II

Con información y datos

Diagramas, gráficas de datos, big data, GIS, BIM, listas...

XXI Congreso Internacional de Expresión Gráfica Arquitectónica

Universitat Politècnica de Catalunya

Barcelona , 28, 29 y 30 de mayo de 2026

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Oficina de Publicacions Acadèmiques Digitals de la UPC
Jordi Girona 31,
Edifici Torre Girona, Plant 1, 08034 Barcelona
Tel.: 934 015 885
www.upc.edu/idp
E-mail: info.idp@upc.edu

ISBN: 979-13-88098-49-9

DOI: 10.5821/ebook-EGA.26.2.00

El Congreso EGA 2026 celebrado en Barcelona lleva un título-manifiesto: *Certezas e incertidumbre.* Los tiempos en los que se desarrolla nuestra docencia y nuestra investigación son inciertos, no solo por desastres naturales o acontecimientos provocados, sino porque la globalización hace que la incertidumbre se propague. El congreso de Barcelona en el año en que la ciudad es capital mundial de la arquitectura ha de servir para reflexionar sobre lo que hacemos y en el momento en que estamos.

Esta colección de 5 libros recoge lo que se ha presentado en las jornadas de Barcelona, recogiendo el testigo de Porto 2024. En esta ocasión, desde la convocatoria en que se recibieron 233 propuestas de comunicaciones, procedentes de 67 universidades de 16 países, 169 comunicaciones han superado dos rondas de revisiones por pares ciegos. Con lo que el congreso EGA se consolida como referente internacional y de calidad. Las cinco líneas temáticas en que se han organizado las comunicaciones dan pie a los cinco volúmenes que siguen.

DOI: 10.5821/ebook-EGA.26.2.00

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II. Con información y datos:
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Volumen dirigido por Aldo Moccia

La evolución tecnológica nos ha proveído de nuevos recursos para el desarrollo de la expresión gráfica y ha provocado impulsos, no libres de discusiones sobre la conveniencia o no de su incorporación al trabajo gráfico. El diseño computacional y los motores de cálculo de inteligencia artificial generativa apuntan a otra revolución que debemos encarar, asumir y asimilar.

Además, gracias al manejo de esa tecnología hemos aprendido a dibujar lo que calculamos, a graficar de manera inteligible e inteligente los resultados de simulaciones, de mediciones, de datos que sería imposible manejar sin la computación. Lo más significativo es que nuestra habilidad demostrada en saber explicar cosas con dibujos ha aportado al mundo de la información la capacidad de hacer inteligibles los datos masivos. Convertir una información inabarcable en algo comprensible pasa por dibujar.

En los capítulos de este libro se desgrana el uso de la información para el diseño. Cada uno es una aportación sobre la creación, el análisis y la visualización de datos complejos relacionados con el contexto urbano, indicadores sociales, el rendimiento medioambiental, la eficiencia energética y otros aspectos de la arquitectura sostenible y resiliente. Se exploran las posibilidades del uso de datos para el diseño como el diseño paramétrico, generativo, algorítmico y evolutivo. Cómo trabajar el modelado de la información constructiva (BIM), cómo hacerlo con los sistemas de información Geográfica (SIG), qué derivas nos esperan en el terreno de la robótica, la fabricación digital y la IA.

DOI: 10.5821/ebook-EGA.26.2.00

Contenido del volumen

Dynamic mapping of seasonal landscape phenomena across Italy's inner areas

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Abstract:

This contribution focuses on the mapping of seasonal landscape qualities across Italy's inner areas, by exploiting the potential of the integration of Remote Sensing (RS) and Geographic Information System (GIS), which can support interactive Web-based Map (WbM) applications with the main aim to provide firstly the knowledge of these territories and secondly support the engagement of new territorial development strategies oriented to sustainable tourism. Specifically, the research provides an overview of the Dynamic Mapping Methodology (DMM), which enables showing seasonal landscape phenomena both at large-scale and small-scale contexts, by exploiting the potential of multispectral satellite and UAV-based imagery acquisition. By considering that inner areas are largely defined by 'voids', extensive natural, semi-natural, and agricultural landscapes, this research seeks to uncover the hidden potential of these territories, resulting from seasonal landscape expressions derived from colour changes. Specifically, it aims to develop a visual tool which can support decision makers to establish strategies oriented to increase the attractiveness of some marginal places, promoting them as unconventional destinations to be experienced at specific times of the year. In this perspective, by exploring, at the national level, the landscape features across inner areas, the research shows some of the applications of DMM to different case studies, matching potentialities, limitations and future development.

Keywords: gis, inner areas, mapping, remote sensing, seasonal landscapes.

Thematic area: [II] …with information and data.

1. Introduction

This contribution focuses on the mapping of landscape qualities of Italy's marginal areas, by exploiting the potential of the integration of Remote Sensing (RS) and Geographic Information System (GIS), which can support interactive Web-based Map (WbM) applications, with the main aim to foster knowledge of these territories and secondly support the engagement of new territorial development strategies oriented to sustainable tourism. Specifically, the research focuses on the so-called 'inner areas' (Agenzia Coesione Territoriale) of the country, where new visual tools are required to enhance the level of attractiveness of these places, which need to uncover their potentialities and better exploit the existing territorial assets. By considering that the landscape of those areas is mainly characterized by 'voids', extensive portions of natural, semi-natural, and agricultural lands, the research tries to explore the hidden potentialities of these areas, which hold even strong potential in terms of aesthetics, especially if it is considered the visual perception of the landscape. In this perspective, the open spaces, which are commonly perceived as empty and uniform, can gain an added value by considering the landscape expressions resulting from natural phenomena and productive agricultural cycles from an aesthetic point of view. Particularly, the colour changes, which mark the places over the seasons, in terms of space and time, affect the overall character of the landscape, which can be recognized by communities even as a distinctive feature (Arriaza et al., 2004) (Stobbelaar, 2007) (a relevant example in this sense is well represented by the outstanding flowering of the lands in Castelluccio di Norcia, in the Umbria region in central Italy). These specific seasonal phenomena, mostly related to plant life cycle within agricultural production, which affect specific landscapes, have a short duration (a few weeks) and change quickly in terms of space and time (e.g., spring flowering, the controlled floodings, the autumn leaves colouring) (fig.1-4), deserve special attention in terms of tourism opportunities, especially for marginal areas.

Fig. 1 Foliage across coniferous forest in the northern Alpine region. Val d'Ayas (Aosta Valley Region).

Fig. 2 Rapeseed spring blooming across an arable landscape in southern Italy (Basilicata region).

Fig. 3 Controlled flooding in the agricultural landscape of paddy-rice in between Piedmont and Lombardy regions.

Fig. 4 Daffodils summer blooming in the Alpine landscape at Oasi Zegna (Piedmont region).

In recent years, some of these places affected by seasonal phenomena have emerged as slow-tourism destinations, considering the opportunities to link them with the experiences of other related fields, such as local food and wine production, as well as the rediscovery of intangible heritage related to traditional and cultural practices and events. Nevertheless, there is a lack of visual tools to help decision-makers and visitors set site-specific experiences through the landscape. The specificity and temporality of these seasonal phenomena, which affect specific landscapes across Italy (Sestini, 1963), such as the ones of agricultural arable lands and croplands (e.g., paddy-rice fields, rapeseed fields, poppies), require the definition of a specific methodology and the adoption of dedicated mapping techniques able to capture both spatial and temporal data. In this framework, a great contribution is provided by Remote Sensing (RS) applications, which enable the observation of the landscape from a zenithally point of view and the collection of accurate spatial data. If the mapping target is centred on the scale of landscape, the detection can be managed by High-Resolution (HR) mapping techniques, such as those from satellites, which enable to capture of large portions of territories (e.g., one satellite tile covers an area of 100 km²). Whilst if the focus is on small areas and on smaller objects, such as flowers and leaves on the fruit groves, vineyards, grasslands with spontaneous species like daffodils and crocus, the mapping process requires the adoption of Ultra-High-Resolution (UHR) sensors equipped on Unmanned Aircraft Vehicles (UAVs), which enable the detection of objects at a finer scale (less than 10 cm) (Yao et al.,2019). Specifically, the research shows how the 'Dynamic Mapping Methodology' (DMM), based on the following workflow: acquisition of multispectral imagery (MI) through RS applications (Sentinel-2 mission by EU Copernicus Earth observation program or UAVs survey platform), GIS-based map processing and visualization of landscape phenomena by Vegetation Indices (VIs) computing, and interactive WbM visualization, which enables to share knowledge about these phenomena, and open to further research activities and related applications. By analysing some case studies, selected across inner areas

DOI: 10.5821/conference-EGA.26.2.14

of the country, the research provides an overview of the application of the DMM at different scales of investigation, which enables the addition of a 'new layer' of spatial information to the existing ones. Specifically, by integrating heterogeneous layered spatial information, related to different categories such as the ones of minor heritage places, places related to food production, seasonal conditions of the landscapes, and underused infrastructure (minor railways, historical paths, minor roads, slow routes), that support the accessibility of the places, within a multisource geodatabase, new ways to use these places can be promoted according to the cycle of seasons, with the main aim of encouraging territorial rebalancing. The WbM, as a shared device that makes visible spatial information in a graphic support, on the one hand enables the improvement of users' interaction with places, both remotely and on-site by mobile devices, and other hand, can play a key role in increasing the level of awareness of the inhabitants of their landscape and territorial assets, which can support local actors in promoting sustainable development strategies.

2. Mapping seasonal landscapes across Italy's inner areas

Before overviewing the mapping methodologies and techniques that are useful to visualize the seasonal phenomena that affect specific landscapes, it is important to understand the 'where' these landscapes are localized across the country and 'what' their main spatial features are, so to plan dedicated territorial strategies. The mapping of Italy's inner areas potentially affected by seasonal landscape phenomena has been carried out by merging two different levels of investigation, which affect both the degree of marginalization of some areas of the country and their landscape features, which can be better enhanced through territorial strategies supported by visual devices. The first level has concerned the identification of the inner areas of the country according to the National Strategy of Inner Areas (SNAI). The second one was more about the analysis of their landscape features by considering the European mapping program named Corine Land Cover (CLC) (ISPRA). The SNAI, which is an Italian placed-based policy for the territorial rebalancing and cohesion of marginalized territories, working in following period of time 2014-2020 and 2021-2027, has classified inner territories as the ones which are far away from the main urban centers, which supply the essential services in terms of mobility, education and health, so to concentrate major efforts and investments for the revitalization of local economies. In the current research, the inner areas are the ones classified and named by SNAI as "D-intermediate, E-peripheral, and F-ultra peripheral" areas. By selecting them and analysing their spatial features at the national level, it is visible that these territories cover about 58% of the Italian land surface and affect 48% of municipalities. By exploring the land cover features of inner areas classified as D, E and F, according to the CLC (the third level of information enables the identification of 44 land cover classes), it is visible that about 80% of their land cover is potentially affected by seasonal landscape phenomena. More in detail, seasonal landscape phenomena specifically refer to temporary landscape conditions, linked to certain times of the year, shaping their visual and aesthetic character, which are mainly perceivable throughout the colour changes or the presence of water, which profoundly affect the visual perception of these landscapes. Particularly, six different landscape phenomena have been identified by considering their outstanding visual features, their spatial patterns and their peak timing (seasonality). Precisely they are the so called 'foliage', autumn leaves colouring, which affect especially large portions of mountainous landscapes characterized by the presence of broad leaf, coniferous and mixed forests; the 'controlled floodings' of paddy rice-fields over the spring season, which radically change the appealing of this agricultural landscapes over the seeding stage; the 'spring flowering', which affect the productive landscapes characterized by fruit groves and complex cultivation patterns; the 'autumn colouring' of vineyard landscapes, which are also testimony of the cultural and historical values of their territories; the 'spring flowering' of productive landscapes characterized by arable lands, such as rapeseeds, wheat and poppies; the outstanding spontaneous 'spring flowering' over the mountainous landscapes characterized by the presence of natural grasslands and pastures. The analysis of the CLC datasets makes evident that especially the landscapes characterized by 'forests' and 'arable lands', which are widely spread across the inner areas D, E and F of the country, by covering respectively 19% (27% of the Italy's land surface is the total covered by forests) and 17% (27% of the Italy's land surface is the total covered by arable lands) of Italy's overall land surface, can increase their level of attractiveness for sustainable tourism purposes, taking into account their potentialities related to seasonal phenomena, due to their large extensions. Within the inner areas already mentioned, even the landscapes characterized by 'fruit groves and complex cultivation pattern' and 'natural grasslands and pastures', which cover respectively 4% (9% of the Italy's land surface is the total covered by fruit groves and complex cultivation patterns) and 3% (4% of the Italy's land surface is the total covered by natural grasslands and pastures) of Italy's overall land surface, can be of interest for activating strategies for enhancing their specific landscape features, due to their medium extensions. Among the other seasonal phenomena which occur over the landscapes characterized by 'vineyards' and 'paddy-rice fields', which cover respectively 1% (2% of the Italy's land surface is the total covered by vineyards) and 0% (1% of the Italy's land surface is the total covered by paddy-rice fields) of Italy's overall land surface, only the vineyards, due to their territorial extensions, can be of interest for establishing territorial strategies, because half of the total surface at the national level of the vineyards lie in the inner areas. The spatial distribution of seasonal landscapes across the inner areas of the country is visible through the map (fig.5), whilst the corresponding statistical data are shown in the table (tab.1).

3. Dynamic Mapping Methodology

This paragraph reveals the main features of the Dynamic Mapping Methodology (DMM), which enables the visualization of how seasonal landscape phenomena change in terms of space and time by using the zenithally point of view, which is typical of maps. Once the potential locations of the landscapes affected by seasonal phenomena are known, the DMM enables the detection of their seasonal temporary conditions, by exploiting the potential of RS and GIS based applications which enable the processing of MI through which are computed the Vegetation Indices (VIs), which are proxies that can be used for detecting vegetation colour changes, beyond health and density vegetation. The DMM involves three different steps: the MI acquisition, the MI processing with GIS for VIs computing, and the visualisation of seasonal landscape phenomena by computing VI thresholds on maps. MI acquisition is related to the size and the spatial features of the landscapes. In this sense, different mapping techniques can be employed. When the target is centred on a large portion of landscape, for example 100 km² (e.g. forests, arable lands), MI is provided by satellites orbiting around the Earth. MI provided by Satellite are framed within the High-Resolution (HR) mapping techniques, whose spatial resolution is 10 m. In this case, the DMM is fed by a continuous flow of MI, provided by a Satellite orbiting around the Earth, which, every 3-4 days, at mid-latitude, provides updated information about the Earth's status. Nowadays, these kinds of spatial information are freely available through the European Program Copernicus, and specifically through the Sentinel-2 satellites (Fu et al., 2020) (European Space Agency). If the seasonal phenomena take place on small landscape portions (e.g. 1 km²) and result from small objects like flowers and leaves on the fruit groves, vineyards, grasslands with spontaneous species, the Ultra-High-Resolution (UHR) mapping techniques are required to detect smaller objects. In this second way, Unmanned Aircraft Vehicles (UAVs) equipped with a multispectral camera are required to record UHR MI, which enables the detection of objects at a finer scale.

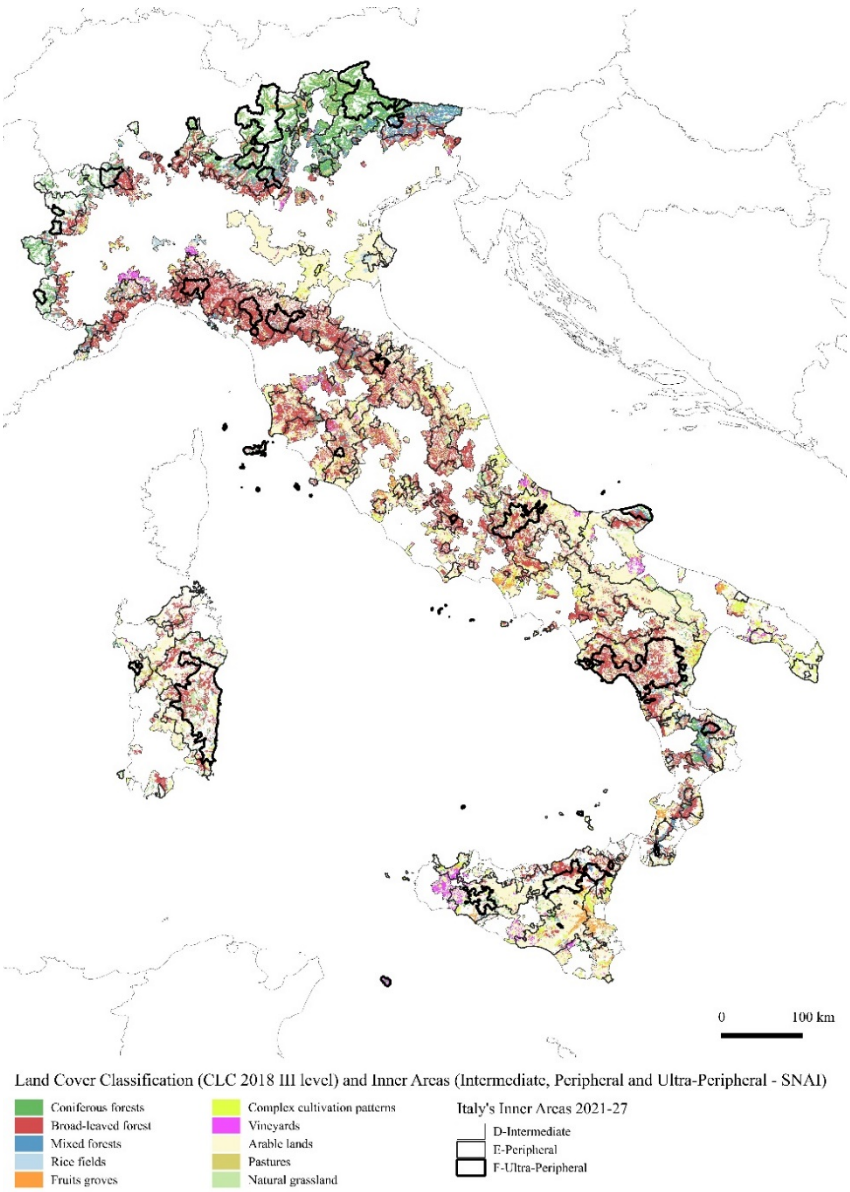

Fig. 5 Land Cover Classification of the potential seasonal landscapes across the Inner areas of the country according to SNAI 2021-2027 (map by author).

Tab 1. *Statistical data related to CLC and Inner Areas (Intermediate, Peripheral Ultra-peripheral) SNAI 2021-2027.*

Seasonal Phenomena	**Land Cover - Landscapes**	**CLC 2018 Classes**	**Total Surface [km^2]**	**Surface [%]**	**Inner Areas [Intermediate] D [km^2]**	**Surface [%]**	**Inner Areas [Peripheral] E [km^2]**	**Surface [%]**	**Inner Areas [Ultra-Peripheral] F [km^2]**	**Surface [%]**	**Total Surface Inner Areas D+E+F [km^2]**
Foliage	Broad leaf, Coniferous, Mixed Forests	311-312-313	80.714	27%	21.223	7%	27.447	9%	8.395	3%	19%
Controlled floodings	Paddy rice fields	213	2.943	1%	261	0%	81	0%	2	0%	0%
Spring flowering	Fruit groves and complex cultivation patterns	222-242	25.953	9%	6.977	2%	3.973	1%	533	0%	4%
Autumn coloring	Vineyards	221	6.269	2%	1.691	1%	744	0%	77	0%	1%
Spring flowering	Arable lands	211-212	80.962	27%	20.361	7%	24.102	8%	7.450	2%	17%
Spring flowering	Natural Grasslands and Pastures	231-321	12.219	4%	2.753	1%	4.225	1%	1.840	1%	3%
			209.059	69%	53.266	18%	60.572	20%	18.297	6%	44%

		Seasonal Landscapes D/Tot D [%]		Seasonal Landscapes E/Tot E [%]		Seasonal Landscapes F/Tot F [%]
* Italy's land surface 302.073 km2	75.550	82%	78.838	77%	22.272	82%
	Tot land surface D		Tot land surface E		Tot land surface F	

The MI processing is managed by GIS, for satellite imagery, or by Metashape combined with GIS, for UAV-based data acquisition, which enables the computation of VIs by combining multispectral bands through dedicated algorithms. The VIs result from the combination of the reflectance values of light recorded on the different bands of the electromagnetic spectrum collected through MI (Tucker, 1979). Each seasonal landscape phenomenon requires the computation of specific VIs, in relation to their features (e.g., detection of colour nuances, water). The last step concerns the visualization of seasonal landscape phenomena by computing VIs thresholds, which enable showing the landscape phenomenon occurring in a certain area and in a certain period. By reiterating the same workflow for different time MI acquisition is possible to visualize dynamically the spatial-temporal evolution of the landscape phenomena. Whilst the high-temporal resolution of satellite MI acquisition, which follows the revisit time of each mission, enables the DMM to work with a huge amount of data worldwide, in a semi-automatic way, the UAV-based MI acquisition can be reiterated over time, but requires dedicated site visits and surveys with human surveillance, with great efforts in the data acquisition and processing.

4. Application of DMM to different case studies

This section provides some insights into the application of DMM, targeting different case studies across Italy's inner areas, which reveal the applicability of the methodology and the potential of MI acquisition through satellite and UAVs. The investigation of seasonal landscape phenomena, such as the foliage in the forests, the controlled flooding in the paddy-rice fields, and the spring flowering of rapeseed in the arable lands, which affect large-scale landscape contexts, requires the application of DMM based on satellite MI acquisition. Once the satellite imagery has been acquired in a specific time interval and with a low cloud-cover percentage, it is necessary to compute VIs by combining different spectral bands within specific algorithms to map the searched seasonal phenomenon.

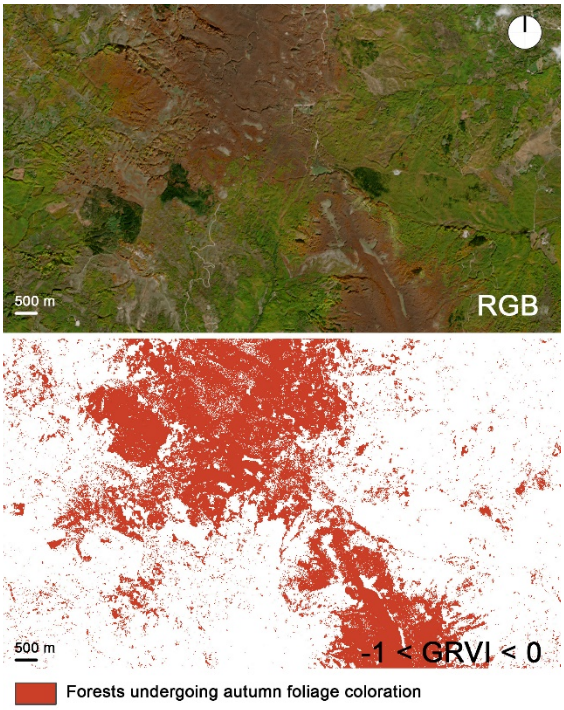

Fig. 6 Mapping foliage across the beech forest in the Lucanian Apennines in the Potenza province. Comparison between Sentinel 2A image RGB (2025 November 4th) and negative values of GRVI.

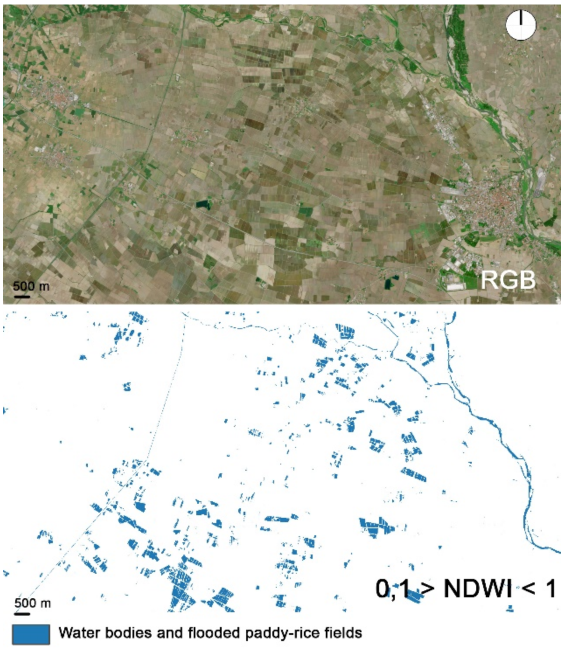

Fig. 7 Mapping the water bodies and the controlled floodings in the agricultural landscape of paddy-rice fields between Piedmont and Lombardy region. Comparison between Sentinel 2A image RGB (2025 May 15th) and positive values of NDWI.

DOI: 10.5821/conference-EGA.26.2.14

For instance, the detection of foliage phenomenon across the landscape characterised by beech forests in central and southern Italy is first visible by observing the true colour (RGB) imagery acquired by satellite, and then it is detectable in an accurate way by processing the Green Red Vegetation Index (GRVI), which combines the green and red spectral bands. Specifically, the GRVI index enables the distinction of the green surfaces from those in colour (Motohka et al., 2010). More in detail, by computing GRVI and then setting a specific threshold to select negative values, it is possible to visualize and highlight only the areas affected by the autumn colouring phenomenon and analyse its temporal evolution (fig.6). The DMM can also be applied for mapping other seasonal landscape phenomena, such as controlled flooding on paddy-rice fields or the flowering of rapeseed over the spring season, which affect large landscape portions. The applicability of DMM to other case studies requires that the VIs processing be adapted to the vegetation and crop types, as in the case of paddy-rice fields, which are filled with water over the seeding stage in the spring season (e.g. application of Normalized Difference Water Index – NDWI) (fig.7). The landscape mapping at a finer scale can be based on UAV system, that can be used to get more accurate spatial data (Colaceci et al., 2022). Precisely, seasonal landscape phenomena, that need to be analysed at the scale of flowers or leaves within smaller areas, as in the case of spontaneous daffodils summer blooming across the grasslands in the mountainous landscapes, require to be mapped through UHR MI by dedicated UAV survey. In this case, the spatial resolution of MI, about 2-3 cm/px, enables to distinction of small flowers, like the ones of white daffodils widespread in the grasslands, from the other objects (fig.8).

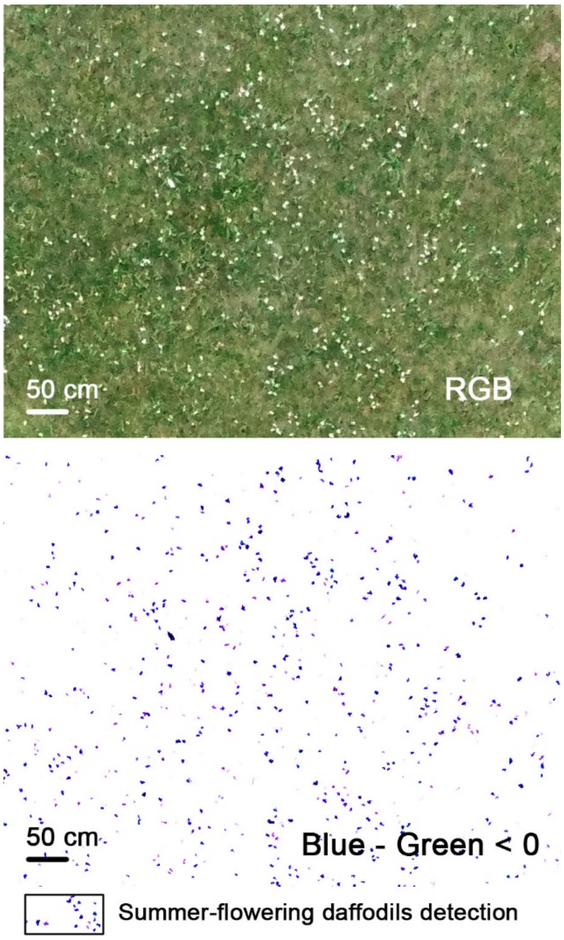

Fig. 8 UHR Multispectral imagery acquired by UAV survey (DJI Matrice 300 RTK equipped with Micasense Altum Multispectral camera 2.26 cm/px). Comparison between RGB and threshold negative values computed by the difference between Blue – Green spectral bands (image by author).

Table 2 shows the main differences between satellite and UAV-based data acquisition and their potential application to different landscape scales, by matching spatial and temporal resolution, number of bands, acquisition procedures, processing, and visualization.

Tab 2. Comparative analysis between Satellite and UAV-based data acquisition, processing and visualization.

	Landscape scale	Multispectral Camera	Bands	Image Resolution Typology	Spatial Resolution	Temporal Resolution	Data Acquisition	Data Processing	Data Visualization
Satellite Sentinel-2	Large/Medium	X	12	High-resolution imagery (HR)	10 m/pixel 20 m/pixel 60 m/pixel	3-5 days	automatic	GIS	GIS-based map
UAV	Small	X	6	Ultra-High-resolution imagery (UHR)	Flight altitude (less than 10 cm/pixel)	on-site survey	user-controlled	Metashape/GIS	GIS-based map 3D model

In this sense, the proposed case study of summer daffodils flowering, localized in the north-western area of Piedmont region at Oasi Zegna in the Biella province, shows the applicability of DMM by recording MI by UAVs. In this specific case, image processing and Vegetation index computation were performed by an integrated Metashape-GIS workflow. The detection of summer flowering of daffodils seems to be effective by computing negative values within the difference between blue and green spectral bands.

5. Discussion, Conclusion and future developments

This contribution has shown that at the national level, large portions of the landscape and open spaces within the inner areas of the country can potentially be affected by seasonal phenomena, which can play a key role for improving tourism attractiveness. At methodological level, the research has shown the applicability of DMM as a tool for mapping the seasonal landscape phenomena across Italy's inner areas, by focusing on the integration of RS and GIS, which enable processing MI from satellites and UAVs. Specifically, the DMM seems to be flexible in the adaptability and replicability to the different landscape contexts, and to different data acquisition modes (satellites and UAVs). However, further investigations need to be undertaken to fix more accurate VIs' thresholds for the different seasonal phenomena, whose appearance is also linked to many unpredictable climatic factors (e.g., temperature, sunlight exposure, water provision) and human interventions linked to crop rotation.

Beyond the VIs optimization, the future developments of this work should be addressed to make a more effective output map related to each data acquisition, more easily accessible to end-users (decision makers and visitors), within interactive WbM applications with the integration of navigation services to effectively support the fruition of the places. Some limitations of the overall method concern the cloud-cover factor, which affects the satellite MI acquisition and the weather conditions in the UAV survey, which can negatively affect the imagery performance and prevent the VIs processing. In this perspective a future development of this research could concern a deeper analysis of the accessibility of the potential locations of seasonal landscape phenomena within Italy's inner areas, so to select only the places that can actually be reached by visitors. This would provide insights and more accurate route analysis and processing about how easily these places can be reached, ultimately supporting the development of more targeted and effective territorial strategies. In this perspective, the dynamic mapping of seasonal landscape phenomena could play an interesting role, if the territorial strategies across the Italy's inner areas will take into account, in a more integrated vision, even the enhancement of the other territorial assets, as the ones of natural and built heritage, the ones of traditions and events, the ones related to food and gastronomy, but also the infrastructural accessibility, which enable visitors to get unconventional destinations. In this perspective, some places can be revitalised across Italy's inner areas, making new alternative destinations to the most frequented ones, acting as a territorial rebalance. From a visual representation perspective, the DMM provides a further layer of investigation into landscape features, enriching traditional static representations by integrating both spatial and temporal dimensions. This enables the tracking of the evolution of landscape phenomena through the seasons, making updated information about the places available.

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