



## **Developing a framework to observe and analyze anthropogenic geomorphology across millennia**

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Human beings, as a geomorphological agent, have been altering the landforms and leaving their fingerprints across the Earth surface for millennia. It has been widely recognized that these anthropogenic modifications contribute to erosion, sediment transport, and natural hazards (Tarolli and Sofia, 2016). However, the lack of a robust understanding of human evolutionary processes across the Earth is still a challenge for the scientific community. This work provides a theoretical framework to observe and analyze anthropogenic geomorphology, integrating social and physical science.

Human driving forces on Earth's topography manifest in various ways, and can be summarized as follows:

- (1) Meaningful patterns deliberately inscribed in the surface of the landscape by past societies such as tombs, geoglyphs and megaliths can be read and interpreted as cultural artifacts.
- (2) Habitation areas made from durable material represent one of the more significant technical innovations in terms of reshaping the Earth's surface. These encompass a range of settlement patterns from rock shelters to cities with buildings, boundary walls and road networks. The density and extent of occupation correlates strongly with topographic variability in the landscape.
- (3) Traces of features related to subsistence, for example, hearth-pit for built -fires, agriculture and pasture for food production, mining for development resources, reveal the development of complexity in early societies and allow us to elucidate the dynamic relationship between humans and their environment. Most of activities involving the intensive exploitation of resources lead to some extent of soil contamination and sediment in the terrain.
- (4) The management of water for both supply, sanitation, reclamation and irrigation shows significant human adaptation of the Earth's topography. Water-supply features including pipes, canals, tunnels, reservoirs, cisterns and dams from ancient times can still be found nowadays. For millennia, humans built embankments, created ditches, dams and reservoirs, and today they construct wetlands to treat municipal or industrial wastewater. These anthropogenic landscape changes play a highly significant role in hydrogeomorphology, such as water and sediment dynamics.
- (5) Refuse disposal systems exhibit the complexity of resource exploitation by human beings; ranging in scale from middens and tells to modern landfills, these features are typically visible in landscape topography and can be identified through spatial variability of other geophysical and geochemical properties.
- (6) Bomb craters and warfare trenches also attest to a particular category of human behaviour that can be usefully explored through material culture. They can also cause considerable modification to the physical landscapes and to the soil.

Based on these anthropogenic features, we applied remote sensing techniques such as LiDAR and airborne imagery to create high-resolution topographic models, characterize objects, and interpret the palimpsest of traces of human activity, thus providing the new opportunity for a better understanding how Earth surface has developed, and will develop, under the influence of human drivers.

### Reference

Tarolli, P., Sofia G. (2016). Human topographic signatures and derived geomorphic processes across landscapes, *Geomorphology*, 255, 140-161, doi:10.1016/j.geomorph.2015.12.00