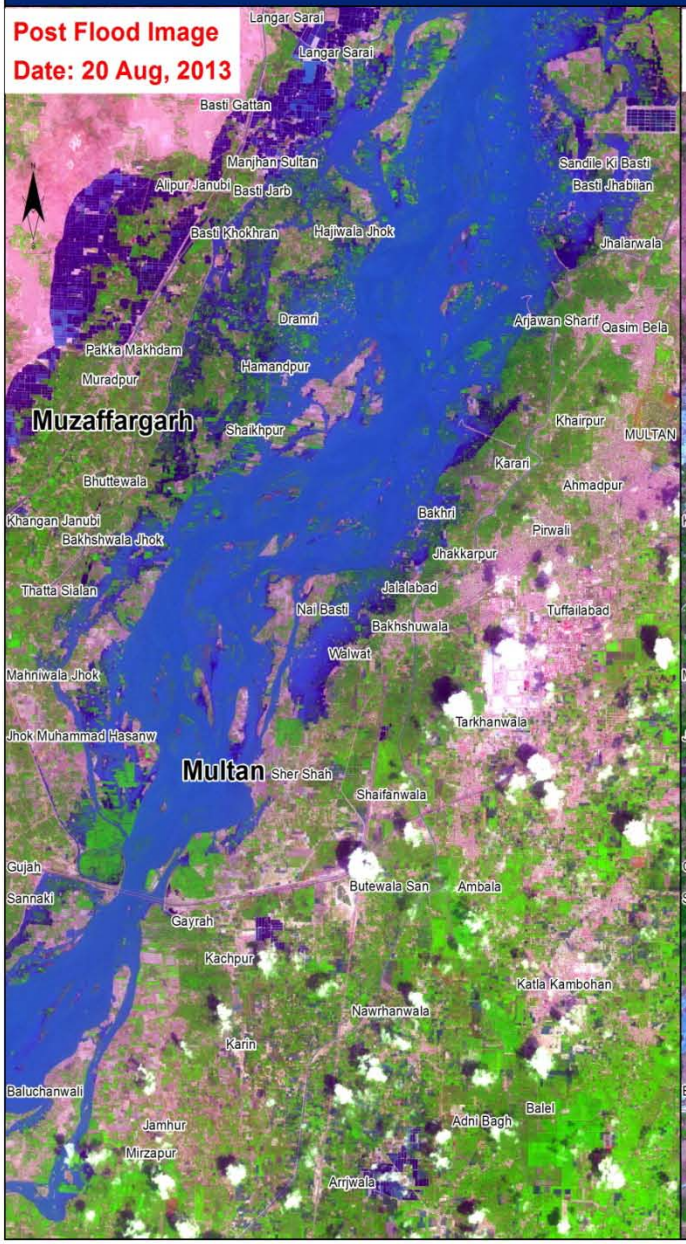
- Detailed damage assessment
- Monitoring of reconstruction and rehabilitation activities
- Studying & improving preparedness

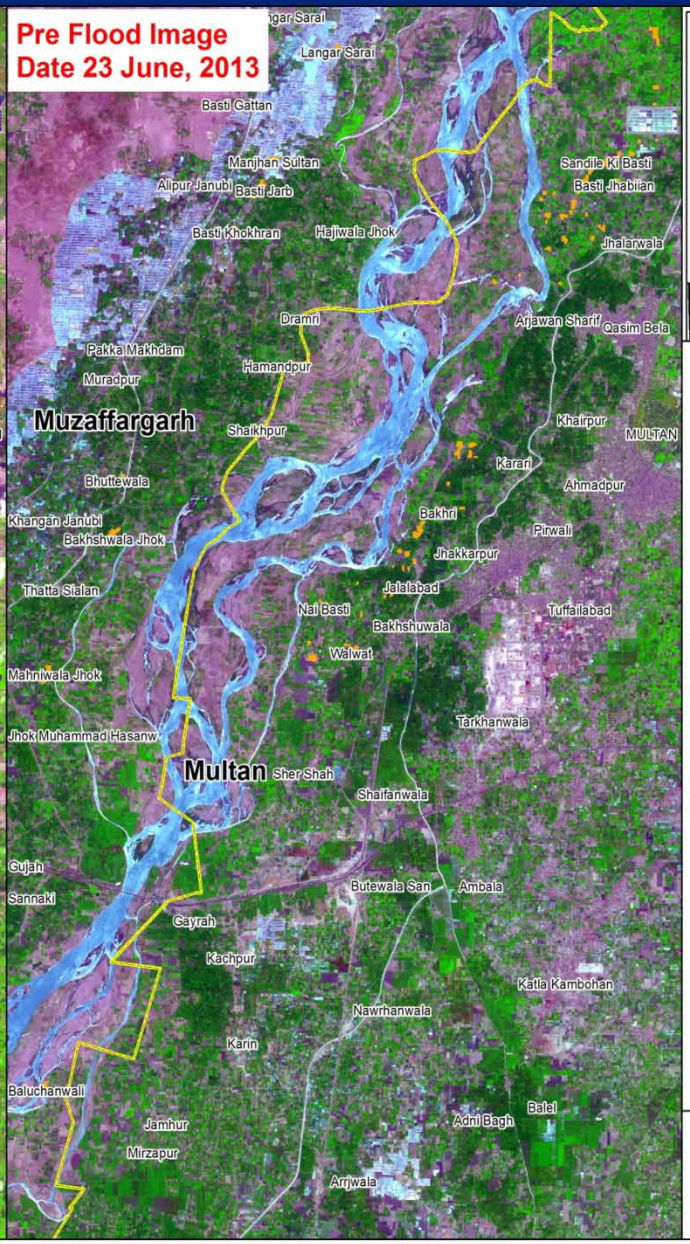
Multi-Sector Initial Rapid Assessment Tool

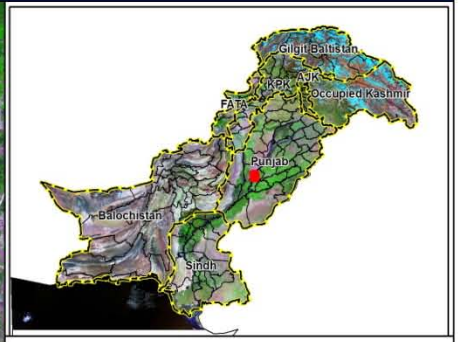
MIRA Process & Timeframe

- Secondary Data – within 72 hours
  - Situation overview
    - Satellite imagery and maps showing extent of damages –UNOSAT, SUPARCO
    - District Profiles available – Govt. Data
    - **District Baseline data and MIRA District Checklist – Govt.**
- Primary Field Assessment – within 1 week
  - Community level assessment – **KI questionnaire and Direct Observation checklist**
  - Identify needs
  - Priority areas (affected)
  - Vulnerable population

EXTENT OF RIVER CHENAB AS ON AUGUST 20,2013







District Boundary

Affected Settlement 89

Rice Fields in Pre Flood Images

Inundated Area

This map shows extent of River Chenab on August 20, 2013 as compared to June 23, 2013

This analysis is based on pre & post disaster satellite imagery collected by SPOT sensors at Satellite Ground Station,SUPARCO Islamabad. This analysis has yet to be validated in the field.

Projection: UTM Zone 42 N
Datum: WGS84

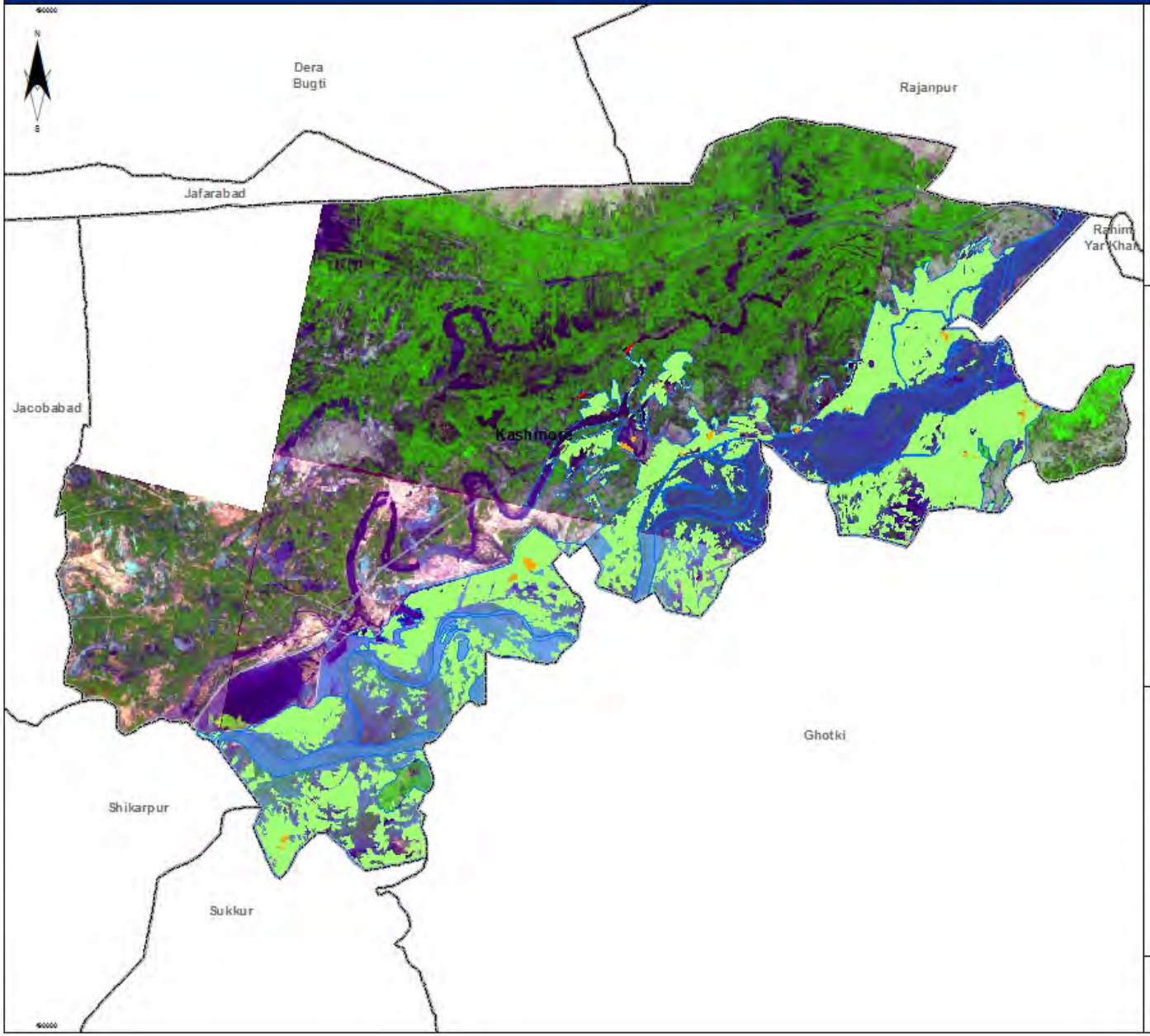
SUPARCO is host to UN-SPIDER Regional Support Office in Pakistan

0 1.5 3 6
Km

SUPARCO

KASHMORE DISTRICT FLOOD/RAIN 2013

Thematic Map - Affected Infrastructure



District Boundary		
Flooded Area	623	Sq Km

Inundated Infrastructure

National Highway	1	Km
Provincial/District Road	5.4	Km
Kacha/Paka Road	234.6	Km
Railway	1.5	Km
Bridge	0	
Settlement	48	
Agriculture Area	362	Sq Km

This map presents preliminary analysis of flood affected areas.
This analysis is based on post-disaster satellite imagery collected by SPOT sensors on 20-08-13 at Satellite Ground Station,SUPARCO Islamabad.
This analysis has yet to be validated in the field.

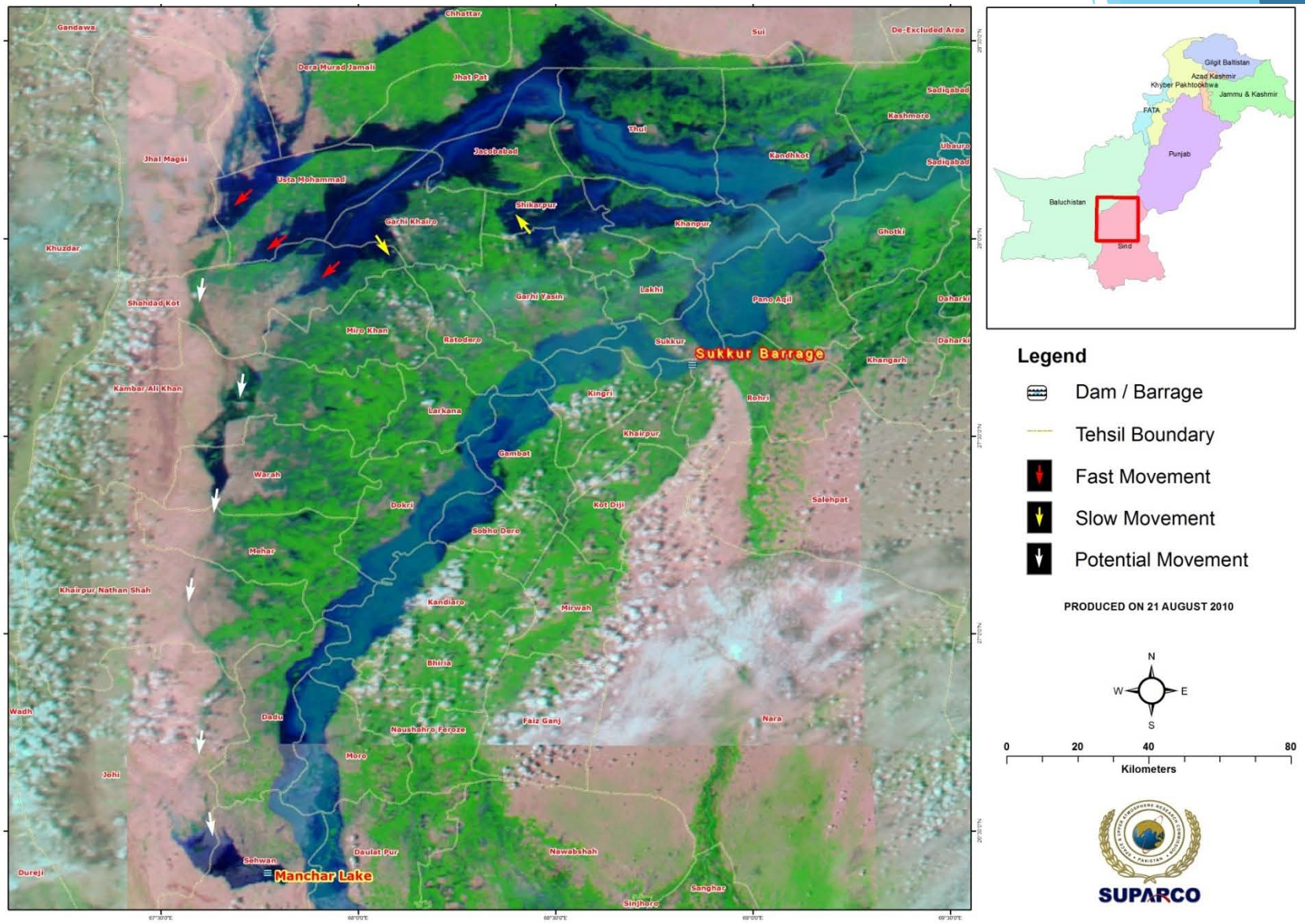
SUPARCO is host to UN-SPIDER Regional Support Office in Pakistan

Projection: UTM Zone 42 N
Datum: WGS84

0 5 10 20
Km

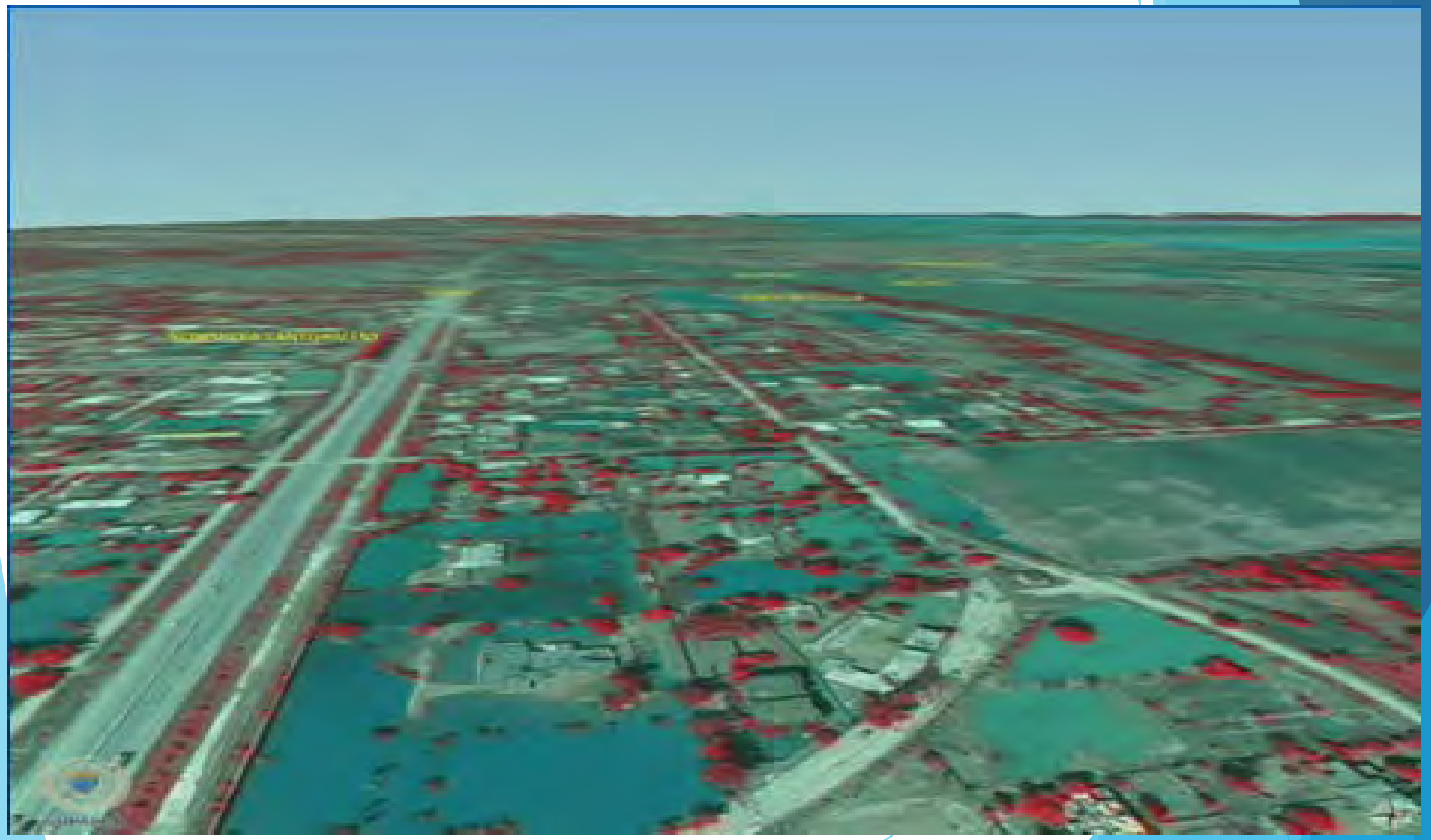
SUPARCO

Flood Flow Monitoring (Flood 2010)



Visualization

SUPARCO



Contribution of SUPARCO in:

Preparedness

- Nation-wide baseline data (LULC)
- Rapid mapping
- R&D in Flood Early warning system (I-IFAS)
- Flood-prone area mapping
- River bank erosion
- Monitoring snow-melt

Rescue and Early Recovery

- Timely dissemination of information to line agencies
- Flood monitoring
- Rapid Damage assessment
- 2D, 3D visualization

Reconstruction & Rehabilitation

- Detailed damage assessment
- Monitoring of reconstruction and rehabilitation activities
- Studying & improving preparedness

Damage and Need Assessment

- Detail Damage Assessment are carried out and reports are provided to NDMA/PDMAs for planning reconstruction and rehabilitation activities and Preparation of PDNAs
- In the wake of 2010 super flood, the World Bank and Asian Development Bank led the Damage and Need Assessment (DNA) exercise
- SUPARCO was requested by the World Bank for providing an analysis of flood related damages using satellite imagery and mapping of affected regions
- Sectors covered were housing, roads, bridges, rail, airports, agriculture and irrigation

Collaboration with Food & Agriculture Organization, FAO, UN

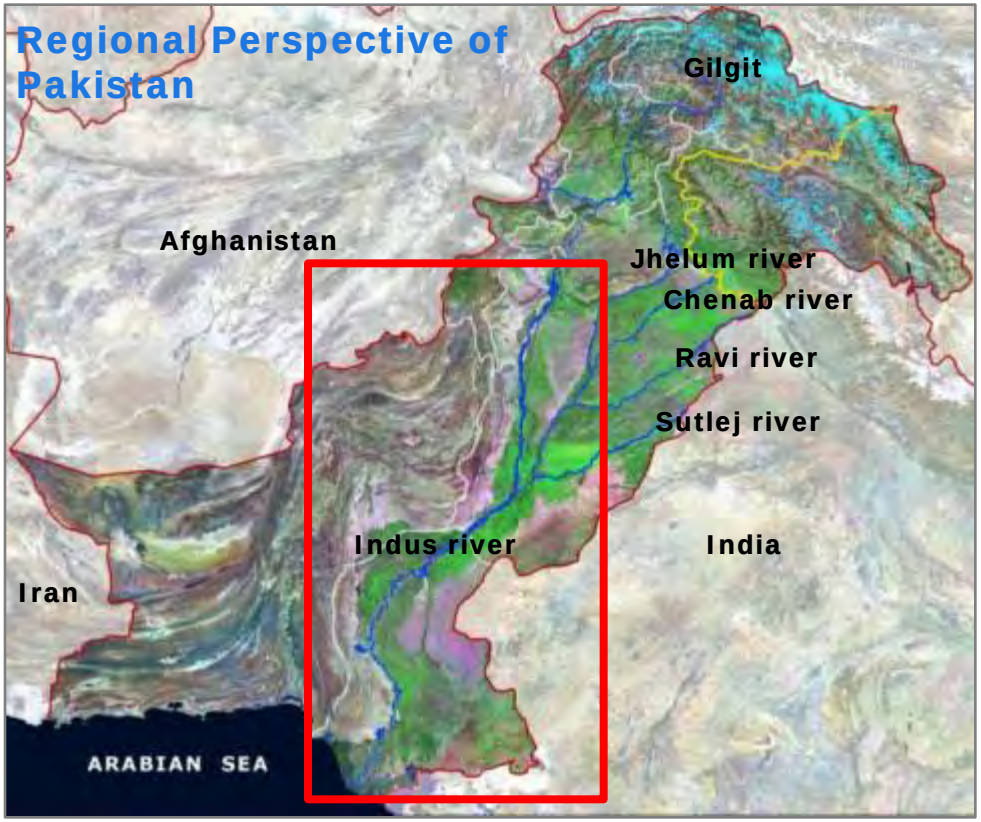
FAO, UN in collaboration with SUPARCO undertook rapid crop damage assessment in the flood affected districts. This included:

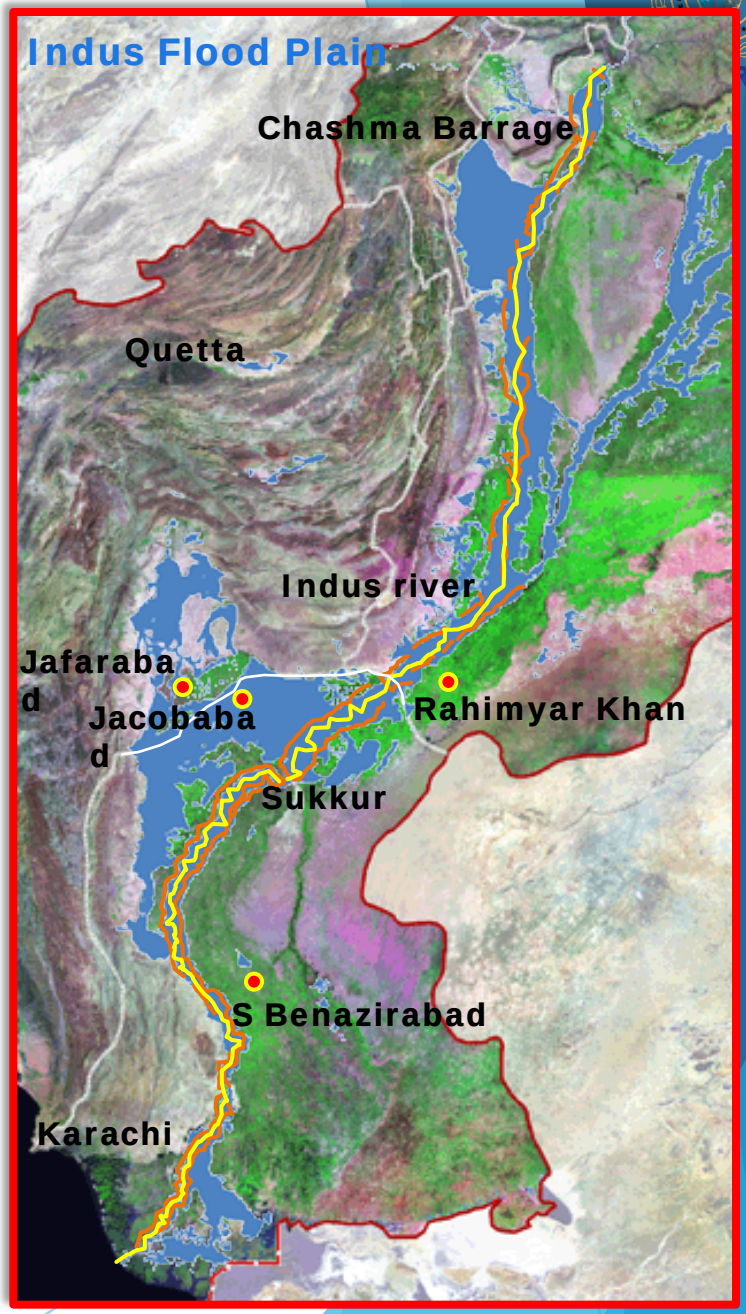
- Flooded area breakdown by crop and district
- Date of inundation of affected districts and recession
- Displaced population in the affected districts and food needs
- District-wise crops damage statistics were prepared and provided

Damage Assessment Reports

Mitigating the Effects and Beneficial Utilization of Flood Water (A Case Study – 2010 Flood)

Flood Situation 2010





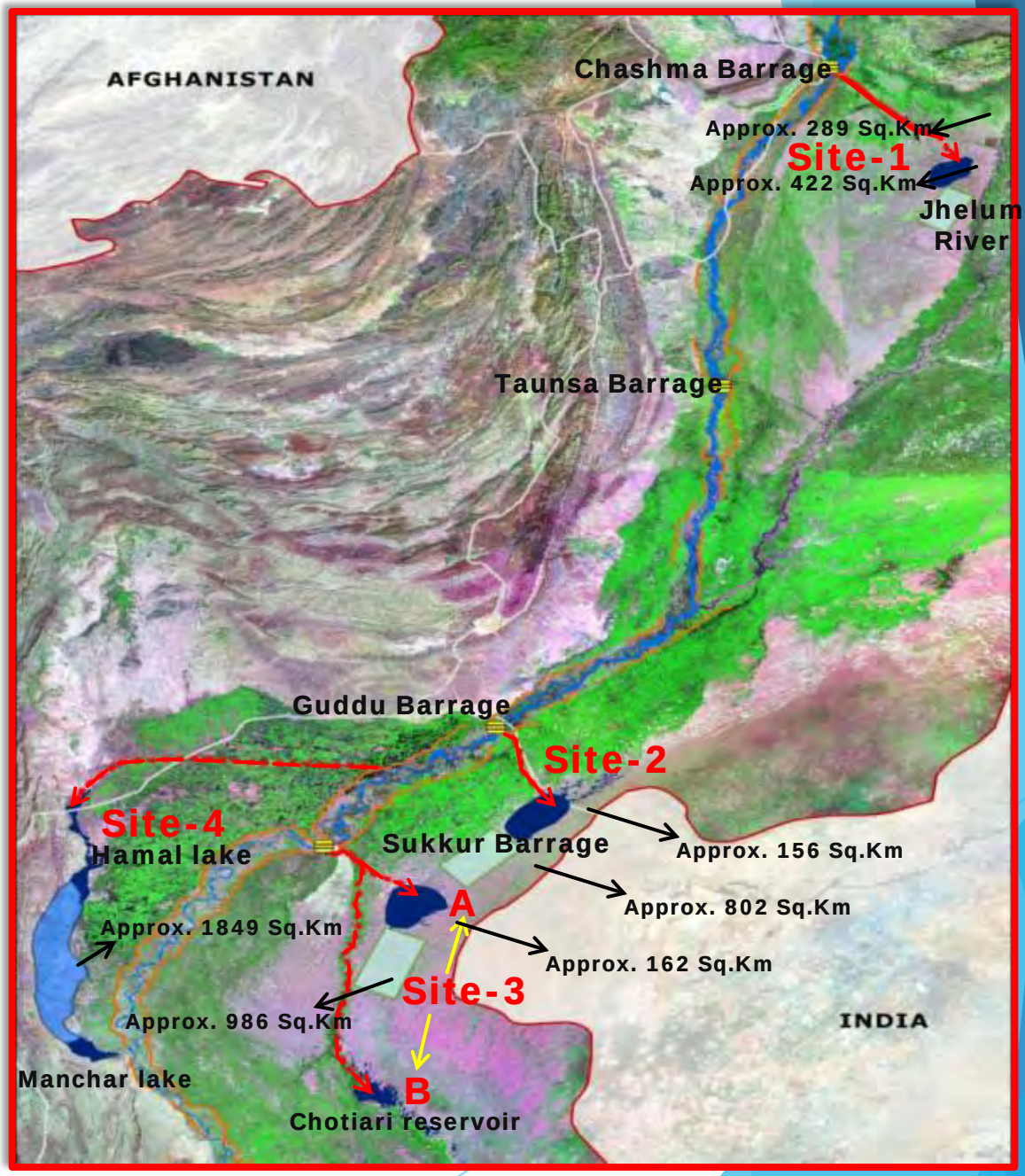
Normal flow

Embankments

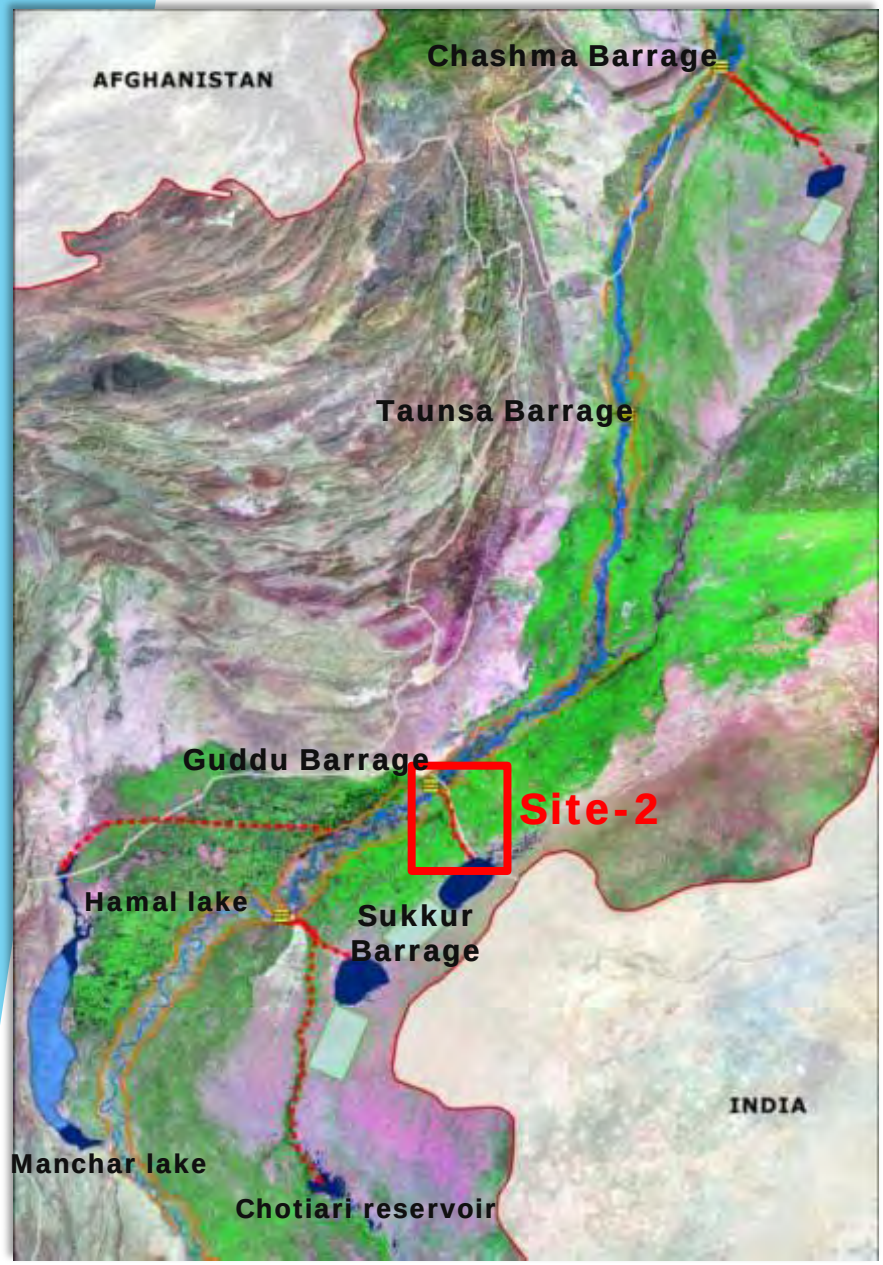
Flood /Rain water extent - 2010

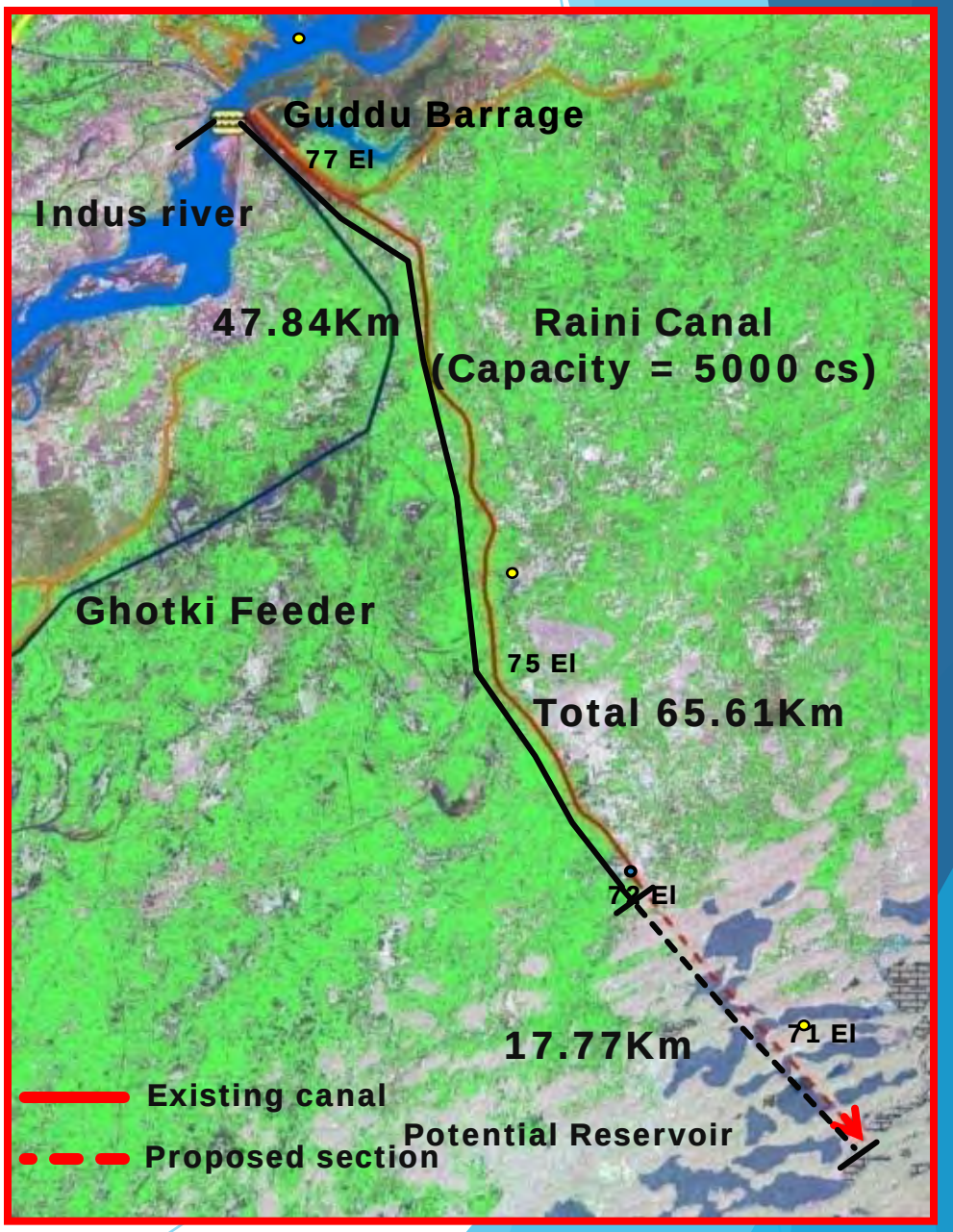
Diversion of Water

Flood and Torrential Water Storage Sites

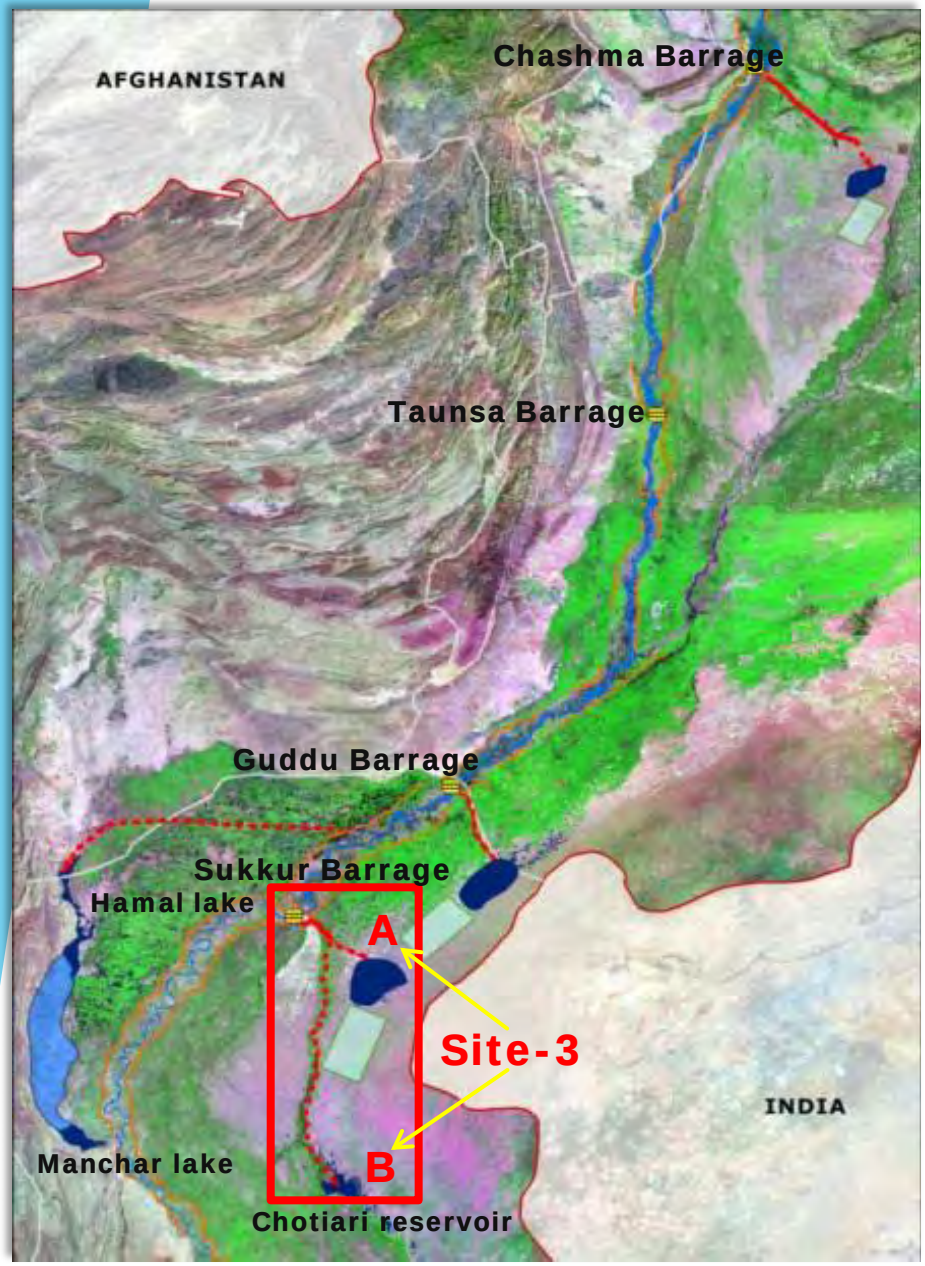


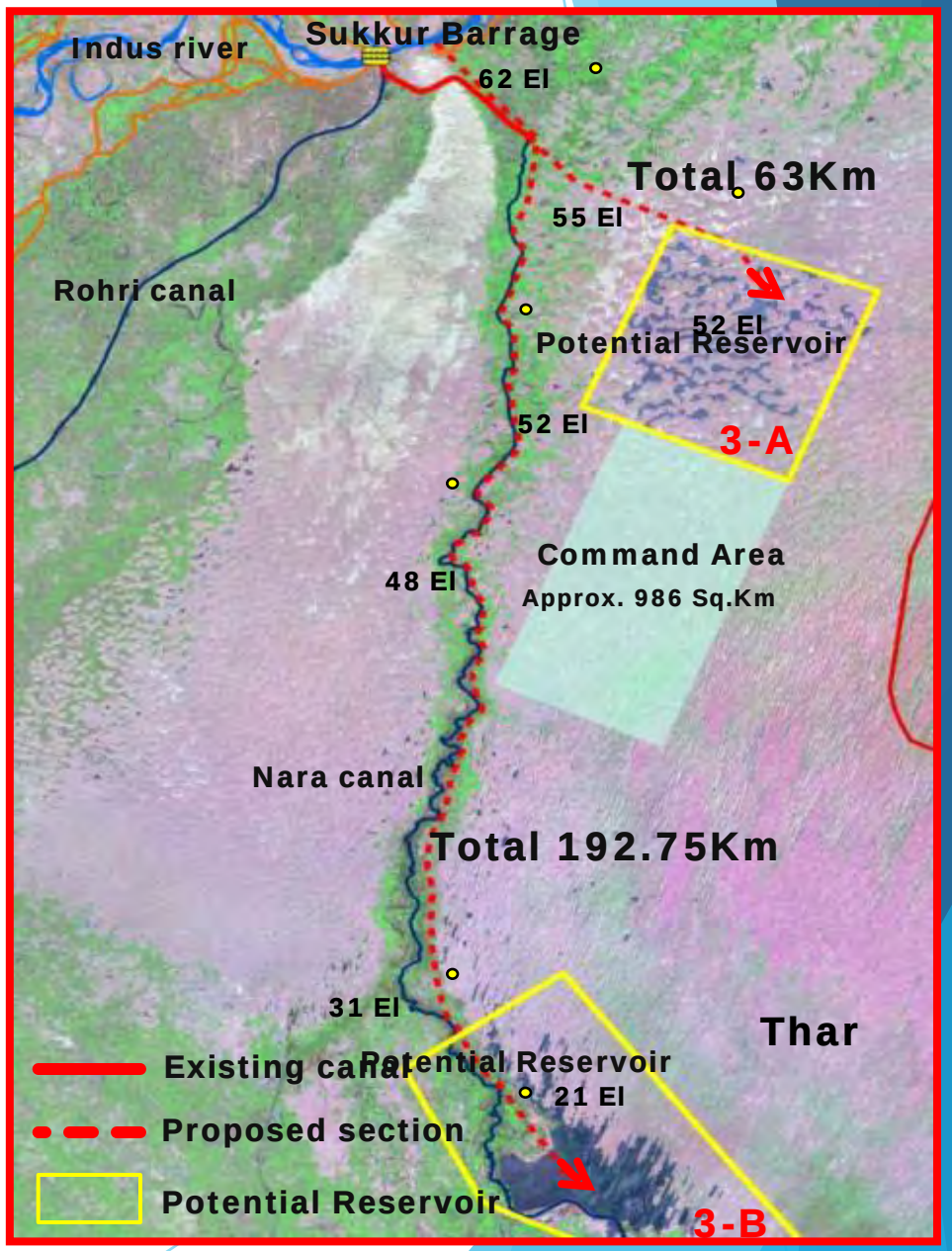
Proposed Site – 2: Guddu Barrage





Proposed Site – 3: Sukkue Barrage





Future Plans

- Preparation of inventory of Landslides for the north part of the country
- Identification and mapping of Landslide prone areas
- Identification and mapping of Earthquake Prone areas
- Preparation of Guide maps for Vulnerable Communities of the disaster prone areas
- Development of Flood model for eastern rivers of the country
- Preparation and Production of Risk Maps
- Capacity Development of NDMA and PDMAs for application of space technology for disaster management

International Cooperation in Disaster Management

International Charter Space and Major Disasters

- On Behalf of NDMA, SUPARCO has been registered with Charter as Authorized user
- SUPARCO is host to UN-SPIDER Regional Support office in Pakistan
- SUPARCO is the Member of JPT-3 of Sentinel Asia. Applied for Registration as DANs

Conclusion

- Due to consecutive floods for the last four years, we have developed expertise to mitigate the affects of floods using Remote Sensing and GIS Technology. However, we are looking forward to learn from the experiences and best practices of other countries/ organizations to improve our systems.

- We have no considerable expertise/experience in application of Space Technology for Drought monitoring or early warning and looking forward to learn from Tomorrow's sessions on the subject.

- International/bilateral cooperation among countries, regional and international organizations needs to be enhanced to better manage natural disaster mitigation and relief efforts using space technology.

- SUPARCO shall keep to support all regional and international efforts initiated for minimizing the damages and sufferings face by mankind in the event of natural disasters


Thank You