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Utilising drones in the planning of water conservation structures and restoration projects

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ABSTRACT

Water restoration projects are a crucial part of environmental protection. They are time consuming and require careful planning to ensure correct measures are taken. This is the case especially in Finland, where the projects are implemented as volunteer work or with part-funding.

The thesis is an explorative, qualitative study. The aim was to explore and present new methods for the planning of water restoration and to study the possible benefits of drone imagery. The chosen area, Savilammi, was captured with a drone. From the captured images, photogrammetric and orthographic images were created. These images and the photogrammetric 3D-model of the watershed were researched, analysed and compared to the traditional 2D aerial photography. The 3D-model was modified for demonstration for this thesis and the restoration project.

This study shows that drones are a great tool for environmental project planning, offering cost-effective and precise results that reduce the amount of labour. The orthophotographic and photogrammetric images offer accurate and multi-functional maps that can be modified and analysed.

Integrating drones as a tool for environmental restoration projects can enhance the outcome, efficiency and sustainability by providing more accurate data that helps to achieve better results. Drone imagery contribute to the environmental technology field as a new approach to environmental restoration projects for a better and healthier environment.

This research acts as a contribution to the environmental technology field in hope of opening new possibilities for future research regarding this area of expertise. This will help to innovate new ways of conducting research and to create new applications for drones in the planning of water conservation structures and restoration projects.

Keywords: drone, restoration project, water restoration, photogrammetry, 3D-model

CONTENTS

1 INTRODUCTION

Drones are a relatively new phenomenon in the world. The use of drones has been increasing in the last few years, and new ways to utilize drones are being invented all the time. In the environmental technology field, they are a potential new tool (Wakefield 2024). With studies like this thesis and with the advancements of technology, drones could become an integral tool for environmental projects.

Watershed restoration projects in Finland are often conducted as volunteer work by small societies and individual landowners. Financial resources for restoration are in many of the cases low, and that is why cost-effective methods for mapping to building of a wetland are favoured.

Orthophotographic maps and photogrammetric 3D models can be used to plan and visualize topography and vegetation zones of the planning area, and to help in the designing of wetland structures**,** islands, banks and sedimentation pools. By capturing drone imagery, collecting research material and conducting comparative research on the material and possibilities like general aerial photography that are offered by today’s technology, this thesis explores the advantages of these emerging technologies.

The purpose of this study is to demonstrate the effectiveness of photogrammetric 3D models and orthophotographic mapping with a small commercial class drone. This study shows that such mapping can be cost effective without relying on expensive Real-Time Kinematic (RTK) navigation and positioning system, or Light Detection and Ranging (LiDAR) modules, and that the accuracy of the drone imagery is substantial for the planning process of constructed wetlands.

The demonstration of this thesis is done by utilising a drone in planning of a water restoration project for the Summa River restoration project. This is achieved by focusing on the development of photogrammetric imaging methods for accurate, modifiable 3D models, and orthophotographic imaging, which consists of highly accurate, geometrically corrected aerial images.

1.1 Summa River restoration project

The main purpose of the Summanjoki (Summa River) restoration project is to start the rivers catchment areas restoration so it's ecological state would achieve a good level by 2027 on the affected peat production, agricultural and forestry industry water areas (Ihaksi et al. 2022, 3). At the same time the goal is to figure out what can be done to the ending peat production areas that would improve the condition of the Summa River.

The Summa River watershed is located in the areas around Kouvola, Kotka, Hamina and Luumäki. The area is around 569 km^2 and consists of around 16% of agricultural areas, 74% of forests, 4.5% of wetlands and swamps and 5% including built areas and waterbodies (Summanjoen kunnostushanke 2024). Savilammi, which is the area of interest for this study and the restoration project, is located in Sippola, Kouvola. Savilammi is old wetland, that has been drained for agricultural and livestock farming purposes. Savilammi's area is around 22 hectares, and the upper drainage basin area is 650 hectares, where around 30% is meant for agriculture. Savilammi's area is around 3.4% of the upper drainage basin's area, when the minimum requirement is 1-2%. (Ruohtula 1996 cited in Summanjoen kunnostushanke 2024.) From Savilammi, the water runs down to the Summa River in Ruotila.

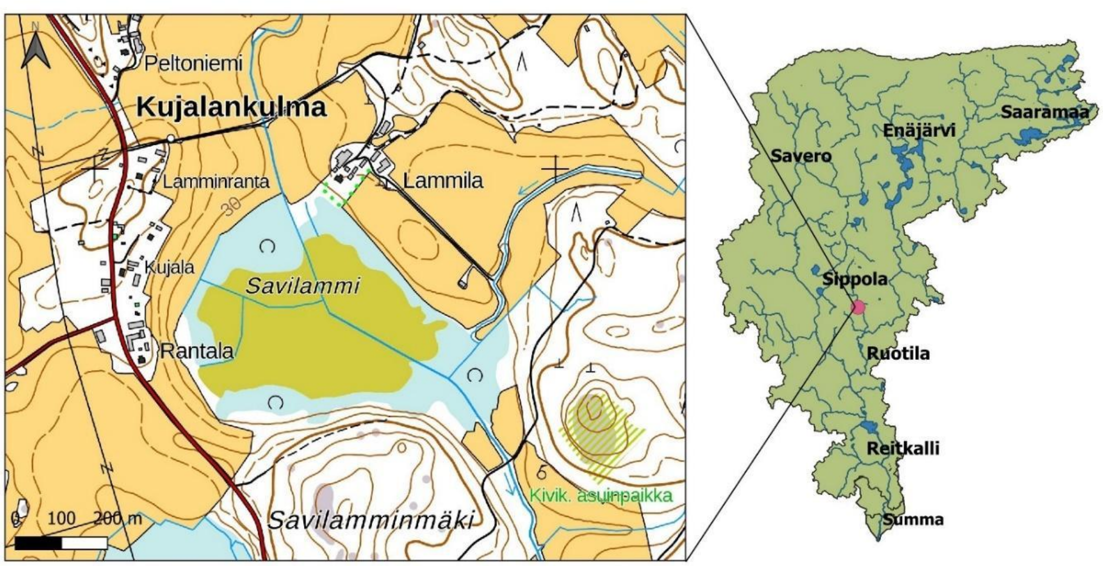

Figure 1. Location of Savilammi on the watershed area of Summa River (Summanjoen kunnostushanke 2024)

The objectives of the project are to improve the water quality of the Summa River by reducing diffuse loading and equalizing large flow fluctuations of the river. Figure out how the areas of peat production can be repurposed so the condition of the river would improve in a way that the peat industry workers would find new livelihoods, and to increase the cooperation and the flow of information between landowners and water protection associations.

The first task in the planning process is to find target areas for measurements, restorations and wetland construction. This is done by studying catchment area maps and conduct VEMALA-nutrient and solid loading simulations to find out the level of nutrient loading that comes to the area and leaves it. After the target areas for restoration and wetland construction have been confirmed, and nearby areas are mapped for water quality monitoring, the communication between the stakeholders, which includes land- and forest owners, cities, forest associations, producer associations and cooperatives and local residents must be established. With active and coordinated communication, a trustworthy relationship with the water protection associations and the land users can be created. With this the implementation of the water protection action program with the cooperation of the landowners taking into consideration their livelihoods can be promoted. (Kymijoen vesi ja ympäristö 2024.)

Figure 2. Aerial photo of Savilammi from north-west (Piispanen 2024)

2 LITERATURE REVIEW

The concept of water restoration is an important aspect of the environmental field. Many different substances wash up from the soil naturally. These substances are things like mineral based soil, humus and organic matter and nutrients. Without these things waterbodies would not have life. If there are too much of nutrient loads coming into a waterbody, it will be harmful for the environment. Excess organic matter causes eutrophication. Eutrophication means the excess growth of phytoplankton, macro algae and aquatic vegetation. It is caused by nutrients, nitrogen and phosphorus that are found in water. Nitrogen and phosphorus often transport to waterbodies through agricultural fields and forests. Eutrophication is emphasised in smaller shallow lakes and ponds, where the water does not change quickly, also called longer water retention time. Over time, eutrophication causes a decrease in oxygen levels which creates circumstances where aquatic life cannot survive. (Vesi 2021c.)

Watersheds are areas of land from where all streams, channels and rainfall drain to a congruent water outlet, like rivers and bays. Watersheds do not have a specific size. They can be very small or very large to seize most water from an area. Watersheds also work as precipitation collectors. (USGS, Water Science School 2019.) As explained by Water Science School,

> Larger watersheds contain many smaller watersheds and Watersheds are important because the streamflow and the water quality of a river are affected by things, human-induced or not, happening in the land area "above" the river-outflow point (USGS, Water Science School 2019).

2.1.1 Water restoration of watersheds and rivers

Waterbody restorations are done to improve water quality, living habitats, biodiversity, and ecosystem sustainability.
The majority of waterbody load is scattered load from fields, forests, and scattered settlements. The load gathers to rivers and lakes from numerous ditches and streams. Waterbody restorations start from figuring out the amount and sources of the load. The aim of the restorations is to first try blocking the

loading substances from leaving the watersheds, or to stop them as quickly as possible. Doing the restoration from an early stage of the problem is much more efficient and less laborious than separating harmful substances from ditches or streams. The load that accumulates from forestry and agriculture, is best reduced by preventing soil erosion. This can be done with erosion protection and protection zones. The loading substances that still get into streams and ditches should be stopped as fast as possible. Things that help with that, are changing and meandering channels, wetlands and flow control structures. (Vesi 2021a.)

Much of organic matter and nutrients flush away to rivers. These matters and nutrients move down the channels. Rivers offer flowing oxygenated water, nutrients and shelter help create conditions for a very diverse ecosystem. Rivers that branch act like a vast network for plants and animals like fish to travel and spread through. (Vesi 2021b.) River restorations are done to help return the natural ecological conditions. Some methods to turn rivers into more like the natural state is by doing technical restorations like creating fish passes and removing dams. Restoring rivers is beneficial for the water ecosystems all the way from the source to the sea. (European Center for... n.d.)

2.1.2 Drones

Drones are unmanned aerial vehicles (UAVs). They are controlled automatically or independently by following a set flightpath, instructions or by being remotely controlled. Drone sizes vary, from a few grams to thousands of kilograms. Different drones can be used in many ways. Some drones are meant for private use, other drones are meant for the police or other authorities. There are two types of aerial drones: multicopter drones that resemble helicopters and fixed wing drones which resemble more airplanes. (Droneinfo 2023.) The general difference between consumer and professional-level drones is in the camera quality and the accuracy and reliability of the GPS system.
There are many benefits to using drones such as cost efficiency and accurate and versatile data. These aspects are very useful in the planning phase when charting. Before drones, areas were mapped using manned aircraft, which is

more expensive, time-consuming and gives less accurate results than drones do now.

2.1.3 Drones used in environmental restoration projects

Restoration projects require careful planning. The needed labour for this can be reduced by using drones to figure out the baseline surveys which include the mapping of species, vegetation and ecosystems and thorough monitoring to be sure of the needed steps of the restoration. (Gann et al. 2022 cited in Robinson et al. 2022, Chapter 3: Restoration planning.) Drones provide significant reductions in time and labour. Compared to the use of satellite imagery the drone photography offers more precise measurements, imagery and resolution (Alvarez-Vanhard et al. 2021 cited in Robinson et al. 2022, Chapter 3: Restoration planning.) Drones can be utilized to capture large-scale topographic maps with photogrammetric methods (Cruzan et al. 2016 cited in Robinson et al. 2022, Chapter 3: Restoration planning). With benefits like cost-effectiveness, there are other good aspects to using drones that might not be immediately thought of, such as safety risks. Some wetlands and rugged terrains can be hard and risky to navigate, but with a drone one can get the needed imagery from afar. This will reduce the risks of injury on a person. (Greening Australia 2023.)

With flight planning software, Ground control points can be set to precise locations. By utilizing software, the data from a drone can be used to create different maps and models, like 3D point cloud models and Digital elevation models (DEM) (Lowe et al. 2019). By using precise location points, accurate and identical data can be acquired multiple times. Utilizing this, one can for example study the vegetation or water level changes in a chosen area. Another advantage about drone imagery is that satellite imagery is not always available on the wanted timeline or the satellite imagery might have clouds blocking the view. Drones have been used for some purposes in the environmental field before. Isoaho did a study in 2022 where drones were utilized in hydrological tracking of restored swamps. The acquired drone material was used to study the elevation changes on ground levels and orthophoto interpretation. (Isoaho 2022.)

In 2021, Ahonen did a thesis study on the utilization of drones to review topwater movements and accumulation of water using drone terrain models. The study shows that drones were useful and time saving in the environmental project. (Ahonen 2021.)

2.1.4 Typical methodology for wetland planning

Gathering the basic information is the beginning and an important part of the planning. The usual information gathered includes landowners, land use, and restrictions regarding the area. The planning of wetland restoration starts with visiting the site and the study and analysis of 2D map. The viewing angle is two dimensional from straight above or from the ground. The idea of doing this is to get an overall idea of the chosen area. Visiting the area physically is important, since the environment can change overtime, and aerial photos do not necessarily show the present condition of an area. It would be very hard to get the details of the landscape, like the vegetation and elevations levels from a 2D picture or a map.

The point is to also make sure that the wetland is possible to restore while being cost-effective and so it does not cause harm for the nearby land use, environment or the general interest. It is also important to consider the ecosystem, when planning the wetland. Some wetland areas are crucial for aquatic birds and other animals for survival. (Alhainen et al. 2015, 24-25.)

2.1.5 Orthophotography, Photogrammetry and LiDAR

Orthophotographic images are geometrically corrected aerial photographs that have a uniform scale. Orthophotographic images are formed in WebODM. The drone takes numerous images from a 90-degree angle. The photos are stitched together with a frontal overlap of 80% and a side overlap of 75%. (see Figures 4 and 5) Using GPS data, the software georeferenced the images, so they align with real-world coordinates. The software calculates the distance from the camera lens to the pixels. If the camera lens correction factors are known, the errors from the distance calculations can be corrected. The height is obtained from the drone's GPS and barometric data, which comes from a sensor which measures air pressure.

Orthophotographic images are used for accurate measurements of areas and distances without any distortion, that are caused by things like, angles, camera lenses, relief displacements and aircraft attitude. They are used in observing topography and measuring the areas of ditches, forests and vegetation zones and applicable species identification. The images can be useful for many fields of study and organizations. These things include scientific fields, universities, and the government. The data can be used in projects like landscape architectures, agriculture, geographical studies, civil engineering, and environmental protection. (Illinois Geospatial Data…n.d.)

Figure 3. Orthophotographic photo of Savilammi (Piispanen 2024)

In Photogrammetry, images are captured and combined to create imagery with highly accurate measurements, to survey distances between objects or terrain. Photogrammetric imaging method is usually used to create high-quality 3D-models of a chosen area by overlapping (Figures 4 and 5) pictures taken from differing angles and positions. The number of pictures taken can range from a hundred to thousands, depending on the size of the imaged area. (DJI Enterprise 2021.) Like with orthophotographic imagery, the images are aligned with identifying similarities from the photos, while utilising the drone GPS data for spatial positioning. The image distortions are corrected, and the software merges the photos together to create a photogrammetric image.

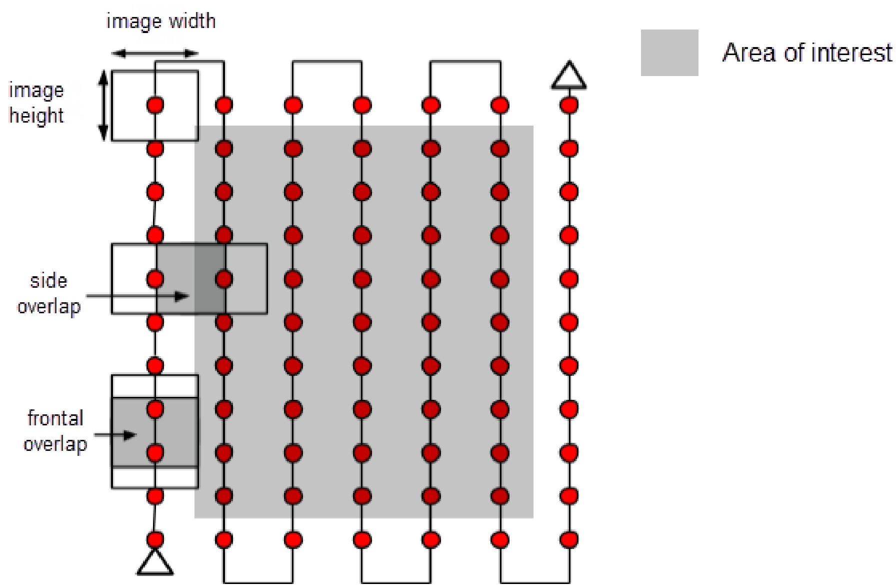

Figure 4. Image overlapping example (Aerotas)

Figure 5. Drone images used in overlapping

3 MATERIAL AND METHODOLOGY

The restoration project group already mapped out an area, Savilammi. It is one of the key watersheds in the Summa River area. Savilammi has an important role in the restoration project representing an area that has strong nutrient load from fields.

3.1 Used software

3.1.1 ArcGIS

ArcGIS is a geographical information system software, that is used to handle and analyse geographical data to create maps with layered visualization. It is used by governments and private companies/institutions worldwide. ArcGIS establishes a large platform for sharing geographical information publicly or inside organizations. With ArcGIS, one can create complex maps with data like raster spatial data, that can be analysed in different purposes. ArcGIS has the capability to create detailed maps and models, like 3D-rendering and flow maps, while using high resolution imagery and real-time data. (Geospatial World 2020.)

3.1.2 WebODM

WebODM is an open source commercially available software that is used for the processing of aerial drone imagery. It is used to generate georeferenced maps. WebODM also has a vegetation condition modelling function. Further processing is done in open-source 3D software like Blender 3D or CAD to plan the wetland embankments, pools, vegetation areas, fields, and islets.

3.1.3 DJI FlightHub

DJI FlightHub is a cloud-based software tool for drones that can be utilized to create very detailed flight paths for DJI drones, manage data and get real-time information. It can be used to set waypoints, flight altitudes, flight speed and parameters like camera angles. (DJI Enterprise n.d.)

3.1.4 DJI Terra

A 3D model reconstruction software. Terra utilizes photogrammetry and supports 2D and 3D reconstruction of visible light. It is best utilized with DJI drones and created to work as a solution for land surveys, construction, agriculture and transportation planning. (DJI Terra 2017.) DJI Terra works like WebODM but is meant specifically for DJI drones and is more user-friendly than WebODM.

3.1.5 Blender

Blender is a 3D modelling software. It is widely used in the graphics, interactive 3D applications, VR, visual effects and 3D modelling sectors. Blender offers modelling tools like sculpting and texturing. It is a largely used tool in hobbyists and professionals. (Blender Foundation 2019.)

3.2 Drone used

Drone used in the imaging was a DJI Mavic 3 Enterprise. (Figure 6) It is a versatile drone meant for commercial use. The idea behind the drone is to act as a cost-effective solution for tasks like mapping and inspections. The drone combines advanced technologies to provide a balanced solution between capabilities and cost. (DJI Enterprise 2021.)

Figure 6. Picture of a DJI Mavic 3 Enterprise drone (DJI Enterprise)

3.3 Drone Imaging

A flight plan was created with DJI FlightHub. The drone was set to fly autonomously at 60-metre altitude and at the speed of 15 m/s**.** A short comparative study was conducted by testing changing of drone flight speed from 15 m/s to 6 m/s. This was done to observe the difference in image quality. 15 m/s is the default flight speed set in FlightHub. The decision to try a flight speed of 6 m/s was to minimize the errors in the imagery. The same flight plan that was set for 15 m/s speed was also used for 6 m/s flight speed. The drone was set to fly autonomously in Savilammi, and it took the drone 15 minutes to complete the flight. WebODM creates reports in PDF format that have values and images that are compared. The flight plan for Savilammi can be seen in Figure 7. In photogrammetry, the altitude is recommended to be under 100 metres and preferably between 30 and 60 metres (Datumate 2023). The quality of the pictures or Ground sampling distance (GSD) was 1.35 cm per pixel when altitude was 60 metres above ground level. This data was from FlightHub's flight planning, which calculates the number of pixels per centimetre based on the drone's flight altitude. Figure 7 shows the oblique imagery map for the slower 6 m/s flight.

Figure 7. DJI FlightHub 2, Oblique map screenshot

Two methods of aerial photography were used. The normal 90-degree angle photography and oblique imagery, at the angle of 45 degrees, shown in Figure 8. Oblique imagery was also used because it gives a much more accurate imaging than the basic 90-degree aerial photography. All imagery used in this thesis has been taken from the faster 15 m/s flight, unless stated otherwise.

Figure 8. Drone image during flight recording (Piispanen 2024)

3.4 Processing Data

The acquired material data was processed in ArcGIS and WebODM. These images were modified using a 3D modelling software, Blender. This was done to clean up polygons and try different structure ideas for the planning. These 3D images were used as examples in the thesis and in the restoration project. The Digital Elevation Model image from WebODM was imported into ArcGIS for colour corrections, to make the elevation levels more pronounced. WebODM created orthophotographic images and 3D models that can be downloaded as geotagged image files. The 3D models were analysed and compared to general use imagery and literature. Lastly, conclusions of the research results were conducted.

4 RESULTS

4.1 Orthophotographic images

Figure 9 shows a 2D orthophotographic image taken of Savilammi, utilising the DJI Mavic 3 Enterprise drone. This was created from the faster flight at 15 m/s. WebODM created the images that can be seen in Figures 3, 9, 10, 11 and 13.

Figure 9. Orthophotographic photo of Savilammi (Piispanen 2024)

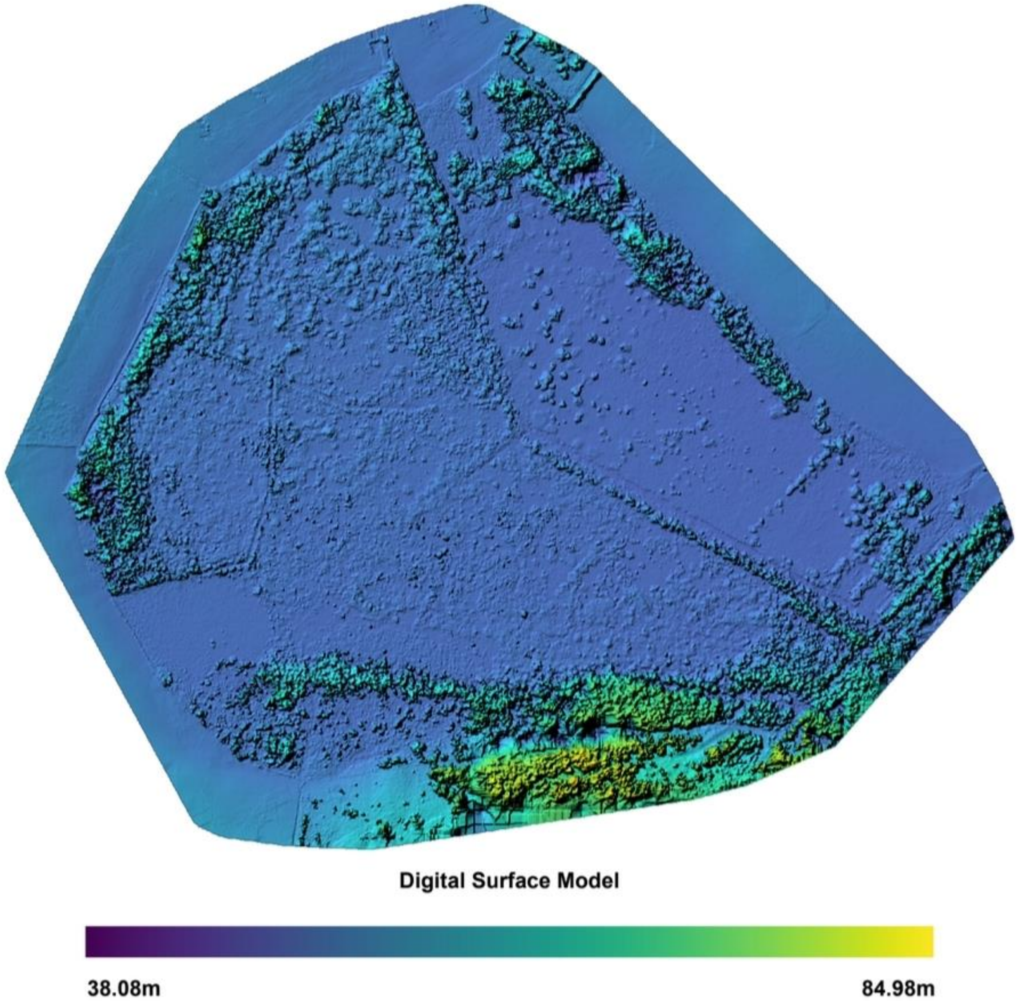

Figure 10. Digital Surface Model image of Savilammi

Orthophotographic Digital Surface Model (DSM) image seen in Figure 10 was taken with the DJI Mavic 3 Enterprise drone to represent the elevation of the Savilammi wetland area. This same image was imported into ArcGIS so the colours can be changed, to make the elevation differences easier to interpret. The colour corrected version can be seen in Figures 11 and 12. The DSM image shows ditches and vegetation in addition to the shape of ground surface. Figure 12 has letters that were used to mark and show where and what sort of landscape features are located in the area.

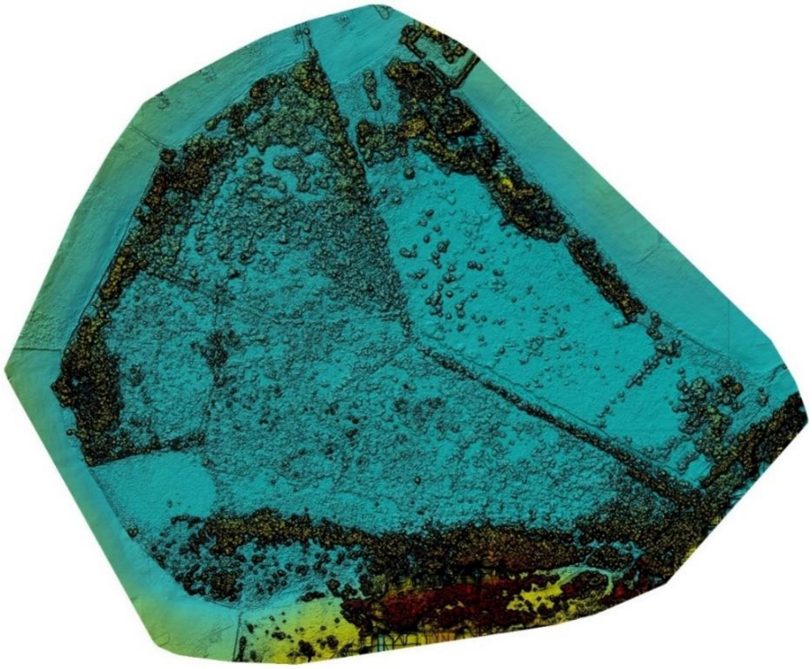

Figure 11. Digital Surface Model image with colour corrections (Karell, Jantunen 2024)

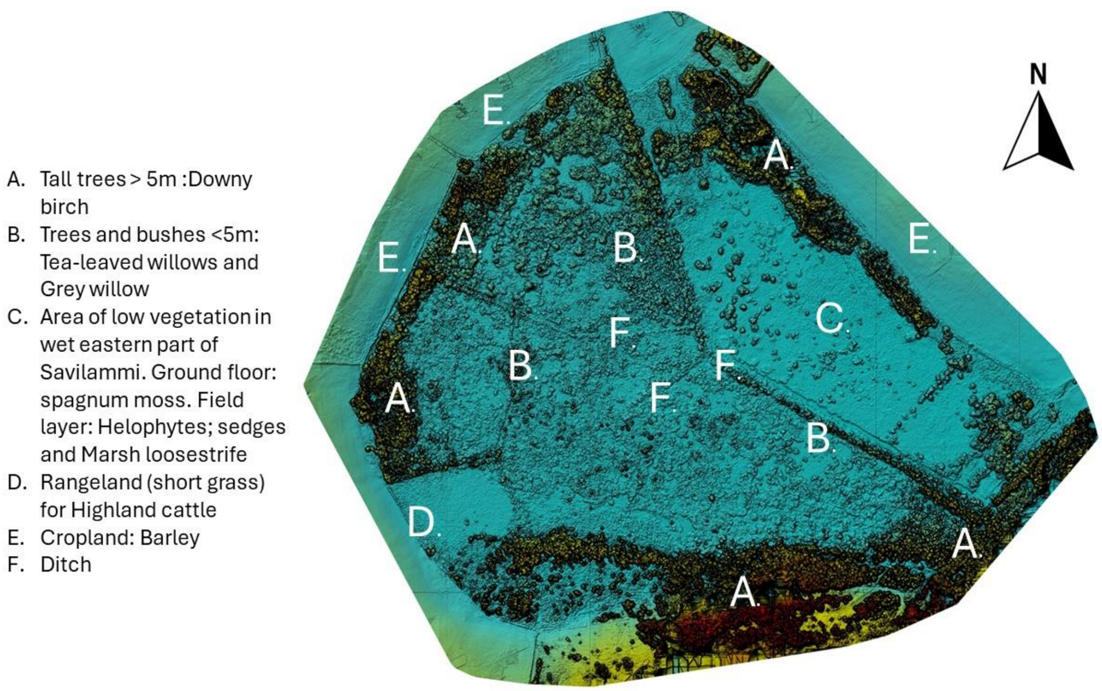

Figure 12. Colour corrected DSM image with vegetation legends (Karell 2024)

Figure 13 shows an image created with the WebODM vegetation condition modelling function. The image shows the vegetation condition in the Savilammi area.

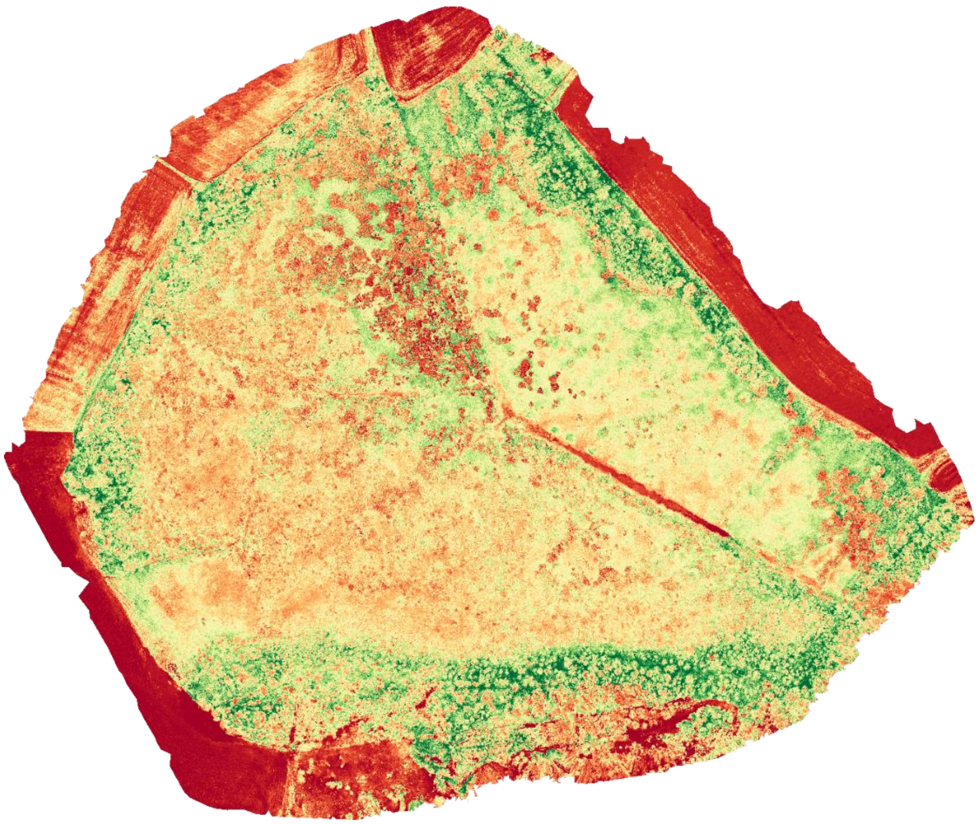

Figure 13. WebODM Vegetation Condition Modelling function image

4.2 Photogrammetric images

The photogrammetric 3D model of Savilammi consists of 1370 images that have a side overlap of 70% and forward overlap of 80%. This overlap is visualised in Figure 5. Photogrammetric images are represented in Figures 14, 15, 16 and 17. Larger images can be seen in appendices 2, 3, 4 and 5. The 3D model file was imported into Blender, where the model was analysed and edited.

Figure 14. Photogrammetric image of the Savilammi

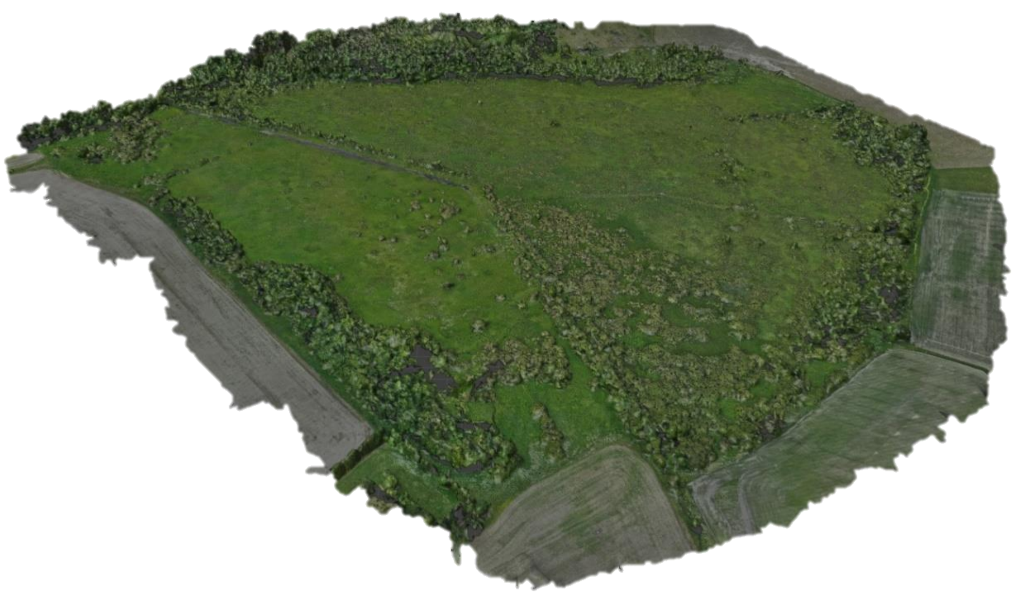

Figure 15. Photogrammetric image of Savilammi, Sideview

Figure 16. Closeup of a photogrammetric image of the Savilammi area

The 3D model was modified in Blender to create an example of what can be done with the software. A small basin was created for the planning of Savilammi. This can be seen in Figures 17 and 21.

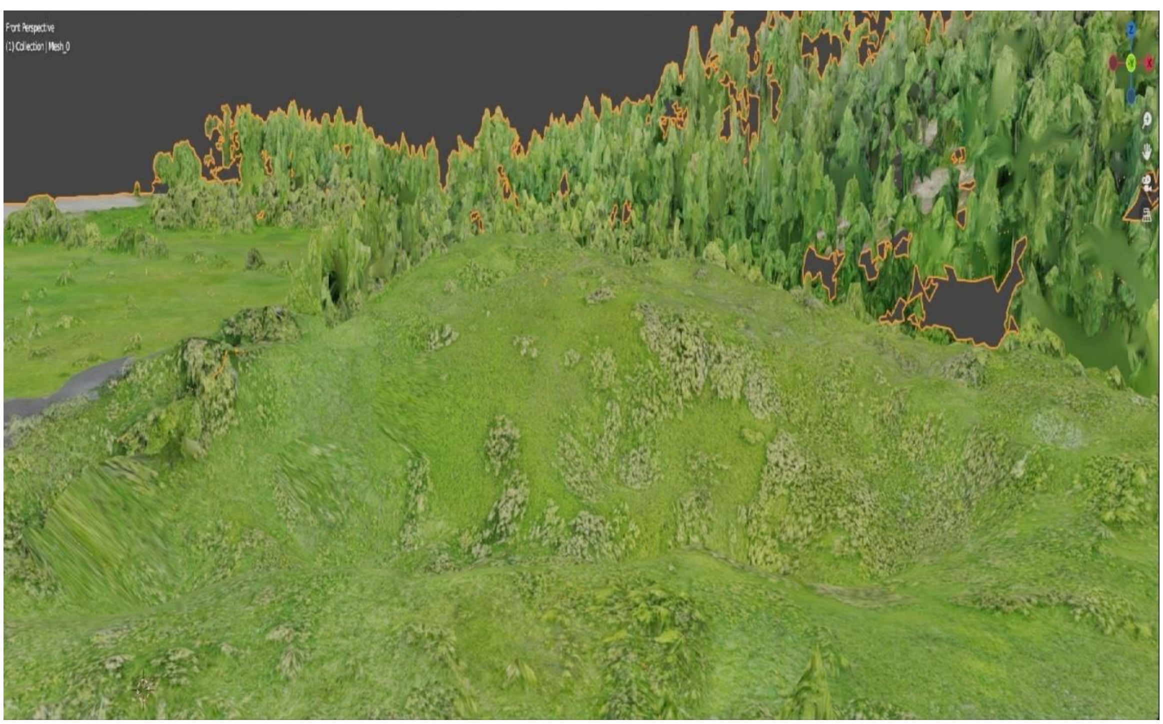

Figure 17. Edited ground for Savilammi area using Blender (Karell 2024)

5 DISCUSSION

5.1 Orthophotographic images

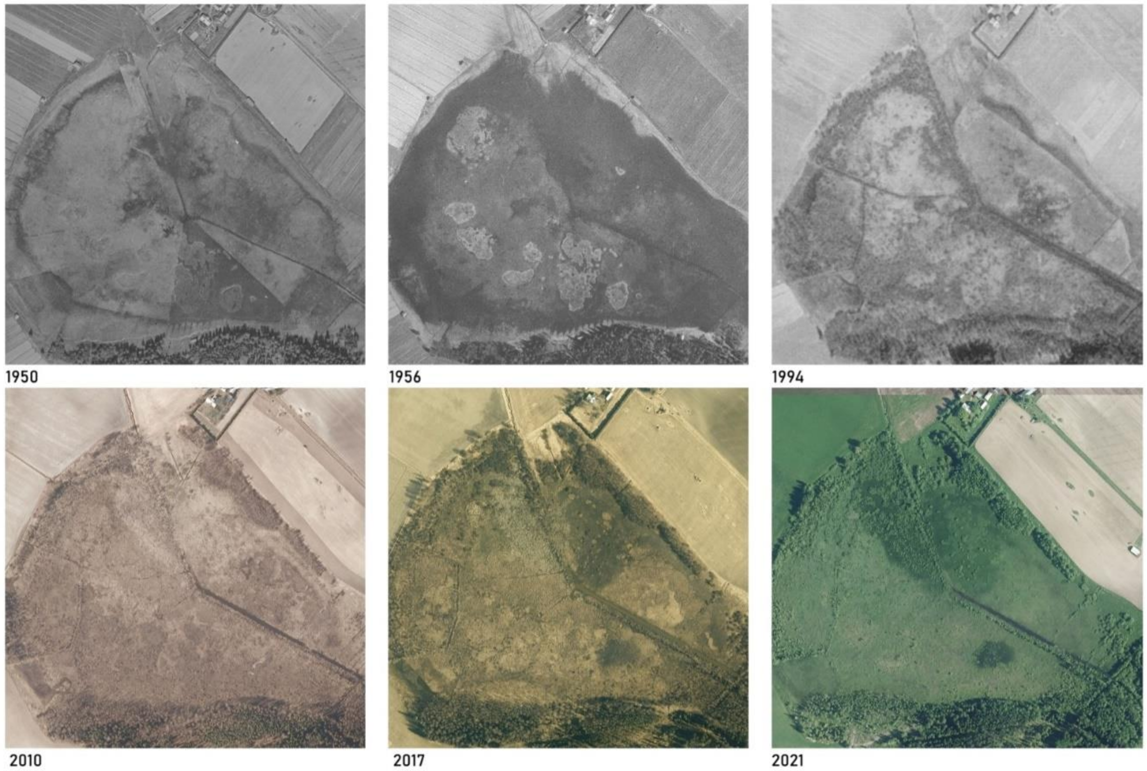

Figure 18. Documented aerial photos of Savilammi (Maanmittauslaitos, Paikkatietoikkuna 2024)

Figure 18 represents a comparison of aerial photos of Savilammi, taken from National Land Survey of Finland. These aerial photos have been taken of the area in the years 1950, 1956, 1994, 2010, 2017 and 2021. These pictures in Figure 18 show how the area has changed in the last seven decades. Compared to the drone orthophotographic images taken during this study, it demonstrates how much more accurate drone images can be.

Figure 19 represents a comparison of a part of Savilammi area, to showcase the difference between image quality between drone orthophotos and aerial photos taken from the MapSite of the National Land Survey of Finland (Maanmittauslaitos, Karttapaikka). The orthophotos on the right side of Figure 19 are cropped images of Figure 3. The original resolution for Figure 3 orthophoto was 14,606 x 12,229 pixels. When examining the images, the drone orthophotographic imagery is much clearer and with better quality that is emphasized when zooming in or cropping the image, when compared to the National Land Survey of Finland's aerial photos. This higher quality imagery can help in the planning of restoration projects and with general research of a chosen area, where one can study the landscape with better precision. The redeeming factor of the NLS aerial photos is the simplicity of acquiring imagery that already exists on their website.

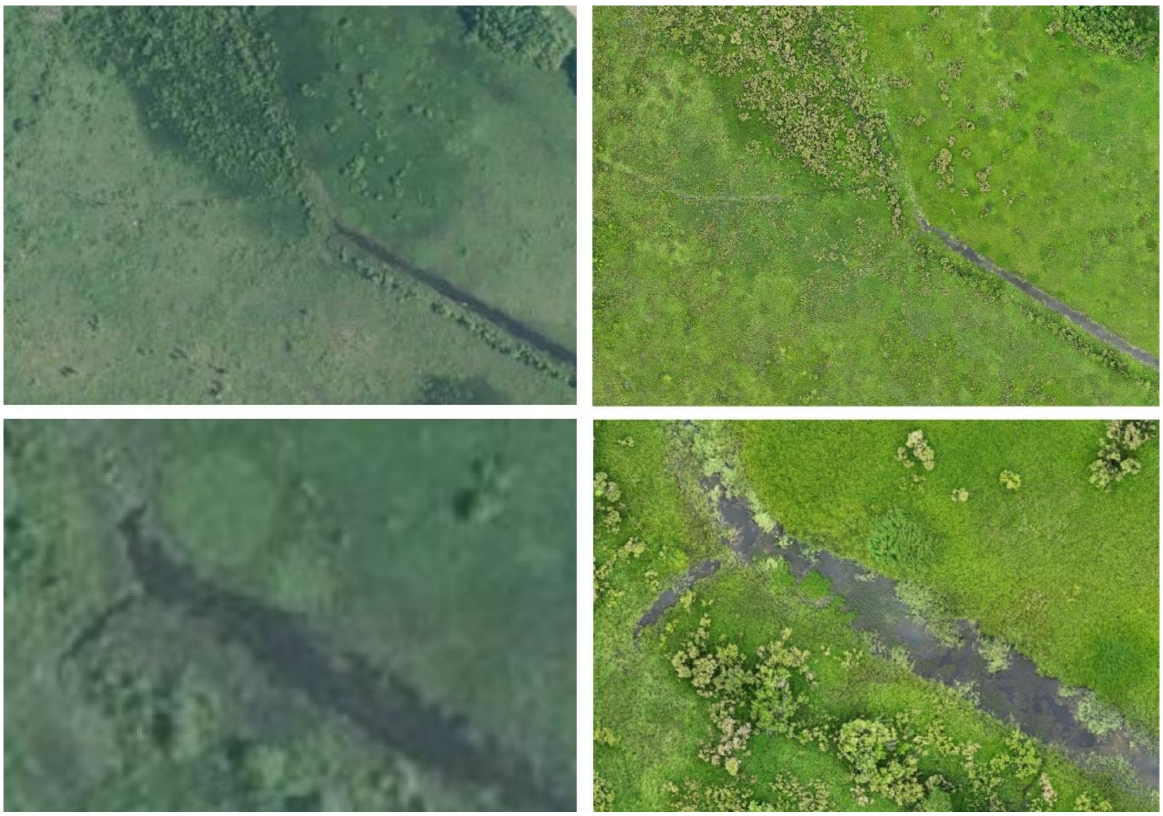

Figure 19. Comparitative image between aerial photos taken from NLS of Finland (left) and Drone orthophotos (right). (Maanmittauslaitos 2024, Jantunen 2024)

The Digital Surface Model image created by WebODM seen in Figure 11 shows the elevations of the Savilammi area. WebODM also added an elevation legend to the bottom of the picture. The legend shows elevation levels from 38.08 metres to 84.98 metres. From this value the drone's flight height should be subtracted to give a more accurate reading. This would mean that the highest elevation is around 25 metres above ground level. The lowest elevation level should be 0 metres above ground level. The accuracy of this cannot be stated for certain and would require multiple test flights on an area with known elevations.

Figure 20. Single drone image during flight (Piispanen 2024)

Figure 20 shows a single image taken during the flight. This is one of the 1370 images that were used to create the orthophotographic and photogrammetric images of Savilammi. The vegetation mapping seen in Figure 13 can be useful in the area research process and when presenting plans for other stakeholders. The specific image is already in the use of the watershed planning. The colours indicate the vegetation condition in red, green and blue. Green areas are spots where the vegetation is healthy, red spots indicate areas where the vegetation is small leaved or open field. Yellow indicates that the vegetation condition is on a satisfactory level.

5.2 Photogrammetric images

The photogrammetric images in Figures 14, 15 and 16 are 3D models of the Savilammi area which are modifiable and easy to analyse, for example when using DJI Terra or Blender. The model can be turned in any direction, can be zoomed into, modified to create new structures like banks, basins, bridges or sedimentation pools. Trees and shrubbery can be deleted or added. This can be a great tool when working on water conservation structures or restoration projects. (see Figure 21)

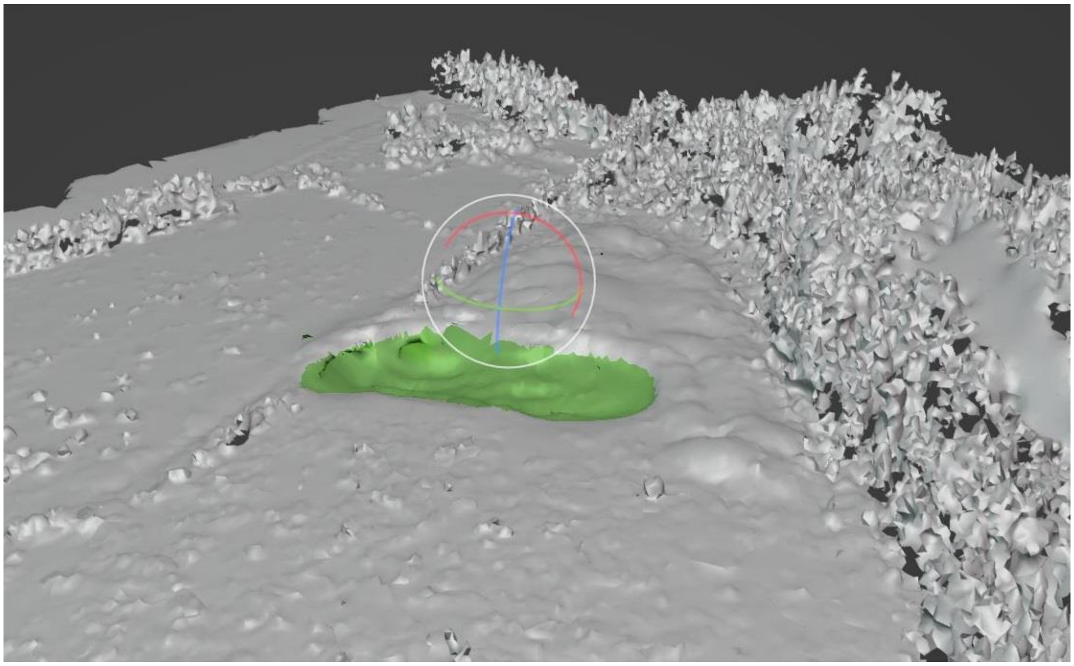

Figure 21. Modifed ground of Savilammi in Blender

The 3D model of Savilammi as seen in the Figures 14, 15 and 16 are already in use of the Savilammi restoration project. to help in the planning of the watershed restoration. Orthophotos seem to be better for close inspections of the area because the 3D models often have polygons from trees or shrubbery that do not give an accurate representation of the vegetation, or even small landscape changes. This can be seen in Figures 22 and 23, squared in red. For restoration projects, these issues do not affect the overall outcome of the planning process by much as there are orthophotos of the area and with experience one could deduce whether it is vegetation or geological formations.

Figure 22. Closeup of the 3D model of Savilammi

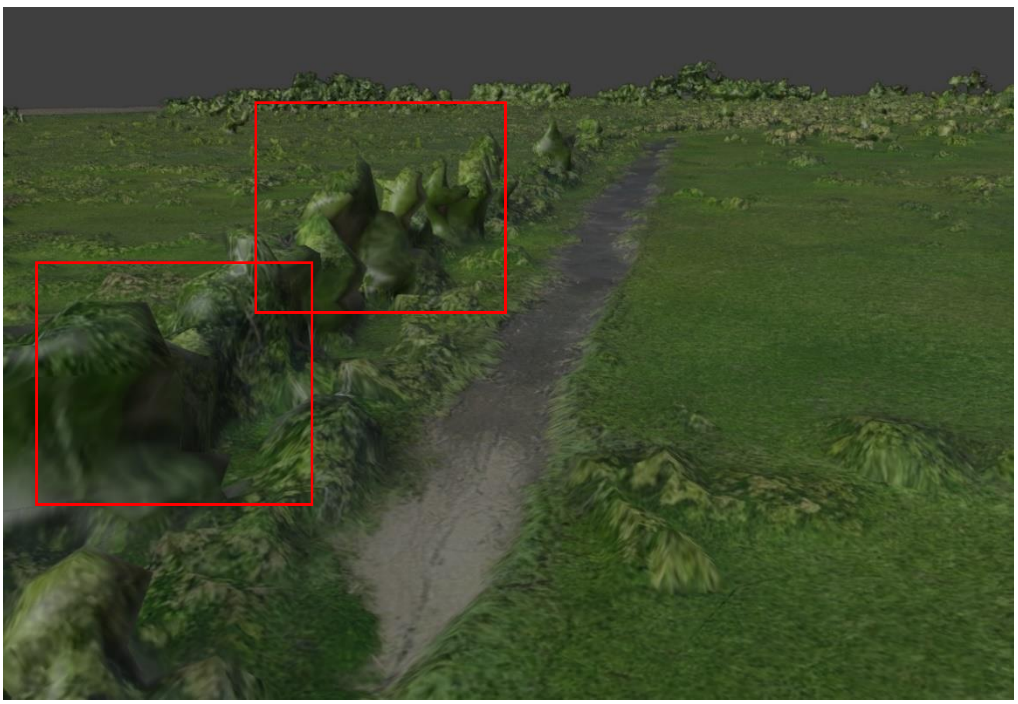

Figure 23. Closeup of the 3D model of Savilammi

5.3 Drone imaging comparison

From two different flights for Savilammi, WebODM created reports, that gave data and images that were compared. The difference between 6 m/s and 15 m/s is not significant. The faster flight took 1402 images where 1370 or 97.7 %, were usable for photogrammetric image construction according to WebODM. On the slower flight, the drone took 1221 images where 1196 or 98.0% were usable. When comparing the orthophotographic images from these two flights, there is a difference between the quality of the images. A difference between the slower and the faster flights can be seen in Figure 24, squared in red. A similar issue was noticed with the drone photogrammetry in the faster flights 3D model as well, but the issue was not as significant. There was a clear error with the taller trees in the Savilammi area.

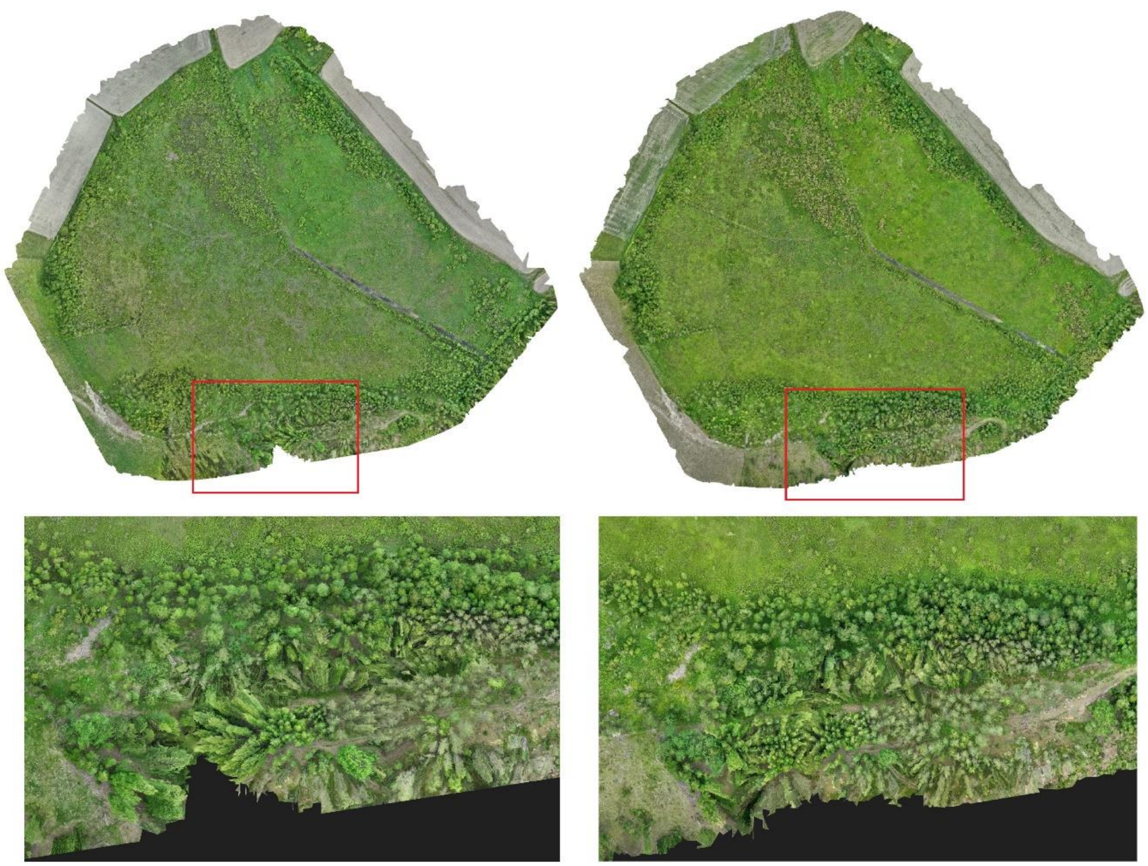

Figure 24. Slow (left), Fast (right), flight speed orthophoto error comparison

The error could be a random or caused by the movement of tree branches and leaves. By conducting multiple flight runs in the same circumstances, one could exclude different variables causing the error. The overall image quality of the orthophotos is very similar. There seems to be very little point to conduct these flights on the slower speed of 6 m/s. The difference in colour and vegetation can be seen because in the Figure 24 since the faster flight was done on 28th of June, and the slower flight was done on the 2nd of August. The DJI Mavic 3 Enterprise drone has a rolling shutter instead of a mechanical shutter, that cameras usually have. This allows for the camera to keep up with the fast 15 m/s speed for drone flights.

LiDAR and photogrammetric imagery offer different types of benefits in drone mapping. LiDAR technology is particularly good at detecting small details. It is capable to penetrate vegetation to map terrain and can be used in low-light conditions without issues. Photogrammetry can miss these small details, but it is also cost-efficient and more available because of the costs and software that is easily available. LiDAR technology’s cost and weight are the main reason why it is not so largely used, especially in environmental projects, when cost-efficiency is important. In some cases, it would be beneficial to combine both technologies. Although LiDAR can be better, photogrammetry offers photorealism that LiDAR cannot produce, because it does not track colour information.

6 CONCLUSION

Water restoration projects are an important part of the environmental field. Making the projects easier to conduct is an important thing that will make for a better future. Restoration projects are time-consuming and require careful planning. These projects in Finland usually are conducted as volunteer work or by funding aid. These aspects create the need to be cost-effective.
Drones offer time reductions and reductions in the amount of labour. The labour can be reduced by utilizing drones to do baseline surveys of a chosen area for its vegetation, landscape formations, and the ecosystem.

The aim of this thesis was to conduct an exploratory qualitative study on the usage of drones in the planning of water conservation structures and restoration projects, focusing on the possibilities of photogrammetric and orthophotographic imaging methods.

Drone imagery allows for more accurate and versatile data for background research and planning for a chosen area. The orthophotographic and photogrammetric imagery taken with drones are better than traditional aerial or ground photos. When considering the time and labour reductions, drones help make the planning and execution of restoration projects easier and more effective. The result of incorporating drones in an environmental restoration project enhances project outcomes and helps contribute to a better and more sustainable future for the environment.

For the future development of the environmental field, it would be beneficial to produce more theses to further develop the idea of drone utilization. This would create more learning opportunities for the environmental field.

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LIST OF FIGURES

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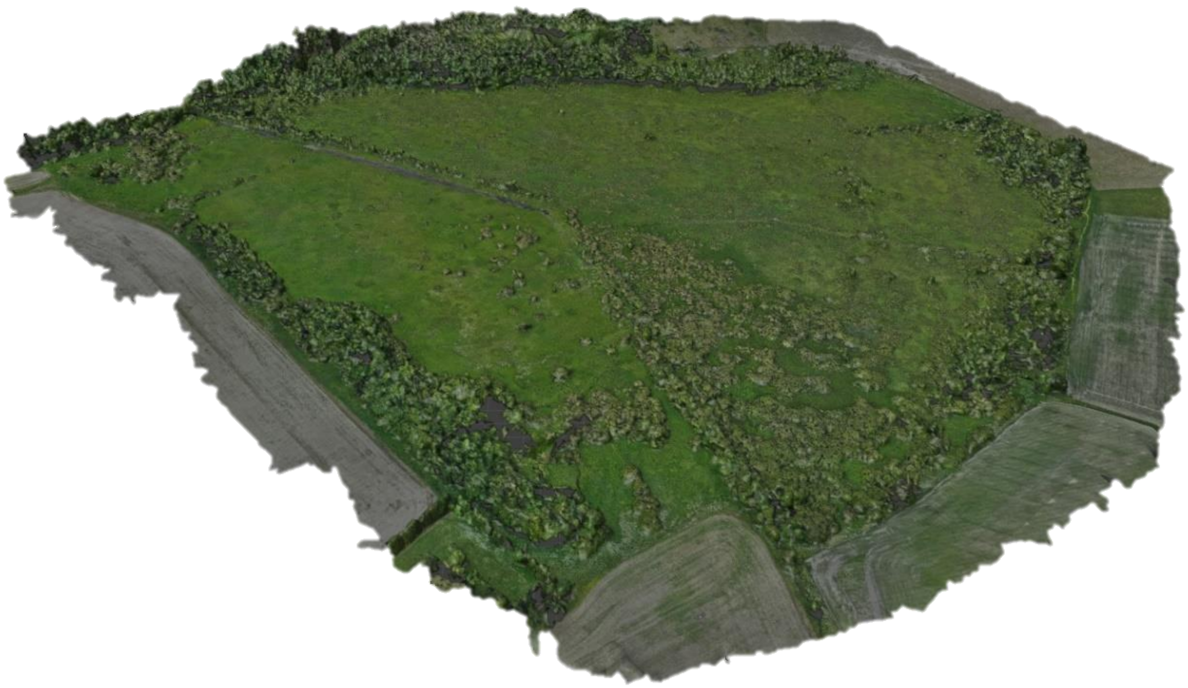
Orthophotographic image of Savilammi

Photogrammetric 3D model of Savilammi

Photogrammetric 3D model of Savilammi, Sideview



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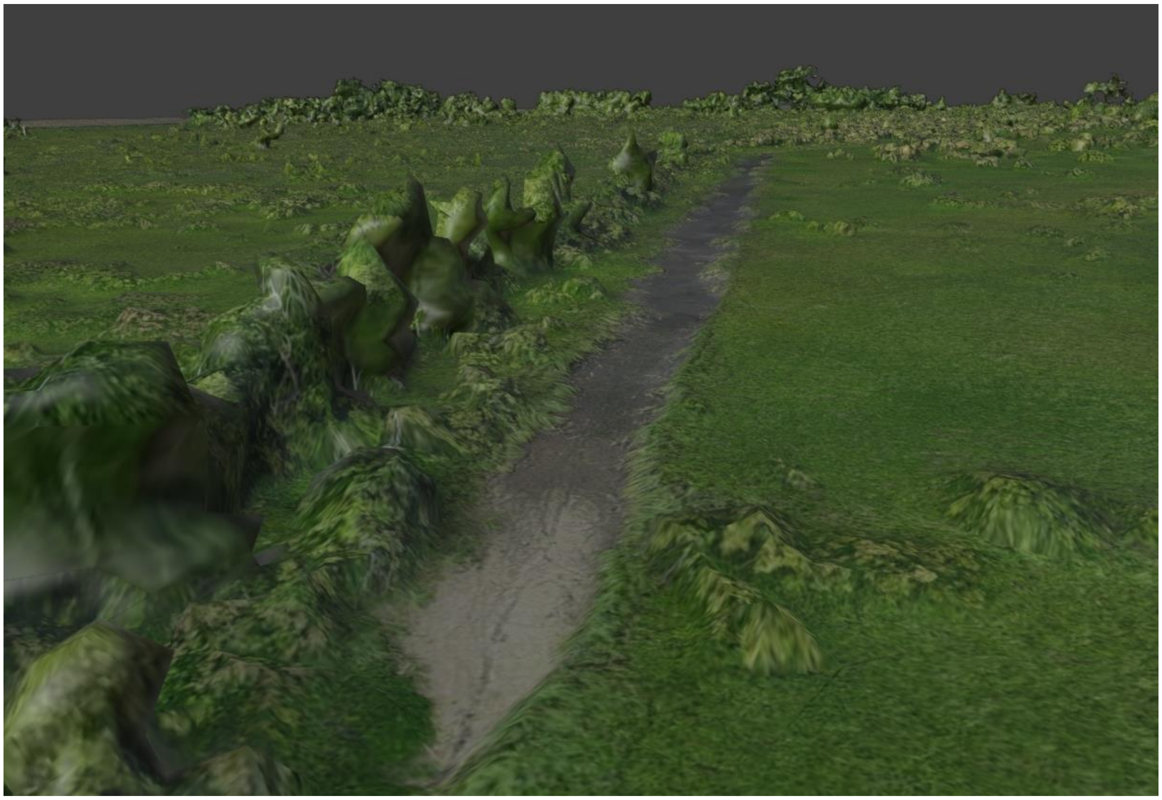
Closeup of a photogrammetric image of the Savilammi area

Modified ground of Savilammi in Blender



Appendix 6/7

Single drone image during flight

Appendix 7/7

Slow (left), Fast (right), flight speed orthophoto error comparison