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Editorial

Drones in the Sky: Towards a More Sustainable Agriculture

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Nowadays, with an increasing world population, the production of bio-resources becomes a strategic sector for supporting any sustainable society. Nevertheless, due to the intensified environmental pressures and the threat of climate change, it is necessary to change the approach toward the production, processing, and disposal of these resources. The global agendas for the finished decade called for a competitive bio-economy as a key element for smart growth. As we approach 2030, accelerated efforts should be made to achieve Sustainable Development Goals (SDGs). This will give even more prominence to modernizing our societies, reaping the benefits of information and communication technologies (ICTs) to strive for climate neutrality. The need to achieve sustainability constitutes a challenge but also a strong incentive toward modernisation in a highly competitive global economy [1].

Technology has the role of helping to address the challenges for such rational use of resources. More specifically, new advancements in agronomy R&D have the ability to improve the management of renewable biological resources and open new markets in food, energy, and bio-based products [2]. In the last few decades, Earth observation from space enabled many people (policy makers, technicians, farmers, producers, etc.) to perform informed decision-making, allowing the monitoring of results [3,4]. In this context, the exploitation of remote sensing data has become one of the most important tools used in modern agriculture to analyse and assess the production and use of resources. The availability of remote sensing images, using a range of sensors from space has completely transformed the way of monitoring and managing this sector. However, effective agricultural management at a local scale often requires obtaining images with a high spatial and temporal resolution. This type of data is difficult and generally costly to obtain, either by satellite imagery or even by using conventional airborne data.

Over the past few years, UAVs (Unmanned Aerial Vehicles), RPAs (Remotely Piloted Aircrafts), and drones have emerged in the market, closing the gap between data collected using satellite remote sensing or manned aircraft and ground-based methods. The production of drones has experienced explosive growth, with further expansion predicted for the near future, with estimations that the annual global market could reach over 40 billion USD by the next two years [5]. We are therefore faced with a sector with enormous potential for expansion, in which R&D and continuous technological advances are configured as fundamental elements to make their extraordinary growth perspectives a reality.

The reasons that led these platforms to experience such a boom can be mainly associated with a steady price decrease in the last few years, parallel to the hardware and software developments that have taken place during that time. Improvements in the stability and reliability, payload capacity, and flight duration of UAVs increased significantly with the development of autonomous flight controllers [6] and power supply technology [7], which enable more sensor types to be mounted even on small UAVs.

Multi-source UAV sensing data, with high temporal and spatial resolutions, can be collected with a range of onboard sensors (e.g., optical, lidar, thermal, multi/hyper-spectral,

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and radar), driving new applications of remote sensing, such as powerline inspection, atmospheric research, disaster management, urban planning, mapping, etc. While having practical applications in almost every imaginable civil field, UAV technology has become a particular interest in agronomy [8–10]. The use of drones allows aerial views of crops, trees, land, or water bodies to be obtained and is sensitive enough to detect subtle changes that cannot be readily identified at ground level or using satellite imagery. Even beyond the scope of this Special Issue, some UAVs are made for specific purposes; far from the exclusive focus on remote sensing, drones can also efficiently replace manpower doing tasks such as chemical spraying, planting, etc. The high penetration and widespread of drone-based sensing in sectors such as agriculture is not a mere coincidence and can be clearly associated with several factors. On the one hand, many of these applications require large spatial coverage across extensive fields, or densely vegetated areas, which are difficult to access on foot, or simply areas that are inaccessible from the ground such as tree canopies or buildings. In these cases, UAVs become indispensable allies, replacing in-field labour intensive inventory and inspection practices.

On the one hand, applications using UAVs in this sector often occur in rural areas, which are sparsely populated. For that reason, safety and privacy become less of an issue than in the case of densely populated urban areas [11]. However, the rise of a completely new market with such potential requires the existence of clear and proportionate regulation, which allows the growth of use under safe conditions and respects the rights of individual people. With greater or lesser speed, we are witnessing a generalised flexibilization of regulations worldwide. It is to be hoped that in the coming years, there will be major changes in the legislation on the use of UAVs, aimed at making compatible security with the flexibility necessary for the development of the sector. Flying BVLOS (Beyond Visual Line Of Sight), for example, will permit the coverage of extensive areas of land and further improve the efficiency of any monitoring task.

Technical and regulatory developments yield significant improvements day-by-day on issues of cost, reliability, efficiency, safety, and operability of remote sensing using unmanned aircraft [12,13]. These devices are currently taking on new applications in the primary sectors, transforming them into a high-tech industry, with decisions being based on real-time gathering and processing of data. Therefore, we must expect to find unforeseen applications in the years to come. There is no doubt that, in this scenario, UAV-based sensing will be a critical technology to meet productivity needs for such a populated world and support greener practices [14]. Therefore, the current goal of researchers is to support the technical development of drone- and sensor- technology, and even more important, to identify key applications for them, generating a benefit for the entire society.

This Special Issue in Agriculture aims to collect state-of-the-art manuscripts related to local-scale applications of UAV-based remote sensing in precision agriculture and horticulture, with a prospective focus on sustainability. Thus, expected submissions include all those topics related to production efficiency and resource optimization by means of the use of drones and onboard aerial sensors as decision support systems. For instance, contributions proposing new methods towards a more rational use of pesticides, fertilizers, and water, will be particularly welcome (e.g., studies on weed mapping and management, vegetation health assessment and disease detection, drought and irrigation management, etc.). Investigations that focus on yield estimation and optimization, vegetation growth monitoring and the extraction of detailed biophysical information of the crops from UAV-based imagery also fall within the scope of this Special Issue.

From a methodological point of view, UAVs are permitting accurate autonomous flight and detailed information extraction for use in farm management based on a range of sensors. Therefore, the type of sensors employed in this collection of research articles may include but is not limited to, high-resolution RGB cameras, multispectral and hyperspectral cameras, LiDAR sensors, and TIR sensors. A fusion of different UAV sensors or the combination with other ground-based sensor systems used for transforming traditional agricultural processes into more efficient ones is conceivable and desirable. Different

image analysis techniques, and different modeling approaches, for example, multivariate regression, decision trees, or artificial neural networks are also encouraged.

Ultimately, contributions to this Special Issue, exploring novel applications of low-altitude remote sensing using drones towards more sustainable agriculture, are expected to be valuable for both researchers and agronomists, as well as for farmers and advisors.

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