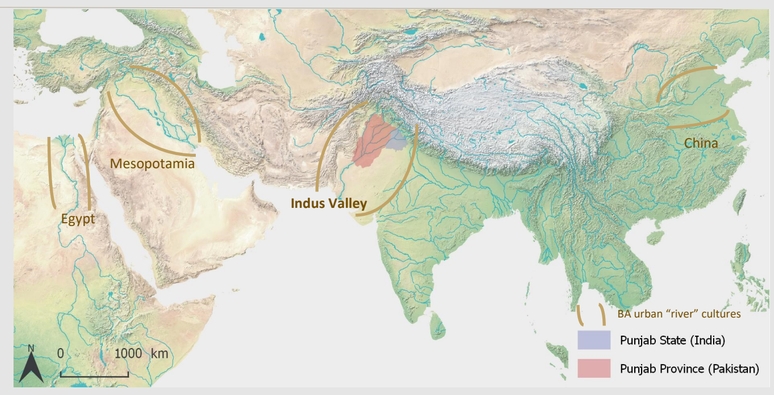
APPLICATIONS OF MULTI-TEMPORAL DATA AND CLOUD COMPUTING FOR THE STUDY OF PAST SETTLEMENT AND LANDSCAPE DYNAMICS IN THE PUNJAB REGION

Arnau Garcia, Hector A. Orengo, Francesc C. Conesa, Adam S. Green, and Cameron A. Petrie
McDonald Institute for Archaeological Research (ag2023@cam.ac.uk)

INTRODUCTION

Description and objectives of the project:

- This contribution presents the first results of the MSCA-IF funded project **Water Management Strategies and Climate Changes in the Indus civilization (WaMstrIn)**. This project participates in a coordinated program carried out by researchers from the McDonald Institute for Archaeological Research (https://www.arch.cam.ac.uk/research/projects/two-rains) with the aim to develop consistent methodologies for the use of big sets of multi-temporal satellite images in the study of prehistoric and historical landscapes (Petrie et al. 2017). The particular object of study is the relationship within settlement dynamics of the Indus Civilisation, first urban culture in South Asia (3000-1900BC), and the changing hydrographic network of the Indus basin.
- The methodological approach is based on:
  - (1) the analyse of large repositories of multi-temporal multi-spectral satellite images and DEM's, using specifically created algorithms and parallel cloud computing applications for the detection of (a) paleo-channels and (b) signatures of disappeared human settlements
  - (2) the creation of a geodatabase of historical sources to complement and contrast the results obtained and support the implementation of machine -learning processes.
- WaMStrIn project is applying this methodological approach in the Indus middle basin (historical region of Punjab, Eastern Pakistan and North-western India). It represents one of the world's most productive agricultural areas, capable of sustain large populations both in in the present and in the past, including the Bronze Age Indus cities.
- Three preliminary case studies are collected here to illustrate the potentiality to identify features of interest and the problematics for the interpretation of the results obtained. They represent illustrative example to discuss the opportunities and difficulties in using new multi-temporal data and cloud computing in highly anthropized landscapes affected by important transformations in recent periods.



Historical and Geographical context:

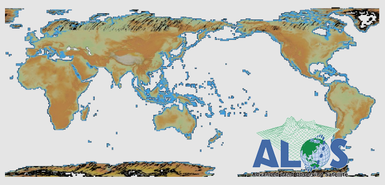
- The historical Region of Punjab occupies the middle Indus basin and its major tributaries (Jhelum, Chenab, Ravi, Beas and Sultej). The fluvial regime is characterized by the irregular seasonality related to summer (monsoon) and winter rains.
- The Indus Valley or Harappan civilization is the name of a Bronze Age Urban culture, which extended through the Indus basin alluvial plains and the nowadays arid surrounding areas (Gujarat, Cholistan, Baluchistan) during the 3rd MM B.C., and contemporary to other Ancient "river civilizations".

MATERIALS & METHODS

Historical Cartography

Early 20th C (1905-1947) Survey of India (SOI) maps of the study areas have been georeferenced in a GIS environment. Regressive analysis is complemented by other cartographic material (19th—20th C)

Relief analysis



DSM "ALOS World 3D-30m" (http://www.eorc.jaxa.jp/ALOS/en/aw3d30/aw3d30v11_format_e.pdf)

"Multi-Scale Relief Model (MSRM)" algorithm (Orengo & Petrie 2018). Google Earth Engine Platform

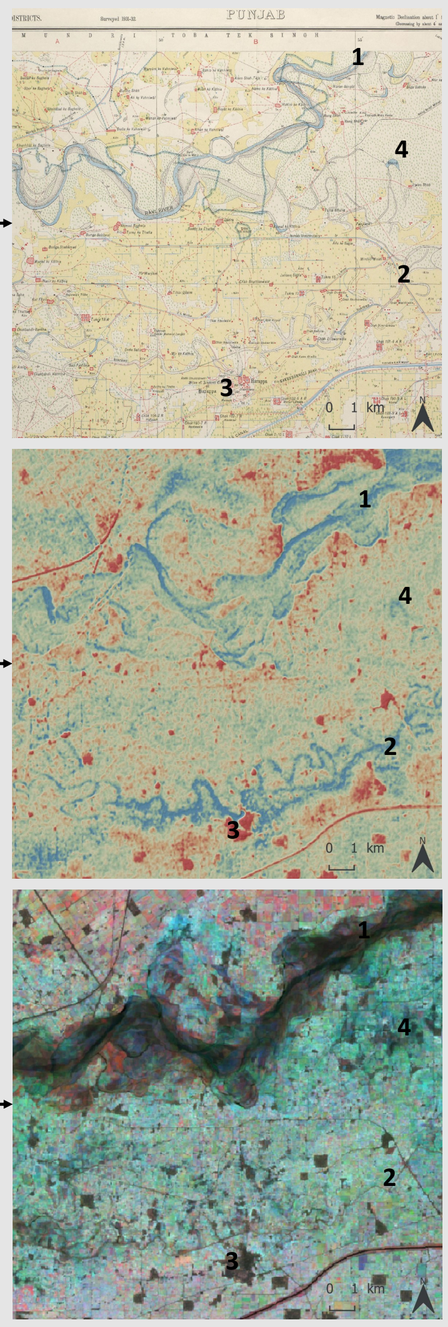
Multi-temporal multi-spectral satellite image

Landsat 5 images (1984-2013) (https://landsat.usgs.gov/landsat-collections)

"Seasonal Multi-Temporal Vegetation Index (SMTVI)" algorithm (Orengo & Petrie 2017). Google Earth Engine Platform

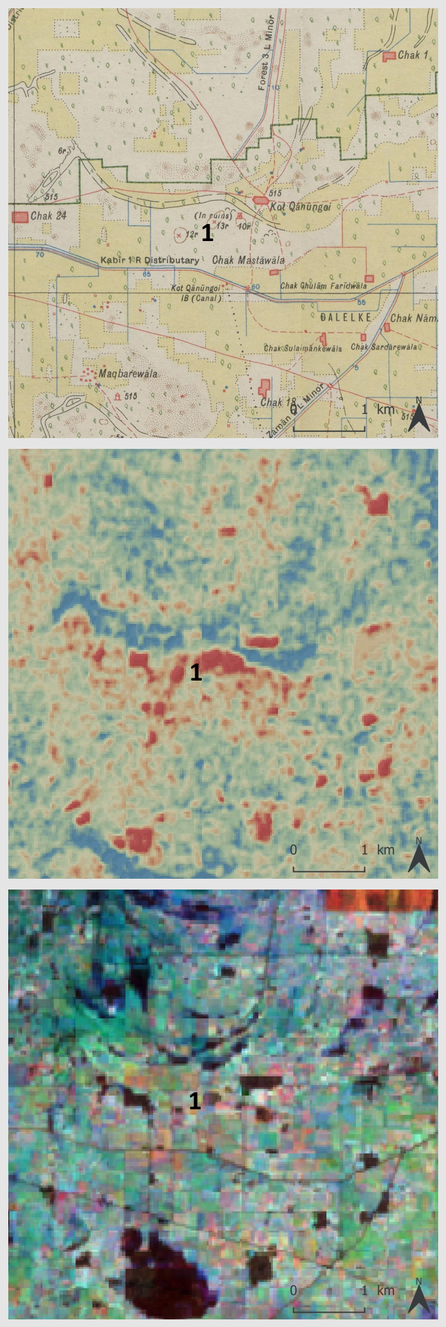
EXPLORATORY STUDY CASES

Paleochannels



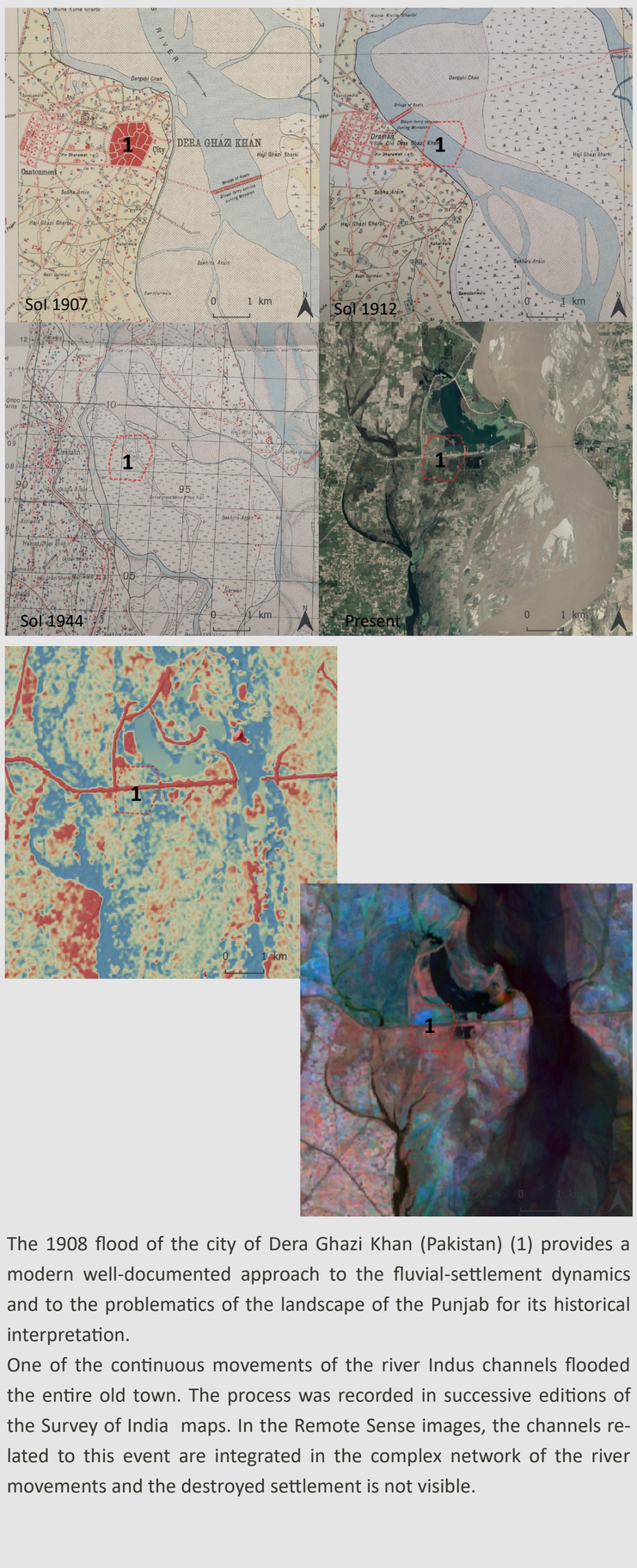
Active and inactive river-courses can be identified through their marks on the topography and on the surface reflectance.
The example shows a section of the actual main course of the river Ravi (1), including its multiples changes. A Southern channel of the river (2), nowadays intermittently active, can be identified next to the Ancient City of Harappa (3). Other less evident remains of older channels can be spotted as well (4).

Mound Features



A characteristic type of archaeological sites documented in the Indus basin have the form of round mounds, consequence of the building and later abandonment of human-made structures (Greene & Petrie 2018).
Some, like the example here (1), were recorded as small hills in the old maps before they were flattened by modern agricultural developments. They might also have left traces in the topography and surface reflectance.

Historical floods



The 1908 flood of the city of Dera Ghazi Khan (Pakistan) (1) provides a modern well-documented approach to the fluvial-settlement dynamics and to the problematics of the landscape of the Punjab for its historical interpretation.
One of the continuous movements of the river Indus channels flooded the entire old town. The process was recorded in successive editions of the Survey of India maps. In the Remote Sense images, the channels related to this event are integrated in the complex network of the river movements and the destroyed settlement is not visible.

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Two Rains

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