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Outstanding Student Poster Contest

Development and Calibration of Hydraulic Models Using GIS and Remotely Sensed Data

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Abstract and Research Motivation

Floodplains are morphologically dynamic areas of strategic economic, environmental and socio-political interest. Accurate models of floodplain hydrodynamics are essential tools for mitigating severe social and economic losses associated with floods. This study investigated the possibility of building and calibrating hydraulic models using remotely sensed data to overcome issues of scale, and only limited field access on an 80 km reach of Aras River that forms the boundary of the Islamic Republic of Iran and the Nakhchivan Autonomous Republic (Azerbaijan).

Study Area – Aras River

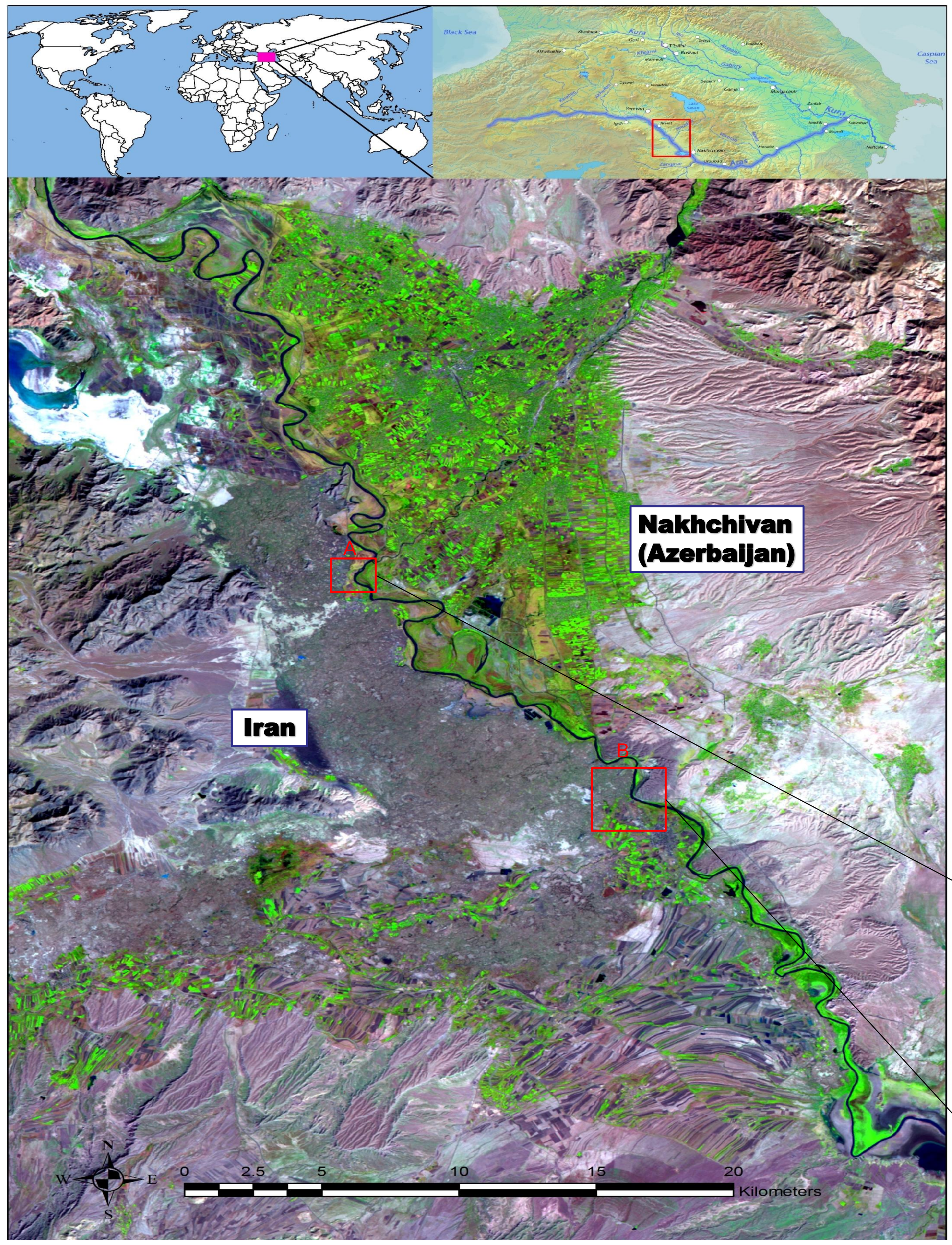

Figure 1: Study area, 80 Km of Aras River, borderline between Iran and Nakhchivan, South Caucasus

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Data and Methods

1. Comparison of Shuttle Radar Topographic Mission (SRTM) and Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) Digital Elevation Models (DEM) (Fig. 2).
2. Calibration of remotely-sensed DEM against a 1:2000 scale (total station) ground-survey derived DEM that included 245 river cross-sections (Figs. 3-6).
3. Implementation *of* one dimensional hydrodynamic model of the river and floodplain using the U.S. Army Corps of Engineers - River Analysis System HEC-RAS and HEC-GeoRAS within ArcGIS9.3.
4. Calibration of model (flood discharge & rating curve) at two gauging stations.
5. Classification of Landsat imagery to classify flood inundation (Tables 1-3, Fig.7).
6. Evaluation of model performance by comparing the simulated flood inundation extents with those derived from satellite imagery (Fig. 7).

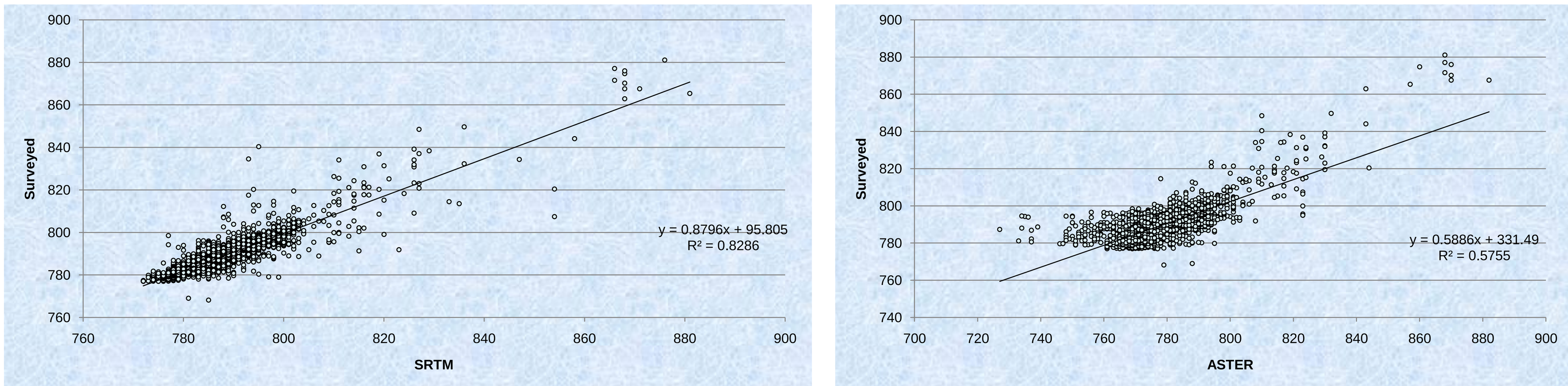

Figure 2: Comparison of Elevation of Ground surveyed points with remotely sensed data, SRTM and ASTER

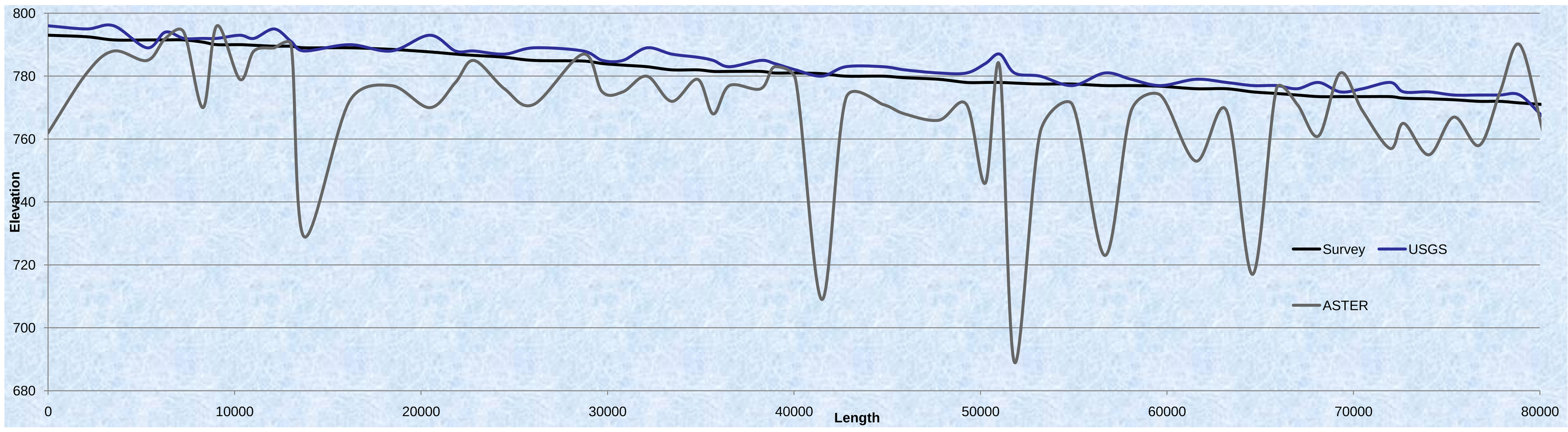

Figure 3: Longitude profile of Aras river extracted from surveyed Topographic and Remotely-sensed SRTM and ASTER

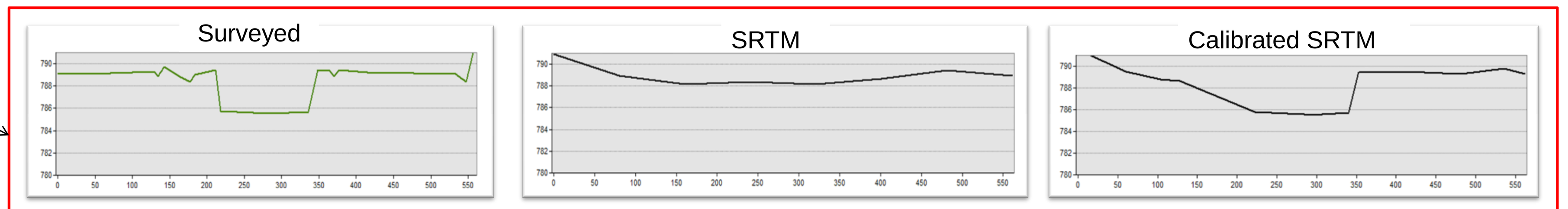

Figure 4: Composition of cross-section of Aras River surveyed (left), SRTM (centre) and Calibrated SRTM (right)

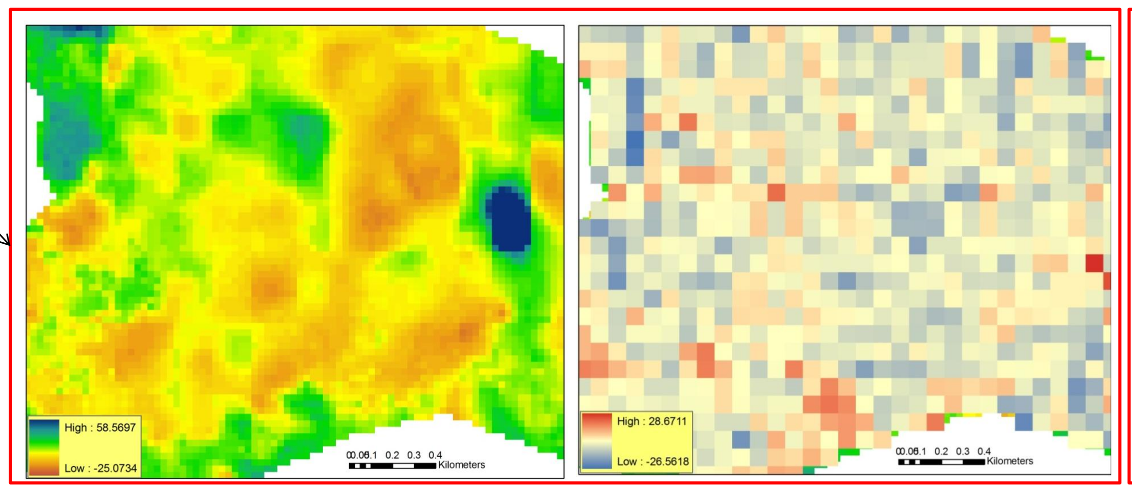

Figure 5: Distribution of Cut/Fill areas in ASTER (left) and SRTM (right)

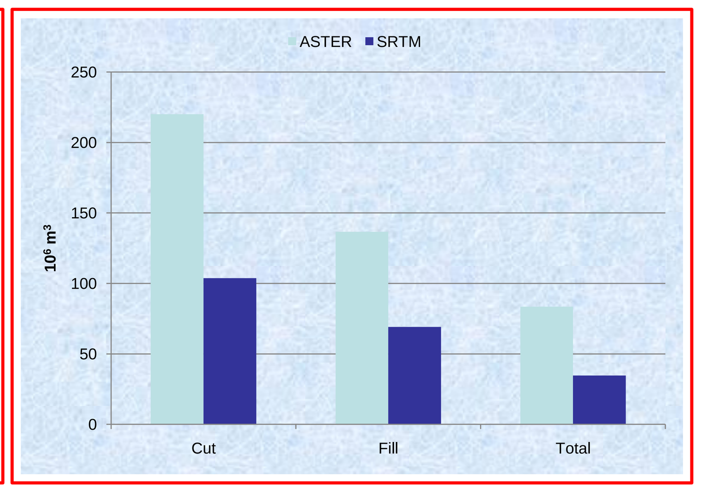

Figure 6: Cut/Fill volumes in ASTER and SRTM

Results

1. Comparison of ASTER and SRTM data with survey data revealed that SRTM data had stronger relationship with surveyed data than ASTER data (R^2 =0.83 SRTM, R^2 =0.58 ASTER).
2. Both ASTER and SRTM replicate the floodplain topography and water surface slope well, but not the channel bed topography and channel morphology (no sensor penetration through water). A calibrated SRTM DEM was created by interpolating the 245 cross sections (Fig. 4).
3. Cut/fill analysis improved accuracy of SRTM data in comparison to ASTER data (Fig. 5-6).
4. Single band density slicing was the most accurate method to classify inundation over unsupervised and supervised classification (see Tables 1-3).

Table 1: Comparison of overall accuracy (%) of single band density slicing

Method \ Image	11/05/2003	10/10/2003
Density Slice Band4	90.53	95.38
Density Slice Band5	98.16	97.75
Density Slice Band7	94.9	94.7
Density Slice of NDWI	94.4	100

Table 2: Comparison of overall accuracy (%) of three unsupervised options

Method \ Image	11/05/2003	10/10/2003
Band1-5 and 7	92.36	85.53
Bands 2,4,5, 7 & NDVI	98.9	96.2
Bands 2,4,5, 7 &NDWI	99.16	96.6

Table 3: Comparison of overall accuracy (%) of three supervised options

Method \ Image	11/05/2003	10/10/2003
Band1-5 and 7	54.37	54.38
Band1-5 and 7 + NDVI	54.38	54.35
Band1-5 and 7+ NDWI	54.41	54.5

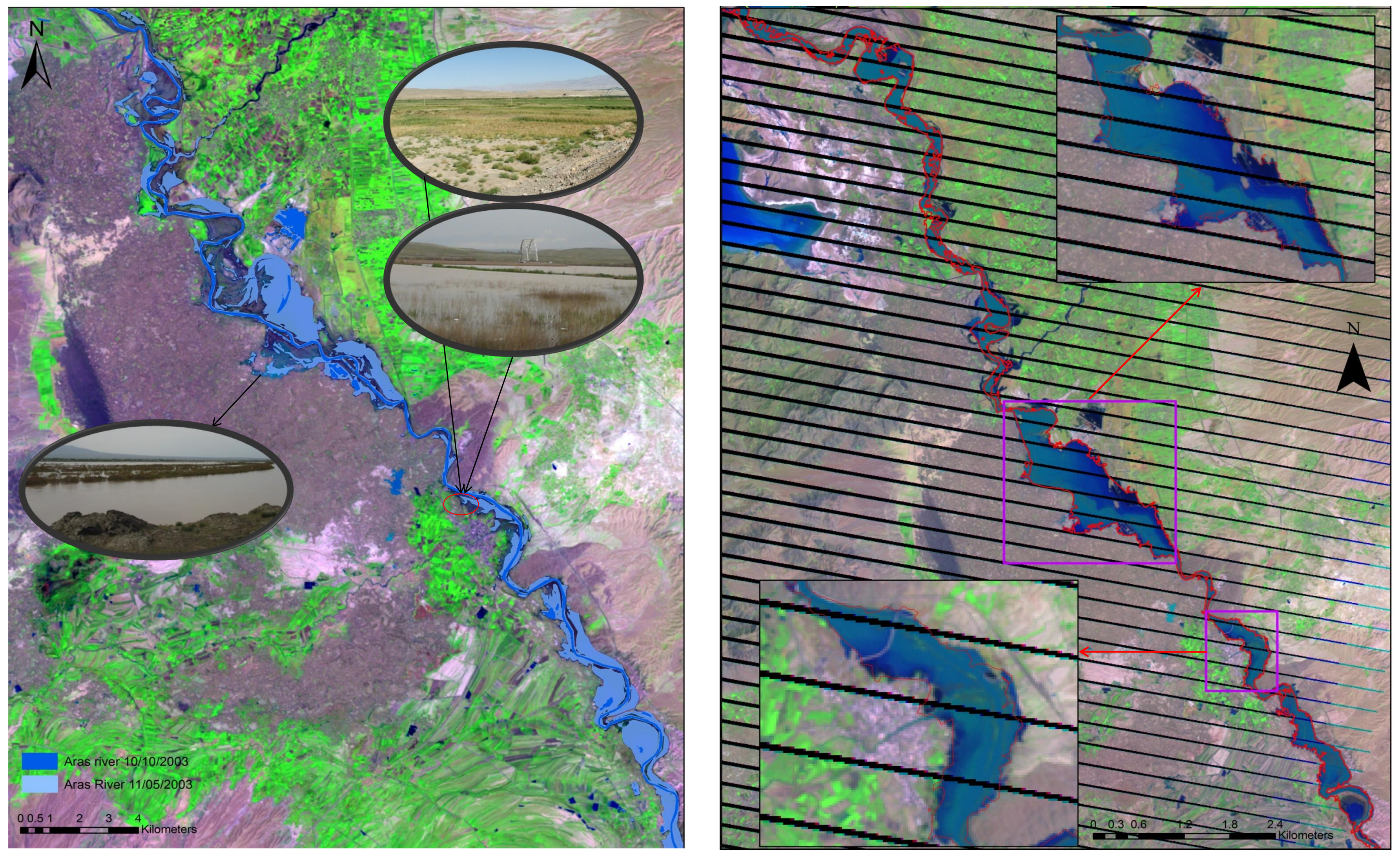

Figure 7: Landsat flood inundation for two events used for flow calibration (left), and classified flood extent (blue) and the modelled flood extent (red line) from HEC-RAS/HEC-GeoRAS(right).

Conclusions

1. SRTM data can be used to extract floodplain topographic data for hydraulic models to simulate inundated area with considerable accuracy, though surveyed channel data is also required.
2. Landsat images can be used to map flood inundation and calibrate/validate flood inundation models for inaccessible areas.
3. A simple density slice classification of the Normalised Difference Water Index (NDWI) and mid-infrared band 5 produced higher classification accuracy than other tested methods.
4. Utilising remotely-sensed datasets integrated with field data, hydraulic models and GIS techniques has potential to improve simulation and prediction of the spatial extent of floods. This is particularly the case for large, data-poor or even ungauged areas.

References

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