Preliminary Assessment of 2010 Flood Impacts in Pakistan: Extent and Coverage of Impacts and Adaptation Strategy

Natural Resources Division
Pakistan Agricultural Research Council

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Preliminary Assessment of 2010 Flood Impacts in Pakistan: Extent and Coverage of Impacts and Adaptation Strategy[1]

1. Analysis of River Flood Flows at Rim Stations and Barrages

The data of major Rivers of the IBIS (Indus Basin Irrigation System) were collected from various agencies and a database was developed for the period covering July 2nd 2010 to September 1st 2010. The temporal data of major Rivers was used to develop the trend line and analysis of the peak intensity and duration. The results of flood flows of major Rivers are presented and comparison is made at various Rim Stations and Barrages. The Rim Station at Indus is Tarbela, Jehlum at Mangla, Chenab at Marala, Ravi at Balloki and Sutlej at Sulemankie.

1.1. Indus River Flows at Rim Stations and Barrages

Indus Flood Flows at Tarbela, Kalabagh and Chashma

The flood flows of **Indus River** at **Tarbela, Kalabagh and Chashma** are presented in **Figure 1**. The first flood peak of 527,000 cusecs at **Tarbela** occurred on July 30th 2010. It continued for almost 48 hours with slight reduction in flood of 510,000 cusecs. In fact this peak was for four days with some further reduction starting from 29th July to 1st August. The second flood peak of 526,000 cusecs occurred on August 10th 2010, which also continued for three days with some reduction in flows.

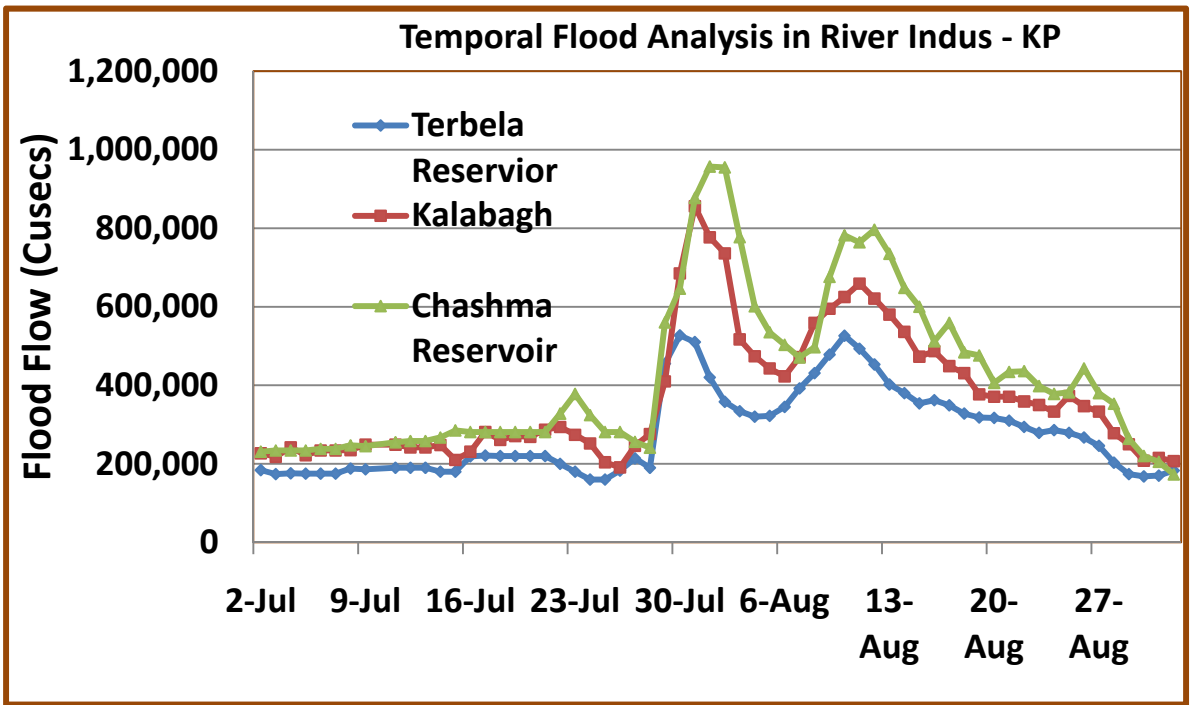


Figure 1. Flood flows of Indus River at Tarbela, Kalabag and Chashma during July-August 2010

[1] ***The Report is based on the work done by the Team of NRD: Dr. Shahid Ahmad, Dr. Bashir Ahmad, Irfan Ali, Imran Ahmad, Naveed Mustafa, Tariq Mustafa, P. M. Moshabbir, Arshad Ashraf, Rozina Naz, Mohammd Afzal.***

The first flood peak of 856,000 cusecs at **Kalabagh** occurred on July 31st 2010. It continued for almost 72 hours with slight reduction in flood. The second flood peak of 659,000 cusecs occurred on August 11th 2010, which also continued for four days with some reduction in flows.

The first flood peak of 957,000 cusecs at **Chashma** occurred on August 1st 2010. It continued for almost 72 hours with slight reduction in flood. The second flood peak of 796,000 cusecs occurred during August 10-13 2010, which also continued for four days with some changes in flows.

The important point to consider is that peak flood flows continued upto 96 hours with slight changes in flows, which shows that there were rapid runoff to the river system and longer peaks were largely due to prolonged rainfall in the catchment areas. This is a clear indication that prolonged rainfalls of higher intensity coupled with degraded watershed conditions resulted in prolonged flood peaks. There is a misperception that it is the only degraded watershed conditions which resulted in prolonged peaks, which is not true. Because watershed yield is a combination of erosivity of rainfall, its duration and quantity, which is the major factor contributed in prolonged peaks for the Indus River at Tarbela, Kalabagh and Chashma.

Indus Flood Flows at Taunsa, Guddu and Sukkur Barrages

The flood flows of **Indus River** at **Taunsa, Guddu and Sukkur** are presented in **Figure 2**. The first flood peak of 794,000 cusecs at **Taunsa** occurred on August 2nd 2010. It continued for almost 5 days with slight reduction in flood. The second flood peak of 777,000 cusecs occurred during 11-15August 2010, which also continued for five days with some changes in flows.

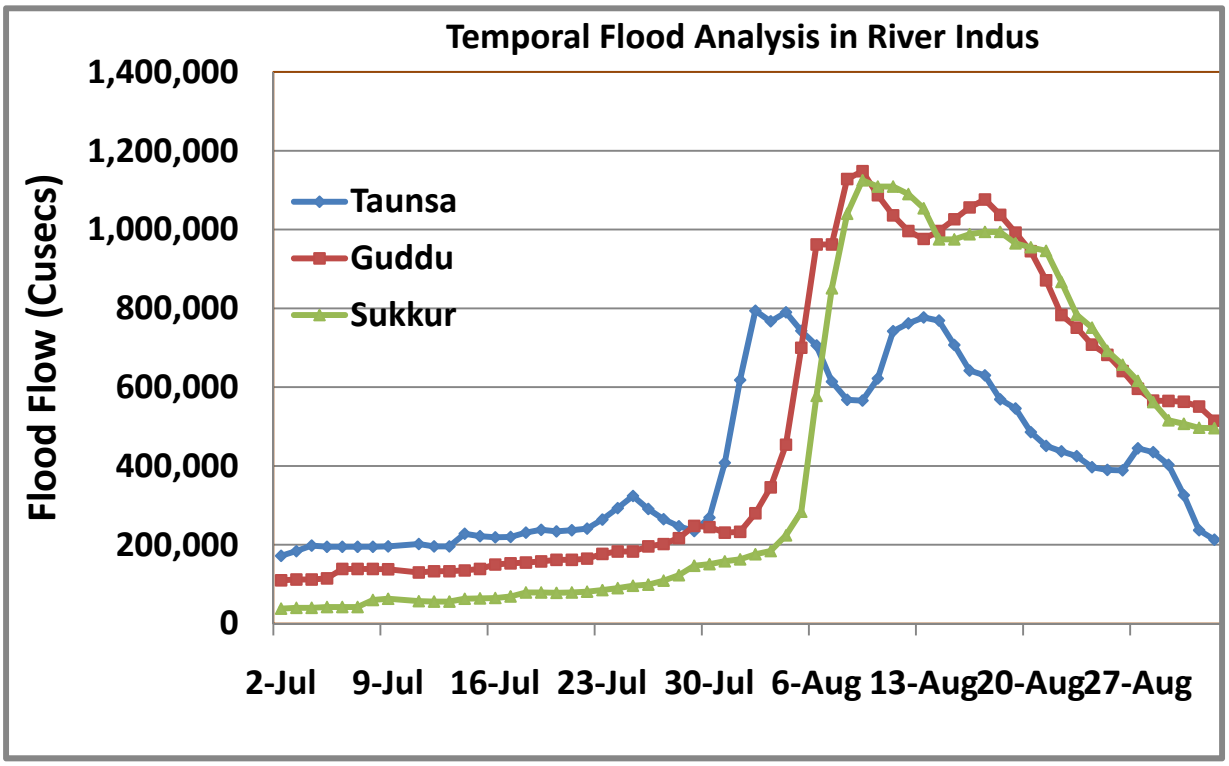


Figure 2. Flood flows of Indus River at Taunsa, Guddu and Sukkur during July-August 2010

The first flood peak of 1148,000 cusecs at **Guddu** occurred during August 8-18 2010. It continued for almost 11 days with slight changes in flood. Although the flood situation prevailed but there was a continued decline up till September 1st 2010.

The first flood peak of 1125,000 cusecs at **Sukkur** occurred during August 8-18 2010. It continued for almost 11 days with slight changes in flood. Although the flood situation prevailed but there was a continued decline up till September 1st 2010.

The situation of extremely prolonged peak of over 11 days is a clear indication that there is neither capacity in the IBIS for flood attenuation nor it was practiced, even if there is any possibility of managing the flows to attenuate flood peaks in the IBIS. The obvious reason is the lack of adequate storage upstream or downstream of Tarbela to attenuate the flood peak. The Sindh province has experienced the worst floods of history because the country was not able to develop any storage on Indus Main since 1976.

Indus Flood Flows at Kotri Barrage

The flood flows of **Indus River** at **Kotri** are presented in **Figure 3.** The first flood peak of 939,000 cusecs at **Kotri** occurred during August 22nd to September 1st 2010. It is still in a situation of floods. It already continued for almost 11 days with slight changes in flood. The situation after September 1st will be presented in the second Report.

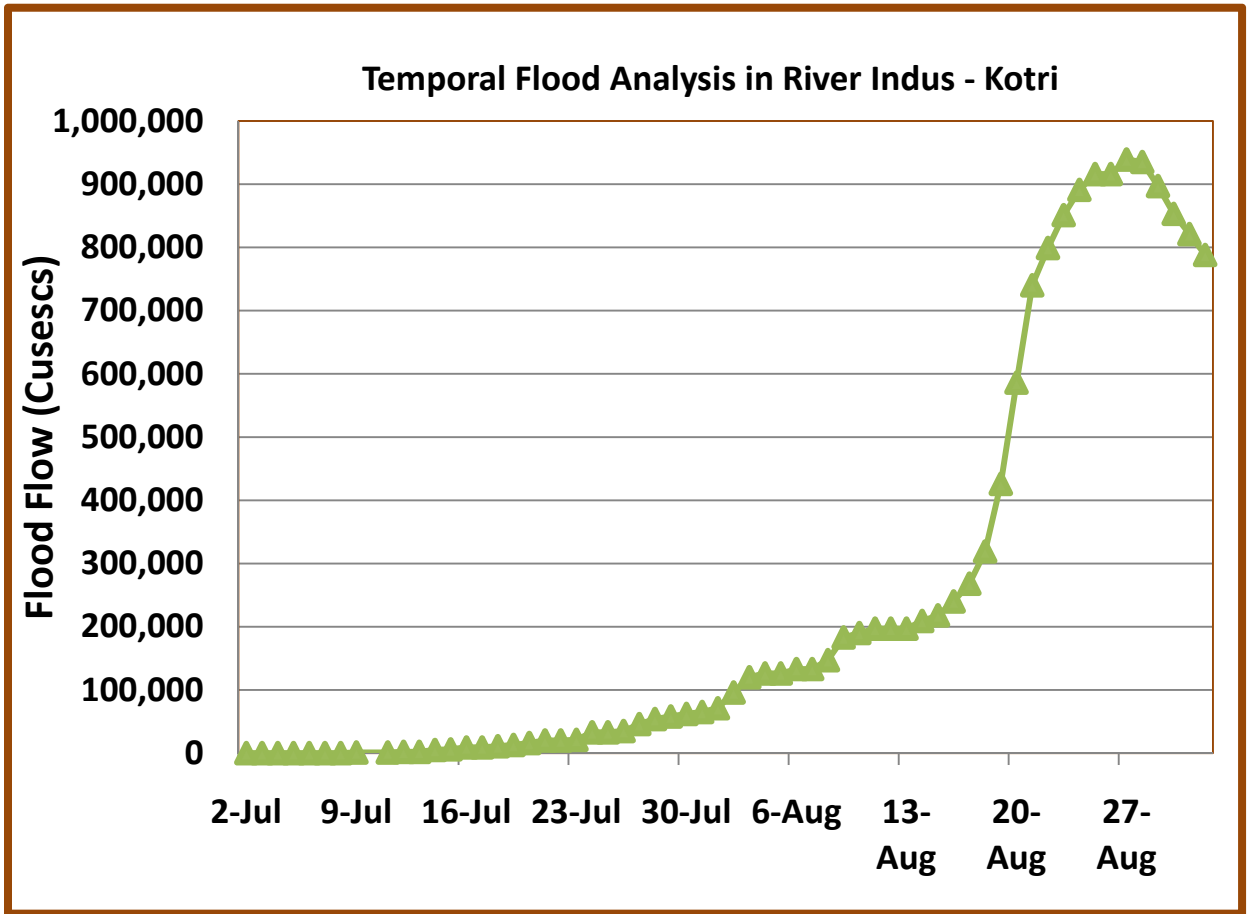


Figure 3. Flood flows of Indus River at Kotri during July-August 2010

1.2. Kabul River Flows at Rim Stations

The flood flows of **Kabul River** at **Warsak** and **Nowshera** are presented in **Figure 4**. The first flood peak of 132,000 cusecs at **Warsak** occurred during July 29-31 2010. It continued for almost 72 hours with slight reduction in flood. The second flood peak of 135,000 cusecs occurred on August 10th 2010, which also continued for two days with some reduction in flows.

The first flood peak of 187,000 cusecs at **Nowshera** occurred on July 29th 2010. There is missing data for few days therefore duration of peak could not be assessed. But there are chances that it will be in line with the flows at **Warsak**. The second flood peak of 249,000 cusecs occurred on August 8-12 2010, which also continued for five days with some changes in flows.

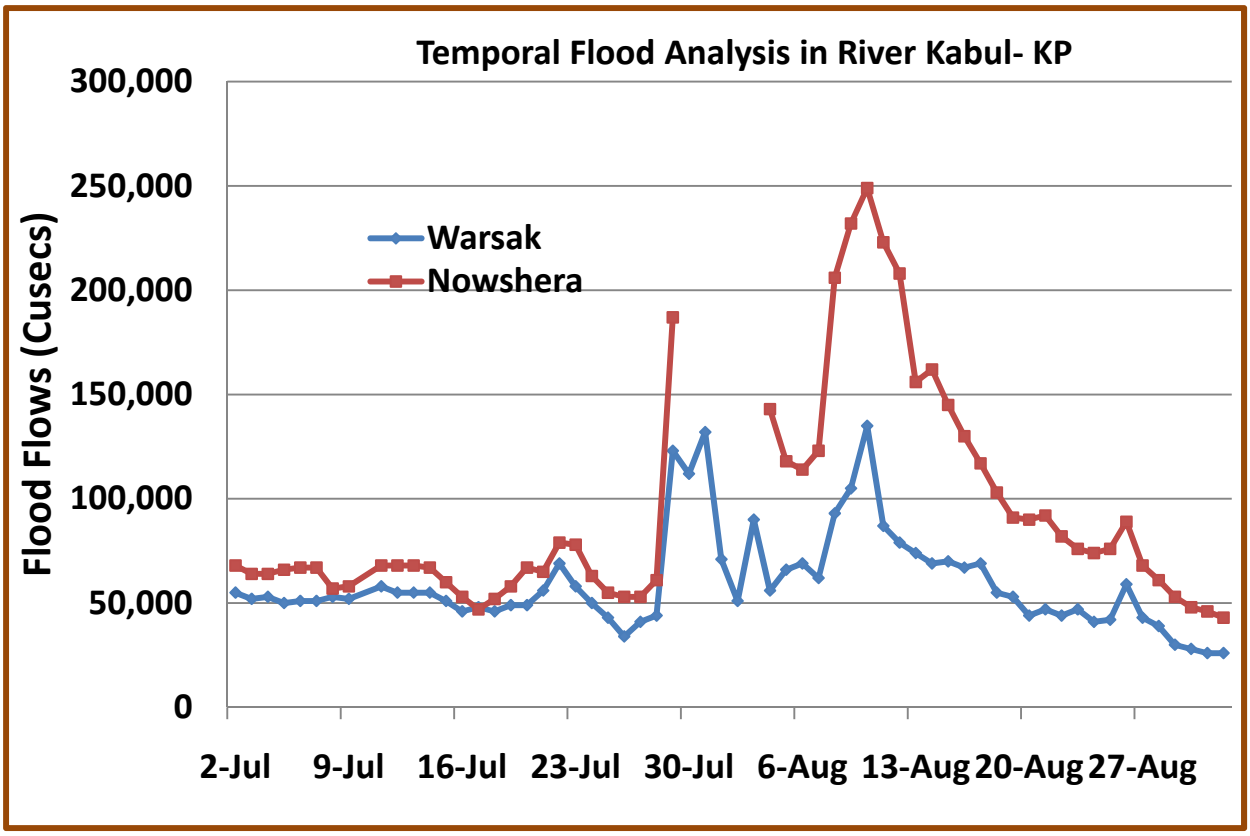


Figure 4. Flood flows of Kabul River at Warsak and Nowshera during July-August 2010

1.3. Jehlum River Flows at Rim Station and Barrages

The flood flows of **Jehlum River** at **Mangla, Rasul and Trimmu** are presented in **Figure 5**. The first flood peak of218,000 cusecs at **Mangla** occurred during July 29 to August 1st 2010. It continued for almost four days with slight reduction in flood. There was no second flood peak.

The first flood peak of 233,000 cusecs at **Rasul** occurred during July 31st to August 4th 2010. It continued for around 5 days with some changes in flood flows. There was no second peak.

The first flood peak of 323,000 cusecs at **Trimmu** occurred during August 5-13 2010. It continued for around 9 days with some changes in flood flows. There was a slight second peak of 204,000 cusecs on August 29th 2010.

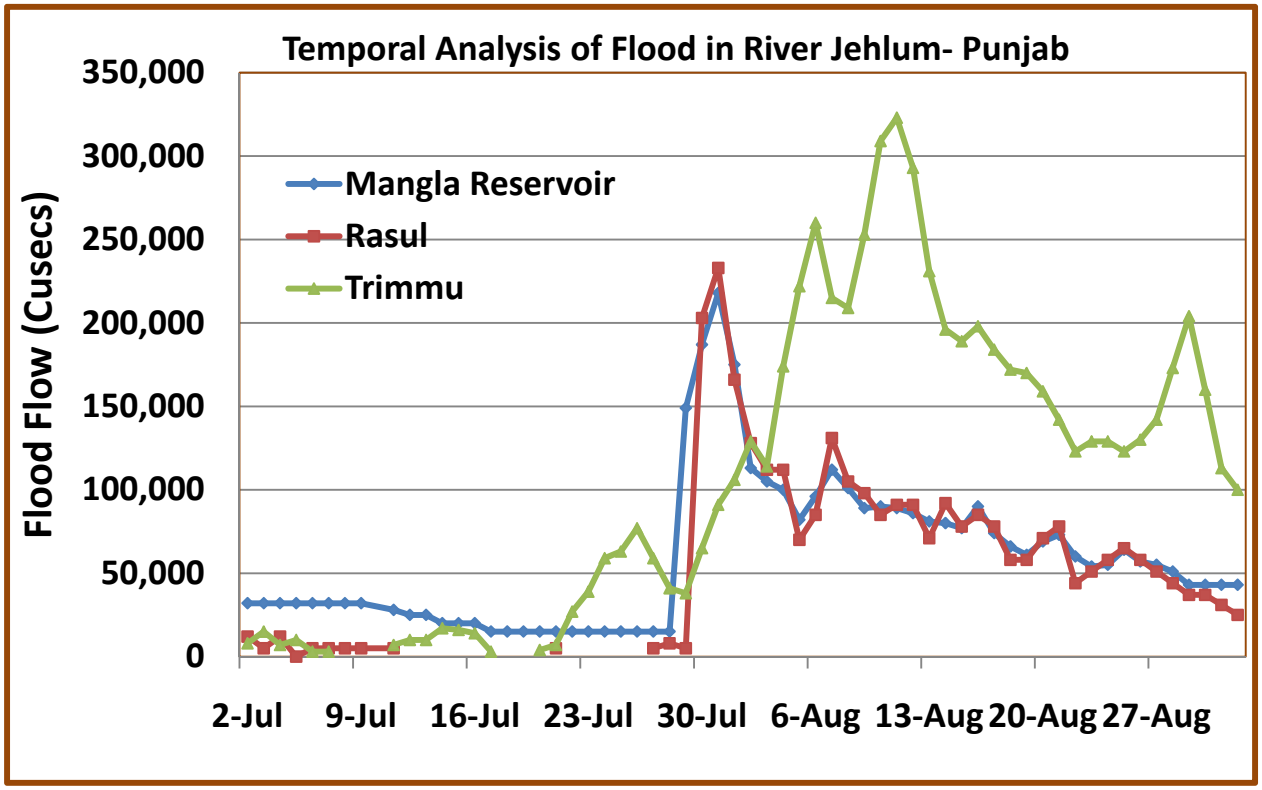


Figure 5. Flood flows of Jehlum River at Mangla, Rasul and Trimmu during July-August 2010

1.4. Chenab River Flows at Rim Station and Barrages

The flood flows of **Chenab River** at **Marala, Khanki and Qadirabad** are presented in **Figure 6**. The first flood peak of 187,000 cusecs at **Marala** occurred on July 28th 2010. It continued for almost three days with reduction in flood. The second peak of 177,000 cusecs occurred on August 7th 2010, which continued for around 24 hours.

The first flood peak of 221,000 cusecs at **Khanki** occurred on July 29th and continued for three days. The second flood peak of 328,000 cusecs at Khanki occurred on August 7th 2010. It continued for less than 24 hours.

The first flood peak of 219,000 cusecs at **Qadirabad** occurred on July 29th 2010. It continued for less than 24 hours. The second and larger peak of 299,000 cusecs occurred at Qadirabad on August 7th 2010.

1.5. Ravi River Flows at Rim Station and Barrages

The flood flows of **Ravi River** at **Shadhra, Balloki and Sidhnai** are presented in **Figure 7**. The first flood peak of 42,000 cusecs at **Shadhra** occurred on July 22nd 2010. It continued for almost three days with reduction in flood. There was no second peak.

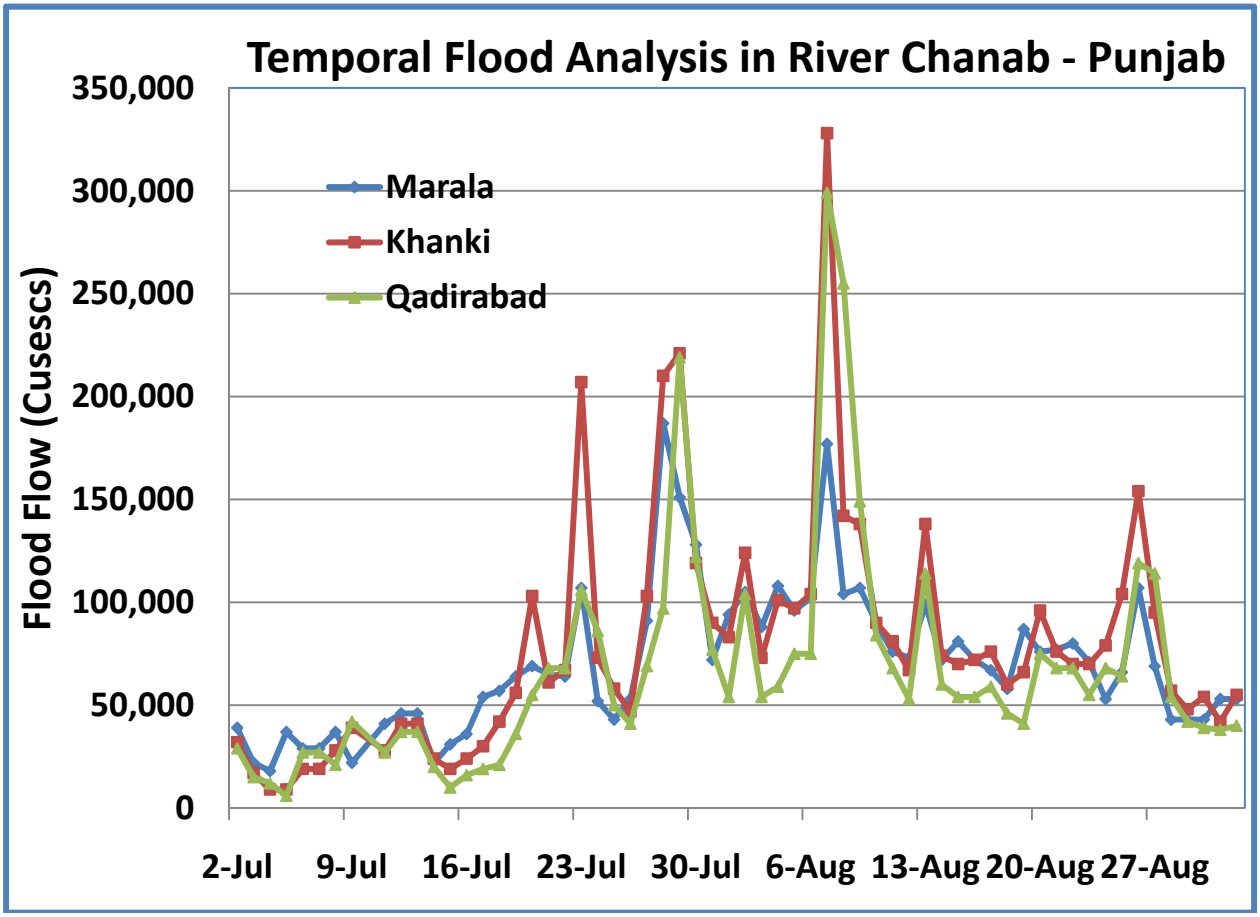


Figure 6. Flood flows of Chenab River at Marala, Khanki and Qadirabad during July-August 2010

The first flood peak of 25,000 cusecs at **Balloki** occurred on July 25th 2010. It continued for almost three days with reduction in flood. The second flood peak of 36,000 cusecs at **Balloki** occurred during 23-28 August 2010 with minor changes in flood flows.

The first flood peak of 17,000 cusecs at **Sidhnai** occurred on August 4-11 August 2010. It continued for almost eight days with reduction in flood. The second flood peak of 14,000 cusecs at **Sidhnai** occurred during 28-31 August 2010 with minor changes in flood flows.

1.6. Sutlej River Flows at Rim Station and Barrages

The flood flows of **Sutlej River** at **Suleimankie and Islam** are presented in **Figure 8**. The flood peak of 41,000 cusecs at **Suleimankie** occurred during August 27-30 2010. It continued for almost four days with some variation in flood flows. There was no second peak.

The first flood peak of 16,000 cusecs at **Islam** Headworks occurred on August 31st and September 1st 2010. It continued for almost two days with reduction in flood. As the first peak occurred during late August and beginning of September and the forecast of rainfall during first decade of September is an indication that there are chances of second flood later part of September.

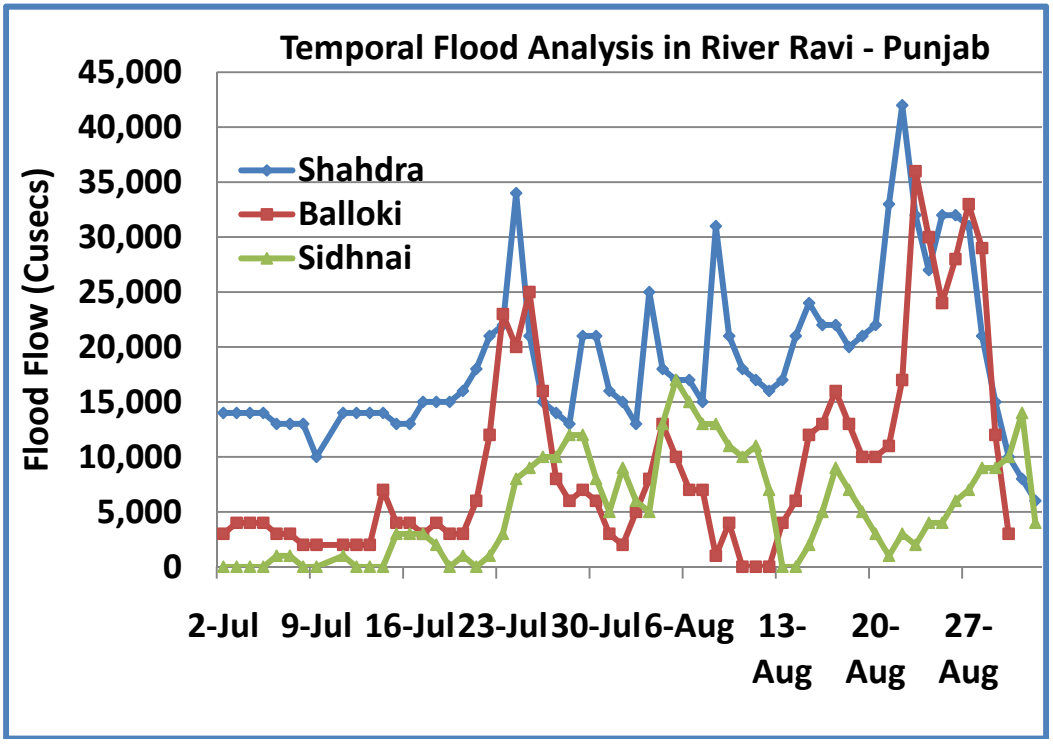


Figure 7. Flood flows of Ravi River at Shadhra, Balloki and Sidhnai during July-August 2010

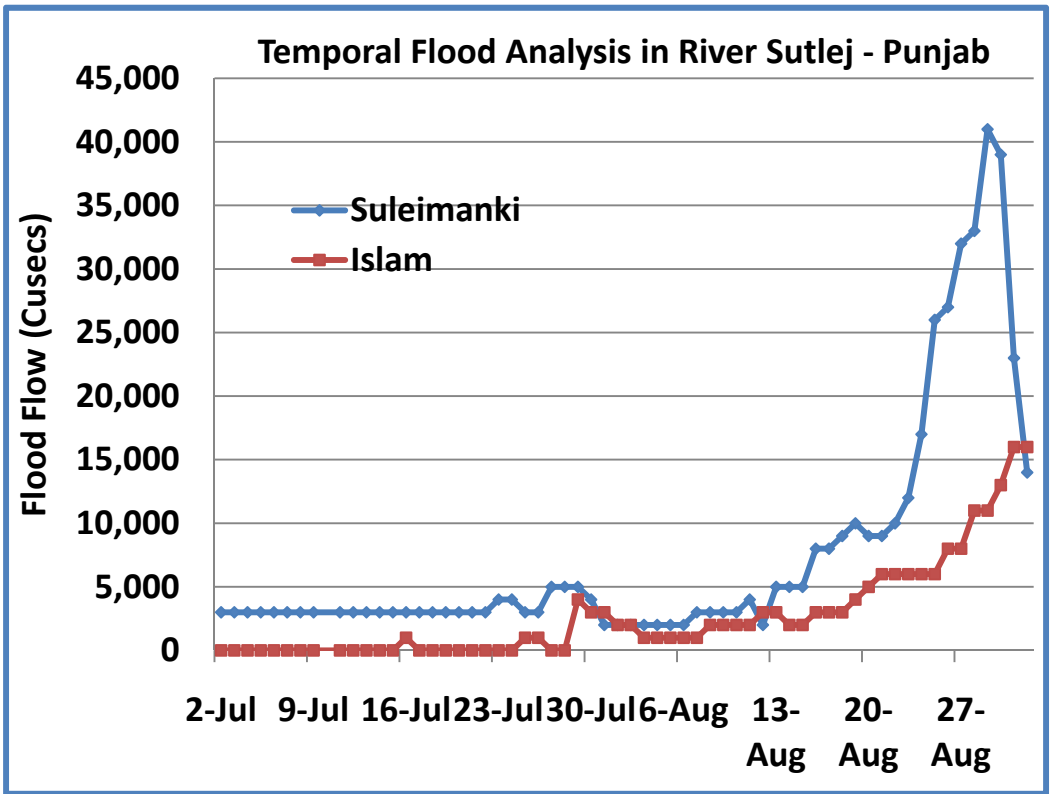


Figure 8. Flood flows of Sutlej River at Suleimankie and Islam during July-August 2010

1.7. Findings of the Flood Peak Analysis

The findings of the flood peak analysis are:

- The prolonged and high intensity rainfall in watershed areas and plains resulted in highest peaks of the history and these peaks were prolonged even up to 11 days. This is an indication that prolonged rainfall and degraded watershed conditions contributed significantly for highest and prolonged peaks of the history.
- The highest and prolonged peaks also are an indication that the current storage is inadequate to have any significant impact on flood attenuation. The analysis of flood also revealed that in future for avoiding the damages associated with floods there is a need to have considerable storage capacity on Indus Main, downstream and upstream of Tarbela so that this storage can be used for flood attenuation and use stored water during the dry years to sustain irrigated agriculture.
- The watersheds have degraded to an extent that peaks are enhanced and there is an urgent need to develop a comprehensive and practical strategy for watershed management. It is also important to note that watershed management is extremely expansive and require huge resources to have any significant impact on Indus Main. This would require to link watershed management interventions with livelihood generation so that these interventions are owned by rural communities.
- The flood situation indicated that there is hardly any strategy for breaching the bunds to save the Headworks. There are no planned escapes on Indus Main which can reduce the impact of floods. The recent flood indicated that there is an urgent need to develop River Basin Management Strategy including flood and drought management. The strategy would include planned escapes where flood water can be channelized under certain productive objectives of recharging groundwater through developing lakes. In fact, wetlands concepts are never considered while developing irrigated agriculture in the IBIS.
- The flood control programmes failed during recent flood because there were hardly any preparedness at all levels. There is also an urgent need to review and restructure the Flood Control Commission because in the field there is hardly any mechanisms to verify that flood control measures were introduced or not.
- River training and management is a weak area and needs rethinking.

2. Assessment of Flood Impacts

Comprehensive work on flood assessment is being done by the UNOSAT. The UNOSAT has used the satellite images extensively and identified the flood ponded area all over the country. The work done is remarkable. The NRD Flood Damage Assessment Cell was able to develop active collaboration with UNOSAT and now GIS files are being provided to the Cell for analysis at NRD. Normally, the institutions do not provide such files. The maps available for download can't be used for analysis (**Figure 9 and Annexure I**).

Initially, the NRD Flood Damage Assessment Cell downloaded the available maps at UNOSAT and later on collaboration was developed to have access to actual data and work files so that analysis of flood damages can be made as per requirement of the country. The work done by the Cell will also be provided to the UNOSAT so that it is available to other users.

The assessment made by the NRD Flood Damage Assessment Cell indicated that around 9.542 million acres are affected by floods in the country. The highest damage area is in Punjab of 3.786 million acres followed by Sindh (3.321 million acres), KPK (1.221 million acres), Balochistan (1.206 million acres) and Kashmir (0.009 million ha). The details are given in **Table 1**.

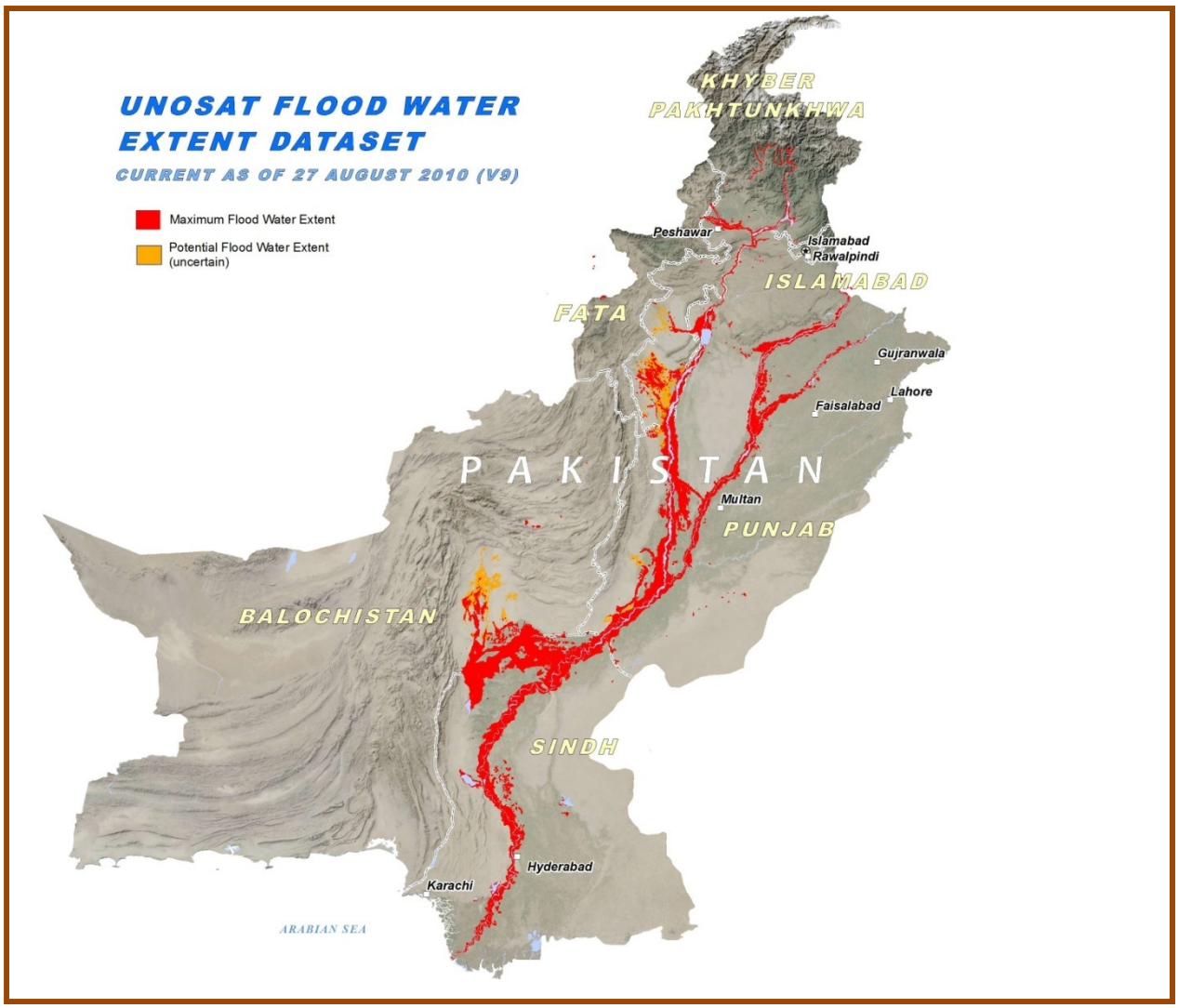


Figure 9. UNOSAT Floodwater Extent Dataset

Table 1. Flood affected areas of Pakistan (in 'km^2' and 'acres')

Province	Area	
	(km^2)	(acres)
Sindh	13441.57	3321411.31
Punjab	15321.27	3785884.99
Balochistan	4941.9	1205825.6
KPK	4922.907	1220641.03
Kashmir	35.2	8696.9
Total	38662.847	9542459.83

After the detailed assessment of damages of flood at the country and province level, the second effort was made to assess the distribution of damaged area under different land uses. The land use systems analysis of Punjab's area damaged by floods indicated that almost half of the area affected by floods is classified as irrigated agriculture flowed by rangelands, bare soil, forest and rainfed/Rod-Kohi farming. In addition,

the area affected by river bed was also significant (8.5% of total damaged area). This shows that 2.517 million acres of agricultural lands (irrigated, rainfed, Rod-Kohi) were affected in Punjab (**Table 2**).

Table 2. Flood affected areas of Punjab province under various land use systems

Land Use	Area (km^2)	Area (acres)	Area as Percent of Total
Forest	1743.78	430887.25	11.38
Irrigated Agriculture	7602.24	1878514.13	49.62
Rainfed/Rod-Kohi Agriculture	565.00	139610.38	3.69
Rangeland	1996.40	493310.40	13.03
Bare Soil	1980.82	489460.68	12.93
Settlements	16.77	4144.41	0.11
Rocks	58.98	14574.50	0.38
Un-cultivated Land	36.02	8900.81	0.24
River Bed	1298.71	320912.40	8.48
Desert	22.54	5570.04	0.15
Total	**15321.27**	**3785884.99**	**100.00**

The agricultural area affected by floods in provinces is (**Tables 3 to 6 and Figures 10 to 14)**):

- In Punjab 2.517 million acres of agricultural lands were affected by floods;
- In Sindh 1.824 million acres of agricultural lands were affected by floods;
- In Balochistan 1.20 million acres of agricultural lands were affected by floods;
- In KPK 0.623 million acres of agricultural lands were affected by floods;
- In Kashmir 0.004 million acres of agricultural lands were affected by floods.

The land use analysis indicated that 6.168 million acres of agricultural land is affected in Pakistan from the flood damages.

Table 3. Flood affected areas of Sindh province under various land use systems

Land Use System	Area (km^2)	Area (acres)	Area as Percent of Total
Forest	2001.46	494559.78	14.89
Irrigated Agriculture	6175.27	1525909.10	45.94
Rainfed/Rod-Kohi Agriculture	385.22	95186.84	2.87
Rangeland	2963.95	732391.39	22.05
Settlements	15.39	3802.72	0.11
Rocks	14.92	3686.13	0.11
Un-cultivated Land	824.03	203617.03	6.13
River Bed	1057.18	261229.85	7.87
Desert	4.16	1028.46	0.03
Total	**13441.57**	**3321411.31**	**100.00**

Table 4. Flood affected areas of Balochistan province under various land use systems

Land use	Area (km^2)	Area (acres)	Area as Percent of Total
Forest	0.1	20.9	0.002
Irrigated Agriculture	1677.6	414529.7	34.377
Rainfed/Rod-Kohi Agriculture	838.9	207280.1	17.190
Rangeland	5.6	1384.3	0.115
Bare Soil	2275.6	562292.0	46.631
Rocks	10.8	2667.3	0.221
Un-cultivated Land	71.2	17605.5	1.460
River Bed	0.2	45.9	0.004
Total	**4879.9**	**1205825.6**	**100.000**

Table 5. Flood affected areas of KPK province under various land use systems

Land Use Systems	Area (km^2)	Area (acres)	Area as Percent of Total
Forest	186.296	46034.827	3.8
Irrigated Agriculture	2212.50	546721.755	45
Rainfed/Rod-Kohi Agriculture	305.20	75418.759	6.2
Rangeland	1720.123	429005.408	35
Settlements	21	5155.464	0.5
River Bed	477.194	117916.511	9.4
Total	**4922.907**	**1216334.868**	**100**

Table 6. Flood affected areas of Kashmir province under various land use systems

Land Use Systems	Area (km^2)	Area (km^2)	Area as Percent of Total
Forest	8.9	2202.7	25.3
Irrigated Agriculture	3.6	890.6	10.2
Rangeland	0.5	115.0	1.3
Bare Soil	10.9	2686.9	30.9
River Bed	11.3	2801.7	32.2
Total	**35.2**	**8696.9**	**100.0**

The provincial assessment of flood damages in agriculture is based on the district level assessment. The details of flood damages at districts level are presented in **Annexure II**. This information is crucial for developing strategy for adaptation to the flood impacts.

3. Adaptation Strategy

There is a need to develop strategy for adaptation of interventions for restoration of the flood affected areas in Pakistan and management of river basin system.

2.1. Strategy for Restoration of Flood Affected Areas

The elements of the proposed strategy for restoration of flood affected areas especially agriculture sector are presented as under:

Restoration of Agriculture and Livelihood

- Develop adaptation interventions for the plantation of forthcoming Rabi crops in flood affected areas. The crops include: wheat, rapeseed, mustard, Rabi vegetables, fodders, etc. Vegetables which can provide returns in 30-40 days be selected so that initially these vegetables provide family nutrition and later on as a source of livelihood. Even the concept of Kitchen Gardening at household level should also be used.
- Develop early mechanisms for cleaning and grading of available grains and use the best grade for seed, as certified seeds are not available in the country to meet the large requirement of flood affected areas.
- Provision of graded grains as seed to flood affected farmers for plantation during Rabi season.
- Provision of diesel fuel and daily remuneration to the local tractor rentals to provide tillage machinery at reasonable bulk rate.
- Package may include plantation of 1-5 acres of Rabi crops to the affected farmers at no cost in terms of seed and seedbed preparation and plantation cost. Beyond 5 acres of plantation package of sharing of seed cost alone may be provided up to 25 acres and rest will be the responsibility of farmer. The objective should be to provide this support to many compared to few with full package including fertilizers. Some of the scientists are of the opinion that fertilizer support may be provided free of charge. This will increase the cost of the package and benefit the few.

Irrigation and On-Farm Water Management

- Damage assessment and reconstruction of damaged irrigation structures including Barrages, Headworks, Regulators, weirs, diversion bunds, breaches, etc.
- Rehabilitation of secondary and tertiary irrigation systems. Identification of secondary irrigation systems (distributary and minor canals) for rehabilitation through active involvement of farmers and their organization. Contractors should not be involved because the country can't afford poor quality work at higher cost and with rent seeking.
- Rehabilitation of watercourses by the farmers and their organizations so that water is available to the farmers and canal water is not affecting the Rabi crops due to damaged watercourses and minors/distributary canals.

Other Farming Systems

- Develop action plan for the Katcha areas and recession agriculture so that future floods should not damage tubewells and other infrastructure in these areas.
- Develop strategy for storage of runoff in reservoirs and ponds for supplemental irrigation in Barani areas.

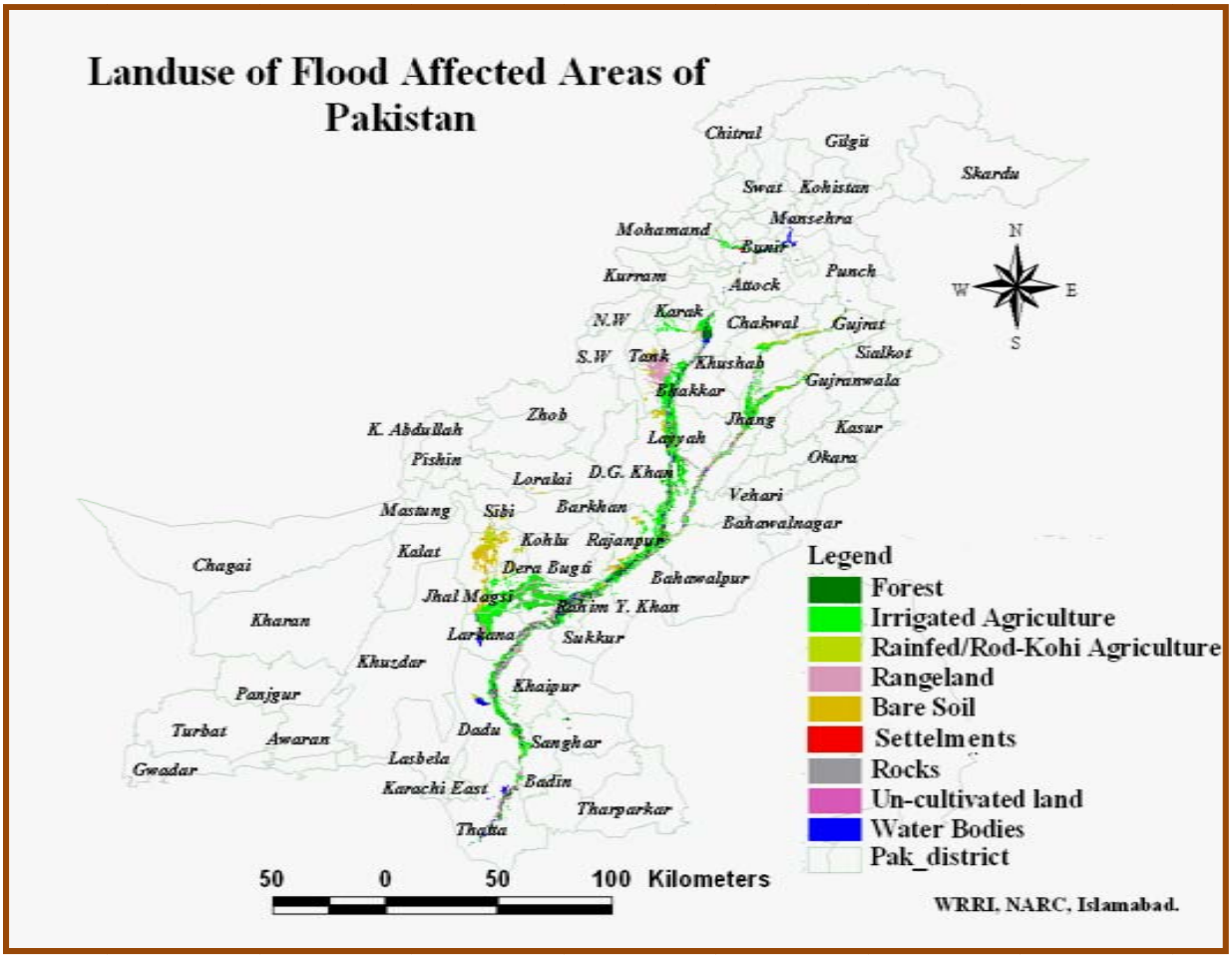
River Basin Management

- Experimental watersheds like Rawal, Mithawan and Sulaiman ranges of Barkhan and Musa Khel may be taken as PARC already has its presence in these areas for developing mass scale movement of watershed management at experimental level, where basic interventions can be designed and

implemented in a cost-effective way so that these can be adopted at large scale in the forthcoming small dams watershed areas.

- Develop a Conceptual Framework for River Basin Management so that in future floods are not taken as means of devastations rather opportunity to divert flood water for productive purposes. Concept of flood escapes in river system be developed and linked with recharging groundwater and developing freshwater aquifers in deserts and unproductive areas.

Figure 10.


Landuse of Flood Affected Areas of Pakistan
Chitral
Gilgit
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Swat
Kohistan
Mansehra
Mohamand
Buner
Kurram
Attock
Punch
N.W
Karak
Chakwal
Gujrat
S.W
Tank
Khushab
Sialkot
Bhakkar
Gujranwala
Zhob
K. Abdullah
Layyah
Jhang
Kasur
Pishin
Okara
Loralai
D.G. Khan
Vehari
Mastung
Sibi
Barkhan
Bahawalnagar
Kohlu
Rajanpur
Kalat
Chagai
Dera Bugti
Bahawalpur
Jhal Magsi
Rahim Y. Khan
Kharan
Larkana
Sukkur
Khuzdar
Khairpur
Panjgur
Turbat
Awaran
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Figure 11.

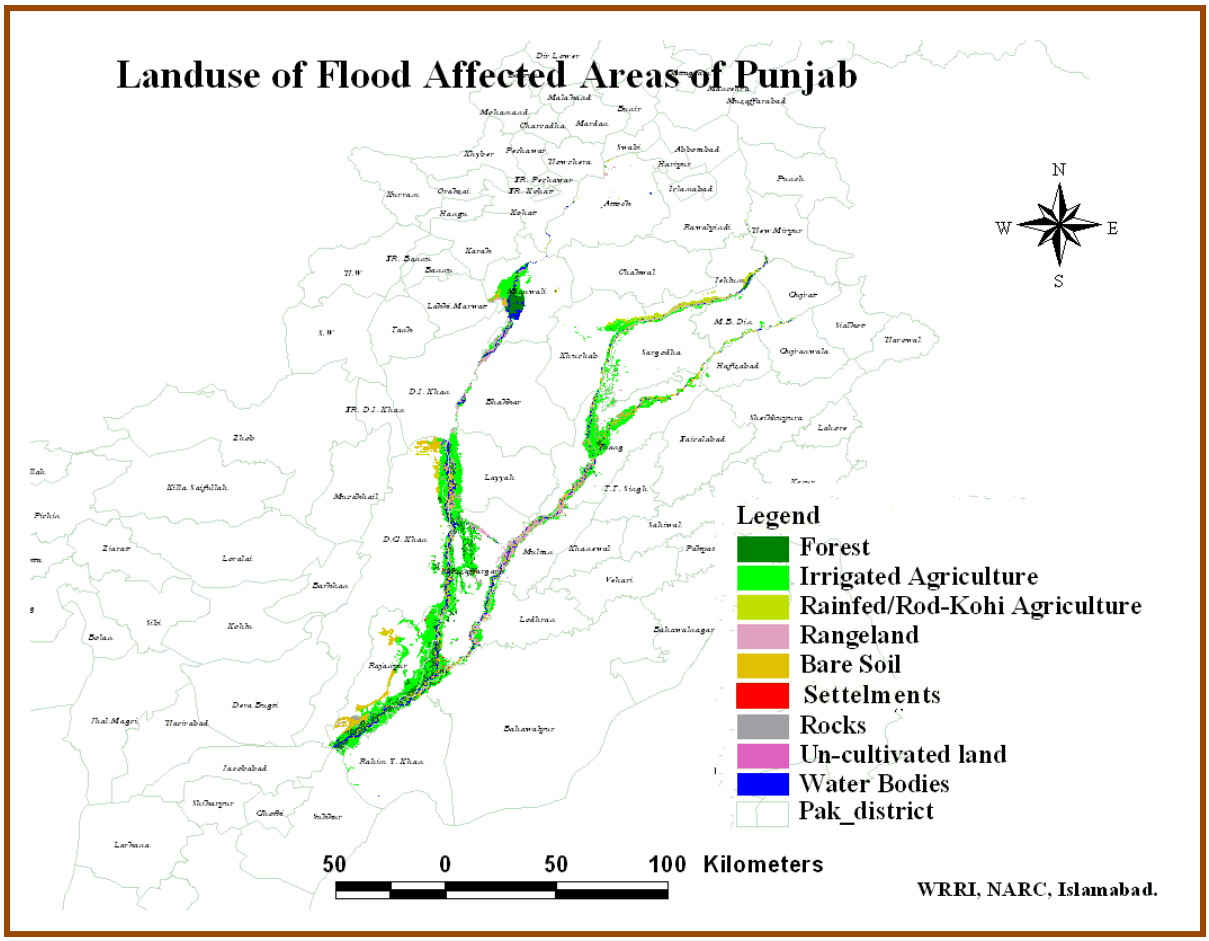
Landuse of Flood Affected Areas of Punjab
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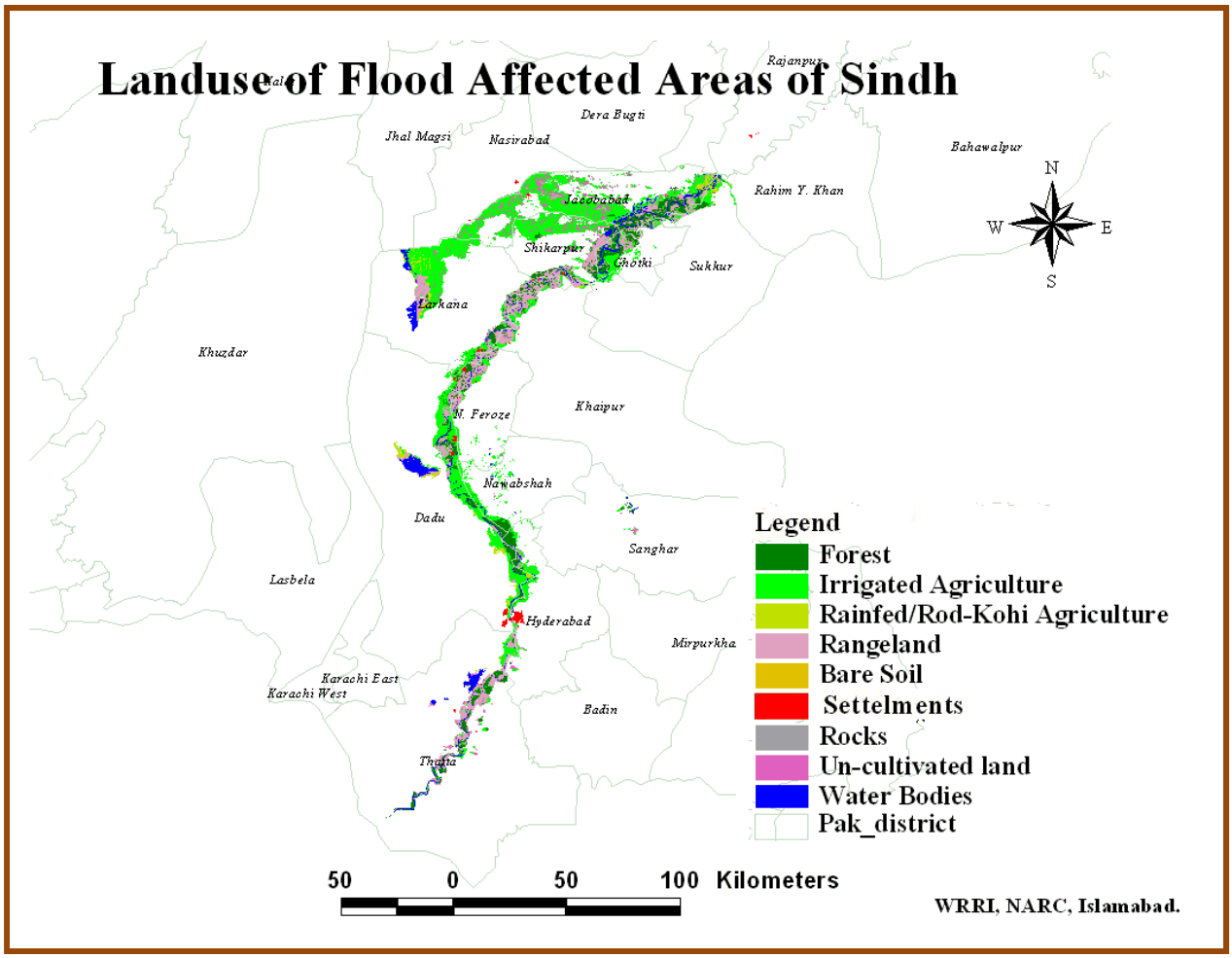
Figure 12.


Landuse of Flood Affected Areas of Sindh
Rajanpur
Dera Bugti
Jhal Magsi
Nasirabad
Bahawalpur
Rahim Y. Khan
Jacobabad
Shikarpur
Ghotki
Sukkur
Larkana
Khuzdar
Khaipur
N. Feroze
Nawabshah
Dadu
Sanghar
Lasbela
Hyderabad
Mirpurkha
Karachi East
Karachi West
Badin
Thatta
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Rainfed/Rod-Kohi Agriculture
Rangeland
Bare Soil
Settelments
Rocks
Un-cultivated land
Water Bodies
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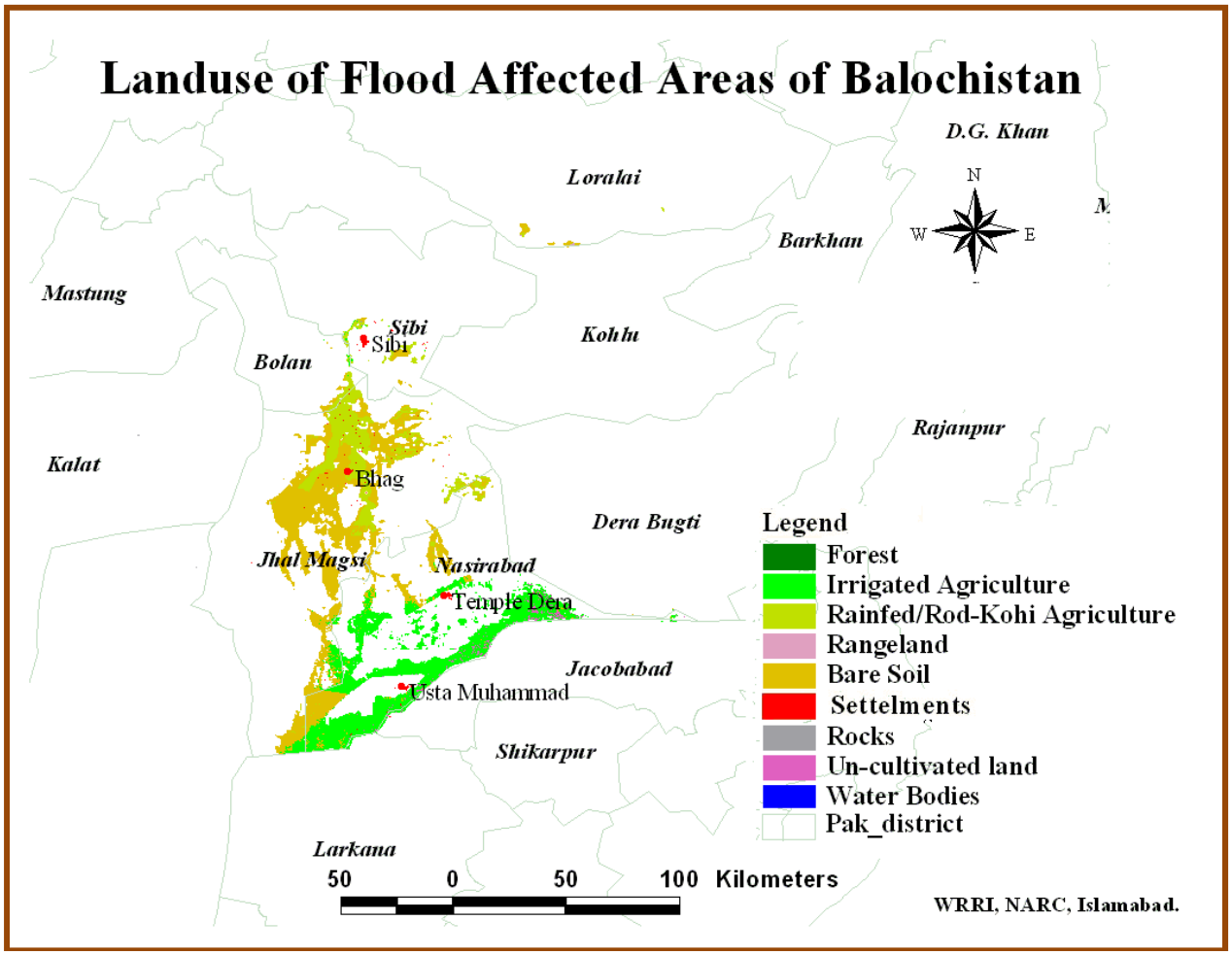
WRRI, NARC, Islamabad.

Figure 13.


Landuse of Flood Affected Areas of Balochistan
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Irrigated Agriculture
Rainfed/Rod-Kohi Agriculture
Rangeland
Bare Soil
Settelments
Rocks
Un-cultivated land
Water Bodies
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Nasirabad
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Jacobabad
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WRRI, NARC, Islamabad.

Figure 14.

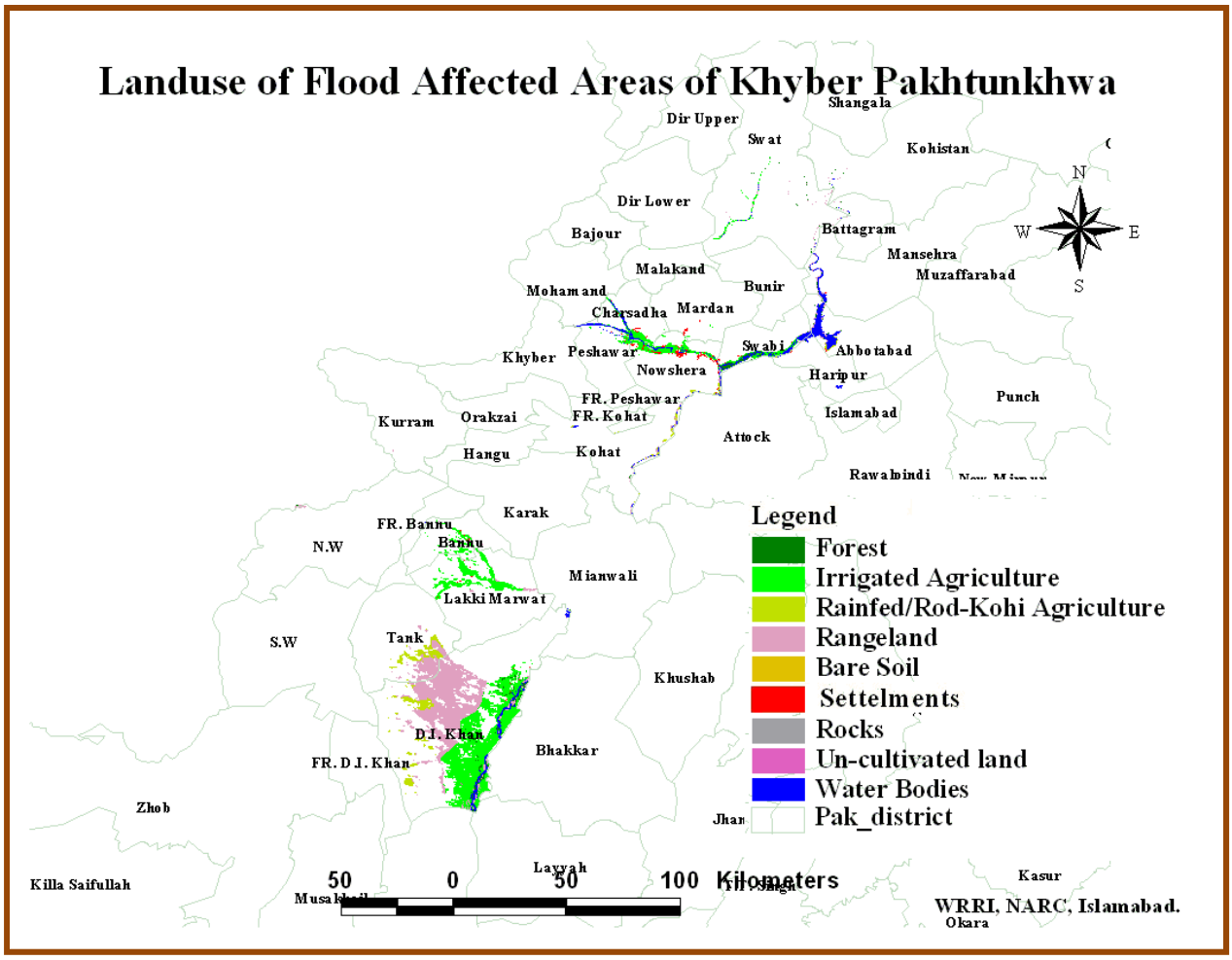
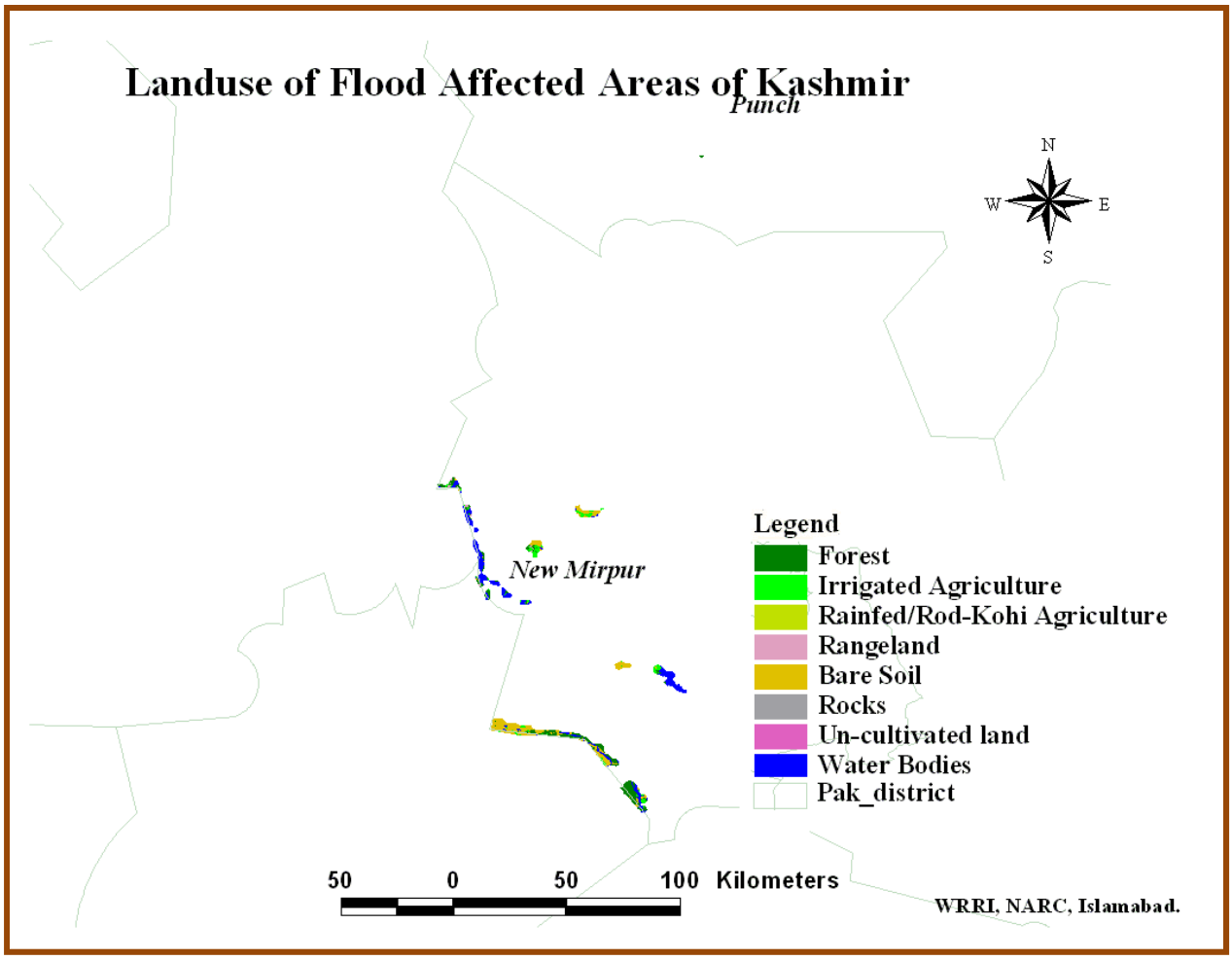
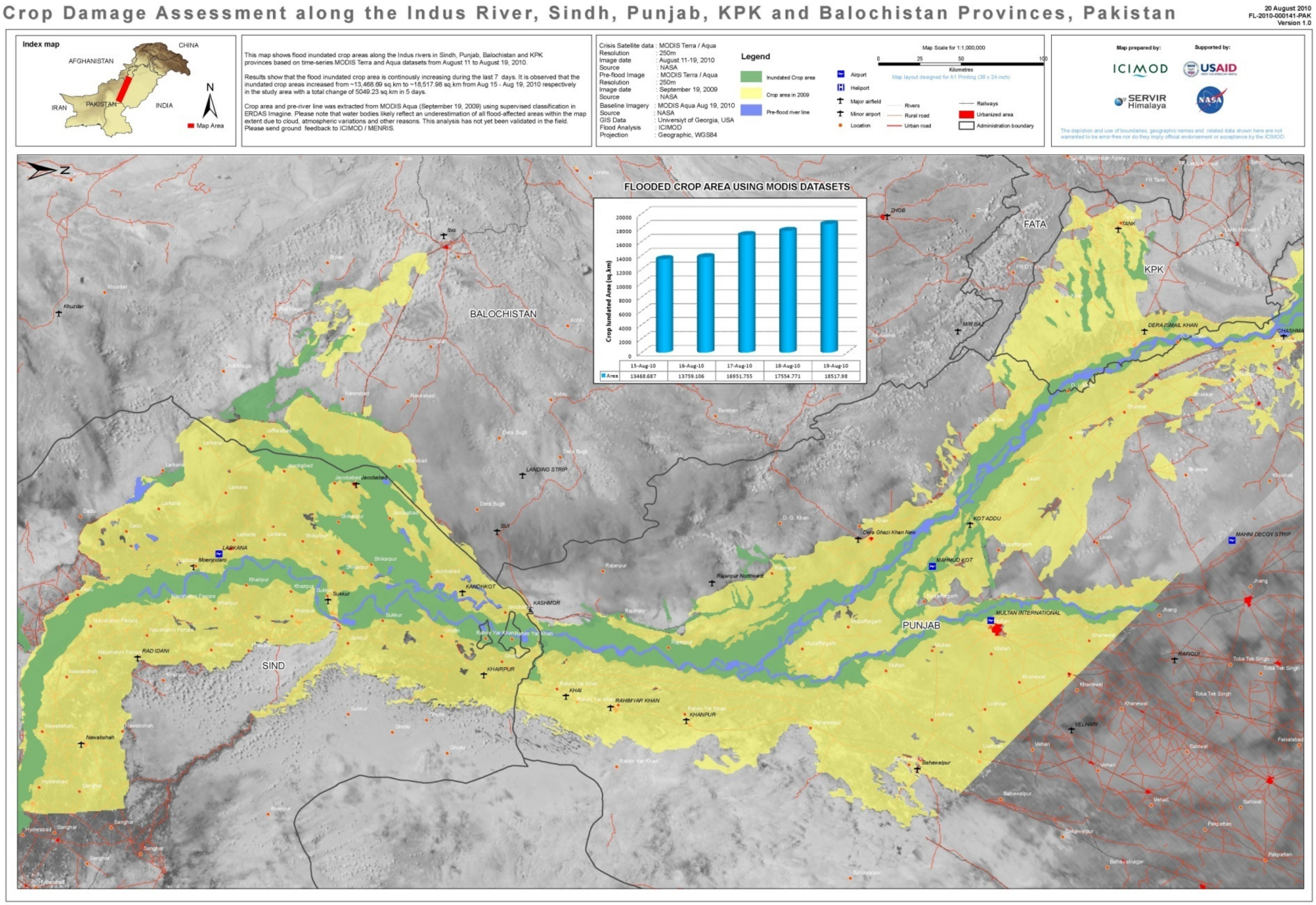

Landuse of Flood Affected Areas of Khyber Pakhtunkhwa
Shangla
Dir Upper
Swat
Kohistan
Dir Lower
Bajour
Battagram
Mansehra
Muzaffarabad
Malakand
Bunir
Mohamand
Charsadha
Mardan
Swabi
Abbotabad
Khyber
Peshawar
Nowshera
Haripur
FR. Peshawar
Punch
Islamabad
Kurram
Orakzai
FR. Kohat
Attock
Hangu
Kohat
Rawalpindi
Karak
FR. Bannu
Bannu
N.W
Mianwali
Lakki Marwat
S.W
Tank
Khushab
D.I. Khan
Bhakkar
FR. D.I. Khan
Zhob
Jhan
Layyah
Killa Saifullah
Kasur
Okara
50 0 50 100 Kilometers
WRRI, NARC, Islamabad.
N
W
E
S
Legend
Forest
Irrigated Agriculture
Rainfed/Rod-Kohi Agriculture
Rangeland
Bare Soil
Settelments
Rocks
Un-cultivated land
Water Bodies
Pak_district

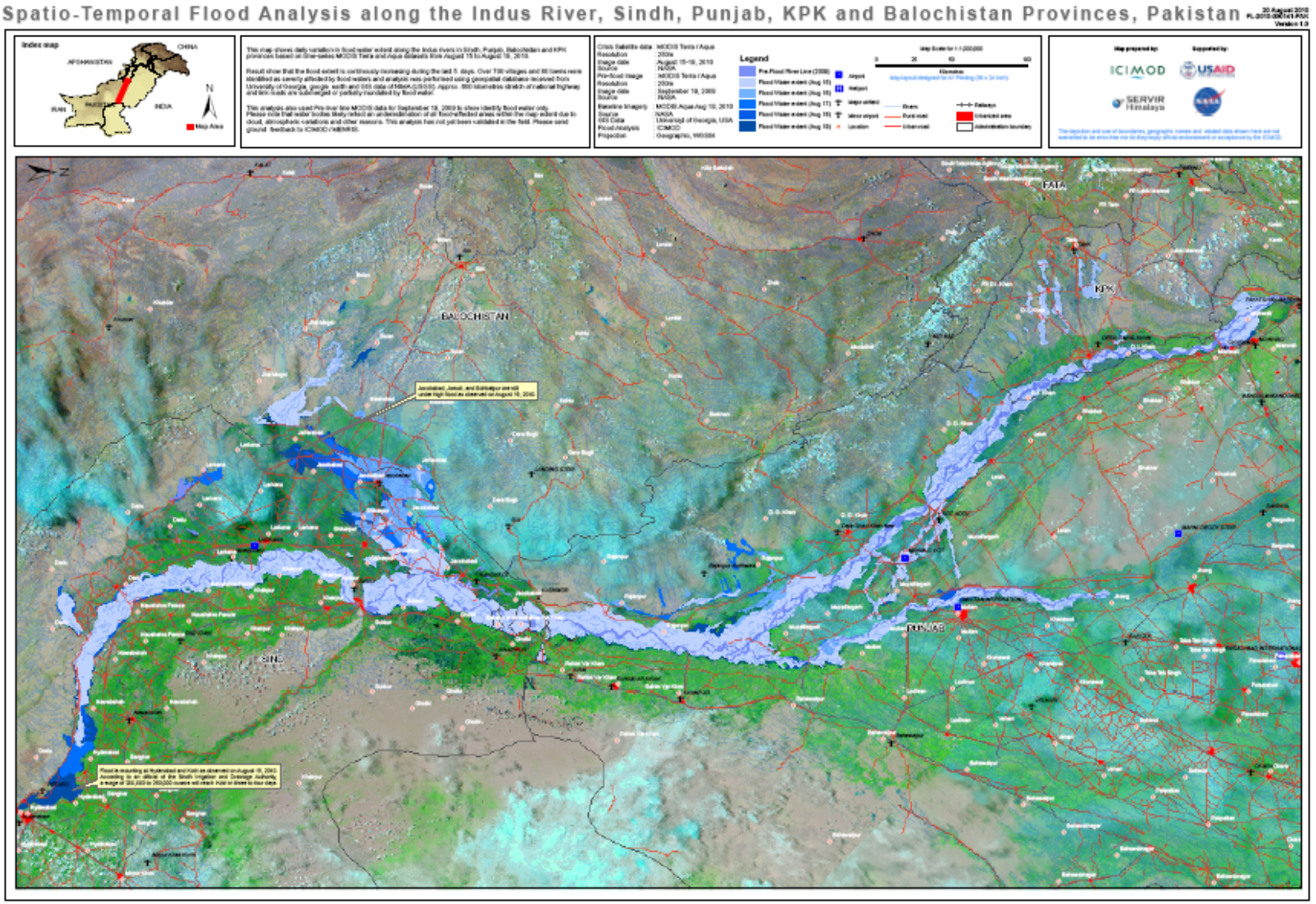
Figure 15.


Landuse of Flood Affected Areas of Kashmir
Punch
N
W
E
S
New Mirpur
Legend
Forest
Irrigated Agriculture
Rainfed/Rod-Kohi Agriculture
Rangeland
Bare Soil
Rocks
Un-cultivated land
Water Bodies
Pak_district
50 0 50 100 Kilometers
WRRI, NARC, Islamabad.

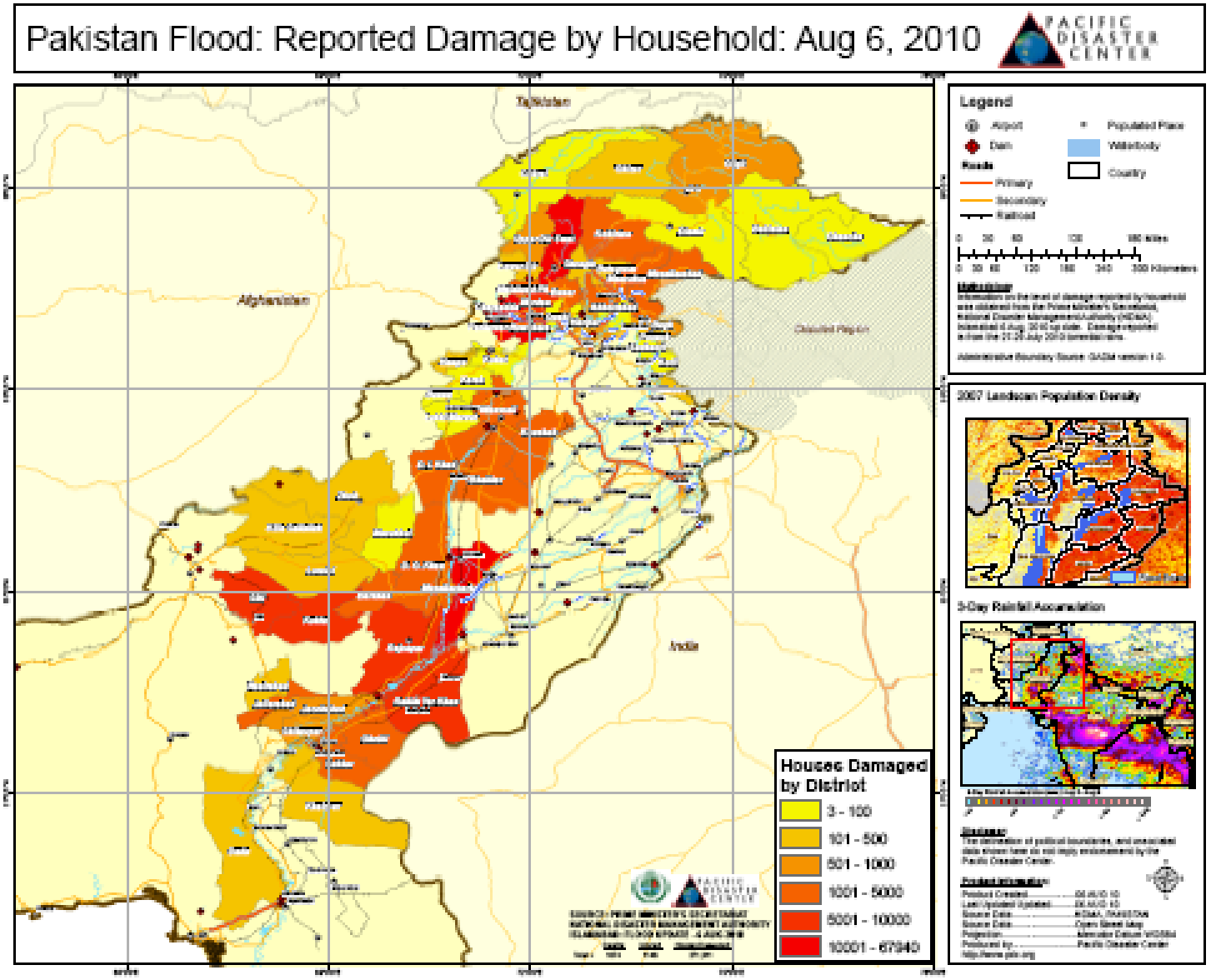
Annexure I.1.


Crop Damage Assessment along the Indus River, Sindh, Punjab, KPK and Balochistan Provinces, Pakistan
20 August 2010
FL-2010-000141-PAK
Version 1.0
Index map
CHINA
AFGHANISTAN
IRAN
PAKISTAN
INDIA
N
Map Area
This map shows flood inundated crop areas along the Indus rivers in Sindh, Punjab, Balochistan and KPK provinces based on time-series MODIS Terra and Aqua datasets from August 11 to August 19, 2010.
Results show that the flood inundated crop area is continously increasing during the last 7 days. It is observed that the inundated crop areas increased from ~13,468.69 sq.km to ~18,517.98 sq.km from Aug 15 - Aug 19, 2010 respectively in the study area with a total change of 5049.23 sq.km in 5 days.
Crop area and pre-river line was extracted from MODIS Aqua (September 19, 2009) using supervised classification in ERDAS Imagine. Please note that water bodies likely reflect an underestimation of all flood-affected areas within the map extent due to cloud, atmospheric variations and other reasons. This analysis has not yet been validated in the field. Please send ground feedback to ICIMOD / MENRIS.
Crisis Satellite data : MODIS Terra / Aqua
Resolution : 250m
Image date : August 11-19, 2010
Source : NASA
Pre-flood Image : MODIS Terra / Aqua
Resolution : 250m
Image date : September 19, 2009
Source : NASA
Baseline Imagery : MODIS Aqua Aug 19, 2010
Source : NASA
GIS Data : Universiyt of Georgia, USA
Flood Analysis : ICIMOD
Projection : Geographic, WGS84
Legend
Inundated Crop area
Crop area in 2009
Pre-flood river line
Airport
Heliport
Major airfield
Minor airport
Location
Rivers
Rural road
Urban road
Railways
Urbanized area
Administration boundary
Map Scale for 1:1,000,000
0 25 50 100
Kilometres
Map layout designed for A1 Printing (36 x 24 inch)
Map prepared by:
Supported by:
ICIMOD
SERVIR Himalaya
USAID
NASA
The depiction and use of boundaries, geographic names and related data shown here are not warranted to be error-free nor do they imply official endorsement or acceptance by the ICIMOD.
FLOODED CROP AREA USING MODIS DATASETS
Crop Iundated Area (sq.km)
15-Aug-10 16-Aug-10 17-Aug-10 18-Aug-10 19-Aug-10
Area 13468.687 13759.106 16951.755 17554.771 18517.98
BALOCHISTAN
FATA
KPK
PUNJAB
SIND

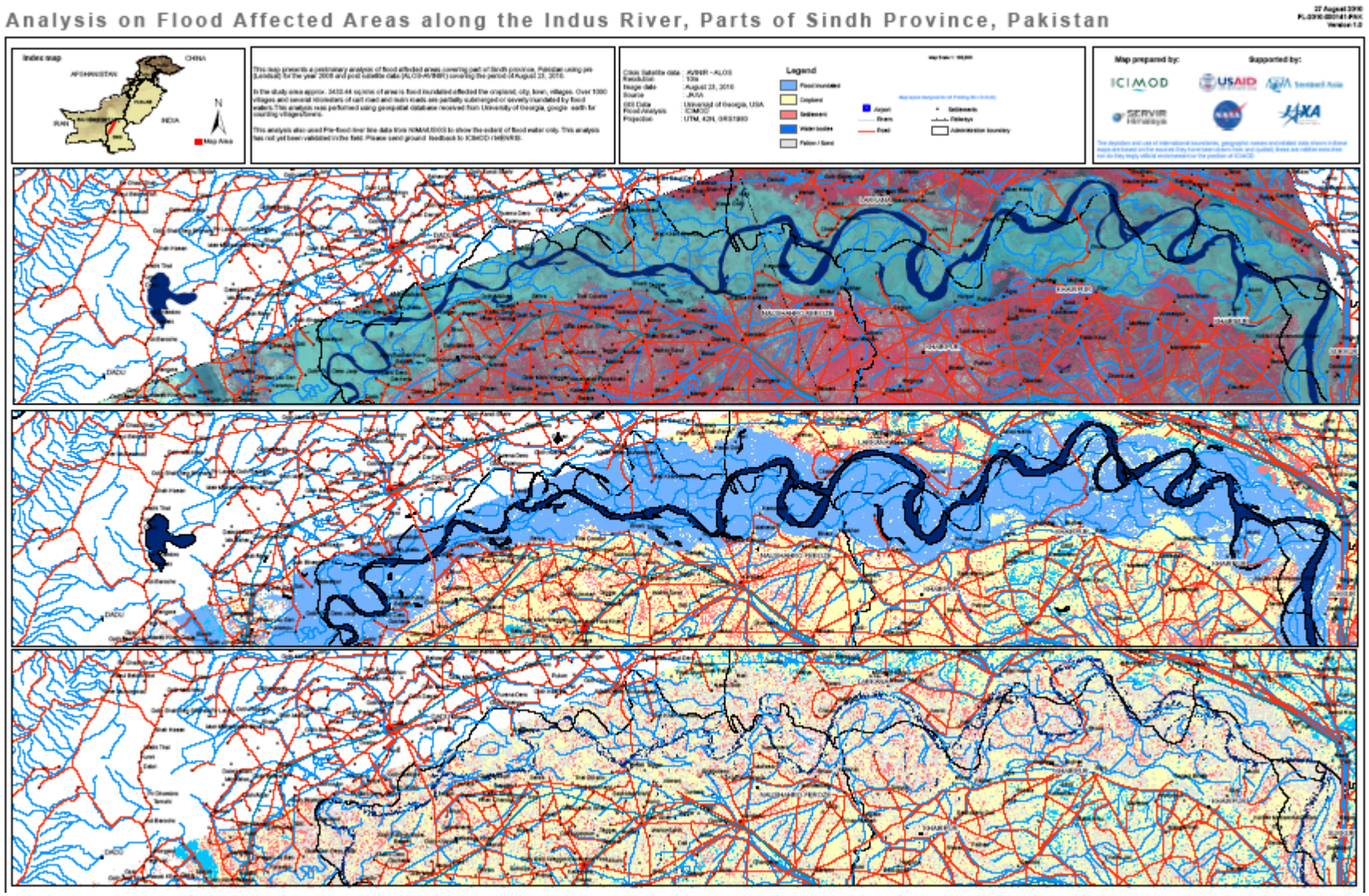
Annexure I.2.


Spatio-Temporal Flood Analysis along the Indus River, Sindh, Punjab, KPK and Balochistan Provinces, Pakistan
Index map
CHINA
AFGHANISTAN
IRAN
INDIA
Map Area
Legend
Pre-Flood River Line (2009)
Airport
Heliport
Dams
Railways
Urbanized area
Administration boundary
Map prepared by:
Supported by:
ICIMOD
USAID
SERVIR Himalaya
FATA
KPK
BALOCHISTAN
PUNJAB
SIND

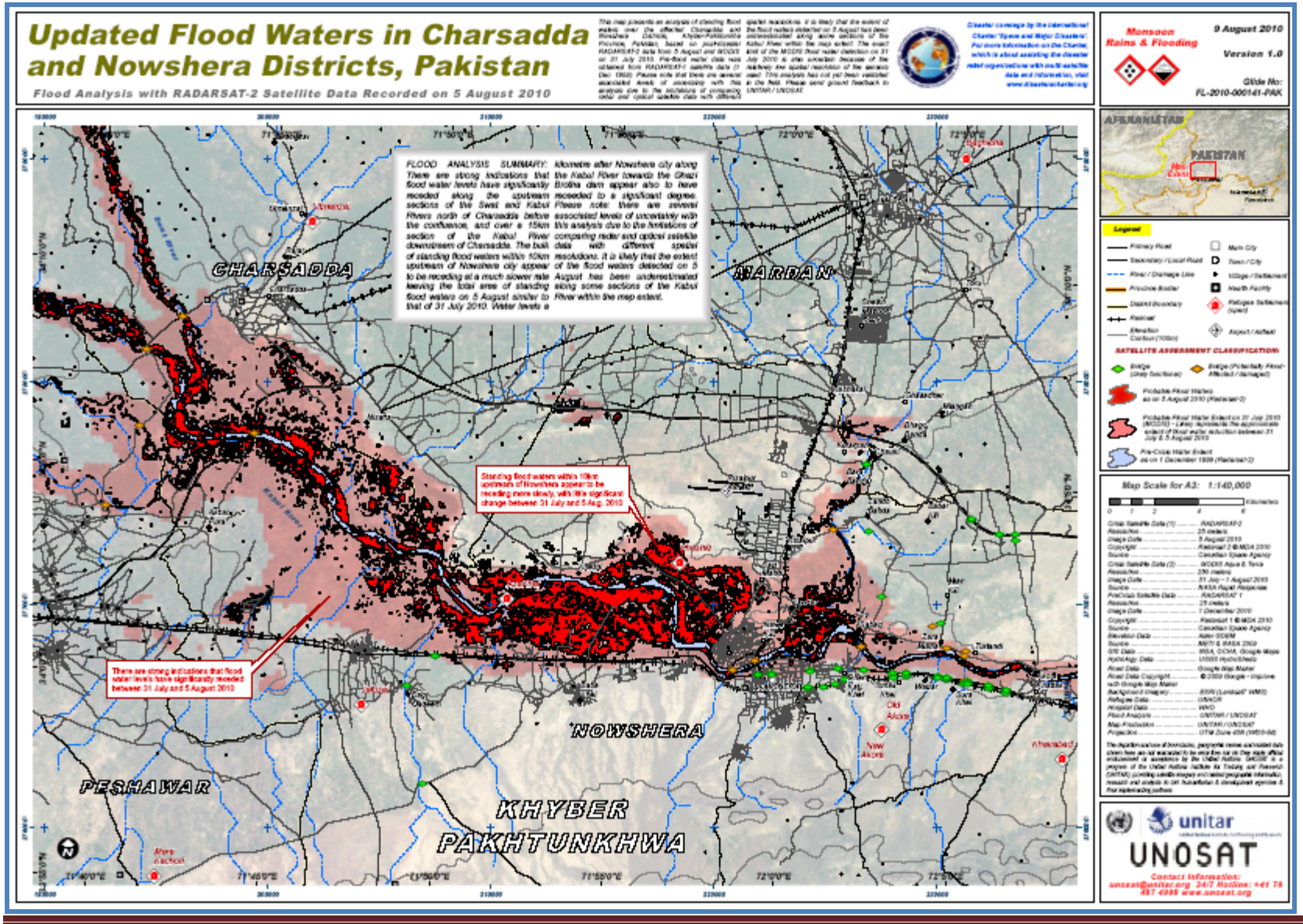
Annexure I.3


Pakistan Flood: Reported Damage by Household: Aug 6, 2010
PACIFIC DISASTER CENTER
Tajikistan
Afghanistan
India
Legend
Airport
Populated Place
Dam
Waterbody
Roads
Country
Primary
Secondary
Railroad
2007 Landscan Population Density
3-Day Rainfall Accumulation
Houses Damaged by District
3 - 100
101 - 500
501 - 1000
1001 - 5000
5001 - 10000
10001 - 67940

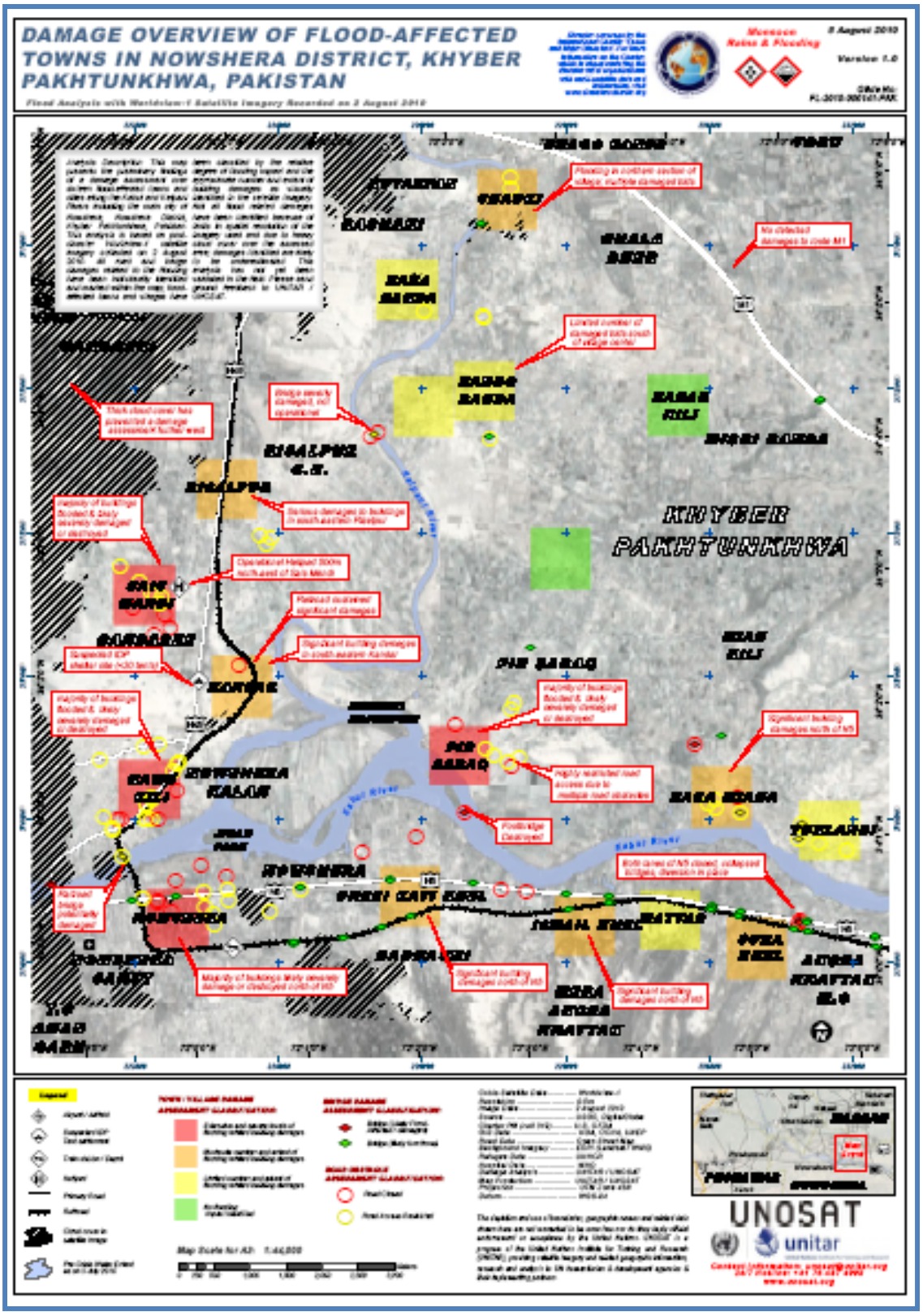
Annexure I.4


Analysis on Flood Affected Areas along the Indus River, Parts of Sindh Province, Pakistan
Index map
AFGHANISTAN
CHINA
IRAN
INDIA
PAKISTAN
Map Area
N
Legend
Map prepared by:
ICIMOD
Supported by:
USAID
SERVIR Himalaya
NASA
JAXA
DADU
KHAIRPUR
NAUSHAHRO FEROZE

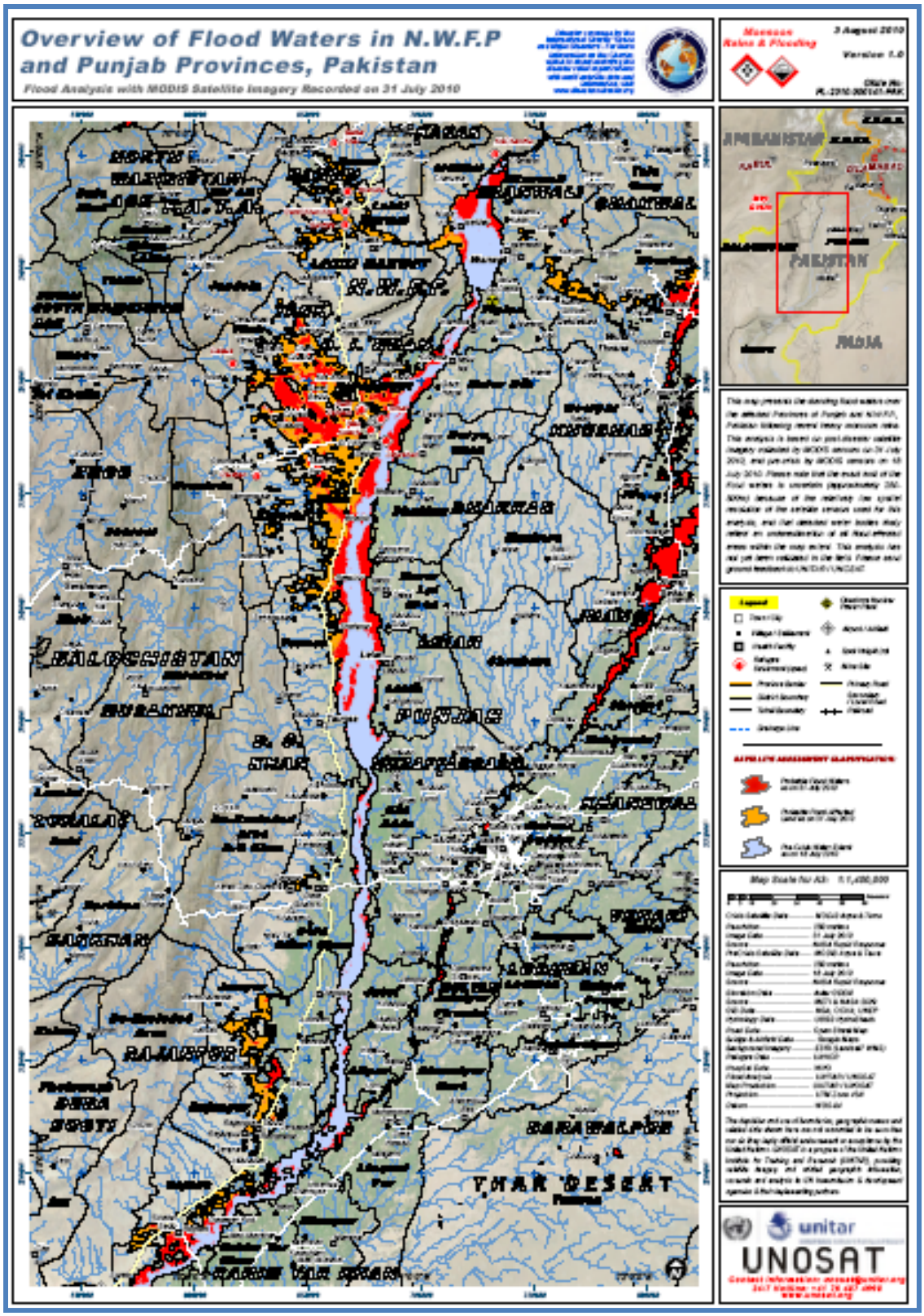
Annexure I.5.


Updated Flood Waters in Charsadda and Nowshera Districts, Pakistan
Flood Analysis with RADARSAT-2 Satellite Data Recorded on 5 August 2010
Monsoon Rains & Flooding
9 August 2010
Version 1.0
Glide No: FL-2010-000141-PAK
FLOOD ANALYSIS SUMMARY: There are strong indications that flood water levels have significantly receded along the upstream sections of the Swat and Kabul Rivers north of Charsadda before the confluence, and over a 15km section of the Kabul River downstream of Charsadda. The bulk of standing flood waters within 10km upstream of Nowshera city appear to be receding at a much slower rate leaving the total area of standing flood waters on 5 August similar to that of 31 July 2010. Water levels a
kilometre after Nowshera city along the Kabul River towards the Ghazi Brotha dam appear also to have receded to a significant degree. Please note: there are several associated levels of uncertainty with this analysis due to the limitations of comparing radar and optical satellite data with different spatial resolutions. It is likely that the extent of the flood waters detected on 5 August has been underestimated along some sections of the Kabul River within the map extent.
CHARSADDA
MARDAN
NOWSHERA
PESHAWAR
KHYBER PAKHTUNKHWA
Standing flood waters within 10km upstream of Nowshera appear to be receding more slowly, with little significant change between 31 July and 5 Aug. 2010
There are strong indications that flood water levels have significantly receded between 31 July and 5 August 2010
AFGHANISTAN
PAKISTAN
Legend
SATELLITE ASSESSMENT CLASSIFICATION
Map Scale for A3: 1:140,000
unitar
UNOSAT

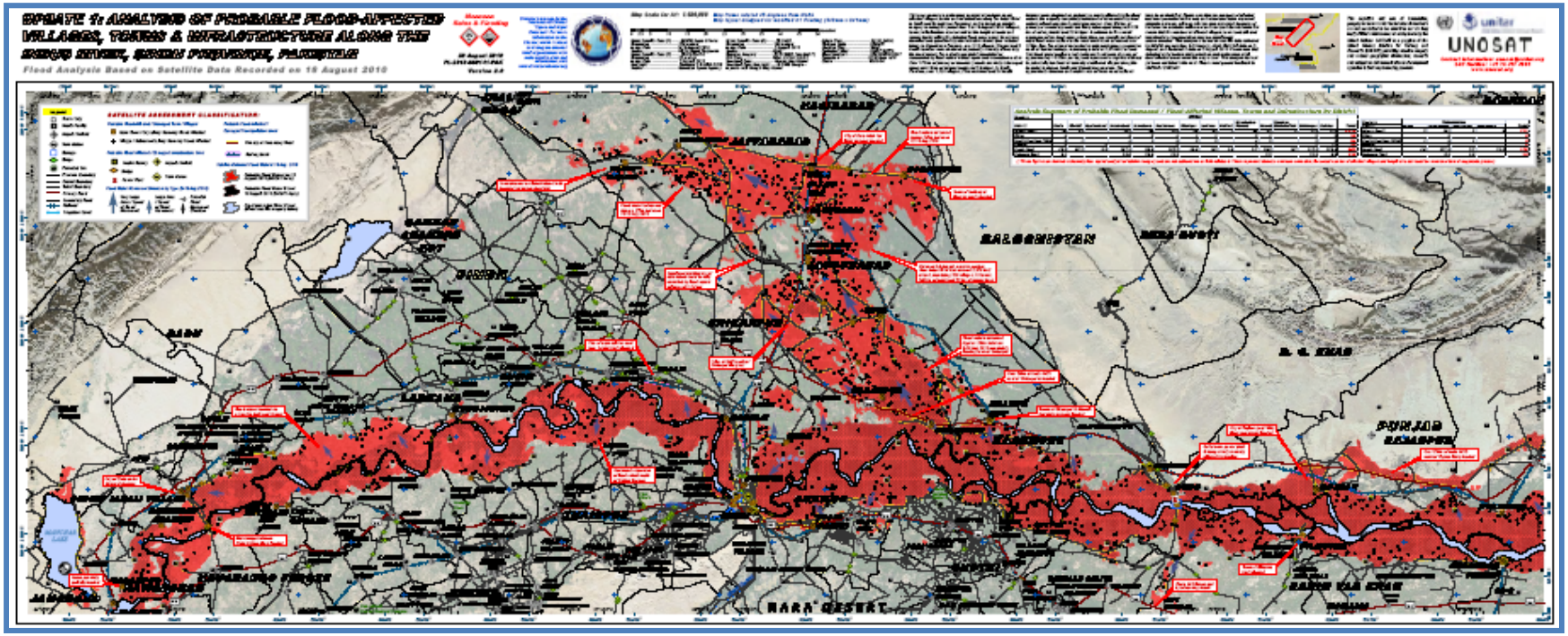
Annexure I.6.


DAMAGE OVERVIEW OF FLOOD-AFFECTED TOWNS IN NOWSHERA DISTRICT, KHYBER PAKHTUNKHWA, PAKISTAN
Flood Analysis with Worldview-1 Satellite Imagery Recorded on 3 August 2010
Monsoon Rains & Flooding
8 August 2010
Version 1.0
KHYBER PAKHTUNKHWA
UNOSAT
unitar

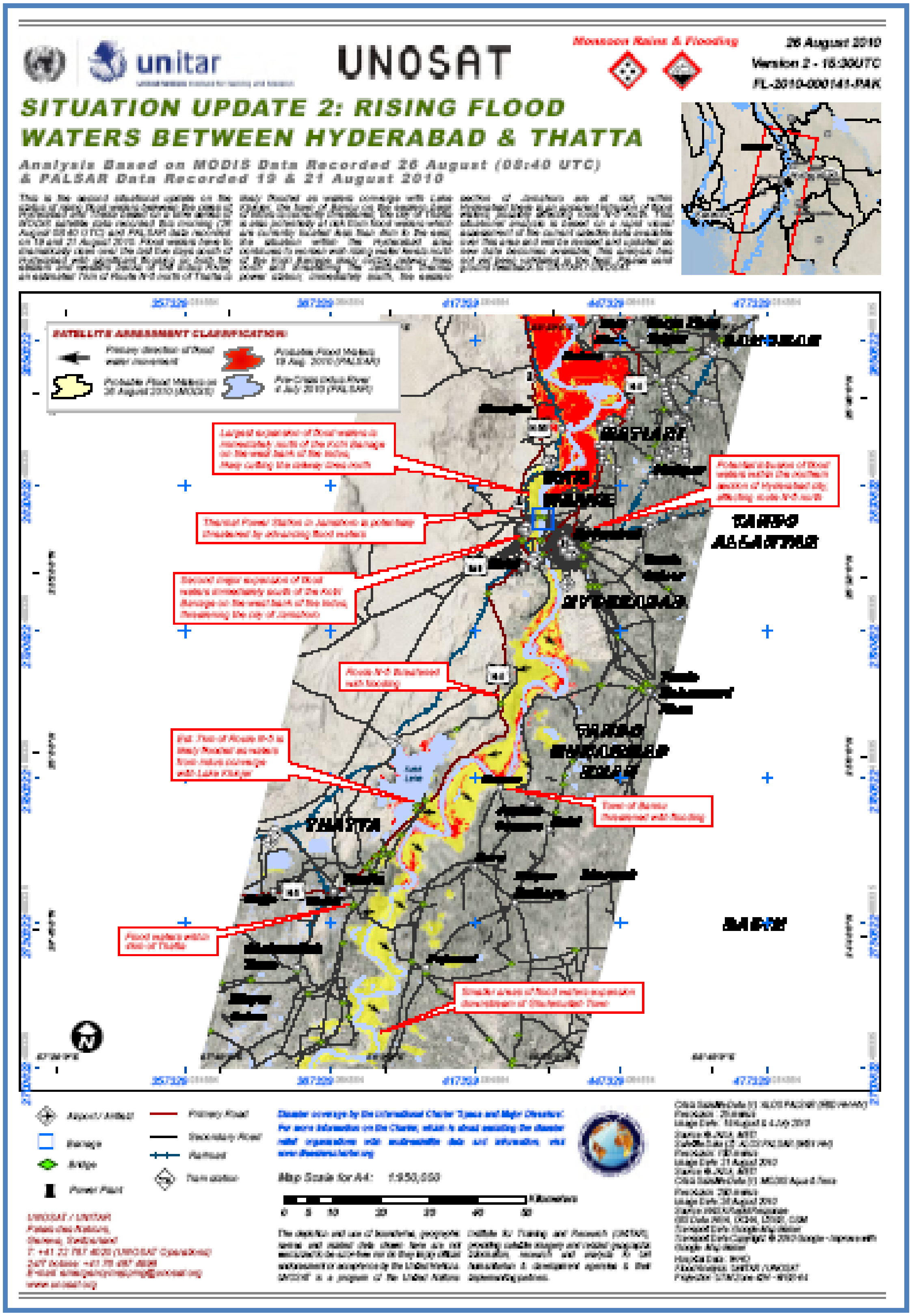
Annexure I.7.


Overview of Flood Waters in N.W.F.P and Punjab Provinces, Pakistan
Flood Analysis with MODIS Satellite Imagery Recorded on 31 July 2010
Monsoon Rains & Flooding
3 August 2010
Version 1.0
AFGHANISTAN
PAKISTAN
INDIA
BALOCHISTAN
PUNJAB
SINDH
THAR DESERT
unitar
UNOSAT

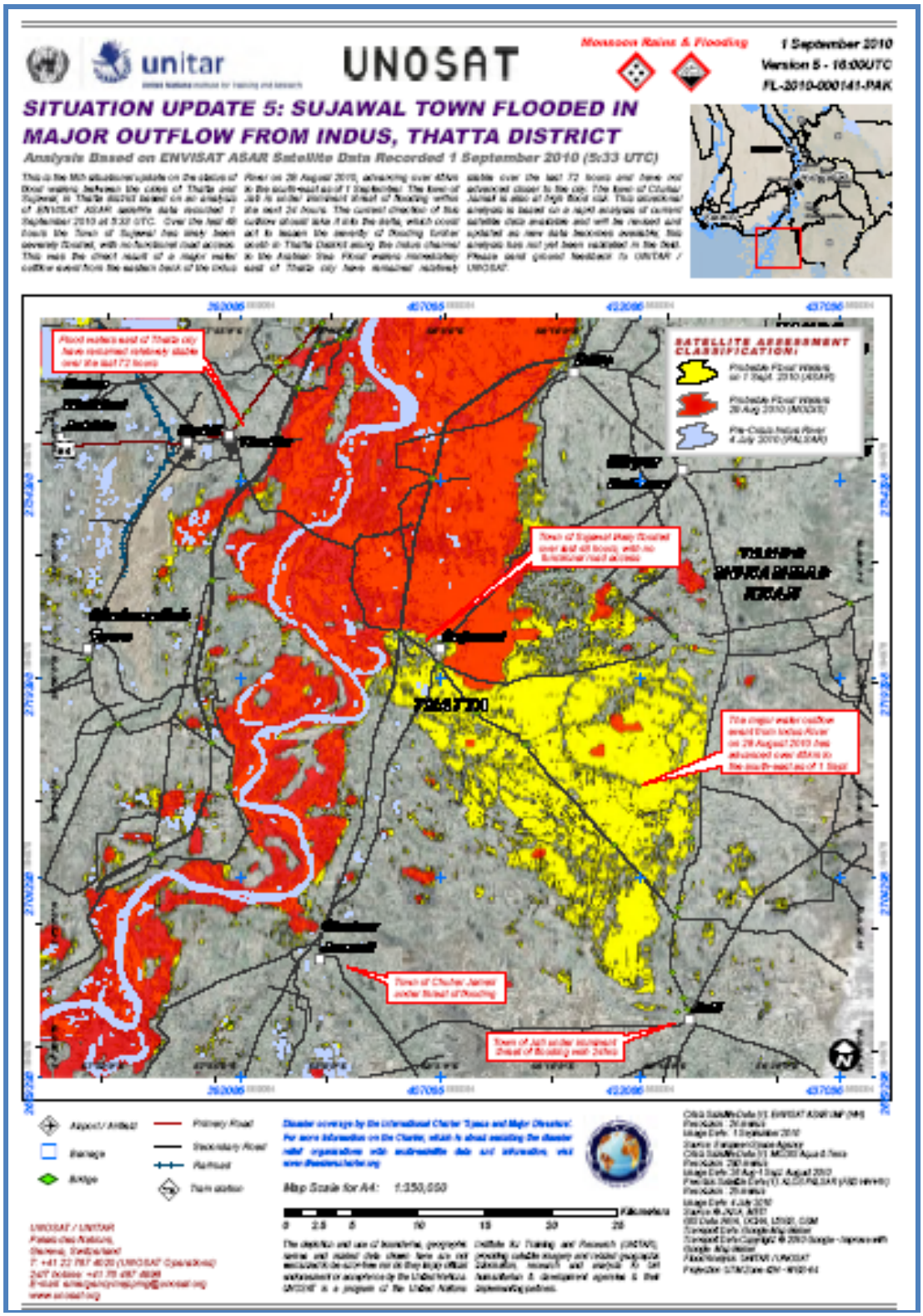
Annexure I.8.



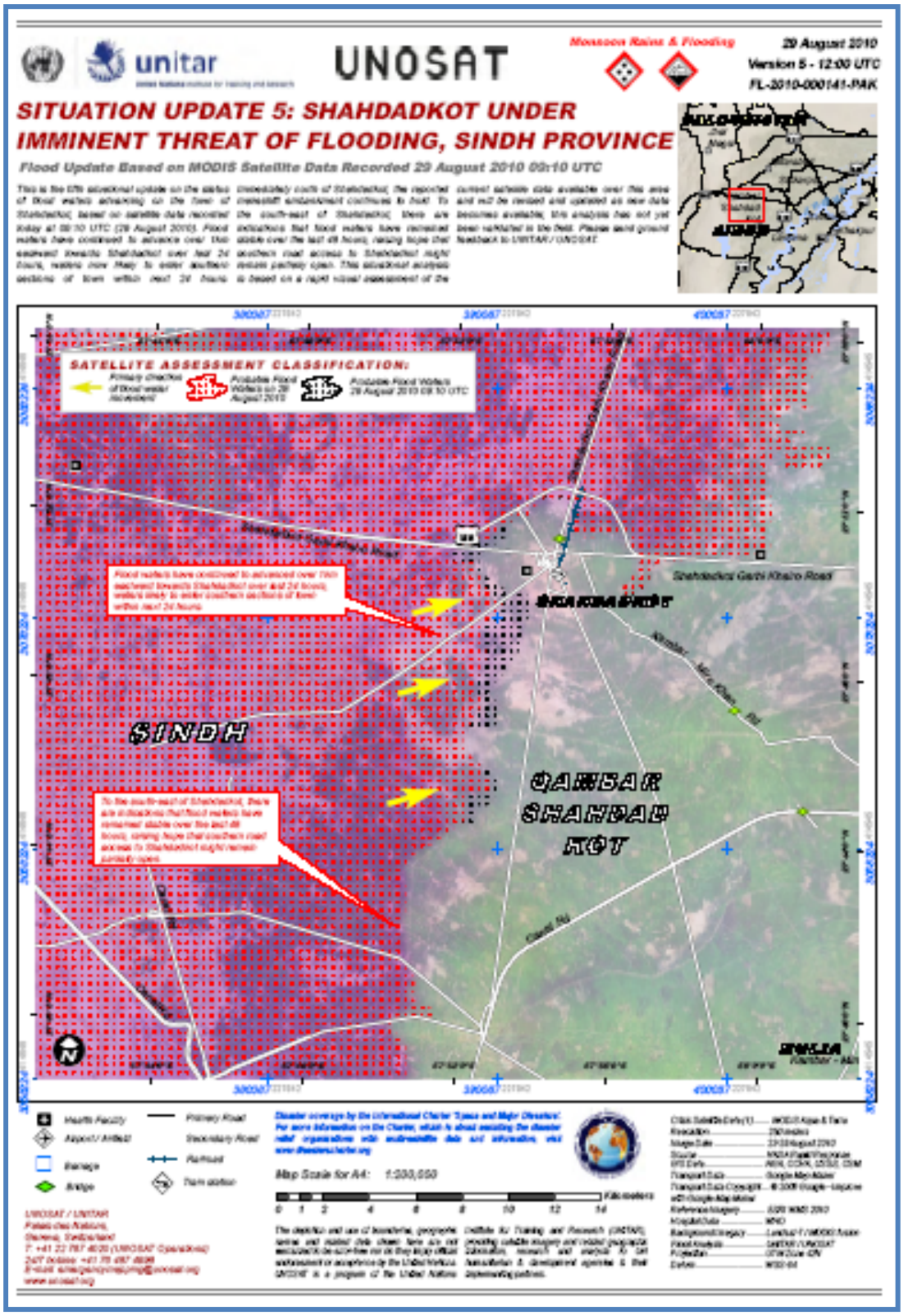
Annexure I.9.


unitar
UNOSAT
Monsoon Rains & Flooding
26 August 2010
Version 2 - 15:30UTC
FL-2010-000141-PAK
SITUATION UPDATE 2: RISING FLOOD WATERS BETWEEN HYDERABAD & THATTA
Analysis Based on MODIS Data Recorded 26 August (08:40 UTC) & PALSAR Data Recorded 19 & 21 August 2010
HYDERABAD
THATTA
MATIARI
BADIN
Map Scale for A4: 1:950,000

Annexure I.10.



Annexure I.11.



Annexure – II. Flood Affected Areas of Different Land Use Systems of Pakistan for Various Districts

II.1. Flood Affected Areas of Different Land Use Systems of Punjab (area in 'acres')

S. No	District	Forest	Irrigated Agriculture	Rainfed/Rod-Kohi Agriculture	Rangeland	Bare Soil	Settlements	Rocks	Un-cultivated Land	Water Bodies	Deserts	Total
1	Attock	1427.4	8.2	8131.3	8175.8	0.0	0.0	0.0	200.7	4564.8	0.0	22508.4
2	Bahalwapur	9416.5	28146.0	0.0	7914.2	8795.5	0.0	0.0	0.0	2448.9	4255.5	60976.7
3	Bakkar	8355.4	26108.6	0.0	37981.1	23.8	0.0	284.0	0.0	10830.8	0.0	83583.9
4	Gujrat	596.6	843.8	659.7	318.7	461.9	0.0	0.0	0.0	3910.2	0.0	6791.2
5	D G Khan	28472.5	196859.5	12965.7	27313.4	92960.9	281.2	63.0	1820.3	42619.8	0.0	403356.7
6	Gujranwala	41.0	1572.9	0.0	28.8	3792.8	0.0	0.0	14.3	1658.8	0.0	7108.9
7	Hafizabad	10.6	6643.2	0.0	739.4	7682.6	0.0	0.0	0.0	1289.5	0.0	16365.5
8	Jehelum	12214.9	5577.3	73581.9	18378.5	255.8	112.4	15.4	170.4	6415.8	0.0	116722.9
9	Jhang	13755.3	227825.7	0.0	80821.3	76263.7	792.1	0.0	937.3	28587.8	0.0	428983.4
10	Khushab	1147.6	69832.3	21993.0	3526.5	8544.5	353.1	165.1	609.4	3575.8	0.0	109747.7
11	Layyah	24372.8	144605.7	0.0	34583.1	21444.4	0.0	203.3	0.0	20945.3	78.9	246233.8
12	Lodran	1164.5	41657.7	0.0	16444.4	4215.1	117.40	0.0	243.0	3108.5	0.0	66950.8
13	M B Din	967.5	21362.0	612.6	3235.8	6454.0	0.0	0.0	278.3	2426.5	0.0	35336.9
14	Miyanwali	71331.1	110767.0	4717.9	34419.2	16338.0	433.9	236.2	47.2	48270.3	0.0	286561.2
15	Muzafargarh	129518.9	356236.1	0.0	82788.1	57548.7	4982.1	0.0	2256.7	59707.7	703.0	693741.6
16	Rahim Yar Khan	18995.5	56327.4	0.0	5271.8	6427.7	4667.0	0.0	164.5	14369.5	498.7	106722.5
17	Rajanpur	93994.4	384051.2	6706.9	14401.1	126253.8	3318.7	13584.4	657.5	44786.0	0.0	687754.3
18	Sargodah	797.1	69804.8	5116.4	25370.4	20654.5	548.6	22.2	739.8	5765.7	0.0	128819.9
	Total	416580.4	1748230.1	134486.0	401712.3	458118.4	15606.9	14573.9	8140.0	305282.5	5536.2	3785884.99

Annexure – I.

II.2. Flood Affected Areas of Different Land Use Systems of Sindh (area in 'acres')

S. No	District	Forest	Irrigated Agriculture	Rainfed/Rod-Kohi Agriculture	Rangeland	Settlements	Rocks	Un-cultivated land	River Bed	Total
1	Khaipur	23006.2	30675.0	2081.6	92025.0	876.3	0.0	0.0	6390.6	155055.0
2	Ghotki	67740.6	54959.4	0.0	31953.1	0.0	0.0	0.0	17893.7	172547.0
3	Sukkur	17893.7	30675.0	14059.3	25562.5	0.0	0.0	0.0	3834.3	92025.0
4	N. Feroze	21728.1	49299.5	0.0	71575.0	4381.7	0.0	1278.1	7668.7	155931.4
5	Nawabshah	16615.6	60071.9	0.0	0.0	0.0	0.0	3834.3	0.0	80521.9
6	Jacobabad	94581.3	482657.1	10225.0	77965.7	1752.7	1278.1	112475.1	39621.9	820557.0
7	Shikarpur	47290.6	176783.1	0.0	69018.8	2154.4	0.0	39621.9	10225.0	345094.0
8	Larkana	30675.0	276075.2	175906.8	112475.1	876.3	2556.2	16615.6	923.4	616103.8
9	Sanghar	6390.6	3834.3	0.0	0.0	0.0	0.0	2556.2	1278.1	14059.3
10	Dadu	76687.5	220970.2	34509.4	65184.4	5258.1	0.0	1278.1	4739.2	408627.1
11	Hyderabad	29396.9	69420.5	1278.1	19171.8	2556.2	0.0	10225.0	7668.7	139717.5
12	Thatta	66462.5	43456.2	6390.6	146984.5	0.0	0.0	12781.2	20988.4	297063.7
	Total	498469.2	1498877.9	244451.0	711916.3	17856.0	3834.3	200665.8	121232.4	3321411.3

Annexure – I.

II.3. Flood Affected Areas of Different Land Use Systems of Khyber Pakhtunkhaw (area in 'acres')

S. No	FIRST_FIRS	Forest	Irrigated Agriculture	Rainfed/Rod-Kohi Agriculture	Rangeland	Settlements	River Bed	Total
1	Peshawar	0	17629.9	0	0	76	979.4	18685.3
2	Charsadha	0	28403.8	0	0	145.6	1958.8	30508.2
3	Nowshera	979.4	47013.2	2938.3	3917.7	3953.63	3917.7	62719.93
4	Mardan	0	1958.8	0	0	0	0	1958.8
5	Swabi	12732.7	11753.3	0	979.4	0	14691.6	40157
6	Kohat	979.4	0	2938.3	2938.3	0	2938.3	9794.3
7	Mansehra	0	0	0	3917.7	0	10773.8	14691.5
8	Battagram	979.4	0	0	979.4	0	979.4	2938.2
9	Abbotabad	2938.3	0	4897.2	7835.5	0	29383.2	45054.2
10	Haripur	0	0	0	979.4	0	5876.6	6856
11	Kohistan	979.4	0	0	979.4	0	0	1958.8
12	Malakand	979.4	0	0	0	0	0	979.4
13	Swat	1958.8	6856.1	0	5876.6	0	2938.3	17629.8
14	D.I. Khan	23506.6	340846.1	35259.9	341825.6	0	28403.8	769842
15	Tank	0	0	32321.6	51910.4	0	0	84232
16	Bannu	0	22527.1	0	1958.8	0	0	24485.9
17	Lakki Marwat	0	82273.2	0	2938.3	979.4	0	86190.9
18	Mohamand	0	0	0	979.4	0	0	979.4
19	N.W	0	0	0	979.4	0	0	979.4
	Total	46033.4	559261.5	78355.3	428995.3	5154.63	102840.9	1220641.03

II.4. Flood Affected Areas of Different Land Use Systems of Balochistan (area in 'acres')

S. No	District	Irrigated Agriculture	Rainfed/Rod-Kohi Agriculture	Rangeland	Bare Soil	Rocks	Un-cultivated Land	Total
1	Loralai	0.0	1801.6	0.0	4804.2	0.0	0.0	6605.9
2	Zhob	0.0	0.0	600.5	0.0	0.0	0.0	600.5
3	Sibi	600.5	15013.4	0.0	7806.9	600.5	0.0	24021.4
4	Kohlu	0.0	0.0	0.0	600.5	0.0	0.0	600.5
5	Nasirabad	377737.9	12010.7	0.0	102691.8	2402.1	14412.8	509255.5
6	Bolan	0.0	9608.5	0.0	7206.4	0.0	0.0	16815.0
7	Jhal Magsi	21018.8	169952.0	0.0	434188.4	600.5	0.0	625759.7
Total		399357.2	208386.4	600.5	557298.5	3603.2	14412.8	1205825.6

II.5. Flood Affected Areas of Different Land Use Systems of Kashmir (area in 'acres')

S. No	District	Forest	Irrigated Agriculture	Rangeland	Bare Soil	Water Bodies	Total
1	Punch	28.6	0.0	0.0	0.0	0.0	28.6
2	New Mirpur	1990.8	858.93	243.2	2549.8	2936.2	8079.1
	Total	1919.5	658.93	143.2	2549.8	2836.2	8696.9