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# Assessing the Effectiveness of Precision Agriculture Management Systems in Mediterranean Small Farms

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**Abstract:** While the world population continues to grow, increasing the need to produce more and better-quality food, climate change, urban growth and unsustainable agricultural practices accelerate the loss of available arable land, compromising the sustainability of agricultural lands both in terms of productivity and environmental resilience, and causing serious problems for the production-consumption balance. This scenario highlights the urgent need for agricultural modernization as a crucial step to face forthcoming difficulties. Precision agriculture techniques appear as a feasible option to help solve these problems. However, their use needs to be reinvented and tested according to different parameters, in order to define both the environmental and the economic impact of these new technologies not only on agricultural production, but also on agricultural sustainability. This paper intends, therefore, to contribute to a better understanding of the impact of precision agriculture through the use of unmanned aerial vehicles (UAV)/remotely piloted aircraft systems (RPAS) and normalized difference vegetation index (NDVI) techniques in small Mediterranean farms. We present specific data obtained through the application of the aforementioned techniques in three farms located along the Portuguese-Spanish border, considering three parameters (seeding failure, differentiated irrigation and differentiated fertilization) in order to determine not only the ecological benefits of these methods, but also their economic and productivity aspects. The obtained results, based on these methods, highlight the fact that an efficient combination of UAV/RPAS and NDVI techniques allows for important economic savings in productivity factors, thus promoting a sustainable agriculture both in ecological and economic terms. Additionally, contrary to what is generally defended, even in small farms, as the ones assessed in this study (less than 50 ha), the costs associated with the application of the aforementioned precision agriculture processes are largely surpassed by the economic gains achieved with their application, regardless of the notorious environmental benefits introduced by the reduction of crucial production inputs as water and fertilizers.

**Keywords:** precision agriculture; NDVI; UAV/RPAS; Mediterranean agriculture; GIS; feasibility studies; aerial imaging

## 1. Introduction

The world population is increasing. It is expected that in approximately 30 years, the planet's population will grow from 7.2 to 10 billion [1,2]. At the same time, climate change, urbanization and agricultural overexploitation will contribute to considerable losses of the arable land available for food production, causing serious problems for the production-consumption balance [3–8]. These facts, coupled with the need to produce food in an increasingly sustainable manner, not only in terms of crop efficiency, but also in terms of land use and biodiversity conservation in natural ecosystems, highlight the need to envision the use of new technologies in different productive systems and to assess their environmental, economic and social impact.

Several studies predict the significant impact of these changes on agricultural lands both in terms of production and in terms of farm income, pointing out that modernization processes are crucial to overcoming these difficulties [9–12]. In this scenario, precision agriculture, normalized difference vegetation index (NDVI) techniques and unmanned aerial vehicles (UAV) or remotely piloted aircraft systems (RPAS) appear as feasible options to help solve these issues. In fact, precision agriculture, a farming management model based on observing, determining and responding to inter and intra-field productive variability enables the definition of a decision support system (DSS) for specific farm management with the goal of optimizing returns on inputs while preserving resources [13].

Still, even if NDVI has been used for over forty years, it is a fact that just recently, technological advances in UAV and RPAS technology offered new opportunities for assessing agricultural plot experiments using UAV/RPAS imagery. Vegetation indices (VIs) based on aerial images (Figure 1) derived from consumer-grade cameras became a simple and cheap alternative compared to VIs derived from other types of devices, as is the case of proximal (on-ground) sensors [14].

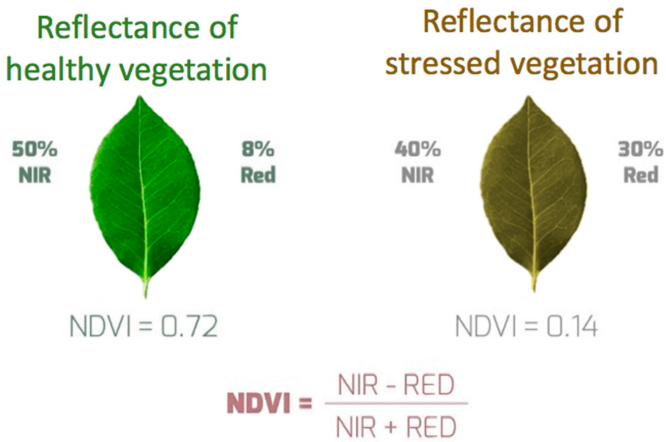


**Figure 1.** Example of the use of a normalized difference vegetation index (NDVI).

Nevertheless, few studies concentrate on the feasibility of these technologies for small-scale corporations, considering not only their cost, but also the knowledge needed to obtain, treat and process the information gathered through the use of these devices. To address this problem, the serious involvement of both agricultural specialists and farmers will be required, in order to assess the economic and environmental impact of these new methods. Moreover, a greater investment in research will be required, to improve the application of these techniques in all the production aspects of a culture, while preventing the deterioration of agricultural systems.

It is a fact, mainly in areas with edaphic limitations, as the Mediterranean basin, that to increase the production of agricultural soils it is necessary to promote cultural intensification using irrigation, among others practices, since in this agromediterranean system water and nutrients constitute an important limiting factor [15,16]. Though this is especially true in the Mediterranean basin, irrigation is so important worldwide it is used in 40% of the total food production and in 20% of all cultivated land [17,18]. It is therefore important to assess the impact that new technologies, as is the case of NDVI, UAV and VIs, have not only in productivity levels but also in reducing economic and environmental costs associated with production. Additionally, this article intends to assess the feasibility of these techniques for small farmers and small agricultural enterprises—for which these technologies are usually not considered cost-effective [19–22]—in order to guarantee the sustainability of the entire system, showing how the use of drones (UAV/RPAS) in the field of agriculture can lower both economic and environmental costs. In this regard, the research intends to contribute to a better understanding of the use of this technology in agriculture, exploring its capacities both as an important planning tool in relation to the sustainability of agrarian ecosystems and as a way of reducing the environmental impact of agriculture, by enabling significant reductions not only in the water use but also in the use of fertilizers. It is expected that the obtained results may, with the necessary adaptations, be extrapolated to other farms with similar characteristics in the Mediterranean basin, and can be a tool for improving resource management, thus reducing the environmental impact of agricultural production.

It is a fact that precision agriculture (PA) constitutes, along with other important approaches, a crucial farm management system, which—considering the combined use of robotics and sensors, drones, advanced GPS and GNSS (Global Navigation Satellite Systems), IofT, weather modeling and the customized application of inputs—enables farmers to reduce the application of crucial elements like water and/or fertilizers. Moreover, PA entails the implementation of techniques and technologies that highlight the relevance of integrating specific ecological principles and biodiversity management procedures into agroscape management, while optimizing inputs to maximize yields. If implemented correctly, these techniques can assure important ecosystem benefits, as the mitigation of farm pollution and the reduction of water consumption, while reducing input costs, maximizing yields, reducing the dependency on external inputs and sustaining or enhancing ecosystem services.

In this regard, the present research aims to contribute not only to a better understanding of the impact of precision agriculture through the use of UAV/RPAS and NDVI techniques in small Mediterranean farms—presenting specific data obtained through the application of the aforementioned techniques in three farms located along the Portuguese–Spanish border, considering three parameters (seeding failure, differentiated irrigation and differentiated fertilization)—but also to determine the benefits associated with the application of these methods in ecologic, economic and productivity terms, thus fostering the use of these procedures in an increasing number of small farms in Portugal and Spain.

## 2. Materials and Methods

### *2.1. Study Area(s)*

The study areas are located on the county of Estremadura, which is located along the Portuguese border (Figure 2).

The study considered 3 different properties:

- Plot A—irrigated parcel of 19.8 hectares dedicated to the production of corn
- Plot B—irrigated parcel of 17.4 hectares dedicated to the production of corn
- Plot C—irrigated parcel of 28.8 hectares dedicated to olive production

According to the collected data, the average annual rainfall is nearly 480 mm, most of which during the coolest season, from October to March. The maximum monthly average temperature corresponds to July, when the temperature reaches 24.7 °C, and the minimum average temperature corresponds to January, with 8.8 °C [23]. According to the *Koppen* classification, the study area corresponds to a *Csa* climate, characterized by hot dry summers and cool wet winters.

According to Nunes et al. (2015), the study area might be generally defined as very heterogeneous regarding geology; still hiperalcaline and basic rocks are the most representative ones [23]. Regarding agricultural production, olive orchards, with 35% (*Olea europea*), cornfields, with 20% (*Zea mays*), and tomato and garlic plantations, both with 15% (*Lycopersicon esculentum* and *Allium sativum*, respectively), are the most representative crops produced in the region [24]. According to the World Reference Base of the FAO Soil Resource (WRBSR) [25], 3 different soil types—fluvisols, luvisols and cambisols—represent the soils present in the analyzed farms.

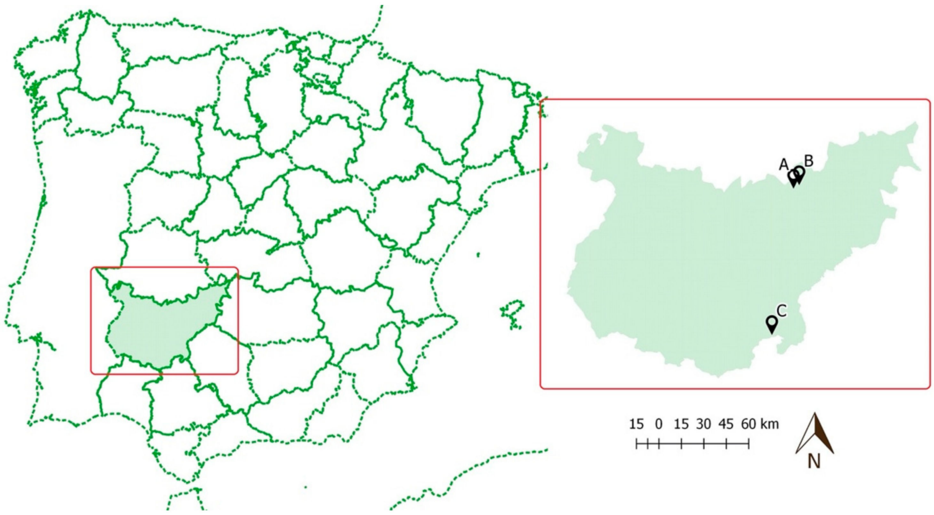


**Figure 2.** Study area—localization map of the 3 selected farms considering the different objectives of the research. Plot A—seeding failure and production estimation; Plot B—potential reduction in the use of agrochemicals; Plot C—irrigation efficiency in olive trees.

A total of 3 farms were selected for the analysis, considering the application of the case study method proposed by Yin (1994) [26]. The number of farms selected was based on the specification put forward by Francis (1999), according to which the number of cases selected should be small enough to grant data manageability, and big enough to assure the collection of adequate data to perform the necessary analysis [27]. This method, considered by several authors a very important research strategy [27–31], enables the analysis and comparison among projects and scenarios, and has been applied in various fields of knowledge, such as medical science, sociology, engineering, planning, agronomy and landscape architecture.

### *2.2. Methodological Approach—Work Plan*

Considering the purpose of the present research, a significant effort was dedicated to the development of a suitable methodological framework, since the study required not only the use of specific technology throughout the research, but also the collection of data during farm activity. It was therefore essential to have a very well established protocol, so that the research did not cause any inconvenient for farming activities. In this regard, the general research methodology (Figure 3) was divided into three main sections, related to case study/property selection, to the collection and analysis of data related to the selected property and to the definition of a flight plan that enabled the collection of NDVI information useful to developing a prescription plan and a cost-benefit analysis both from an environmental and an economic perspective.

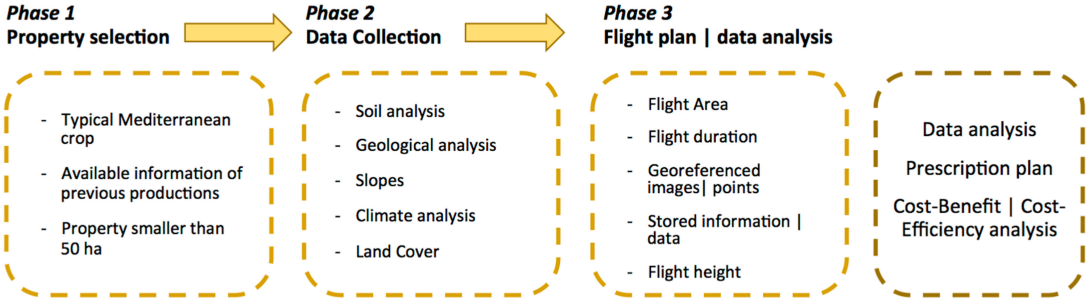


**Figure 3.** Methodological approach diagram.

Bearing in mind the established methodology, the following steps were implemented:

i) Property selection–with the intention of covering the main crops and the most used watering systems at the regional level, the selection was made bearing in mind, on the one hand, the possibility of accessing data from previous years and, on the other hand, the objective of testing the feasibility of the use of drones (UAS/RPAS) in small size agriculture enterprises;
ii) Property data collection–the process was based on the collection and analysis of as much data as was possible, within the boundaries set by the research schedule, considering not only the abovementioned objective, but also the fact that specific criteria associated with the Mediterranean edaphic characteristics should be verified. For this purpose, besides the available data, four soil samples were collected in each property and analyzed in order to verify that there were not significant differences within the property and the fertility of the assessed properties;
iii) Flight plan and data analysis–the definition of the flight plan was a crucial component of the study, since—as mentioned before, and as agreed with the producers—the research should not cause any inconvenient for farming activities. In this regard, and considering the objectives of the present research, after meeting with the client and with the internal team, a flight plan–data collection protocol was established, considering, among other issues, the post-processing and analysis objectives and the expected outputs/results, e.g., yields map, variable herbicide applications map, ripening state map, vigorousness map. The flight plan considered all the relevant flight characteristics, such as the area, duration, flight height, the number of georeferenced images that were going to be captured and the average stored information.

### *2.3. Used Technologies/Equipments*

Considering the objectives of the research, a multirotor drone with two sensors was equipped with a RGB and a Near Infrared Spectrum Region (NIR) camera, with the purpose of elaborating different vegetation indices and showing the agronomic variability that exists within agricultural and production parcels. The specific equipment used in order to obtain this data is specified below.

#### 2.3.1. RPAS

The system with which the flights will be completed is an RPAS—Model DJI Phantom 3 professional, with 4 DJI 2312—960 KV engines, 4 propellers, 2 legs that work as a landing gear and a control system consisting of a programmable transmitter of 8–32 channels. This RPAS, owned by AgPrecision, incorporates a flying electric propulsion system with vertical takeoff and landing capability, which has advanced technology onboard—the reason why it presents a considerable flight stability through a built-in GPS, equipped with a multispectral sensor capable of taking data from the Near Infrared Spectrum Region (NIR).

#### 2.3.2. Cameras/Sensors

The images were taken by two different sensors: a RGB (visible spectrum) and a NIR (MAPIR). The RGB sensor is a 1/2.3-inch CMOS for capturing video (up to 4096 × 2160p at 24 fps with the Phantom 3 Professional) and still images of 12 megapixels. The obtained videos can be exported in MOV or MP4 format. Available image shooting modes include burst, continuous and at intervals.

The NIR sensor, which captures the region of the electromagnetic spectrum in the NIR part, is MAPIR (NIR / Red) Survey2, presenting an image resolution of 16, 12, 8, 5 and 3 megapixels in three possible formats—RAW + JPG, JPG—24bit sRGB; the video resolution varies among 1440p30, 1080p60, 720p120 and 480p240, and may be exported in MP4 (H.264 Codec); the lens optics are 82° HFOV (23mm) f/2.8 aperture, −1% extreme low distortion (Non–Fisheye) glass lens; the Ground Sample Distance (GSD) is 4.05 cm/px (1.59 in/px) at 120 m (~400 ft) AGL; the sensor is a Sony Exmor IMX206 16MP (Bayer RGB), which takes 3 seconds/photo (RAW + JPG) or 2 seconds/photo (JPG).

### 2.3.3. Image Processing

The subsequent processing of the images, to develop a coherent mosaic used both for the RGB and the NIR versions, was realized by means of image processing services in a cloud, since it was considered that the advantages offered by this type of service when compared to the processing in a desktop equipment were outstanding, both in terms of processing speed and result quality. The Dronedeploy cloud processing service (www.dronedeploy.com) was the selected one. Cloud processing enabled us to obtain the following products: RGB Orthophotomap (Geotiff); Point Clouds (LAS); NIR Orthophotomap (Geotiff).

Once the different cloud imaging products were obtained, different spatial analyses were performed using the free open source GIS desktop software-QGIS 16.0, Esri, Portugal.

## 3. Results and Discussion

The obtained results, as it will be shown below, considered not only the data collected according to the pre-established protocol, but also the available data provided by farmers regarding prior campaigns. In fact, though there is a lot of research available regarding precision agriculture [32–35], there is no precise information regarding feasibility studies towards the effectiveness of the use of these management procedures in small farms. In this regard, the following analysis and discussion is considered of the utmost importance in order to promote the use of these processes in small farms, thus fostering sustainable agriculture.

Regarding Property—A (Figure 4), the developed analysis, in this particular case, was requested by the farmer, who considered the soil to be very saturated in some areas during the seeding process. In this regard, he wanted to test the use of NDVI to assess seeding failures and to estimate the production, based on previously collected data.

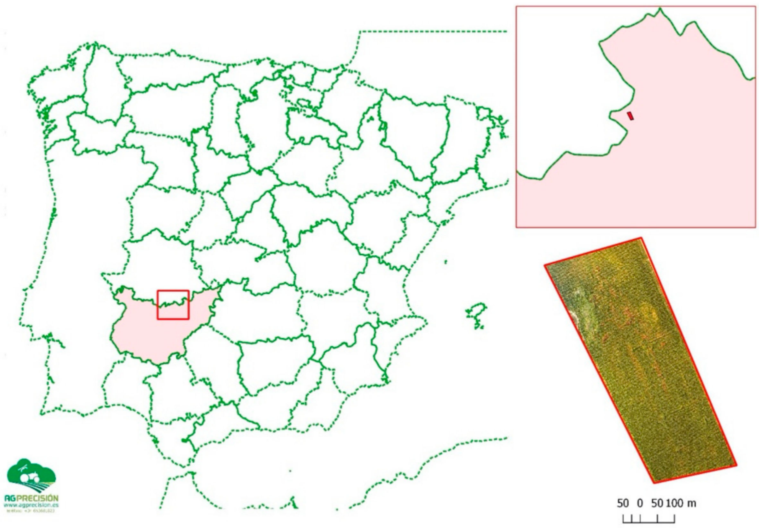


**Figure 4.** Property A—analysis of seeding failure and production estimation.

As shown in Figure 5 the total area left without plants is approximately 3000 square meters, in a property with less than 20 ha. Coupling the collected data with the production data recorded by the farmer in previous campaigns, in which the highest average production levels of the plot were approximately 15 T/ha—in areas where the plants presented high vigorosity, and the lowest levels were around 12 T/ha—it was possible to estimate the production according to the NDVI map (Figure 5). Based on the NDVI values calculated after the flight, with the help of a multispectral sensor, the quantity, quality and development of the vegetation was assessed.

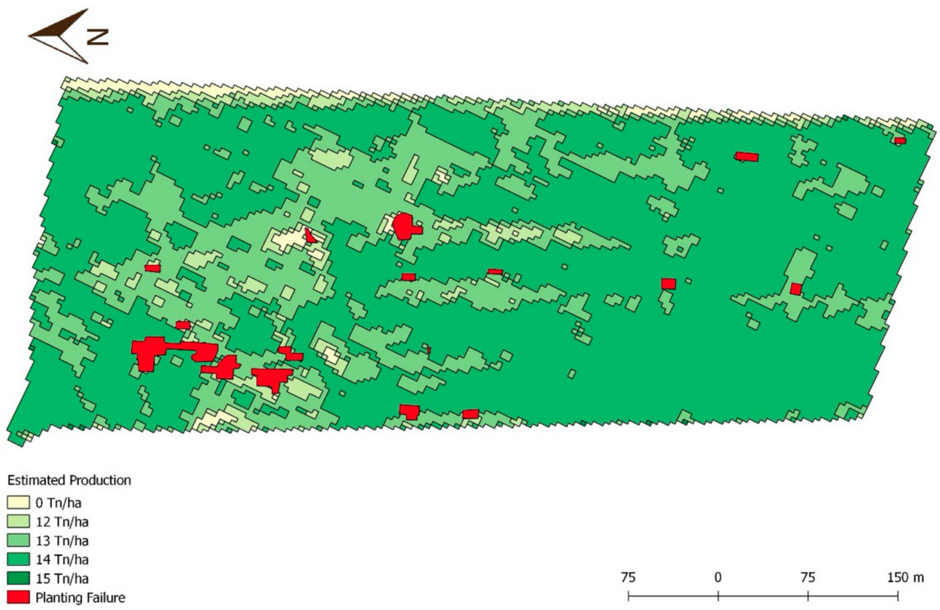


**Figure 5.** Property A—seeding failure and production estimation map based on NDVI indexes.

The elaborated maps, based on the average production of previous campaigns, enabled us to develop a table based on standard productions according to the NDVI information, with which it was possible to ascertain the differences between potential and expected productions both in terms of weight and cost. In this case, the collected data enabled us to verify that the differences in terms of potential and expected production will be of approximately 33.3 T, which in terms of economic productivity represents, considering the price for ton of corn published by MAGRAMA (Ministry of Agriculture and Fisheries, Food and Environment) for the 2016/2017 season (175.6€), approximately 5852.7€, as presented in Table 1.

**Table 1.** Corn productivity analysis.

| Variables | Area (Ha) | Potential Production (15 T/ha) | Potential Income (€) | Expected Production (T) | Expected Production (€) | Balance (€) |
|---|---|---|---|---|---|---|
| 0 T/ha | 0.38 | 0 | 0 | 0 | 0 | 0 |
| 10 T/ha | 0.95 | 14.20 | 2493.1 | 9.47 | 1662.1 | −831.0 |
| 12 T/ha | 5.19 | 77.90 | 13,679.8 | 62.32 | 10,943.8 | −2736.0 |
| 14 T/ha | 13.02 | 195.24 | 34,284.7 | 182.23 | 31,999.1 | −2285.6 |
| 15 T/ha | 0.01 | 0.18 | 32.4 | 0.18 | 32.4 | 0 |
| TOTAL | 19.5 | 287.5 | 50,490.0 | 254.2 | 44,637.3 | −5852.7 |

In this case, the estimation of maize production, considering an approximate cost of 500€ per flight, data analysis and the elaboration of a prescription plan enabled us to ascertain that the potential return of the analyzed services could be of approximately 5300€. While recognizing that in practice it is very difficult to achieve an equal production across the plot, the data obtained constitutes a good indicator of the potential of the use of UAV/RPAS and NDVI techniques to improve production, thus contributing to the increased sustainability of small farms [36,37].

In the event of seeding failure, the result is obvious. The flight must be done during the germination season, so that according to the size of the faults it is possible to verify the feasibility of performing a reseeding considering a cost-benefit analysis. Considering the average cost of a flight (500€ on properties of less than 50 ha), the potential benefits of applying these technologies can be easily realized, even on a smaller scale property where the cost of a flight, data analysis and prescription plan are much higher. These results are in fact very relevant, since they contradict the idea that this type of technology is only feasible for large properties.

Regarding Property—B (Figure 6), the objective was to evaluate the resource economy, considering the goal to promote an effective reduction of the use of fertilizers in corn production. The assessed property presented some limitations related to the use of an irrigation system based on 10 sectors, that caused specific limitations to the elaboration of the prescription plan, which needed to be based on an average of the NDVI from the parcel (Figure 7). Nevertheless, it is a fact that the collected data, considering both the data from previous campaigns and the NDVI results, allowed for an effective reduction on the use of fertilizers, while fostering productivity.

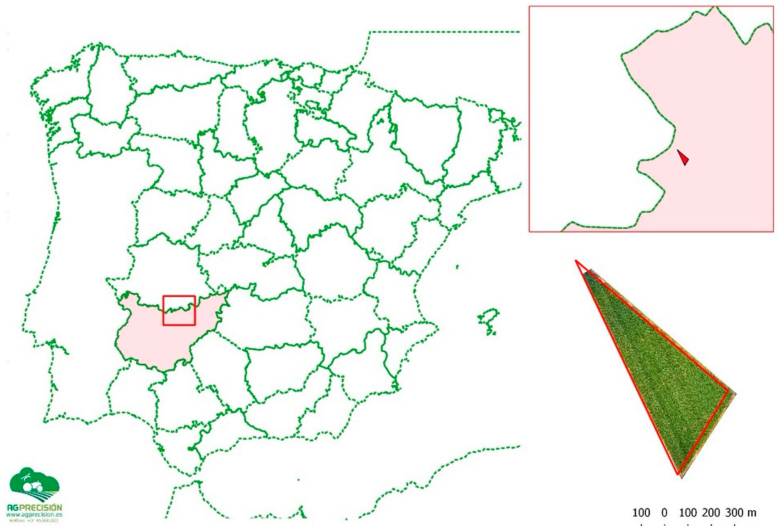


**Figure 6.** Property B—analysis of seeding failure and production estimation.

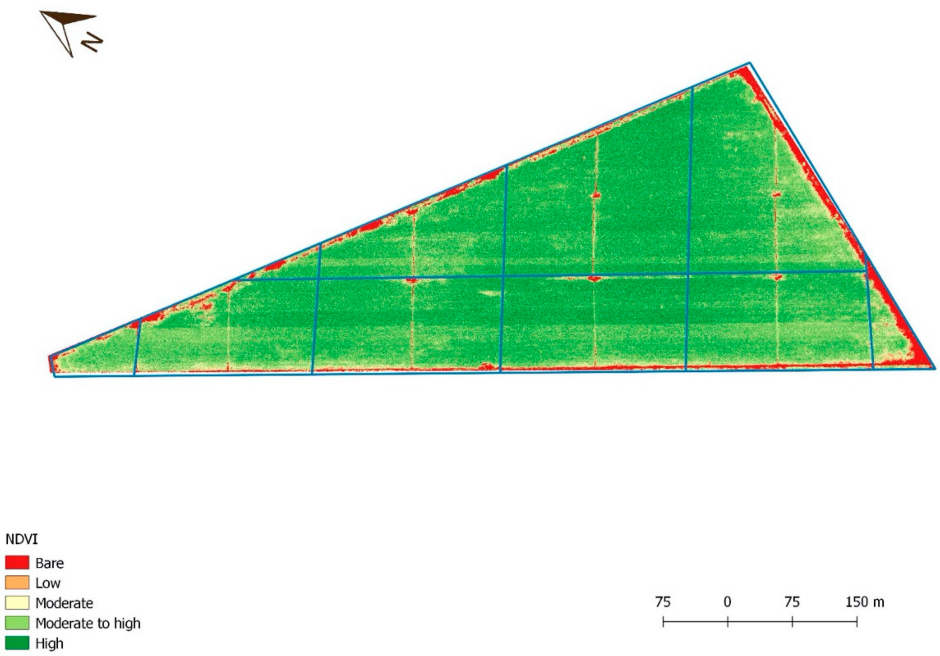


**Figure 7.** Property B—seeding failure and production estimation map based on NDVI.

The use of NDVI enabled the farmer to increase doses only in those sectors where the average NDVI was below the expected level (from moderate to bare), for the culture and production phase, while maintaining or reducing the initial dose of the fertilization plan (230 L/ha) in those sectors that had an average NDVI value close to, or greater than, the expected value (from moderate to high).

This new fertilization plan is expected to correct the deficiency in growth in those sectors where the NDVI presented lower values, thus increasing the productivity of the total parcel. In this way, the use of fertilizers is adapted to real needs, promoting a better management of agrochemicals, resulting in economic and environmental savings and corroborating previous findings [33,38].

The benefits of using the precision agriculture technologies under analysis in this study are evident (Table 2), considering that instead of the traditional 230 units of nitrogen (32 N nitrogen solution) per hectare that were normally applied throughout the property, the fertilization plan proposed a distinguished dose plan per sector (Figure 8), which allowed the farmers to maintain the productivity and enabled a reduction of 211 units of nitrogen in a parcel of less than 20 hectares. Besides the natural cost reduction, augmenting productivity, this measure enabled an effective gain in terms of environmental cost, since there was a reduction of approximately 5% of the overall use of fertilizers.

**Table 2.** Fertilization plan reduction of fertilizer use in corn production.

| Sector | Area (ha) | Dose N (L/ha) | Consumption (L) |
|---|---|---|---|
| Traditional application | 19.29 | 230 | 4437 |
| Proposed application | 19.29 | variable | 4216 |
| 1 | 0.48 | 240 | 116 |
| 2 | 2.42 | 220 | 532 |
| 3 | 3.36 | 230 | 774 |
| 4 | 2.42 | 210 | 508 |
| 5 | 3.7 | 200 | 739 |
| 6 | 2.41 | 210 | 506 |
| 7 | 1.82 | 230 | 419 |
| 8 | 2.03 | 230 | 466 |
| 9 | 0.21 | 240 | 50 |
| 10 | 0.44 | 240 | 105 |

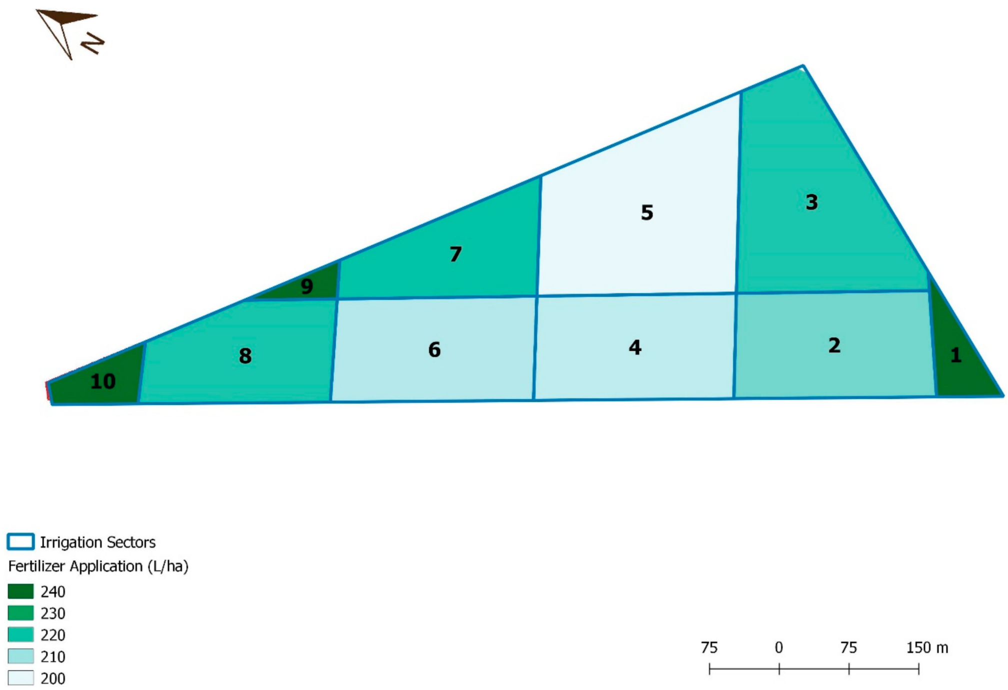


**Figure 8.** Property B—Fertilization Sectors according to the average NDVI of each parcel.

Regarding Property C (Figure 9), the developed analysis was based on the assessment of plant vigorosity to ascertain the suitability of the watering plan/amount of water given to olive trees. The maps that were created enabled us to test the use of NDVI to assess watering failures and to estimate water needs based both on production data previously collected.

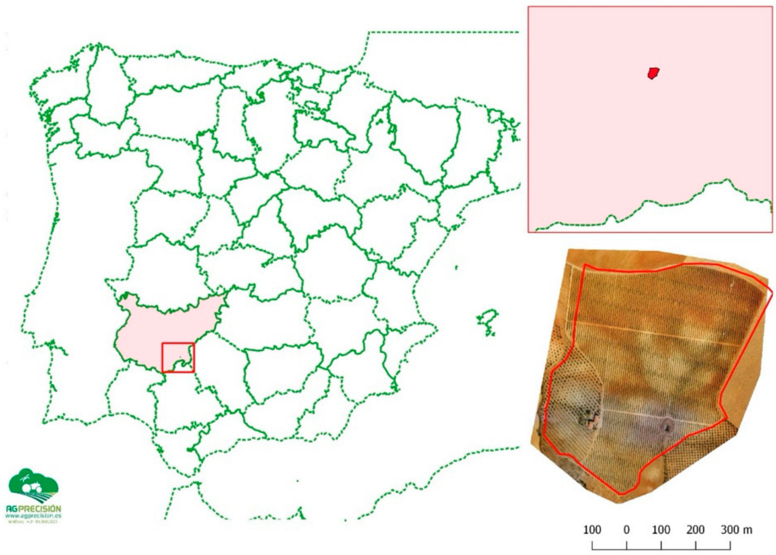


**Figure 9.** Property C—analysis of the effectiveness of irrigation systems/failures in irrigation systems.

With the data obtained during the flight and the subsequent analysis, a density map of the photosynthetic activity of the crop was calculated, in order to establish the average degree of photosynthetic activity for each sector. With this information, a map of the irrigation efficiency (Figure 10) and an irrigation plan were established according to the collected data, identifying the sectors in which the irrigation plan was more efficient and where the plan did not conform to the needs of the crop. This information was crucial to adjust the irrigation plan to the actual needs of the crop, increasing the irrigation in the sectors where the photosynthetic activity was below the average values and maintaining the doses in those sectors where the value of NDVI was the expected one.

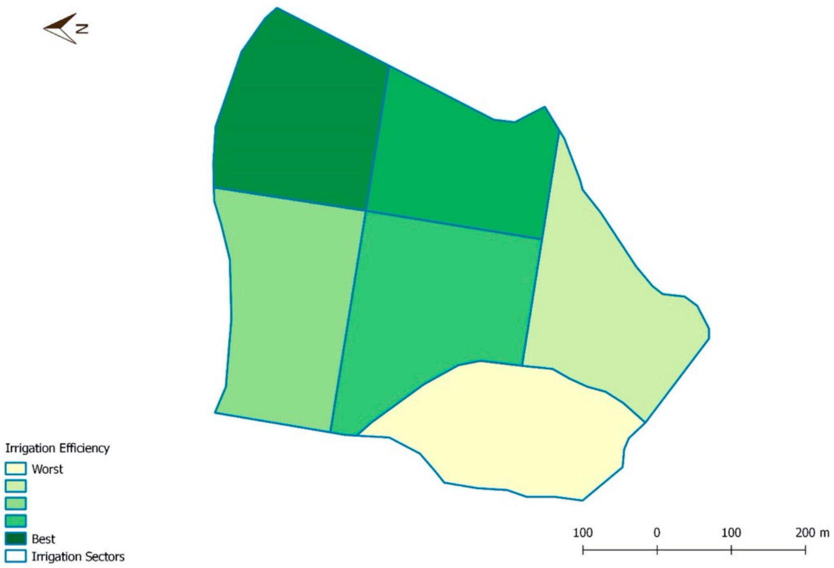


**Figure 10.** Property C—established irrigation areas defined according to the NDVI information.

Additionally, considering that the used methods enabled us to conclude, as it can be observed in Figure 11, that there is a high correlation between the sections of the map with lower vigorosity (red tones) and lower leafiness in the olive trees and the sections of the map with high values of vigorosity (green tones) and greater leafiness among the trees. According to the data collected by the farmer in previous campaigns, an average calculation regarding production losses was performed.

Though not surprising, the expected losses cover the flight/evaluation costs that, as mentioned on the analysis of property A, represented approximately 500€ in properties smaller than 50 hectares.

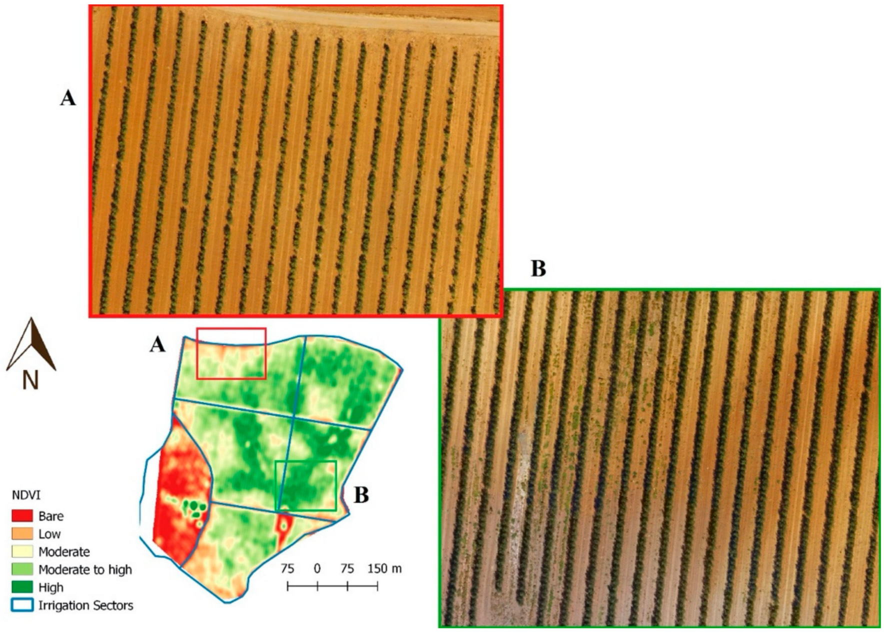


**Figure 11.** Property C—comparison between NDVI and tree leafiness on the analyzed olive orchard.

The immediate correction of the identified irrigation problems enabled an increase in the production of these sectors to a value close to the one initially expected (10 T/ha). The average gains in terms of production, according to data collected by the farmer, might reach 1.7 T/ha—a value that, considering only one hectare, would be enough to surpass the flight/evaluation costs. In fact, if one considers the average price per ton (400€), 1.7 tons represent 680€, proving once again that the provided economic benefits are greater than the costs of using the above-mentioned technologies even in small properties as the one assessed in this study.

Considering both the analysis performed for each property, regarding different parameters, and the obtained data, it is possible to highlight that, contrarily to what is generally defended, even small farms can benefit both economically and environmentally from the use and application of precision agriculture management techniques, through the use of UAV/RPAS and NDVI. In fact, these techniques might be used as ways to reinforce the management process and to correct eventual problems, throughout each of the production phases, ideas that are in line with the ones presented in previous studies, in which the dimension of the property was not considered [19,21,35].

Though it is a fact that a better management of each of the production factors, as water and fertilizers, enables important savings both at the economic and environmental levels, it is crucial to quantify those benefits through a cost-benefit analysis, so that it becomes clear that even in small farms the benefits are greater than the costs. Still, if one considered the acquisition of all the necessary equipment and training (drones, cameras, pilot training, GIS training, etc.), the costs of producing maps as the ones used in this research would greatly exceed the economic savings enabled by the application of precision agriculture techniques in a single agronomic season. Nonetheless, all these services might be acquired at the average costs mentioned in this article, which is why even small farms might benefit from the use and introduction of precision agriculture, viewed as a management process (not a technique), which in agronomic terms defines the management of agricultural parcels based on observation, measurement and performance according to inter- and intra-crop variability. Still, these procedures require the use of a set of technologies consisting of Global Navigation Satellite System (GNSS), sensors and imagery obtained both from satellites and/or UAV/RPAS, along with Geographic Information Systems (GIS) to estimate, evaluate and understand such variations.

In short, and considering the objectives of the present research, one may say that the tested precision agriculture procedures enabled the acquisition of information which allowed, through the application of the right amount of inputs, at the right time and in the right place, to increase production, and thus economic return, and to reduce the environmental impact of production. Moreover, the performed study, though developed for different purposes in each of the three farms under analysis, enabled the farmer to verify how the crop behaves along the plot, giving not only important insights for managing the property, but also for reinforcing the economic and environmental sustainability of the farm. It demonstrated that even in small farms the use of precision agriculture management procedures is economic and environmentally advantageous, since it allowed not only to increase profits (in properties A and C, ranging from 14 to 26%), even considering the costs associated to the use of drones, GIS and technical analysis/recommendations, but also to reduce the environmental impacts associated with the use of fertilizers (property B).

The obtained results create the momentum to implement wider strategies that enable a greater use of UAV/RPAS and NDVI methods not only in Spanish agriculture, but also across Europe, considering that the collected evidence shows that the combined effect of using such methods and technologies might reinforce the sustainability of the agricultural sector, not only in terms of environmental impact, but also in economic terms. Additionally, the fact that there is a growing number of small and medium size companies performing this type of services all over Europe, using UAV/RPAS, and that for this reason the prices tend to be increasingly lower, this type of approach is becoming available to almost every farmer, making it feasible and possible to use even in small farms.

## 4. Conclusions

The obtained results, based on the assessment methods used throughout this research, highlight the fact that an efficient combination of UAV/RPAS and NDVI enables important savings in productivity factors, promoting sustainable agriculture both in ecological and economic terms. Moreover, since the use of UAV/RPAS and GIS in modern agriculture, as in other domains [39,40], facilitates both the diagnosis of the irrigation efficiency or a fertilization plan, in plots where by foot it would be almost impossible to appreciate the failures, the performed study reinforces the fact that precision agriculture constitutes a very important agricultural management procedure that, contrarily to generalized ideas, is also feasible in small farms, since the benefits, as shown, largely outweigh the costs. In fact, the average cost charged to flight performance, aerial imagery and agronomic recommendations—prescription plan was largely surpassed by the economic benefits gained with the introduced recommendations. In this scenario, it is important to mention that the obtained data used for comparison was collected in the farms in previous campaigns.

Considering that the tested parameters in the selected farms covered the most relevant production periods, from seeding and fertilization to fruit/seed growth, obtaining in all of them positive feedbacks, it is also possible to denote that, even if not recommended, precision agriculture procedures constitute a valid management process when applied to specific production phases. Additionally, it is important to note that although it is possible to carry out each of the services separately, this is not the case in small farms, where owners need the full service, considering their lack of capacity to carry out any of the components independently.

Besides the tested purposes, the use of aerial images and NDVI, though not used in this research, provides important information to identify nutrition disorders and diseases in plants, plus the presence of weeds or pests in the field. These utilities, considering the world needs to produce more food in increasingly changing climate conditions, which are impacting staple crops around the world, enable not only the increase of productivity, but also the mitigation of nutrition and disease problems with relative ease, constituting a crucial step towards sustainable agriculture not only in environmental but also in economic terms.

Finally, though considering that further research is needed in order to obtain a more representative pool of data regarding small farms, so that the obtained results may be statistically treated and analyzed, and the findings extrapolated to other regions of similar characteristics in the Mediterranean basin (less than 50 hectares—for which precision agriculture procedures are generally considered not feasible and too costly from a cost-benefit analysis perspective—both environmental and economically), it is important to highlight that the number of accessed case studies is in line with the previous research, considering the used methodology [41–47].

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