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# CASE STUDY ON THE USE OF SCANNING EQUIPMENT UAV IN ORDER TO DRAW UP A MULTIFUNCTIONAL DATABASE, IN CÂRȚIȘOARA LOCALITY, SIBIU COUNTY

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***Abstract***

*The paper presents a case study in which the application of a modern aerial scanning technology with the help of drones is carried out through a specific method, for the creation of a multifunctional database, with a wide applicability in several fields of economic activity and production specific to rural areas, as well as in cadastre real estate advertising works and rural tourism. The choice of the study topic is justified by actuality and necessity, as it contributes significantly to increasing the degree of predictability of the management as a result of the real-time collection of a very large number of data and information, the processing in a short time in order to identify vulnerabilities and their quick and efficient solution, as a result of the increase in knowledge, respectively of minimizing situations of risk and uncertainty. The use of aerial scanning equipment in cadastral works, agriculture, forestry, rural tourism and other important areas for rural development is an activity of great interest and allows to obtain in a short time a large volume of data used for the sustainable development of the community.*

***Key words***: *aerial scanning, drone, multifunctional database, tourism promotion*

## INTRODUCTION

The development of unmanned aircraft systems is a certainty of the present in which society shows increased interest. If at the time of their appearance they were intended and used in various military applications, we have gradually witnessed their adoption by civil society where there is a rapid increase in interest in their use in various civilian applications. They target multiple services that have as a common point the technique of terrestrial measurements using emerging technologies. The use of aerial scanning equipment with the help of drones is based on photogrammetry and remote sensing. The high capacity to collect data and information naturally leads to the design, development, and implementation of a geographic information system, a tool that allows for easy analysis of the collected data (Călina et al., 2022).

Unmanned aircraft systems comprise different components (unmanned aerial vehicle, launch and recovery station, data network, technical support systems, control station, human interface, etc.) whose complexity configures different classes among which the mini UAS is considered the fastest growing class (Iagăru et al., 2022). The growth is due to recognized characteristics such as: low costs, implementability directly from the field, accessibility of technologies (Iagăru et al., 2021), flexibility, etc., which give it advantages and ensure a dominant presence in civil applications in all fields of activity (Aswini et al., 2018; Barbedo, 2019; Călina et al., 2020; Wang et al., 2015; Borra-Serrano et al., 2022; Parraga-Alava et al., 2021).

The first uses of drones in civil applications were made by Yamaha Motor Company (Japan, 1987) through the RMAX-R50 concept dedicated to spraying pesticides on rice crops. Cisneros (2013) proposed the low-cost concept for use in emerging countries in South America (especially Peru). Later, Glen (2015) anticipated the downsizing effect and showed a possible market entry of medium and small UAV robotic systems that take advantage of the size reduction of specific multispectral sensor systems (Iagăru et al., 2022). Regarding drones for precision agriculture/horticulture (aircraft or multicopter type), there are very few bibliographic references (Krishna, 2016). In this case, the elements of interest (performance, flight qualities, specific transport aspects) refer to semi-autonomous flight capabilities, initial acquisition cost, level of complexity of possible missions, maintenance costs (including periodic corrections specific to small drones).

Information collection takes place using sensors mounted on mini UAV. There are four types of sensors that cover almost all research applications in UAV remote sensing in precision agriculture: RGB, multispectral, hyperspectral and thermal sensors (Kovanič et al., 2023). The first three categories contribute to the creation of georeferenced reflectance maps, and the last category to the creation of temperature maps (Maes & Steppe, 2019).

The choice of the study topic is justified by its topicality and necessity, as it significantly contributes to increasing the degree of predictability of management based on the real-time collection of a very large number of data and information, processing in a short time in order to identify vulnerabilities and their rapid and efficient resolution, as a result of increasing the degree of knowledge, respectively minimizing risk and uncertainty situations.

The use of aerial scanning equipment in cadastral works and agriculture for rural development is an area of interest and allows obtaining in a short time a large volume of data that, when properly processed, provides a realistic overview, which leads to the development of relevant strategic options for sustainable community development (Călina et al., 2020).

The concretization of aerial monitoring takes place by carrying out flight missions at certain heights (for example, 100 m), according to a flight plan made by selecting a land area on a Google Earth or Map support. Approvals from the Aeronautical Authority and the Ministry of National Defense for flying over a land area at this height with the specification of take-off and landing points follow; creating the flight plan, aiming first of all to cover the area of interest, then generating the flight paths that the drone must cover, so that the photos taken have an overlap of 70% and the flight times are supported by the battery power (about 25 min for one battery); preparing for the drone take off (favorable weather conditions - clear sky and wind below 7 m/s, telephone network coverage necessary for data transmissions, adequate GPS signal); carefully following the trajectories travelled (Sălăgean et al., 2016).

The images obtained during aerial monitoring of ecosystems are processed with the help of dedicated software leading to the early detection of diseases and pests in the crop; precise mapping of weeds; precision in forecasting; precise application and reduced volume of pesticide solution; optimization of nutrient management; monitoring plant growth (Achtilik, 2015; Zhang et al., 2014). Mini UAVs for disease and pest control manage to maintain their control in identified areas, by applying variable doses of pesticides (Filho et al., 2020).

## MATERIALS AND METHODS

The purpose of the work is represented by the study of aerial scanning equipment and UAV systems, respectively by its use in the data collection process in order to create a multifunctional database corresponding to the current requirements for sustainable development of the territory.

The achievement of the purpose is mediated by the establishment of objectives that represent stages in its achievement. These are:

- geographical and socio-economic characterization of the Cârțișoara locality,
- knowledge of aerial scanning equipment and traffic vectors;
- presentation of the research methodology;
- carrying out a study on the scanning of the Cârțișoara locality in order to create a GIS database.

The research methodology employed is the case study approach, as it allows for a comprehensive examination of the rural economy within the natural environment of Cârțișoara commune, viewed from various perspectives.

This study represents a detailed analysis method applied to complex scenarios and provides an in-depth view of the phenomenon being analysed "in a real-life context and using multiple sources of information (interviews, questionnaires, testimonies, evidence, documents, direct observation, participant observation)" (Glen, B., 2015). In particular, the research methodology utilized both quantitative and qualitative methods in parallel

and complementary ways (Upadhyaya et al., 2022), including secondary analysis of specialized literature and documentation from the Cârțișoara city hall to identify the object of interest, as well as from the Cadastre and Real Estate Advertising Office in Sibiu.
To achieve the established objectives, the research was structured and carried out in four stages, as shown in Figure 1. In stage 1, data and information were collected in accordance with the research purpose using the questionnaire applied at the level of administrative-territorial unit (ATU), secondary analysis of statistical data and relevant specialized literature, and observation for qualitative improvement of information. As a result, an accurate representation was achieved, highlighting critical factors and identifying best practices.

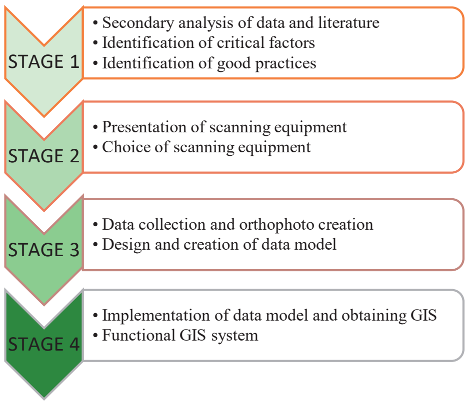


Figure 1. Schematic structure of the research

## Case study

The study was conducted in the locality of Cârțișoara, Sibiu County, located at coordinates 45°43′34″N and 24°34′28″E. The primary objective of this research is to examine aerial scanning equipment and UAV systems and their application in the data collection process. The collected data will be used to design and develop a database aligned with current requirements for the sustainable development of the territory.
Cârțișoara commune is situated in the southeastern part of Sibiu County, in the central region of Țara Oltului, at the base of the Arpășel, Bâlea, Valea Doamnei, and Laița Mountains. To the east, it borders the village of Arpașul de Sus (part of Arpașu de Jos commune); to the west, it is adjacent to Scorei village (belonging to Porumbacu de Jos commune); to the south, it borders Argeș County; and to the north, it neighbors the commune of Cârța.
Documentarily, the commune is attested since the 13th century (yearbook of the Institute of History of Cluj-Napoca, volume VII-1964, page 317). The total area of the commune is 8.576 hectares. The commune of Cârțișoara presents a number of 4 main relief elements with their own specificity in terms of geomorphology. Geology, hydrology, climatology, lora and fauna, as follows: a) the Bâlii plain area; b) the hilly area; c) the pre-alpine area; d) the alpine area.

## Stages of the research

To ensure the successful achievement of the project objectives, the research activities - both fieldwork and office-based - were structured into specific stages, as outlined in Table 1.

Table 1. Stages of carrying out activities

| Activity type | Activity type | Activity type |
|---|---|---|
| Office | Establishing the work stages and inventorying the resources to be used (equipment, software products, documents, data, human resources, etc.) | 01.08.2023 – 30.09.2023 |
| Field | Obtaining raw data through aerial photography | 01.10.2023– 15.10.2023 |
| Field | Carrying out the analysis stage to identify the needs, requirements, and methods for obtaining the data of interest. | 16.10.2023 – 30.10.2023 |
| Office | Validating the raw data collected and performing photogrammetric processing in order to obtain an orthophoto map. | 01.11.2023 – 15.11.2023 |
| Office | Designing, testing, validating, and implementing a specific data model (database). | 16.11.2023 - 30.11.2023 |
| Office | Writing the technical specifications to be used for the administration and operation of the database. | 01.12.2023 – 15.01.2024 |

## Raw data collection by aerial photography

The data collection required the following activities:
• marking (materializing) on the ground of known coordinate points that will be used to georeference the obtained orthophoto map;

• using a GNSS receiver to determine the coordinates of the ground control points (GCP);
• planning and conducting the flight to acquire the photogrammetric data, from which the necessary orthophoto map will be generated.
• marking the ground points using FENO topographic markers.

For easy recognition on the photograms of the points marked on the ground, 50x50 cm marking panels were made and used (by positioning centered on the ground markings) painted in two colors (white/red). At the same time, for the areas that allowed, the marking was done directly on the ground, by applying a layer of paint (white, red).

The GCP coordinates were determined in the Stereo 70 reference system, by using GNSS equipment using the RTK method. Considering that the goal is to achieve a pixel size of 3 cm/pixel, we deemed the use of the RTK measurement method sufficient, as it ensures the required accuracy.

The coordinates were determined for 18 points marked or identified on the ground and which ensure visibility on the acquired photograms. In Table 2 are presented coordinates for 12 marked points.

Table 2.GPS coordinates inventory

| Point no. | X | Y | Z |
|---|---|---|---|
| 1 | 467013.193 | 470317.381 | 494.870 |
| 2 | 466953.872 | 469902.502 | 494.900 |
| 3 | 466731.680 | 469672.695 | 494.950 |
| 4 | 466914.265 | 469494.041 | 495.101 |
| 5 | 466768.974 | 469154.739 | 495.205 |
| 6 | 467204.136 | 469931.276 | 494.400 |
| 7 | 467338.487 | 469895.056 | 494.381 |
| 8 | 467525.948 | 470182.443 | 495.501 |
| 9 | 467744.810 | 470118.427 | 495.602 |
| 10 | 467515.69 | 469716.783 | 495.750 |
| 11 | 467593.025 | 469534.312 | 495.859 |
| 12 | 467661.940 | 469164.808 | 496.050 |

## Planning and execution of the flight

The proposed goal of the graphic data acquisition flight was to obtain data that met certain minimum requirements from a technical and functional (content) point of view, such as:

- ensuring an orthophoto resolution of approximately 3cm/pixel;
- respecting the degree of lateral and longitudinal overlap (60°/85°);
- ensuring ground visibility.

The Matrice 300 RTK UAV was used for aerial scanning and DJI Zenmuse P1 (35 mm) sensor. The construction parameters of the DJI Zenmuse P1 (35 mm) are shown in Figure 2.

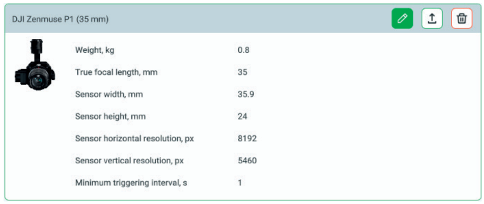


Figure 2. DJI Zenmuse P1 (35 mm) parameters

For flight planning, UgCS Drone flight planning software was used. This software includes background maps on which the area for the photogrammetric flight was identified and marked. Then, the other necessary flight planning parameters were entered: the type and model of the drone used, the specifications of the camera used, pixel size, flight speed, lateral and longitudinal overlap, etc. (Figure 3 and 4, Table 3).

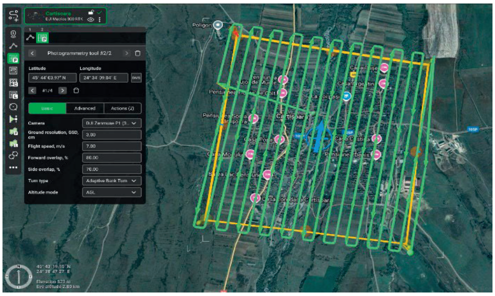

Figure 3. Flight planning and flight parameters

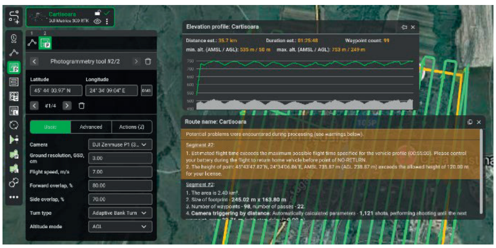

Figure 4. Elevation profile and flight details (area, size of footprint, no. of waypoints, camera triggering details)

Table 3. Presentation of the field book - photogram acquisition

| # Label | X/East | Y/North | Z/Altitude |
|---|---|---|---|
| DJI_0114.JPG | 23.785530 | 44.318153 | 222.074000 |
| DJI_0115.JPG | 23.785585 | 44.318210 | 222.074000 |
| DJI_0116.JPG | 23.785715 | 44.318330 | 221.974000 |
| DJI_0117.JPG | 23.785829 | 44.318433 | 221.874000 |
| DJI_0118.JPG | 23.785963 | 44.318555 | 221.874000 |
| DJI_0119.JPG | 23.786064 | 44.318644 | 221.874000 |
| DJI_0120.JPG | 23.786181 | 44.318745 | 221.874000 |
| DJI_0121.JPG | 23.786275 | 44.318828 | 221.974000 |
| DJI_0122.JPG | 23.786376 | 44.318917 | 221.874000 |
| DJI_0123.JPG | 23.786468 | 44.319000 | 221.874000 |
| Due to volume considerations, only 10 positions from the field notebook are presented for illustration purposes. | | | |

**Processing raw data and obtaining an orthophoto map**

The raw data collected was processed to produce a high-resolution orthophoto map (Table 4). The following activities were conducted during this stage:

- processing the raw data acquired in the field (1,172 photograms);
- generating the primary output: a digital 2D orthophoto map;
- producing secondary outputs, including: Digital Elevation Model (DEM); 3D Digital Surface Model; Point cloud; KMZ map format compatible with Google Earth.

Table 4. Resources required and used for processing raw data (photograms)

| Resource type | Name | Features |
|---|---|---|
| Hardware | Workstation Fujitsu Siemens Celsius R570-2 | Processor:<br>2 x Intel Xeon Six Core X5650, 2.66 GHz, 12M Cache, 6.40 GT/s Intel QPI, 12 Cores, 24 Logical processors<br>Video card:<br>NVIDIA Quadro FX1700, 512 MB GDDR2 128-Bit, 2 x DVI Network: integrated 10/100/1000 Mbps<br>Chipset: Intel 5520<br>RAM: 48 GB DDR3 ECC Storage:<br>HDD 2 x 320 GB 7200 rpm (RAID 1 - mirror) SSD 1 x 500 GB Samsung 850 EVO<br>Optical drive: DVD-RW<br>Operating system: Windows 8.1 Pro 64-bit Monitor:<br>LCD Acer B243HL, 24 inch, 1920 x 1080, VGA, DVI Keyboard, Mouse |
| Software | ZwCAD Professional | ZwCAD offers performance in CAD design and significantly increased work speed, works with files up to DWG 2018 inclusive, includes 3D editing mode. It has efficient functions for 2D drafting and 3D modeling, ZwCAD offers perfect DWG compatibility |
| Software | Agisoft Metashape Professional | Agisoft Metashape Professional is a software product for advanced image processing and generation of 3D models based on static images. This software product is based on 3D reconstruction technology and can process images both under certain predefined conditions and in an unconstrained environment. |
| Software | ArcGIS Desktop | ArcGIS is a software product used for managing various datasets (both geographic and descriptive) and facilitating their manipulation. It allows working with maps and geospatial information and is mainly used for: creating and using maps, analyzing recorded data, sharing information, organizing and managing geographic information within databases, etc.<br>During this stage of the project, ArcGIS was used to georeference the previously obtained orthophoto map. |

The main steps involved in raw data processing using Agisoft Metashape Professional are illustrated in Figure 5. Following the completion of the data processing workflow, a 2D orthophoto map was generated (Figure 6), already georeferenced in the Stereo70 coordinate system.

Point cloud generation was the next step, during which a dense point cloud was created and visualized (Figure 7). This was achieved by aligning the photograms using the estimated camera positions recorded at the time of image capture. The resulting point cloud can be further refined or exported for additional use.

Subsequently, a 3D polygonal model was constructed using processed data and pre-defined parameters.

As shown in Figure 8, ground control points (GCPs) were identified, marked, and integrated into the processing workflow to enhance spatial accuracy.

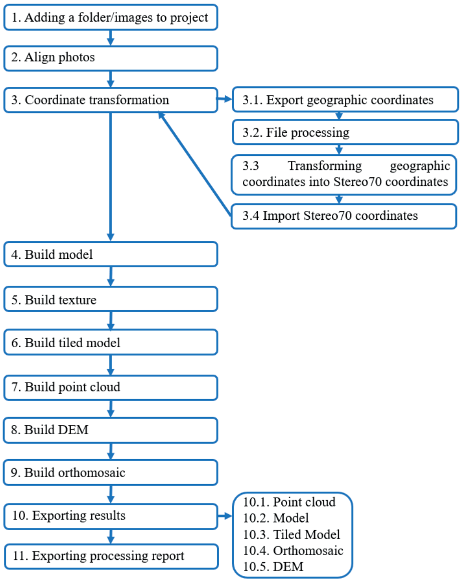


Figure 5. Workflow and results

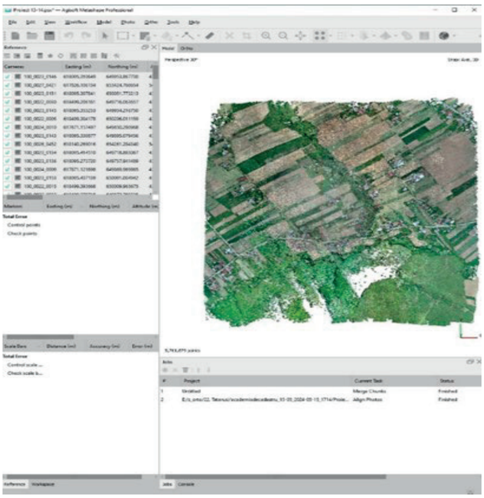

Figure 6. Orthophoto map

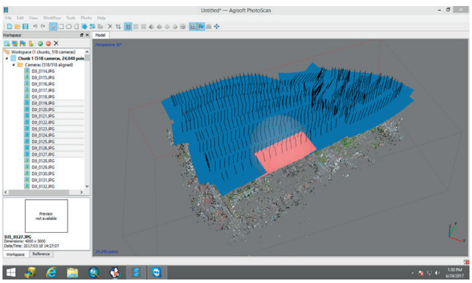

Figure 7. Point cloud generation

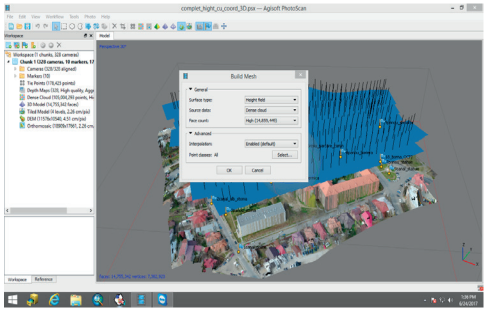

Figure 8. Parameters for generating 3D polygon model

• Surface type: height field – is the specific setting for wide planes (especially in the case of aerial photography);
• Source data: dense cloud – the dense point cloud was utilized as the source, as the goal is to generate a high-resolution orthophoto map;
• Face count: high – specifies the maximum number of facets of the generated model;
• Interpolation: enabled – this allows areas not covered by photograms to be generated through interpolation, based on data from surrounding areas; it is possible that uncovered areas will still remain.

Structure generation – proper structure generation determines the manner and quality of subsequent visualization of the generated model. Therefore, the structure generation was carried out with the proper configuration of the generation parameters:
• The adaptive orthophoto mode was selected for mapping mode, so objects are segmented into flat/smooth areas and vertical parts. This ensures processing quality for both smooth areas and vertical surfaces (such as buildings, walls, etc.);
• Blending mode: defines how pixels with different values (from various photograms) will be merged in the final structure; According to the user manual, the mosaic value was used for the blending mode.
• Enable color correction: true - a helpful option when there are significant brightness variations (though it can be time-consuming and resource-intensive).

After processing, a ground resolution of 2,256 cm/pixel is obtained.

DEM creation - the DEM will be generated based on the processing parameters selected:
• reference system: Stereo 70;

• DEM is build using the existing dense point cloud;
• Interpolation mode: active.

After processing, the obtained DEM resolution is 4.51 cm/pixel. All the obtained results can be saved/exported. Thus, it is possible to export both the main result sought (orthophoto map) and other obtained products such as: point cloud, DEM, etc. (Figure 9).

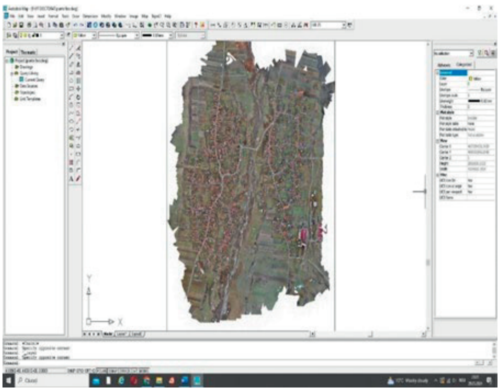

Figure 9. Export results

**Design of the data model (database)**

In general terms, a database is a collection of information that can be accessed and used as needed. Databases, as organized data structures, are present in all fields of activity. If we consider the users of the data and the need to organize it, the concept can be defined more broadly as follows: a database represents a structured collection of logically interconnected information, which can be shared and includes both the relationships between the data and their descriptions. The database design is carried out in such a way as to meet the specific requirements of the users it serves.

Any database must fulfil the basic functions, which are: storing and organizing data, ensuring data accuracy, easy exploitation, non-redundant data recording, ensuring data retrieval and extraction, and updating through CRUD operations (create, read, update, delete).

Database design is a complex process that includes several working phases, from planning the process to maintenance during operation. The main stages of database architecture design are shown in Figure 10.

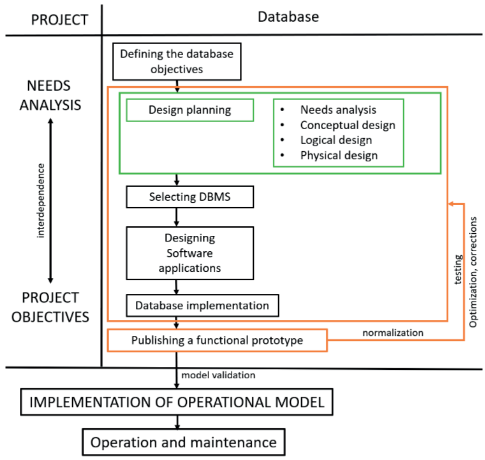


Figure 10. The logical flow for designing a database. Source: Own elaboration, adapted from (Vangu et al., 2023)

GIS systems use spatial databases, which ensure their scalability, allowing them to be used at local, regional, national, or global levels. From an IT perspective, the process of designing, developing, and implementing the database is the same, but the structure and content of the database must be adapted and aligned with the requirements of each project.

The database designing, testing, validating, and implementing is mainly based on the results of the analysis stage. Starting from these results, a structuring and filtering of the data of interest was carried out.

## RESULTS AND DISCUSSIONS

As a result of the case study, the orthophoto map obtained through the application of photogrammetric techniques has multiple uses and can provide valuable data for various applications. Below are the main ways to exploit it.

**Mapping and updating maps**: the orthophoto map can be used to update the digital maps of the area, providing a detailed and up-to-date image of the terrain (Vangu et al., 2025).

**Urban planning and rural development**: local authorities can use the orthophoto map to analyze existing infrastructure, plan expansions, and identify areas for development.

**Tourism promotion**: the orthophoto map can be used to create interactive maps and tourist guides based on real images, enhancing the tourist experience (Chen et al., 2017).

**Land use analysis**: it can be used to assess land use (built-up areas, agricultural land, forests, watercourses) (Budiharto et al., 2021).

**Environmental monitoring**: the orthophoto map allows the analysis of the impact of human activities on the environment and the identification of potential issues (deforestation, erosion, pollution).

Based on the orthophoto map, information can be extracted regarding: the exact boundaries of land and properties, with direct benefits in real estate management; infrastructure and transport networks; the typology of buildings and their use (guesthouses, traditional houses, tourist attractions, etc. can be classified and analyzed); vegetation and natural resources studies; 3D modeling and topographic and spatial analyses (Sedano-Cibrian et al., 2023).

Considering the touristic nature of the Cârțișoara commune, we focused on the possibilities of exploiting the orthophoto map for tourism purposes.

As mentioned before, the most important stage in database design is the needs analysis, which is the stage where a detailed analysis of the requirements and expectations of the end users is carried out. Any aspect overlooked during this stage can compromise the final results.

As a result of the needs analysis stage (through consulting specialized literature and discussions with local authorities and tourism operators), we found that a well-structured local tourism development plan should contain both information about attractions and infrastructure, as well as promotion strategies, services offered, and statistical data about tourists. By using the orthophoto map, we can create interactive maps, optimize routes, and plan sustainable tourism development.

An orthophoto map of a rural tourist locality can significantly contribute to the development and promotion of tourism by providing accurate and up-to-date. Below are the main ways it can be used for promoting and developing local tourism.

**Creating interactive tourist maps**: the orthophoto map can be used to develop interactive digital maps integrated into mobile apps or web platforms; based on it, tourist attractions such as historical monuments, old churches, hiking trails, guesthouses, traditional restaurants, etc., can be marked (Quamar et al., 2023). Tourists can explore the locality virtually before visiting, with access to detailed information about the attractions in the area.

**Planning tourist routes**: the orthophoto map helps in identifying and optimizing tourist routes, whether for hiking, cycling, or car tours. Trails through forests, access roads to lesser-known attractions, or scenic routes for spectacular photos can be marked. Rural tourism organizers can create thematic routes, such as gastronomic, eco-tourism, or historical routes (Hognogi et al., 2021).

**Promoting guesthouses and other accommodation units**: guesthouse and agro-tourism owners can use the orthophoto map to showcase the exact location of their units along with the surrounding landscapes. Maps based on the orthophoto map can help tourists visualize the distances between accommodation locations and main attractions, highlighting nearby facilities like local restaurants, shops, or cultural points of interest.

**Monitoring and developing tourism infrastructure**: local authorities and tourism entrepreneurs can analyze the existing infrastructure and plan the development of new facilities, such as parking lots, camping areas, or viewpoints. Areas with untapped tourism potential can be identified, where recreational activities (e.g., equestrian centers, off-road trails, water sports) can be developed. Issues related to accessibility, such as deteriorated roads or the lack of tourist signs, can be highlighted.

**Analyzing the impact of tourism on the environment**: by comparing orthophoto maps made at different time intervals, the impact of tourism on the environment can be monitored. Areas affected by deforestation, erosion, waste accumulation, or other issues requiring intervention can be identified. This helps promote sustainable tourism by establishing nature protection rules and conserving ecologically valuable areas.

**Creating virtual tours and online promotion**: using the orthophoto map together with high-resolution aerial images, virtual tours can be created for promoting the locality. These can be integrated into tourism websites, online booking platforms, or tourism apps. Tourists can have an immersive experience, exploring the area before deciding to visit.

**Support for tour guides and travel agencies**: Tour guides can use maps derived from the orthophoto map to provide detailed explanations about the relief and history of the locality. Travel agencies can use this data to personalize tourism experiences, offering routes and activities tailored to each visitor type. The orthophoto map can also help organize local events, such as festivals, traditional fairs, or sports competitions.

Therefore, the orthophoto map provides a valuable tool for planning, promoting, and managing local tourism. From creating interactive maps and optimizing tourist routes to developing infrastructure and protecting the environment, this type of data contributes to increasing the attractiveness of a destination and improving visitors' experiences.

Specifically, the orthophoto map can be integrated into GIS, websites, or various tourist applications where a multitude of tourist information can be marked and published, and which can be structured as shown in Table 5.

Table 5. Structuring of the main information that can be included in databases specific to tourist areas.

| Type | Category | Details |
|---|---|---|
| General information about the locality | Geographical location | coordinates, county, distance from major cities |
| | Type of tourism practiced | rural tourism, ecotourism, cultural tourism, agrotourism, etc |
| | Climate and seasonality | optimal periods for visiting |
| | Accessibility | access routes: roads, public transport, nearby airports |
| Tourist infrastructure | Accommodation units | Guesthouses, agrotourism guesthouses, hotels, cabins<br>Accommodation capacity (number of rooms, room types)<br>Facilities (restaurant, swimming pool, accessibility, WiFi, parking)<br>Classification and average prices |
| | Restaurants and local cuisine | Restaurants, inns, traditional wineries<br>Specific regional menus (traditional dishes, local products)<br>Local culinary events (gastronomy festivals) |
| | Tourist routes and trails | Hiking trails, cycling, equestrian routes<br>Difficulty and estimated duration<br>Viewpoints and rest areas<br>Accessibility (for families, athletes, elderly tourists) |
| | Other tourist facilities | Tourist information centers<br>Equipment rentals (bicycles, ATVs, horses, boats)<br>Local transport (taxis, buses, transfers) |
| Tourist and cultural attractions | Natural landmarks | Mountains, lakes, rivers, forests<br>Nature reserves and protected areas<br>Wildlife and flora observation points |
| | Cultural and historical landmarks | Old churches, monasteries, castles<br>Museums and memorial houses<br>Historical monuments and archaeological sites |
| | Traditions and crafts | Pottery workshops, weaving, wood carving<br>Cultural events and traditional fairs<br>Folk music and dances |
| Tourist services and local experiences | Recreational and adventure activities | Guided tours (cultural, gastronomic, ecotourism)<br>Sports activities (mountaineering, skiing, fishing, hunting)<br>Nature-guided excursions<br>Workshops (traditional cooking, basket weaving, cheese making) |
| | Other services | Spa and wellness centers<br>Camping and glamping sites<br>Tour guide services and equipment rentals |
| Statistical data and tourism demand analysis | Annual number of tourists and seasonality<br>Tourist typology (families, adventurers, weekend tourists)<br>Tourist preferences (preferred activities, average budget, length of stay)<br>Assessment of the impact of tourism on the community (economic, social, environmental) | |
| Tourism promotion strategies | Digital marketing platforms (websites, social media, Google Maps, TripAdvisor)<br>Events and fairs (tourism exhibitions, themed festivals)<br>Collaborations with travel agencies and industry influencers<br>Sustainable tourism (environmental protection strategies, local community involvement) | |

Both the previously mentioned datasets and other relevant information can be structured into relational or non-relational data models (databases), as determined by database design

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specialists. Relational databases operate with lower hardware resource consumption but may be more challenging to use for inexperienced personnel. Non-relational models require higher hardware resources but can be much easier to use for basic operations.

Figure 11 illustrates a partial relational model of a database in the tourism domain, which structures and organizes information regarding the types of tourism available in the area, accommodation units and their capacities, types of facilities and their locations, tourist attractions, and transportation capacities to these attractions. The presented model can be completed and extended to include additional relevant information, depending on the beneficiaries (tourists, tourism operators, local authorities, etc.).

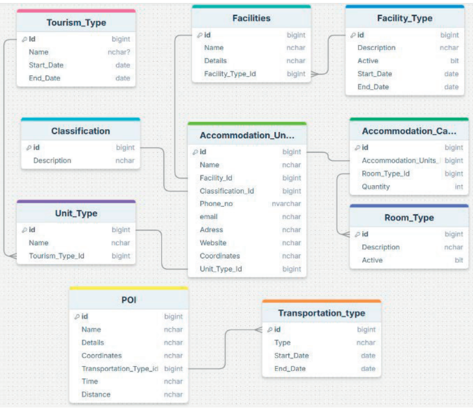


Figure 11. Basic database model for tourism

UAV systems contain a series of emerging technologies that have different levels of evolution and progress, bringing an accelerating role of innovation in a complex mechanism in which those who adopt this innovation early can influence the processes of evolution of technological capacity, with an impact on investments in subsequent stages. The adoption rate of innovation is known to be 20-30%, but taking into account the specific particularities and conditions in Romania, it was found that there is a particularly uneven distribution by age, but it is based on trust in young people who adapt much more easily to new technologies. The proposed topic also has the role of creating a unique integrated framework for analyzing the opportunities, expectations and restrictions of the scalable implementation of UAV systems in the context of the fruition of innovations specific to this emerging field, in the context of the area. The possibility of analyzing different paths of progress at different stages was also pursued, which is why it is valid to apply a quantitative and qualitative analysis to present the opportunities and restrictions of UAV implementation and relevant factors that contribute to or inhibit the technological diffusion specific to UAV missions in the different fields. From the work with students, specialists in the field of terrestrial measurements and farmers, it was observed that in terms of innovation, the use of UAVs is at an early stage because, despite the technological progress at the level of UAV system components, the development of batteries does not yet allow increases in maximum take-off weight, with implications on the maximum payload, specifically affecting active work in precision missions in the different fields of activity. However, there are future expectations of increased performance of propulsion systems and batteries, with an impact on payloads. This aspect is, however, compensated by the advantage of increasing the accuracy of UAV drones and data quality. Innovation is at a level that allows for further growth.

Difficulties in applying this technology also arise due to some operational bottlenecks at the institutional and legislative levels, where transformations are still needed. This leads us to discuss the emergence of signs of scepticism or disappointment given the existence of restrictions on use and safety issues. Legitimizing the use of UAVs is essential in a rather confusing legislative context, but the benefits of previous work by specialists on other sets of UAV applications and missions are relevant. The implementation of UAV systems in specific technology in different fields is also restricted by the level of specialized education, entrepreneurial education and the reduced capacity to create partnerships for the joint use of aerial monitoring platforms and the analysis and interpretation of results. All these problems lead to the emergence of skepticism regarding the interest in this technology, especially among many older people. However, the ambition of those who understood the usefulness of technology for creating sustainable and intelligent ecosystems and their success in implementing UAV systems, was materialized by early detection of vulnerabilities, intervention focused exclusively on them, reducing resource consumption, highlighting the true potential and offering efficient solutions. Agricultural producers and foresters in the future will adopt UAVs in their business portfolios and will better understand the progress they offer in the context of sustainability. Although there are still a number of uncertainties and risks, significant cost reductions and increased performance will favor the recovery phase that will extend sustainably. Users, despite not having specialized education, are surprisingly becoming more sophisticated and demanding superior performance without deeply understanding the aspects of technological leaps.

This study has certain limitations and constraints that should be taken into account in future research. These are related to the following: the goal of offering a comprehensive understanding of the specific processes of innovation transfer in a field characterized by unknown evolutionary dynamics and the lack of relevant data on aerial scanning and precision applications; understanding the capacity of reliability aspects, digital footprint and the influence of innovation dynamics in the field on the performance of aerial scanning and precision applications in the different domains.

The motivation to continue this research is also determined by the fact that the proposed systems work very well from a technical point of view and have the advantage of being easy to use by inexperienced end users. Also, the challenges related to the digital footprint will be further addressed to increase competitiveness in the different fields of activity, where it is very well suited.

The development of a territory/zone/area represents the capitalization under superior conditions of endogenous resources that give it specificity, and the creation of a geographic information system at the UAT level is defining. Rural areas have a relevant heritage of resources that give it specificity and lead to the development of a specific economic structure in accordance with the diversity of endogenous resources that, when digitized, accelerate this process.

## CONCLUSIONS

The commune of Cîrțișoara has many resources that can act as a generator of local development, by outlining a vision of sustainable development, for which a multifunctional base provides faster, more detailed necessary data that underpins the strategic planning process.

The research methodology adopted is the case study because it involves the in-depth study of the rural economy, in the natural setting of the commune of Cârțișoara, from several perspectives.

The development of unmanned aircraft systems is a certainty of the present towards which society shows increased interest, including in collecting data for the creation of a geographic information system.

The design and implementation of a multifunctional database requires:

- the existence of a team of specialists in various fields (cartography, photogrammetry, informatics, etc.);
- the development of a data model (database structure);
- the existence of a graphic support (raster type);

The stages of acquiring raw data through aerial photography and their graphic processing are resource-intensive (financial, time, technical);

The stage of vectorizing the elements of interest and recording the related attributes is time-consuming;

The success of implementing a multifunctional database depends on the team's ability to collect the necessary data;

The structure and content of a geographic information system can be updated at any time (with greater or lesser efforts and, of course, with awareness of all subsequent implications);

The built multifunctional database system allows:

- displaying and extracting results in various forms: images, graphs, tables, maps, etc.;
- ensures flexibility in the analysis of data of interest.

The integration of UAV-based data acquisition, database development, and GIS systems constitutes a synergistic process that generates significant added value. Each piece of equipment and each technological procedure serves a well-defined purpose, contributing to the achievement of broader spatial planning and development objectives.

The methodology proposed in this study was validated through a case study, during which all the designed stages were implemented and the targeted objectives were successfully met.

The generation of an orthophoto map and its integration into an information system designed to support local development represent a multi-stage and complex workflow, where technical operations and data modeling are coherently combined. The first essential stage involves the execution of a photogrammetric flight using an UAV, with the main objective of acquiring primary data in the form of overlapping aerial images (photograms) at a spatial resolution tailored to the project requirements. The flight planning process - including the determination of flight altitude, image overlap, and flight path - plays a decisive role in ensuring the quality and accuracy of the subsequent photogrammetric products.

Following data acquisition, a rigorous photogrammetric processing workflow is applied using specialized software. This involves the alignment of photograms, generation of a dense point cloud, construction of a digital terrain model (DTM), and ultimately, the creation of the orthophoto map. The resulting orthophoto map, which is both georeferenced and highly accurate, serves as a fundamental spatial dataset for thematic data extraction and the development of derived cartographic products.

In parallel with these technical activities, an analysis of user requirements is conducted to design a database tailored to the specific needs of the local community or the field of application. In the present study, considering the predominantly rural tourism profile of the investigated area, the proposed data model was specifically developed to meet the requirements of the tourism sector. Accordingly, the conceptual database schema incorporates relevant entities such as accommodation facilities, tourist trails, cultural landmarks, protected areas, infrastructure networks, and tourist amenities. Performing this analysis concurrently with the orthophoto map generation facilitated the optimization of the subsequent data integration stages.

Although the case study focused on supporting tourism-related activities, the validated methodology is adaptable and transferable to a variety of domains, including environmental protection, territorial planning, urban and rural development, the updating of local cartographic products, and utility and infrastructure management.

Once both the orthophoto map and the database structure were finalized, the database population stage was initiated, with the orthophoto map serving as the primary support for the identification, digitization, and recording of spatial features. The collected data were then integrated into a Geographic Information System, enabling efficient spatial analysis, visualization, and data exploitation.

The final outcome of this workflow is a geospatial database integrated within a GIS environment, with direct applicability for local and central authorities, economic operators - particularly those in the tourism sector - and for the general public, facilitating access to relevant spatial information. The integrated use of these data provides a robust foundation for the development of sustainable development strategies, territorial planning, and the promotion of the region’s touristic potential.

The study undertaken is oriented towards the use of modern methods, means and tools of analysis carried out within the framework of the case study methodology and represents a contribution to the management of strategic orientation activities of sustainable development in the Cârțișoara ATU model, by using modern aerial scanning techniques, creating a GIS database and integrating information for the development of relevant strategic options for sustainable development.

Further research will refer to the establishment of partnerships, entrepreneurial education and specialized education. These, together with the innovative management framework adopted at the level of agricultural and non-agricultural enterprises, are capable of accelerating the implementation and future development of UAV systems.

## REFERENCES


Achtilik, M. (2015). UAV Inspection and Survey of Germany's Highest Dam. Ascending Technologies. pp 1–3. Anderson, K., & Gaston, K. J. (2013). Lightweight unmanned aerial vehicles will revolutionize spatial ecology. *Frontiers in Ecology and the Environment*, *11*(3), 138-146.

Aswini, N., Krishna, E.K. and Uma, S.V. (2018). UAV and obstacle sensing techniques – a perspective. *International Journal of Intelligent Unmanned Systems*, *1*(3), 256-275.

Barbedo, J.G.A. (2019). A review on the use of unmanned aerial vehicles and imaging sensors for monitoring and assessing plant stresses. *Drones*, 3(2), 40.

Borra-Serrano, I., Van Laere, K., Lootens, P., & Leus, L. (2022). Breeding and Selection of Nursery Plants Assisted by High-Throughput Field Phenotyping Using UAV Imagery: Case Studies with Sweet Box (Sarcococca) and Garden Rose (Rosa). *Horticulturae, 8*(12), 1186.

Budiharto, W., Irwansyah, E., Suroso, J.S., Chowanda, A., Ngarianto, H., & Gunawan, A.A.S. (2021). Mapping and 3D modelling using quadrotor drone and GIS software. *J Big Data, 8*, 48. https://doi.org/10.1186/s40537-021-00436-8

Călina, J., Călina, A., Iancu, T. and Vangu, G.M. (2022). Research on the Use of Aerial Scanning and Gis in the Design of Sustainable Agricultural Production Extension Works in an Agritourist Farm in Romania. *Sustainability*, *14*(21), 14219.

Călina, J., Călina, A., Miluţ, M., Croitoru, A., Stan, I., Buzatu, C. (2020). Use of drones in cadastral works and precision works in silviculture and agriculture. *Romanian Agricultural Research*, *37*, 273-284.

Chen, L., Thapa, B., Kim, J., & Yi, L. (2017). Landscape Optimization in a Highly Urbanized Tourism Destination: An Integrated Approach in Nanjing, China. *Sustainability*, *9*(12), 2364. https://doi.org/10.3390/su9122364

Cisneros, L. J. In Peru, Drones Used for Agriculture, Archaeology. AFP News. 2013, pp 1–4. http://phys.org/news/2013-08-peru-drones-agriculture-archaeology.html (accessed June 18, 2024).

Filho, I. H., Heldens, W. B., Kong, Z., & de Lange, E. S. (2020). Drones: innovative technology for use in precision pest management. *Journal of economic entomology*, *113*(1), 1-25.

Glen, B. (2015). Rise of the Field Drones. Precision Agriculture of the Future Employs Robots to Work Fields and it's Here Now. The Western Producer, pp 1–12.

Hognogi, G.-G., Pop, A.-M., Marian-Potra, A.-C., & Someșfălean, T. (2021). The Role of UAS–GIS in Digital Era Governance. A Systematic Literature Review. *Sustainability*, *13*(19), 11097. https://doi.org/10.3390/su131911097

Iagăru, P., Pavel, P., Iagăru, R., & Șipoș, A. (2021). Using drone technology for preserving the economic sustainability of the agricultural holdings. *International Journal of Advanced Statistics and IT&C for Economics and Life Sciences*, *11*(1), 85-90.

Iagăru, P., Pavel, P., Iagăru, R., & Șipoș, A. (2022). Aerial Monitorization - A Vector for Ensuring the Agroecosystems Sustainability. *Sustainability*, *14*(10), 6011.

Kovanič, Ľ., Topitzer, B., Peťovský, P., Blišťan, P., Gergeľová, M.B., & Blišťanová, M. (2023). Review of Photogrammetric and Lidar Applications of UAV. *Applied Sciences*, *13*(11), 6732. https://doi.org/10.3390/app13116732

Krishna, K. R. (2016). Push Button Agriculture: Robotics Drones and Satellite Guided Soil and Crop Management; *Apple Academic Press Inc.: Waretown, New Jersey*, *405*.

Maes, W. H., & Steppe, K. (2019). Perspectives for remote sensing with unmanned aerial vehicles in precision agriculture. *Trends in plant science*, *24*(2), 152-164.

Parraga-Alava, J., Alcivar-Cevallos, R., Morales Carrillo, J., Castro, M., Avellán, S., Loor, A. and Mendoza, F. (2021). LeLePhid: an image dataset for aphid detection and infestation severity on lemon.

Quamar, M. M., Al-Ramadan, B., Khan, K., Shafiullah, M., & El Ferik, S. (2023). Advancements and Applications of Drone-Integrated Geographic Information System Technology - A Review. *Remote Sensing*, *15*(20), 5039. https://doi.org/10.3390/rs15205039

Sălăgean, T., Rusu T., Poruţiu, A., Jutka, D.E.A.K., Manea, R., Virsta, A. and Călin, M. (2016). Aspects regarding the achieving of a geographic information system specific for real estate domain. *AgroLife Scientific Journal*, *5*(2).

Sedano-Cibrián, J., de Luis-Ruiz, J.M., Pérez-Álvarez, R., Pereda-García, R., & Tapia-Espinoza, J.D. (2023). 4D Models Generated with UAV Photogrammetry for Landfill Monitoring Thermal Control of Municipal Solid Waste (MSW) Landfills. *Applied Sciences*, *13*(24), 13164. https://doi.org/10.3390/app132413164

Upadhyaya, A., Jeet, P., Sundaram, P.K., Singh, A.K., Saurabh, K. and Deo, M. (2022). Efficacy of drone technology in agriculture: A review: Drone technology in agriculture. *Journal of AgriSearch*, *9*(3), 189-195.

Vangu, G.M., Croitoru, A., Mitrache, M. and Dima, N. (2023). Design of a GIS Database for Surface Mining. *Journal of Applied Engineering Sciences*, *13*(2), 289-296. https://doi.org/10.2478/jaes-2023-0037

Vangu, G.M., Miluț, M., & Croitoru, A.C. (2025). Use of Modern Technologies Such as UAV, Photogrammetry, 3D Modeling, and GIS for Urban Planning. *Journal of Applied Engineering Sciences*, *15*(1), 165-174. https://doi.org/10.2478/jaes-2025-0020

Wang D-C, Zhang G-L, Zhao M-S, Pan X-Z, Zhao Y-G, Li D-C, et al. (2015). Retrieval and Mapping of Soil Texture Based on Land Surface Diurnal Temperature Range Data from MODIS. *PLoS ONE, 10*(6), e0129977. https://doi.org/10.1371/journal.pone.0129977.

Yamaha. *RMAX-History*. 2014, pp 1–4.

Zhang, C., Walters, D., & Kovacs, J. M. (2014). Applications of low altitude remote sensing in agriculture upon farmers' requests–a case study in northeastern Ontario, Canada. *PloS one*, *9*(11), e112894.