

# REDUCING THE VISUAL IMPACT OF PLASTICULTURE ON RURAL LANDSCAPES BY A SUSTAINABLE MANAGEMENT OF AGRICULTURAL PLASTICS

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## Abstract

The use of plastics in agriculture represents one of the main factors having a major impact on the environmental sustainability of the agricultural sector. The effectiveness, economy and versatility of using different plastic polymers has made these products widespread in highly profitable agricultural activities (orchards and horticulture). However, their incorrect management can determine serious environmental impacts, mainly connected to large quantities of post-consume plastic waste. Another problem is linked to the visual impact that these large clusters can have on the surrounding rural landscape. Indeed, the aesthetic quality of these territories may be reduced, with negative impacts on the surrounding areas - often characterized by a fragile environment and a marked tourist vocation - whose perception is difficult to quantify and evaluate. In this paper, a GIS-based methodology has been implemented, to perform a visual impact assessment, by applying it to the case study of the agri-food district of "Metapontino" (Basilicata Region - Southern Italy). GIS tools, besides allowing complex spatial analysis, revealed as a planning instrument that can be used by public authority also to activate suitable strategies for mitigating the visual impact of plastics on rural landscape, so as to contribute to reducing the plastic footprint of agriculture.

**Key words:** Landscape protection, Protected crops, Plastic covers, GIS, tourism impacts

## Introduction

Agriculture has been one of the sectors in which technological innovation has been constantly researched, in order to improve land productivity and make agricultural work easier. One of these innovations has concerned the introduction of different plastic polymers which are used in different phases of the production cycles (Djakhdane K. et al., 2016). The most evident example is that of greenhouses and tunnels. However, in addition to the benefits, the use of plastics in agriculture causes numerous negative impacts on the environment, such as those related with the mismanagement of large amounts of post-consumer materials, with possible release of macro-, micro- and nano-plastics in agricultural soil, surface and deep water, air, crops, etc., as well as a heavy impact on the sustainability of agricultural productions (Scarascia-Mugnozza et al., 2008; Picuno C., et al., 2019). In addition to these impacts, it should be noted that these wide continuous surfaces covered with plastics, greatly reduce the visual quality of rural landscapes. This is extremely evident in some areas of the Mediterranean (Espí et al., 2006; Nanna et al., 2018). Obviously, the visual quality of the landscape is very important in areas with a marked tourist appeal for public recreation which, in some cases, coincide with areas with a strong agricultural vocation. Visibility analysis, in particular, is increasingly being implemented by landscape planners in effective decision support systems that deal with the best possible land patterning, as well as in assessing the visual impact of given landscape elements (Rogge et al., 2008). In southern Italy, there are several cases; the one analyzed in this work is referred to the agri-food district of "Metapontino" (Basilicata Region), in which the increase of agricultural plastics (in addition to the environmental impact on the various protected areas present) represents a problem for the aesthetic quality of the landscape. In this paper, a methodology to assess the visual impact of plastic agricultural surfaces is presented, by using a GIS methodology (Statuto et al., 2019) reproducible and exportable in other territorial contexts as a simple and rapid application, as well as modular, on the basis of the appropriate level of detail. In addition, the ease of use and calibration of the methodology also makes it a spatial tool for decision support, because it allows to process information useful to the public decision maker to plan interventions for mitigating the visual impact.

## Material and methods

The study area is represented by the boundaries of the municipality of "Policoro" (Basilicata Region - Southern Italy); it covers almost 6800 hectares (Fig.1). It is one of the most important municipalities of the "Metapontino" agro-alimentary district, since there is a strong presence of quality fruit and vegetable cultivations. This, determines an important presence of different types of agricultural plastics

(Fig.2) as well. Indeed, almost 30 percent of the greenhouse crops in the entire Basilicata region are located there.

A previous study (Cillis et al., 2022) showed that in 2017 the Agricultural Plastic Surface (APS) in the municipality of Policoro amounted to about 461 hectares.

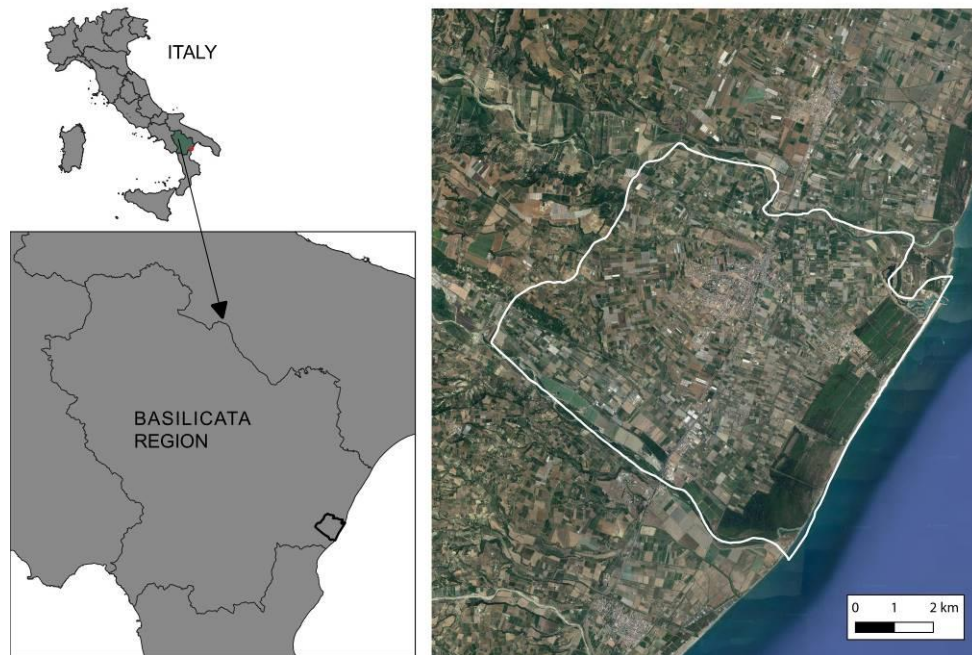


Fig. 1: Location of study area in Italy and Basilicata Region.

This is an important area for public recreation, as it overlooks the Ionian Sea, so during summer period it attracts many tourists. Moreover, the coast and part of the surrounding area is a very important site of natural interest, protected by the Natura2000 network of the European Community.

The first part of the work was to create a dataset of Agricultural Plastic Surfaces (APS) within the study area. Using an integrated approach between manual digitization of orthophotos and semi-automated classification of Sentinel-2 satellite imagery, all plastic surfaces detected in year 2017 (Cillis et al., 2022) have been mapped.



Fig. 2: Example of agricultural plastic used in study area.

Subsequently, in order to evaluate the visual impact of the plastic covers on landscape, the main access roads to areas with the greatest tourist flow have been selected based on the free *OpenStreetMap* database, so as to identify the most important tourist facilities. This information layer in vector polyline format was divided into points on the basis of vertices, since the visibility analysis is based on points. The other fundamental information layer is represented by the Digital Terrain Model (DTM), which has information about the altitude of each point of the territory (Fig.3). For a better analysis and in consideration of the level of detail required for this type of planning actions, a Digital Surface Model (DSM) with a resolution of 5 meters was chosen. This high-resolution DSM allows to detect also street trees or other type of visual barrier in a more accurate way than the DTM, which

represents only the topographic plan. These layers, within the specific QGIS plugin for Viewshed Analysis (Čučković 2016) allowed to perform the visibility analysis by making a cumulative raster. The parameters set concerned the height of the observer (1.5 meters, imagining the height of the view from the car) and the radius of analysis (1000 meters from each vertex). The result is a raster map, in which each pixel is associated with the cumulative value of the viewpoints. The higher the value, the more it means that that area is better visible from the network.

All operations have been carried out with an open-source Geographical Information System (GIS), *i.e.*: the QGIS software, which allows, with some specific plugins, to perform these operations in a subsequent way (Statuto et al., 2019).

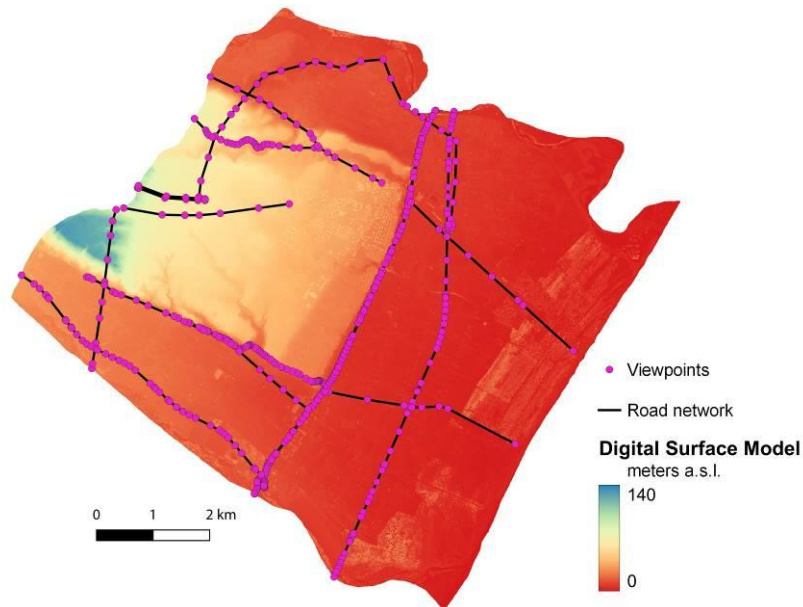


Fig. 3: Information layers used in viewshed analysis.

### Results and Discussion

GIS tools are fundamental to deal with all issues related to landscape (Cillis et al., 2021). In fact, the GIS approach has allowed to test a simple methodology, which is at the same time fundamental for planning rural landscape in areas with a strong tourist vocation, but that at the same time present different types of elements linked to agricultural activity, that may reduce their aesthetic quality. The final map (Fig.4 - Left) shows the areas where there is greater visibility, imagining that the observers are along the main access road to the tourist destinations. This elaboration is easily usable as a tool to support planning activities, because it allows to identify the areas potentially having the best visibility from the road, then possibly put in place strategies to mitigate the visual impact. In fact, in the case of the visual impact of agricultural plastics, a visual overlay can be made between APS and the visibility map to identify critical areas, where agricultural plastics are most visible. In this case study, we concluded that APS are visible almost everywhere from the road network, with few clusters where there is a anyway major overlap (Fig. 4 – Right).

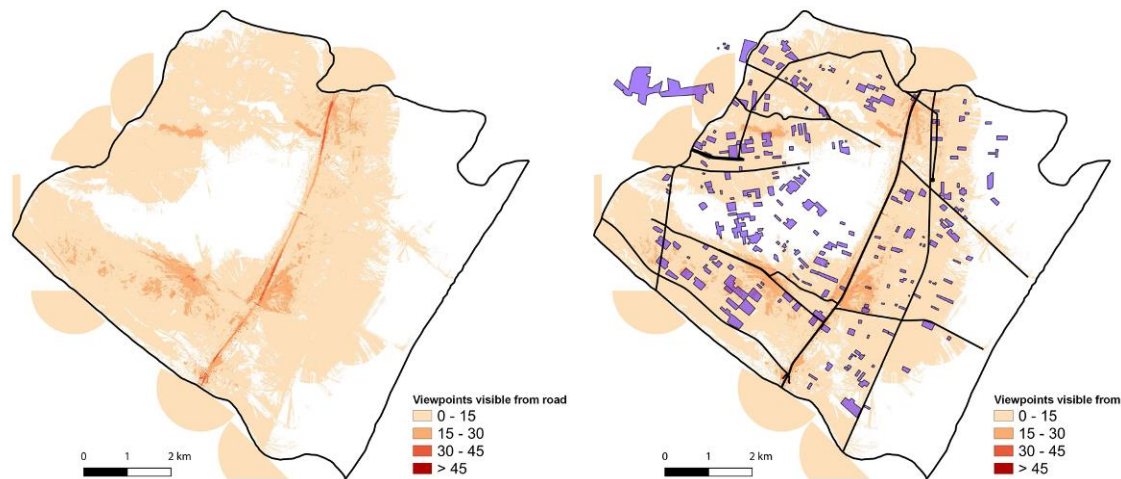


Fig. 4: Viewshed analysis map result (left) and with APS overlay (right).

In this study, the application was limited to a well-defined administrative area, without considering the surrounding areas that still have agricultural plastics. In addition, the greater the level of resolution of the DSM, the greater the reliability of the analysis, so having LIDAR flights available would certainly represent a fundamental support for the application of this methodology. In addition, thanks to GIS, the DSM can be modified to imagine the creation, for example, of a hedge, whose effect limiting the visual impact could be tested.

## Conclusion

The use, management and disposal of plastics in agriculture is one of the most important issues dealt with by the European Community. Alongside the fundamental aspect of environmental impact due to incorrect disposal of plastic waste, there is also the issue on how these plastics impact on the visual quality of the landscape. Indeed, there is a risk of an excessive and concentrated diffusion in some areas with a serious negative visual impact. This problem is evident as many of these areas are those with the greatest tourist appeal for public recreation. So, the use of GIS and visibility analysis allows, thanks to the possibility to manipulate geodata in an immediate way, to make an assessment of this problem, as well as to test actions aimed to mitigate the visual impact.

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### **Souhrn**

V tomto článku byla pomocí aplikace GIS zavedena metodika hodnocení vizuálního dopadu zemědělských plastů (skleníků, tunelů atd.) v oblasti se silným turistickým využitím v jižní Itálii (zemědělsko-potravinářská oblast "Metapontino" - region Basilicata). Plasty v zemědělství, kromě toho, že představují ekologický problém, pokud se s nimi řádně nehospodaří a nelikvidují se, jsou také negativním faktorem ovlivňujícím estetickou kvalitu a vnímání venkovské krajiny. Proto je nezbytné, aby veřejní činitelé a plánovači prováděli opatření schopná zmírnit vizuální dopady, zejména v oblastech se silným turistickým zaměřením. Jednoduchým a účinným nástrojem k dosažení tohoto cíle je analýza pohledových polí v prostředí GIS s otevřeným zdrojovým kódem. Pomocí několika vrstev informací, které lze snadno implementovat a podle potřeby upravovat, lze totiž identifikovat oblasti s lepší viditelností z hlavních silnic. Tyto informace mohou být nápomocny projektantům, kteří mohou zvolit nejlepší strategie ke snížení negativního vizuálního vlivu zejména v turistických oblastech.

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