

## APPLICATION OF SATELLITE IMAGES FOR DETECTION OF ILLEGAL EXCAVATION IN PUGLIA (ITALY)

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### Abstract

The research was conducted on the whole region of Puglia (South of Italy), with particular attention to areas of Tavoliere - Foggia (Arpi, Salapia, Siponto). The purpose is to provide an overview on the phenomenon of illegal excavations in Apulia through consultation, photo-interpretation, georeferencing systematic aerial photographs, historical and recent, and satellite images. In particular, the systematic work of photo-interpretation was carried out on strips of historical aerial photo, orthophotos and finally on satellite images through open source programs such as Google Earth, Bing Maps, Flash Earth.

### Keywords

Archaeology, Illegal excavation, satellite images, Aerial archaeology

### 1. Satellite Images

The need and necessity of a real technological accretion, acted to monitoring and protecting our territory, it has become, in the last decade, a new research foundation. This necessity regards even to the activation of appropriate politics of monitoring, control and maintenance, fundamentals for the conservation and valorization of the cultural heritage and its fruition by community. Among the first platforms used in archaeological environment via Satellite imaging high resolution there is QuickBird (Fig. 1-2).

The use of this platform was created to understand the potential of satellite, panchromatic and multispectral shooting, as tools for the identification, analysis, documentation and monitoring of sites and areas (Fig. 3-4) of archaeological interest (Lasaponara, Masini, Scardozzi 2007). In the search of Tavoliere of Apulia, the use of satellite images, has allowed the identification of more of 1.000 archaeological sites illegally excavated and damages both, with systematic episodes, now documented and located, divided by provinces, provincial capitals, municipalities and villages. Some surviving sites have been studied directly through targeted

surface surveys, displaying a considerable number of illegal excavations and other types of damage (investigations in the territory of Arpi sprang the recognition of 4000 tombs illegally excavated) bringing the total number of interventions to several thousand (Fig. 5-7).



**Fig. 1:** Image captured by the satellite Quickbird.

The need to investigate-examine this extended area arises from the lack of uniform and organized dates concentrated on-focused on

clandestine excavations all over the regional territory.



Fig. 2: Image captured by the satellite Quickbird.

Furthermore peculiarities of Apulian land-territory and modality of ancient human settlements/populating constitute a link between clandestine excavation activity and art trade trends, who takes macroscopic evidences in the region<sup>1</sup>. At the beginning have been used different methodologies of research and analysis as the systematic bibliographical and archivistic documentation, archaeological recognitions, the updating of all previous dates, the addition of new dates on SIT<sup>2</sup>, the consultation, photo interpretation, the systematic georeferencing of historical and recents-new-latest air photos and satellite images. In particular, the work of systematic photo interpretation on stripped historical areas of the I.G.M. (1943), of the R.A.F. (1947), on the flight I.G.M. (1954-55), on the latest photograms of S.A.R.A. Nistri '80, AeroTop S.r.l. (1988), I.A.S. S.r.l. (2002), on ortophoto and on some satellite images.

Satellite images employed have spatial resolution and temporal resolution: the first is defined-specified as the minimum angle that an

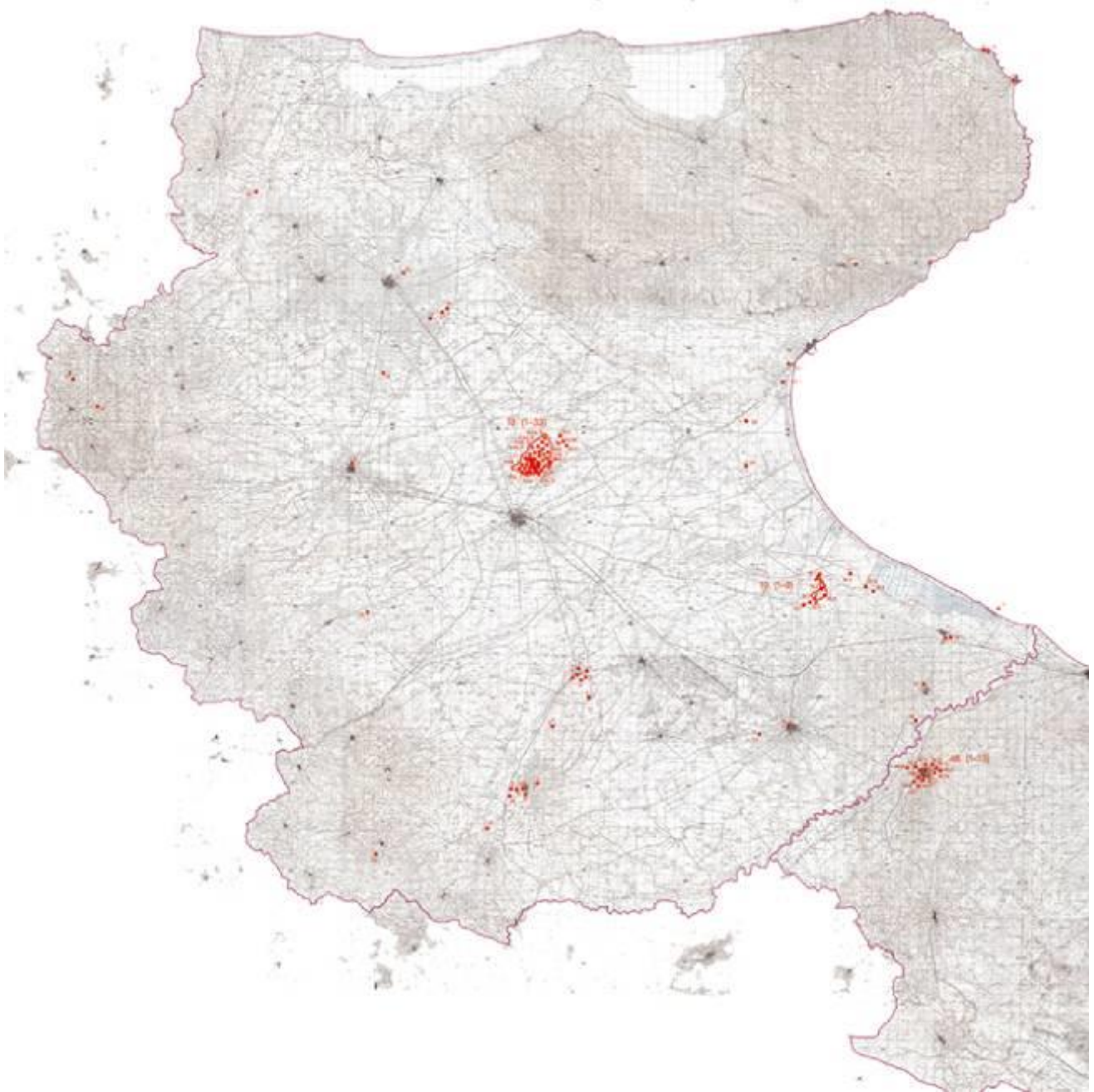
<sup>1</sup> Only Campania and Sicily have cases of illegal excavation similar to Puglia.

<sup>2</sup> The Territorial Information System is owned by the Laboratory of Ancient Topography and Photogrammetry of the Department of Cultural Heritage of the University of Salento. It consists of a database characterized by a class module integrated in the GIS application of the GEOMEDIA - Intergraph software.

optical system recognizes without refraction discomfits otherwise to which dimension corresponding to a pixel in the teledetected image who represents a certain surface (for instance in m<sup>2</sup>) established by the Field of View (FOV) of the sensor.



Fig. 3 - 4: Differences between Naip satellite images and QuickBird.



**Fig. 5:** Tavoliere delle Puglie. Reporting of illegal excavations.

The latest- temporal resolution refers the time interval employed by satellite to fly over again on a given patch. This resolution can be increased employing satellites constellations. This is very helpful to know and distinguish change in a given region. Satellite platforms mainly used in this research are Bing Maps Platform (earlier Microsoft Virtual Earth) Google Earth. First is a geospatial mapping platform produced by Microsoft which permits to create applications due to the position dates and to the levels of geospatial mapping. The image includes samples taken from satellite, aerial images, aerial at 45°,

3D images. GoogleEarth is a graphic 3D application which allows to visualize aerial and satellite photos with a high level of detail. This program permits the data implementation by users and the sharing with others users. Google Earth shows a tridimensional representation of the soil through DEM dates (Digital Elevation Model), stored during the NASA Shuttle Radar Topography Mission. KML language is employed into the program to handle geospatial dates in three dimensions. Mainly of recorded dates are barely known however not exactly positioned, rarely they are puntual analysis object, again, they

are not object of valorisation and legal safeguard operations by organ in charge.

## 2. Reference area

The happening of systematic abusive excavations and related clandestine commerce of ancient relics has assumed dimensions unknown hitherto; because of this, indeed, in recent decades, are been lost historical evidences of inestimable value (Zanker 1996).



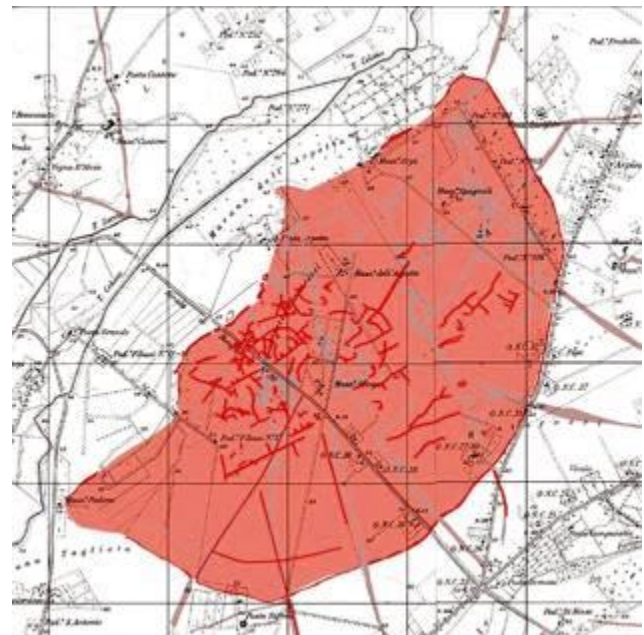
**Fig. 6:** At the top, historical aerial photo of the town of Arpi – Fig. (998 hectares), IGM 1954.

The Tavoliere, with his 4000km<sup>2</sup>, is the most extended level plain of the whole nation. Various hydric flows-courses as the Cervaro, the Ofanto, the Carapelle, the Candelaro, numerous torrential systems coming from the Massif of Gargano and from the Daunian Subappennino, and the proximity of-nearby Adriatic Sea, have enabled, in the centuries, the intensive presence of human settlements, developing, important trade networks thanks to the conjunction of economical activities - based on territorial resources such as cereal-growing, transhumance, processing of wool, salt collection and distribution – who give-back us a series of attestations which boast an high level of material culture.

But a characteristic who inscribes the Tavoliere is the transformation of so many daunian production centres as Arpi, Salapia, Aecae, abandoned during the republican age, right-after Punic wars, in small farming areas,

handing over the resource management to the new foundation colonies.

The levels of the daunian culture are found, even now, in the richness of the grave-goods-funerary equipments of the untouched tombs, excavated, into regular searches, by Superintendence and Universities, and from the large quantity of materials coming from clandestine excavation, which flows into the trafficking and into the increasing frequent cases of sequestration conducted by low enforcement following activities of judicial police (Fig. 8-9).



**Fig.7:** Photogrammetric vectorization of Arpi's area. IGM: 164 SE IV - IV 164 SO. (Laboratory of Ancient Topography - University of Salento).

The almost complete integration of urban areas and they very large extension, would allow a critic lecture of all cultural and material attestations pertaining to populations that came after in this region. But as well as reseachers and officials appointed to safeguard have paid close attention to, so even criminal organisers (archeomafie) made the same, investing men and resources to investigate these territories and earn profits.

The characterist which support undisturbed activity of the robbers is the diffused lack of life presence, since the rural advancement, focused on cereal culture and then including a large extension of the fields.



**Fig. 8:** Photogrammetric vectorization of Arpi's area with updating (red polygons) of archaeological sites damaged.

Again, the clandestine excavation, is not respectful of cultural periods at a previous times, now disregarded, without regulations or seasonal limits in these last years: for instance CEE norms to control the cereal production, ensured that highly productive fields, are left without cultivations, then available to illegal search (Mazzei 1995).



**Fig. 9:** Aerial photo (Carabinieri helicopter) with identification of illegal excavations in the territory of Arpi (ph. M., Guaitoli).

Finally, the rural intended use of these areas, has allowed the complete preservation of numerous necropolis present in the territory.

### 3. Arpi.

Clandestine excavation at Arpi is incentivated principally by richness of necropolis, numerous and localized in different places; characterized by the deposition of metallic materials and by the

presence of forms pertaining to pottery classes of high value and particularly esteemed in the antiques market.

Moreover is not even respected the architectural structure of the tombs, also marketed once been put in the clandestine traffic.

Ravages Arpi's territory started in the early 70's continuing currently until the middle of 80's, era in which being touched the culmination of this phenomenon, and the clandestine organisations became an authentic criminal association.

For about thirty years Arpi has been delivered in the hands of robbers who reinforced their illicit activities depriving of any intervention possibility the organs appointed to the prevention, research and conservation (Andreassi 1979).

### 4 The interpretation of satellite images.

Consultation of satellites platforms open source has allowed a large scale monitoring on the Arpi's territory, in different periods.



**Fig. 10:** Arpi: satellite image (Google Earth 2010) with highlight of any areas damaged by illegal excavations.

Only in the ancient territory of Arpi, in a period between 2002 and 2010, are being individuated 22 areas affected by clandestine excavations, totalling 626 robbed burials in a little less of height years, this result is obviously referable to the detectable evidences from the visible satellite images, but the date could be greater if when considering time frames not covered by satellite image (Figg. 10-14).



**Fig. 11:** Identification of illegal excavations in Arpi through Google Earth in 2013



**Fig. 12:** Identification of illegal excavations in Arpi through Google Earth in 2010



**Fig.13:** Illegal excavations in Arpi through Google Earth in 2007



**Fig.14:** Illegal excavations in Arpi through Google Earth in 2007

In some cases, it was possible to verify all these dates obtained by satellite images through the collaboration with the TPC (nucleo Tutela Patrimonio Culturale dei Carabinieri)<sup>3</sup> who constantly and with so many difficulties, monitors relevant areas via aerial helicopter recognition.

With these available means, results are actually alarming: from aerial and satellite images, only in the Arpi territory are estimated more than 4 thousand plundered tombs. Considering that this data has been acquired at a given interval time, the number of affected tombs could be much higher.

On the other hand, the constant use of satellite platforms open source allows the monitoring of those areas particularly considered at risk and, the individuation of territory portions which could be object of clandestine investigations, supporting the opposite activity from organs appointed to protection, and those of academic researchers.

Furthermore it should be noted the high potential of devices at remote command (drones) that, given their easy availability compared to traditional biposto or helicopters, could be used more frequently and with optimal results, for the monitoring programs and to keep control of areas considered at risk.



**Fig. 15:** Historical photo of robbery of tomb in Puglia.

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<sup>3</sup> Italy was the first nation in the world to have a police department expressly dedicated to combating crimes against the artistic heritage, anticipating a year of the recommendation of the General Conference of UNESCO.

## REFERENCES

- Andreassi, G., (1977). L'attività archeologica in Puglia. In *ACMG XIX*, (pp. 433-435). Napoli, IT: Arte Tipografica.
- Lasaponara, R., & Masini, N., & Scardozzi, G., (2007). Immagini satellitari ad alta risoluzione e ricerca archeologica: applicazioni e casi di studio con riprese pancromatiche e multispettrali di QuickBird. *Archeologia e Calcolatori, XVIII*, 187-227.
- Mazzei, M., (1981). Lupara-Giardino (Foggia), F. 164 II SE. *Taras*, I, 1-2 (pp. 288-309). Galatina, IT: Congedo Editore.
- Mazzei, M., (1985). Serpente (San Severo): rinvenimento di una tomba di età ellenistica. *Taras*, V, 1 (p.125). Galatina, IT: Congedo Editore.
- Mazzei, M., (1989). Foggia, Arpi F. 164 IV SO – IV SE I.G.M. *Taras*, IX, 1-2 (pp.161-163). Taranto, IT: Editrice Scorpione.
- Mazzei, M., (1990). Foggia, Arpi. *Taras*, X, 2 (pp. 302-303). Taranto, IT: Editrice Scorpione.
- Mazzei, M., (1991). Foggia, Arpi. *Taras*, XI, 2 (pp. 236-237). Taranto, IT: Editrice Scorpione.
- Mazzei, M., (1992). Foggia, Arpi. *Taras*, Notiz. XII, 2 (pp. 238, 243-244). Taranto, IT: Editrice Scorpione.
- Mazzei, M., (1994). Foggia, Arpi. *Taras*, XIV, 1 (pp. 63-64). Taranto, IT: Editrice Scorpione.
- Mazzei, M., (1995). *Arpi. L'Ipogeo della Medusa e la necropoli*, (pp. 33-36). Bari, IT: Edipuglia.
- Mazzei, M., (2001). *Atti del Convegno Traffico illecito Patrimonio Archeologico*, VII (pp. 168-181). Comando Carabinieri TPC, (Roma 25-28/06/2001). Roma, IT.
- Mazzei M., (2003) Salapia, in M. Guaitoli (Ed.), *Lo sguardo di Icaro. Le collezioni dell'Aerofototeca Nazionale per la conoscenza del territorio*, (p. 105). Roma, IT: Campisano Editore.
- Zanker, P., (1996) Prefazione. In M. Mazzei, D. Graepler, *Provenienza: Sconosciuta. Tombaroli, mercanti e collezionisti. L'Italia archeologica allo sbaraglio* (p.7). Bari, IT: Edipuglia.