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Minimum Value Product for Marine Litter Detection using drone imagery

Konstantinos Topouzelis

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Supervised by: Konstantinos Kutsikos, Assistant Professor

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Executive Summary

Floating marine plastics are a threatening problem for the world's oceans. The ocean receives waste from human activities, distributing the load widely but not evenly. Marine plastic debris is tied to plastic production, which has grown exponentially over the last 70 years, from some million tonnes in 1950 to hundredths of million tonnes in 2021. It is estimated that around ten million metric tonnes of plastic entered the ocean from terrestrial sources in 2010 alone, with rivers contributing around two million tonnes of plastic waste. Remote sensing is one of the tools necessary for detecting floating marine plastics due to the extensive area coverage. While floating plastics are reported in high concentrations in several places around the globe, no referencing dataset exists either for understanding the spectral behaviour of plastics in the natural environment.

The proposed Minimum Value Product (MVP) is a web platform that uses drone imagery for systematically mapping marine litter in coastal zones. The MVP can create automatically marine litter density maps from drone imagery using a sophisticated Artificial Intelligence (AI) algorithm. Currently, no other companies in Greece have the expertise and scientific background to UAS close remote sensing over the marine environment. A few SMEs provide aerial services for data acquisition only for topographic services or aerial photography. The current proven expertise in mapping spatiotemporal phenomena and changes in the coastal zone is not yet the right product for other SMEs. In the European market, five possible competitors have been identified; however, none of them supplies the entire chain of the mapping services as the current MVP. In the following years, tremendous potential growth is emerging in the plastic litter recycling industry is expected due to the new laws of the public Governments coming from the EU and UN. The MVP can be monetised from an SME with a University spin-off status. The SME can be seen as a natural result of intensive work on drone technology and visualisation of the geoinformation conducted at the University of the Aegean. It will gain from the produced knowledge acquired from the university environment and transform it into a valuable modern product for society.

Target markers and financial data were calculated to ensure SME surveillance. The revenue is set in detailed projections of previous projects experience. The basic estimations for the following three years are doubled yearly (from 25 K€ to 100 K€). The forecast for the worst-case scenario is for around 30% profit in about three years. The personnel costs and significant expenses are analysed in the use of funds section. Future payments have also been calculated, keeping a straightforward basic company structure. The costs were calculated for three basic costs direct costs (rending office, accountant, operational costs), salaries, and initial expenses. The primary source of funding will come from selling products to potential customers. However, the initial funds needed to start the business should be derived from available startup funding schemes.

The MVP product covers several values both in personal and in the corporate environment, e.g. functional, emotional and life-changing. The company is expected to reach high customer loyalty and sustainable revenue growth.

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1. Introduction

The ocean receives solid waste from human activities, distributing the load widely but not evenly. Accumulation of marine debris impacts marine life, but these areas are not well mapped globally, nor are the causes well understood. To monitor impact and to improve our understanding, global observations are required. Typically, synthetic polymers (i.e., plastics) constitute most discarded solid waste entering the ocean every year. This is reflected in surveys of marine debris, which frequently identify plastic as the significant component, contributing from 60% to 80% of the total marine litter. Impacts on marine life depend on the concentration and size of plastic debris and the system's vulnerability. Plastics can affect flora and fauna be responsible for several economic impacts like tourism and fisheries (Suaria & Aliani, 2014).

In particular, Marine Litter (ML) and marine plastic pollution have become the new millennium's tragedy of the commons due to its significant environmental, economic, social, political, and cultural implications. ML negatively impacts coastal and marine ecosystems and their services, ultimately affecting people's livelihoods and well-being. Plastic pollution is not just an oceans issue. Still, climate-related plastic also contributes to greenhouse gas emissions at every stage of its life cycle, from its production to its refining and how it is managed as a waste product. The challenges posed by plastics are because our production and consumption systems are not sustainable. The COVID-19 pandemic and climate change have amplified public attention towards the plastic waste crisis. Although disposable plastic products have played an essential role in preventing the spread of COVID-19, the upsurge in demand for these items challenges Mediterranean efforts in the shorter term to curb plastic pollution and move towards a more sustainable and circular plastics system. The production, consumption and disposal of other single-use plastics (Fogh Mortensen et al., 2021) lead to more significant impacts on the environment and climate, such as increased air pollution and greenhouse gas emissions, waste generation and littering.

The Mediterranean Sea is widely accepted as one of the most affected seas by ML worldwide (Lange et al., 2020; UNEP, 2014). The root causes of ML in the Mediterranean are the same as anywhere else in the world: a complex combination of resource extraction, unsustainable production and consumption patterns, irresponsible behaviour of individuals and economic sectors, fragmented understanding of the problem due to the lack of fit-for-purpose data, lack of adequate policy and legislative frameworks and poor enforcement of existing ones, weak solid waste management practices and misconceptions related to possible solutions. The three largest end-use plastic markets are (1) packaging, (2) building and construction, and (3) the automotive industry, accounting for almost 70 % of all plastics used in Europe. The single largest end-use market for plastics is packaging, which constitutes almost 40 % of European demand. In the Mediterranean, plastics are the most common type of ML, representing some 80% of the items found, with ML originating primarily from shoreline activities. Over 200.000 tonnes of plastic waste enter the Mediterranean Sea every year, a number that is expected to double if significant measures are not taken (G20, 2017; Thevenon et al., 2014).

Due to the European Union Marine Strategy Framework Directive and the Plastics Directive, Mediterranean countries gradually reacted and undertook concrete actions to address ML and plastic pollution. Understanding and awareness of the problem have been substantially enhanced in the past years, however knowledge gaps related to the amounts, distribution, sources, impacts, and solutions remain. In 2021, the declaration on Sustainable Blue Economy stressed further the need for promoting regional coordination and partnership on ML. Within this context, it is evident that the effective management of ML requires the pertinent instruments of Integrated Coastal Zone Management (ICZM) that should be embedded into local development planning. Furthermore, incorporating environmental principles into regional development planning through the improvement of intra-territorial coordination among different stakeholders, is critical toward the sustainable management of coastal and marine resources.

Plastic has received policy attention in recent years. The European Commission presented the comprehensive strategy on plastics in a circular economy, which lays out the EU's approach to addressing the challenges of plastics. The strategy aims to limit plastic leakage into the environment and ensure that plastic products are designed and produced for circularity, including reuse and recycling. These include improving the economics and quality of plastics recycling, curbing plastic waste and littering, driving investments and innovation towards circular solutions, and harnessing global action. As a central component of the European Green Deal, the new Circular Economy Action Plan, put forward in March 2020 by the European Commission, presents a range of policy initiatives that will move the EU towards a more circular economy. Building on the efforts of the EU Plastics Strategy, the Action Plan targets plastics as a critical product value chain. It contains concrete commitments to develop mandatory requirements for recycled content and waste reduction measures for selected products. Also, it is designed to restrict the presence of microplastics in the environment, create a policy framework for promoting bio-based and biodegradable plastics, and ensure the timely implementation of the Directive on Single-Use Plastics. In 2018, the European Commission launched the Circular Plastics Alliance as part of the European strategy for plastics. It aims to boost the EU market for recycled plastics to 10 million tonnes by 2025. The Alliance covers the entire plastics value chain and includes over 175 organisations representing industry, academia and public authorities.

Several groups were established globally to review the present situation and analyse existing and potential response options related to marine plastic litter. These groups evidence four main barriers to combat marine plastic litter, including challenges related to resources, capacity development and technology transfer in developing countries. These are: i) legal barriers generated by the lack of definition and the existence of gaps in legislation, ii) financial barriers, e.g. high-costs that make a specific activity challenging to afford or implement, iii) technological barriers, which are the ones that are related to the production, manufacturing and design of products, consumption systems and all aspects of waste collection, management and recovery, and iv) Information barriers included access to data, research, transparency, and education and awareness.

Floating marine plastics are a threatening problem for the world's oceans. Several scientific publications evidence the issue. These studies aim to tackle the problem with information from observers on a cruise, modelling, and remote sensing. Remote sensing is one of the tools

necessary for detecting floating marine plastics because of the extensive area coverage and frequent observation. Although the remote sensing detection algorithms are immature, several studies have been working in this direction on optical and hyperspectral modelling, on drones or stable cameras, and with the direct use of satellite imagery. While floating plastics are reported in high concentrations in many places around the globe, no referencing dataset exists either for understanding the spectral behaviour of plastics in the natural environment or for calibrating remote sensing algorithms and validating their results.

The main business idea presented in the present thesis is Unmanned Aerial Systems (UAS) equipped with true-colour RGB, multispectral, and hyperspectral sensors for close remote sensing to map emerging phenomena (like marine litter) in the coastal environment. Quantification includes state of the art remote sensing techniques for observing in combination with artificial intelligence algorithms to detect and derive spatiotemporal geoinformation for emerging phenomena in the coastal zone. This process involves creating orthophoto maps to define, measure spatially, and quantify the selected environmental phenomenon. Several publications exist in the bibliography for the need for remote sensing on litter detection (Maximenko et al., 2019; Smail et al., 2019; Topouzelis et al., 2019, 2020). All references describe the need for accurate remote sensing technologies to detect, identify, quantify, and map marine litter. Drone applications on marine litter detection have previously been published on various and complex beach backgrounds (Gonçalves, Andriolo, Pinto, & Bessa, 2020; Gonçalves, Andriolo, Pinto, & Duarte, 2020; Martin et al., 2018). The presented detection approach overcomes significant problems (e.g. overlap) and takes advantage of deep learning models generalisation ability (Gonçalves, Andriolo, Pinto, & Bessa, 2020; Gonçalves, Andriolo, Pinto, & Duarte, 2020; Kylili et al., 2019, 2020; Martin et al., 2018).

Therefore, the presented Minimum Value Product (MVP) for marine litter detection is based on UAS platform technology and can systematically map natural phenomena like marine litter density, coastal erosion, and oil spill detection. In terms of marine litter density product, the proposed solution is the detection and monitoring of marine litter (ML) on coastal zones by creating ML density maps from data taken by Unmanned Aerial Systems (UAS) and analysed with the use of our sophisticated Artificial Intelligence (AI) algorithms. The final product is an all-in-one solution. It starts with UAS data collection in the desired region, then image processing and analysis using sophisticated AI algorithms. Finally, it ends with the production of marine litter density maps that show where the litter are in the desired region and uses an analytics toolbox to monitor spatio-temporal changes of the litter concentration. The proposed MVP and the use from a spin-off company are presented in the following chapters.

2. MVP for marine litter detection: steps and development

2.1. Introduction to Minimum Value Product (MVP)

Minimum Value Product (MVP) is a type of product introduced to the market with the minimum characteristics, i.e. essential functions, but mature enough to attract the customer's attention. The company uses the MVP to receive comments and recommendations from the early adopters and continuously improve over time. The final product is introduced to the market after a series of changes focusing on the customer needs.

With the MVP, companies learn about the product's strengths and weaknesses in the early stages. Therefore, companies build their product or service without investing in many sources at the beginning of a product. The idea is to start small and support the market for the next step. In such a way, companies are introducing new products and services and learning from the customer's feedback without significant investment. The MVP is ideal for attracting early adopters and validating the product idea through customer feedback. The feedback is crucial for understanding the problems, the needs, and the prospects of the product. Many times new products fail because there is no such a need in the market.

The MVP is based on the agile methodology, where the validation and the continuous iterations are adopted. The user inputs are considered when building the new version and releasing it to the customers. Through their feedback new series of development follow until the product reaches a serious level of autonomy. In the agile methodology, the MVP can be seen as the tool of a company for learning with the least amount of effort, the maximum amount of validated information. Many SMEs choose to release an MVP when they want to:

- test an idea with real users and see its usefulness,
- make their decision on the product availability as quickly as possible,
- commit small budget firstly, before devoting a large budget for full development,
- learn if their target's market is sufficient for the product.

The basic question that rises with the minimum value product is how the MVP is developed (whom, technology, materials) and when it will be lounged? The importance and the series for such decisions can be organized, and they are related to business objectives, specific problems, and functionalities.

One of most important is to associate the MVP product with the business objectives. Building a new product is time consuming and requires significant resources. The MVP should be aligned with company's strategic goals and serve them. The team behind the development should be asked about the purpose of the MVP will serve. For example, they have to examine if there is a need for new customers, or about new the products in the ecosystem they offer. If this is the case the MVP has importance and meaning. On the contrary if the company has a strategic decision to focus on the core market, then the MPV should be designed according to their segment and needs.

The second important decision is to identify the specific problems that should be solved or the improvements that are needed. The improvements could be focused on the company's portfolio or the attraction of the customers' loyalty. The MVP should focus on the specific solution that wants to offer to their users. Most of the time, these solutions result from long discussion with them, on problems that were previously raised, and they are in the share of wiliness. The MVP cannot cover all of them and decisions are needed on the needs that the first version of MVP should cover. The MVP will support only a small number of them since it will have confounded functionalities. Therefore, secondary decisions are needed on the functionalities of the first product. These decisions are based on several factors like the:

- cost of the MVP for implementing the chosen functionalities,
- research on the user needs,
- market solutions or the existing solutions from the competitors,
- time that is needed to create functionalities connected with the needs,
- development time between the user feedback and new product release.

The third important decision has to do with the development action. Once the strategic elements are chosen and the functionality of the MVP is decided, there is a need for an action plan for development. The product should be developed with the aim to be successful and viable, meaning that customers must use it for a task or project and of course it must provide a complete user experience. For example, a MVP product can be user interface with limited actions, but it cannot contain half-built features or tools. The MVP must be a product that a company should be able to sell. Some successful examples of successful MVP products are the MVPs from Dropbox, Airbnb, and Foursquare. All companies firstly created something really basic to validate their idea. The founders of Airbnb used their apartment, the Foursquare started only for gamification rewards, and Dropbox for some simple file sharing.

2.2. Agile theory on MVP development

Agile theory in business is based on creating and responding to change in a small time. It can be seen as the opposite of the classical long term business planning with some years forecast of the products and long-term targets. Nowadays, the long-term targets remain in the center of each business, however, the long-term business plans are considered outdated. The agile theory in based on the adaptiveness and the need to response in a turbulent environment. The response to change is very important for adapting to the new products, services, and continus changes. The Agile theory is very popular in software development, where for first time the focus is given on the how the different programmers work together in a structured way. The idea is the adaption in an continues changing environment through a self-organizing team. The team members are very important, however is not the crucial part. Leaders or managers of the team need to make sure that the right skill sets exist in the team. They provide the environment, the space and the tools that allows the team to be successful. Mostly, once the teams are formed the managers do not interact and they step back allowing to the team to create and produce. However, they jump in again when the team cannot deliver, or is unable to resolve issues. The team after the formation should be focused on collaboration, splitting the work on smaller parts and dealing with technical details. That is why agile concept adapted on business theory of development. It is a tool to perform business

analysis on a continues changing environment with high uncertainty. The agile concepts describe the organizational way of the elements support the theoretic idea. They are very basic for further understanding the way of development:

- Work segmentation: The team always divides the work to smaller parts, which when connected back can contribute to the value of the overall product or service. The segmentation is crucial for being able to work on a small part of the product and to better deal with drawbacks and bottlenecks. The division also is important for the team members, since they work on specific area, which would be a functionality in the end of the product. With this way team members know that the whole team is based on them, and they should perform for the team / product success.

- Gradual development: all agile teams are familiar with the gradual development strategy. This means that every version release of the product is usable, and each part is built upon the previous versions, adding functionality and value to the product or the service. The gradual development of the several parts of the product provides continues improvement on the product as a whole and most of the times gives user friendly characteristics.

- Frequent meetings: The team updating strategy is important to save time and energy. Ideally team members should be meet daily (even at the same time) to bring the whole team in the same information statues. Everyone must be updated since this is vital for the project coordination. All members need to describe the completed work, their obstacles and the way forward.

- Iterative development: Agile development is iterative as the way of development is to repeat the development activities in all the segments simultaneously. This is important for the continues developments. Through the continues visit on the same parts of the product and through their improvement the whole product become much better in a small-time frame.

- Milestone oriented: The projects are based on their development on milestones which have always to be analyzed. The project milestones are important to understand the team's strength and weak points, to understand what went wrong and fix it, or was the key points that made it successful.

- Virtual users: Many times, before the release of the product in the public there is a need for external testing. Especially when the user experience is major requirement the team should create virtual users, or "personas" of the future products. These personas work with the product, examine it, give feedback and checks for large blockages.

Hereafter, a description of the MVP product development is given for marine litter detection in the coastal area using drone aerial images and image processing techniques.

2.3. Step 1 - Problem identification

Marine litter detection was first identified during the refugee crisis in Lesvos Island in 2016. In that time, thousands of immigrants were passing from the Turkish borders to the island of Lesvos through two main pathways in the Northern and Eastern parts of the island. After their arrival, several kilos of litter were abandoned on the beaches (lifejackets, clothes, plastic boats etc.). Local authorities were not able to collect the litter, and therefore several coastal areas became very polluted from plastics. That was the first time drones were used to detect and quantify litter on the beaches. The first exploitation occurred due to a first litter assessment from scientists from the Department of Marine Sciences, University of the Aegean (Velegrakis et al., 2016).

The objectives of this preliminary study were to assess: the extent of the marine litter problem due to refugee arrival along the eastern coast of Lesbos; and the efficiency of new technologies to provide quick, accurate and quantitative assessments of the marine litter distribution.

The study shown that the eastern coast of Lesbos faced a very significant environmental problem that was out of control. Vast areas of the coastline were overwhelmed by marine litter, such as shipwrecks, PVC boat remains, lifejackets, discarded clothing and personal items, boat engines and engine fragments. It was also found that litter concentrations varied along the coastline in terms of their distribution over the “land” beach and the nearshore seabed. In some areas, there was extensive littering of the dry beach but not of the nearshore seabed, whereas other sites, both with good and very poor (or no) access, showed small quantities of litter on the dry beach extensive littering on the nearshore seabed. The nearshore seabed offshore of cliff coasts which, due to complete lack of access, have been not used as entrance points, were found to be full of the diverse litter. This may be due to hydrodynamically dispersed debris from neighbouring areas. Drone surveying proved to be a very accurate, efficient and low-cost method to obtain the geospatial information needed for quantifying the litter problem along the coast that is a prerequisite for the efficient planning/implementation of remediation responses.

Figure 1. Refuges flows in the 2016 crisis

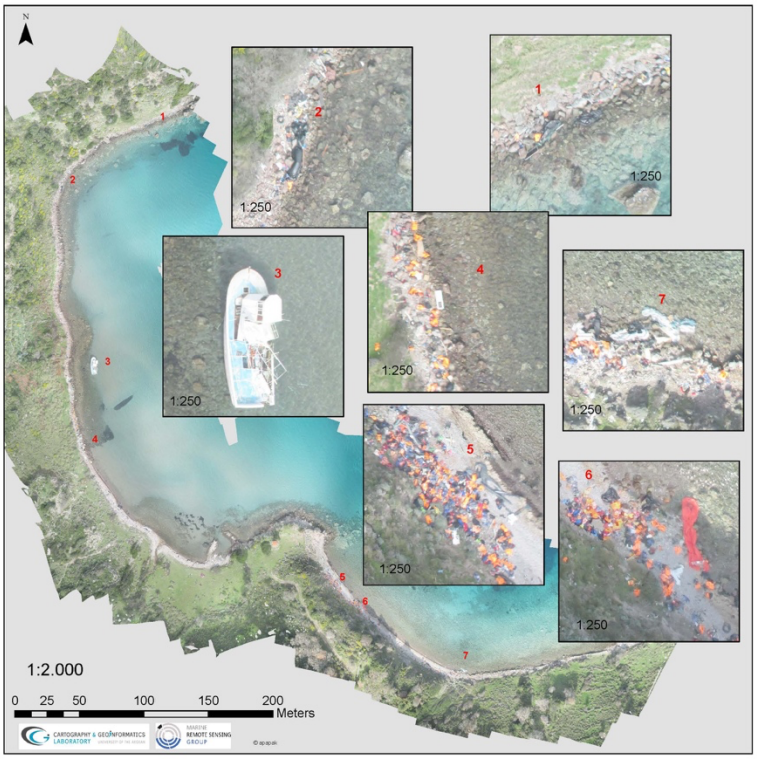

Figure 2. Marine litter map and litter detection on drone data (Northern Area). Adapted from (Velegrakis et al., 2016).

Figure 3. Marine litter map and litter detection on drone data (Eastern Area). Adapted from (Velegrakis et al., 2016).

2.4. Step 2 – Application on a larger area

After a few years, drone imagery was essential to cover a large area and collect aerial images for litter detection. During the second stage of development in the Island of Crete in 2019, more than 5 km of coastline was observed in a single day with aerial imagery. The project was designed as a pilot action combining drones equipped with optical sensors and plastic quantification through photo interpretation by experts. The target was to map and derive an actual number of plastics thus to attain litter density. Litter detection specifications were for macro-litters (i.e. larger than 2.5 cm) lying in the coastal zone. The surveillance designed to support the actions of the A. C. Laskaridis Charity Foundation and the Typhoon project.

Data analysis included the orthophoto map creation and interpretation for marine litter detection. A map generated from the acquired data will consist of all the appropriate optical aids for the marine litters' detection and geolocation. There was a need for litter detection methods based on artificial intelligence (AI) algorithms from that time. However, manual analysis and photo interpretation were performed by a group of experts for the pilot action. The orthophoto map and the detected marine litters tagged with geographical coordinates. In some areas type of plastic was labelled. From the data analysis findings, a report was created with the spots containing a high concentration of litter. This report was in PDF format and all necessary visualisations statistics accompanying the report.

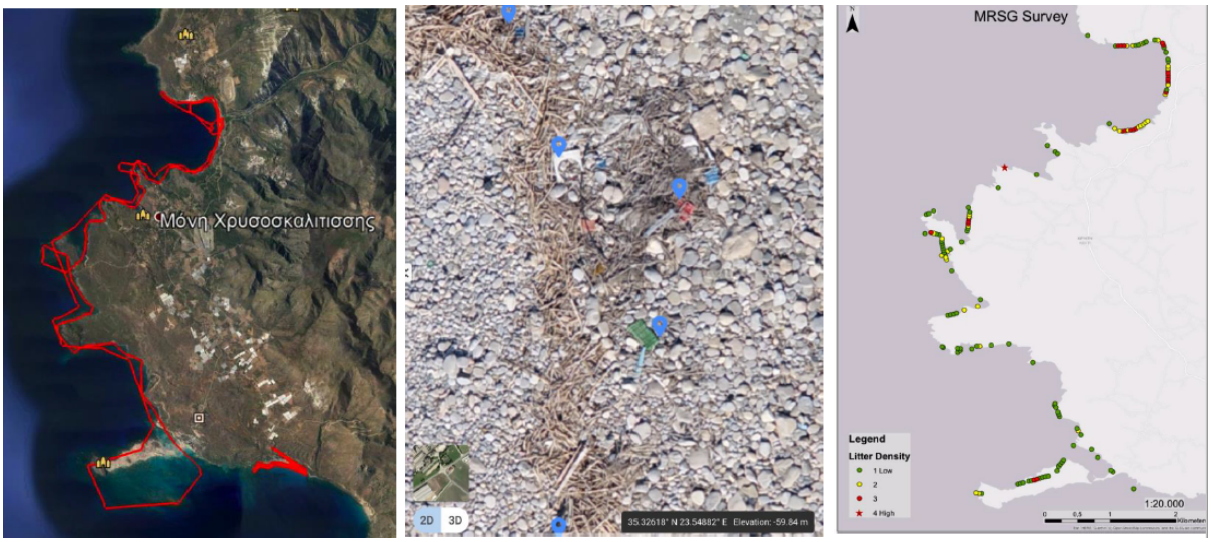

Figure 4. Marine litter map, and litter annotation in Creta case study

Figure 5. Marine litter map, arial image with many litters in Creta case study

In this stage, drones proved to be very useful for coastal area monitoring. Several kilometres of coastline were observed, and areas containing litter were successfully detected. The case study in Crete Island was designed in two days, covering different regions. The first day collected 1000 images from 120 m height and spatial resolution of 2 cm. The coverage was more than 5 km^2 of the coastal area and almost 20 km coastline. On the second day, 500 images were collected in 60 m height, covering more than 4 km coastline. This case study concluded that marine litter is possible; however, machine learning and artificial intelligence

were necessary to move forward. The 1500 images were impossible to analyse timely and adequately from a group of experts. Data had to be standardised, i.e. specific spatial resolution is necessary for the proper detection. Also, the visualisation of the results had to be improved and standardised a for large extend of the litter mapping. Therefore, technology provided valuable datasets, but the image analysis was a drawback for scaling it up.

2.5. Step 3 – MPV version 1, development and automatisation

Continue research and development on the defined problems of the previous steps lead to a first stage of the Minimum Value Product of the litter detection on the coastal area. Firstly, a strategic decision on the minimum detectable size was selected, i.e. 2 cm, the size of a plastic cup of the standard water bottles. This decision was critical for two reasons:

i) it was straightforward to understand and to explain in public since the objective to detect plastic litter, in general, became to detect "plastics that are larger than a cup of a water bottle" and

ii) because the size of 2 cm drove in a decision of the spatial resolution of the aerial images, i.e. 0.5 cm. With such spatial resolution, a water bottle cup will consist of 4 pixels and will be detectable in the datasets.

Secondly, another technical decision on the visualisation method increased the stability of the methodology. The visualisation of the results was decided to follow the reference grid for EU land cover accounts with a spatial resolution of 10 m (or covered area of 100 m^2). With this decision was clear that all the results would be referred to a specific place in the coastal environment. From that decision, the visualisation of the results became very clear, and all the metrics focused on describing the litter detection on the pre-defined area.

Thirdly, the Artificial Intelligent (AI) detection algorithms were used to automatise the procedure further. In that stage, the aerial images had to be tiled in smaller parts and only those containing litter to be accounted for the visualisation stage. That procedure required many samples of the tiles containing litter, and crowd science were used for dataset preparation through a dedicated crow platform called Zooniverse. Next, AI algorithms were designed to perform the analysis and to report the detections, i.e. the number of tiles with litter in the particular 10x10m grid in the ground. Results were promising since the procedure was fully automated and required only some hours for kilometres of coastline.

The developments of the whole product were published in an open access scientific publication and can be used as a reference example of citizen science for litter detection (Papakonstantinou et al., 2021). In this context, citizen science sued for data acquisition and data annotation for ML automatic detection in the coastal zone. The publication proposes a citizen science drone data acquisition protocol to enhance the data collection and apply machine learning detection techniques for "marine litter density maps" creation.

This stage used aerial images as input in deep learning models to identify ML in the coastal zone and create ML density maps. The Zooniverse citizen science tool is used to annotate input data into the litter and no litter classes. The annotation process was implemented quickly with the help of volunteers, making the annotation more efficient and effective. Deep

learning models were examined and trained to distinguish marine litter items from UAS very high-resolution images collected from beaches with complex backgrounds. The evaluation of the results proved the necessity of AI and the automatic procedure. However, generalisation to more complex coastal environments requires re-training. Furthermore, no analytical information was available on the time-series analysis. For example, although it was possible to make queries "how much litter in a certain area," it was impossible to see the differences after a beach cleanup.

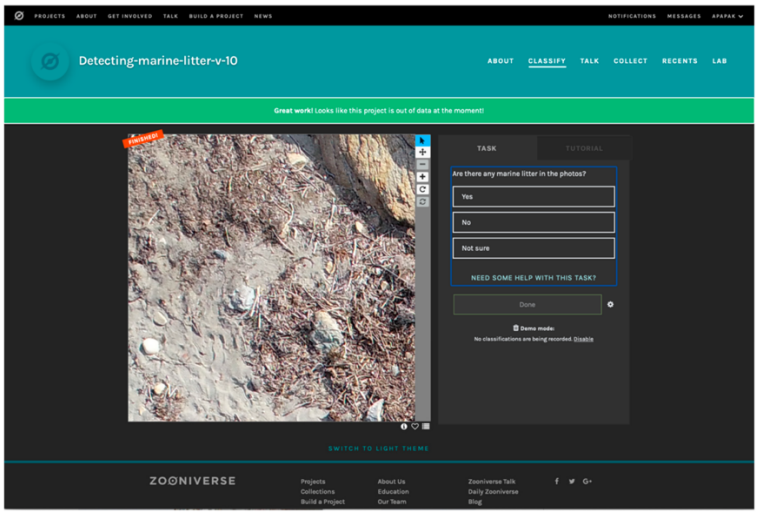

Figure 6. Example of tile for litter – no litter classification in Zoonivese - Adapted from (Papakonstantinou et al., 2021)

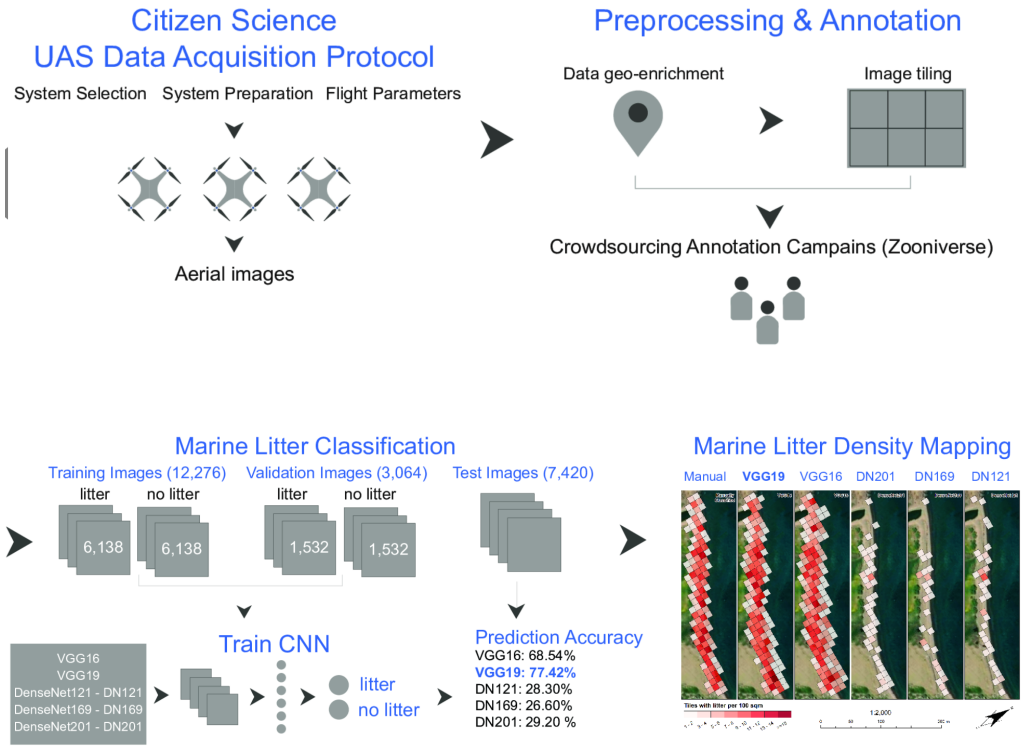

Figure 7 Flow diagram of the detection procedure - Adapted from (Papakonstantinou et al., 2021)

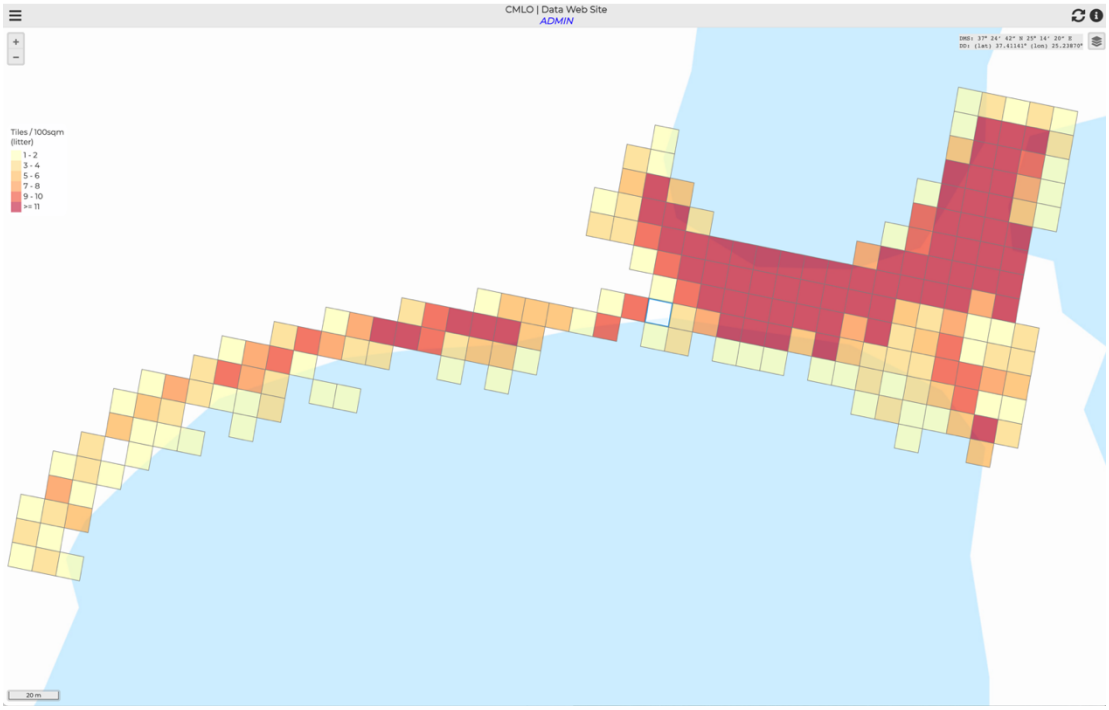

Figure 8. Example of the final marine litter concentration map of the MVP

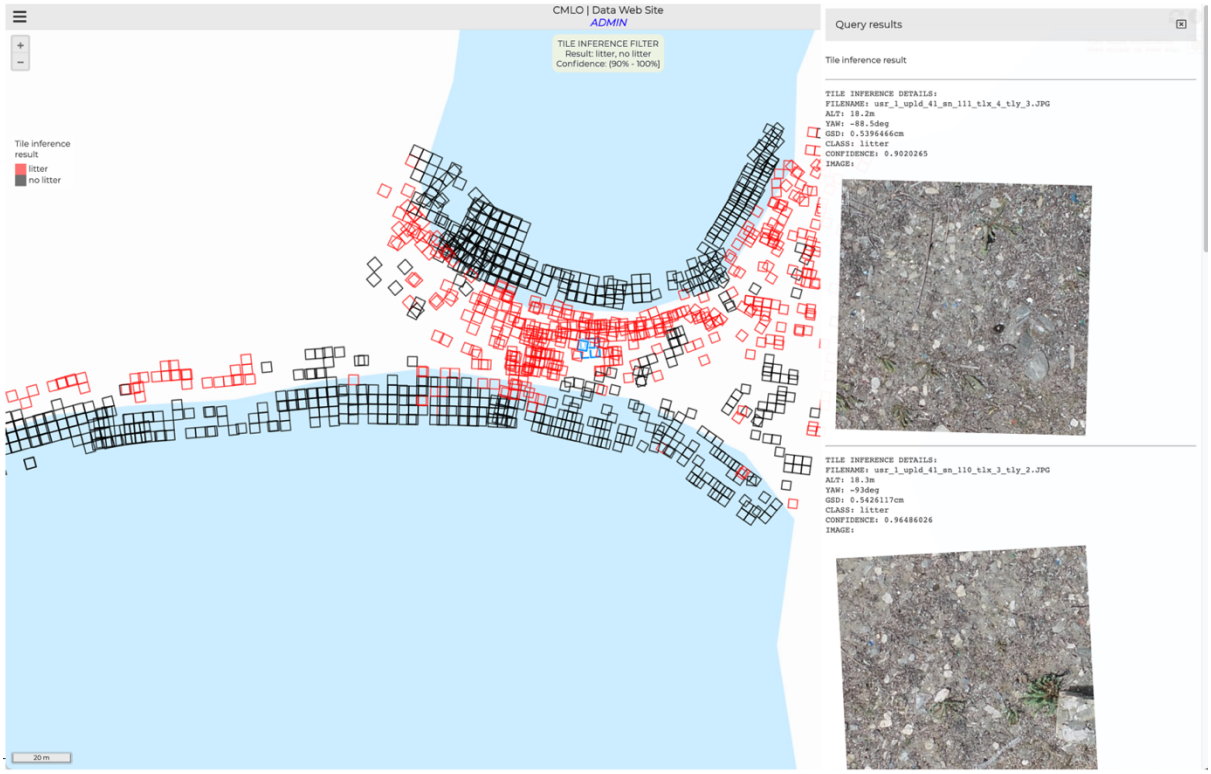

Figure 9. Example of the database with the marine litter of the MVP

2.6. Step 4 – MPV version 2, market-ready

The next stage was the further development of the system, with three essential new features: developing a user-friendly web platform, detecting the actual litter and not the areas of images containing litter (tiles) and an analytics toolbox integrated into the web platform.

After the first feedback of version 1 of the system, there was a clear need for a web platform where the user could register, upload its datasets (aerial images), see all their available areas of observation, and access the results. In this context, the Coastal Marine Litter Observation Platform (CMLO) was born where which aims to detect and map the marine litter in the coastal zone with the combined use of Unmanned Aerial Systems (UAS) and machine learning. The CMLO uses harmonised visualisation methods of the EU standard, with open access through an open geospatial portal. The system provides functionalities for interaction with the results of the detection for every beach that is monitored.

An example of the data used can be seen in the following Figure (Figure 10). On the left, there is an example of drone flight coverage using the dedicated data selection protocol. The height of the flight is dependent on the characteristics of the camera. The spatial resolution of 0.5 cm drives all the flight time, height, area coverage etc. In this example, the ground truth is depicted in the middle image and the aerial observation is given on the right image. In the example of the aerial image with many litters, there is a need to locate the litters, geo-position them, and extract their shape. The system shall analyse hundreds of images in sequel order and create a concentration map of the litter in the area of interest. Litters ideally shall be categorised into categories (e.g. plastics, rubber, wood, ceramics, aluminum etc.). The number of detected litters, their geo-position information are further used as inputs to the analytical toolbox.

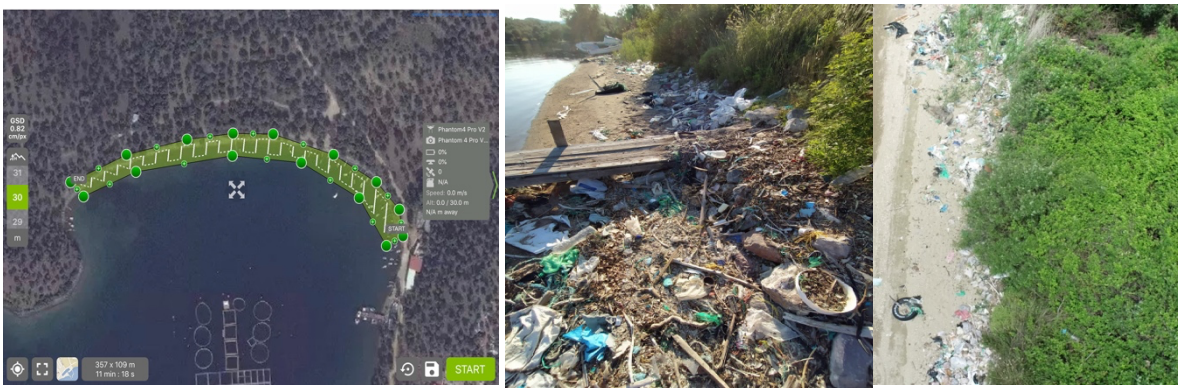

Figure 10. Example of flight coverage (left), ground image (center), aerial image (right)

After a flight, the images collected from drones need to be sent to be uploaded to the CMLO system. Up to version 1, images were sent via the web manually, and a user had to manually upload them to the system. This drawback was essential for further development and was addressed via the customer needs. For this reason, a web-based platform was developed, where users can register, upload their data, and access the previous areas of interest and the platform's results. The system is personalised, where someone can log in and visualise its dataset and result without seeing the results of other users. The preview of the system can be seen in Figure 11. The functionalities include:

i) A prominent web map, where all the available datasets can be seen openly. In this web map, the areas covered are shown as a global overview. Once zoomed, each area is depicted with a vector format, with details on the observation date, an ID number, and the number of the aerial images used to form the observation. Once someone is logged, the whole reporting is available with restrictions on the data owner.

ii) A function and options tab, where the user can register, i.e. create a profile (including user name, password and email address). This information will follow the user on every action on the system.

iii) An uploading and execute tab, where the user can upload the dataset, see the results (reports and statistics) and explore the actual litter detections on the aerial images.

The system is user friendly, allows several permissions on the users, give access to the actual datasets and results in several formats. The web browser functionalities are ideal for every user and allow access from any device (personal computer, tablet, or mobile browser).

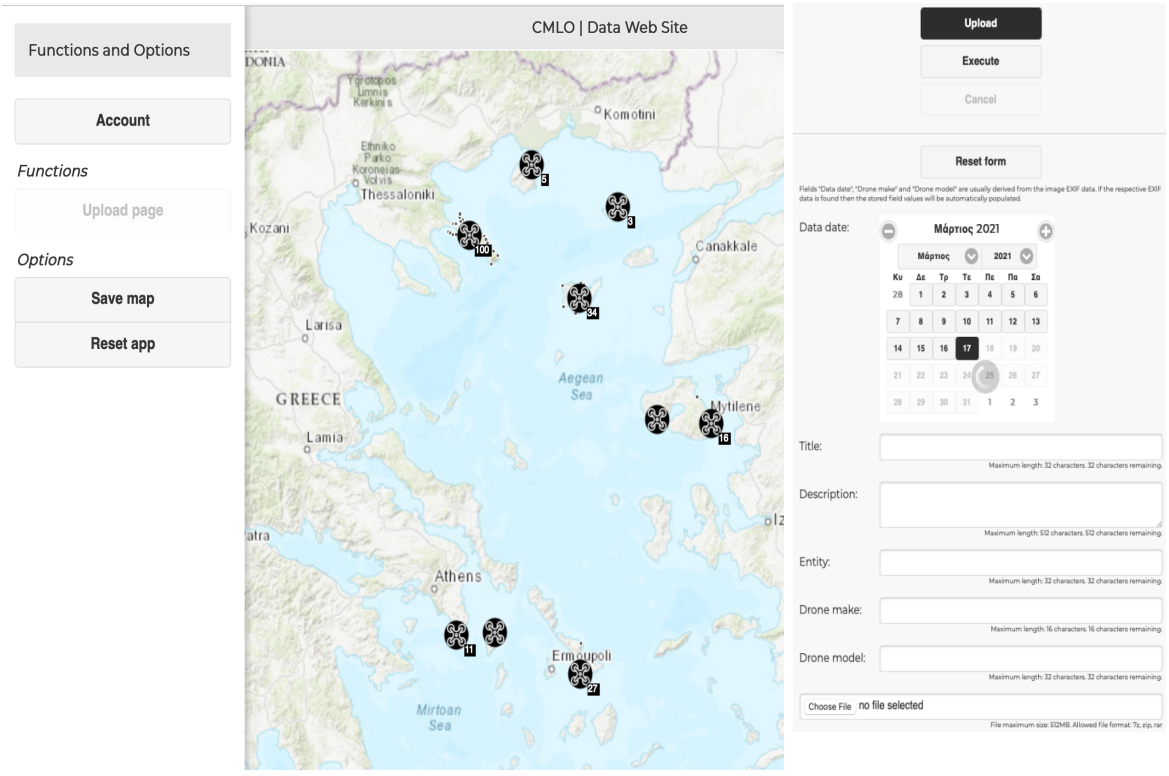

Figure 11. Preview of the Costal Marine Litter Observatory (CMLO) platform

Once the user is logged, the litter concentration map is available. The systems provide information on the number of detection per observation area (10x10m), access the aerial images connected with the observed area, and locate the images associated with the detections. Also, the system can provide information on the litter that exist in the neighbouring area through queries, e.g. number of litter in a certain radius or a defined area. In addition, automatically statistics are calculated according to the query. A preview of the system is given in Figure 12, where all the functionalities are presented.

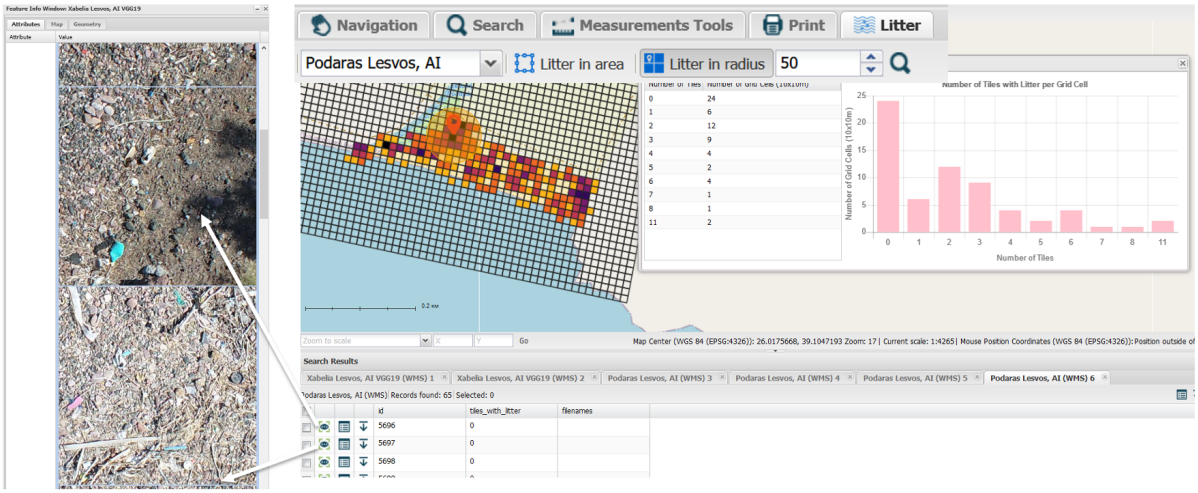

Figure 12. Preview of the final MVP product

The major development of version 2 of the MVP is the ability to locate the actual litter vector, i.e. the shape of the litter (and not the area containing the litter), and to categorise into seven main litter categories (plastic, rubber, ceramic, iron, textile, wood, and unknown). This categorisation is essential for further processing the actual number of litters, the type of litter, and the area they cover. This data is further processed through their position, and therefore the litter concentration map is based on the actual litter detections. An example of the AI algorithm functionality is given in Figure 13.

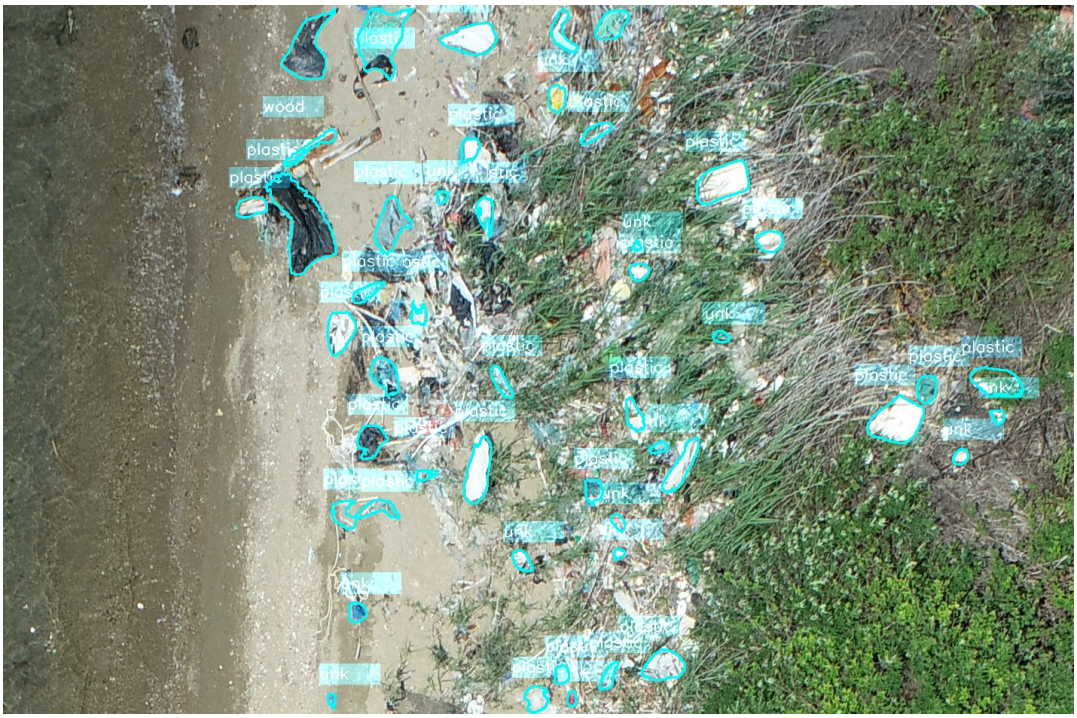

Figure 13. Example of the marine litter detection through object recognition

3. Target market and financial planning

This chapter introduces all the aspects of the company that will monetise the MVP. It introduces the target market, current competition, marketing and sales plan, operational technicalities, and financial plan.

3.1. Target market

In recent Goldman Sachs report (2021) on drone usage, has identified the potential increase in drone services worldwide. It is estimated that the global market will be doubled by 2025, reaching 45.8 billion dollars. Hence, it can be said that globally there is a noticeable positive trend of this emerging market. As this market is brand new in Greece, there is no available report to our knowledge that measures the size of it. However, it is believed that there will be a tremendous potential growth in the plastic litter recycling industry due to the new laws the current Government is planning to pass about banning single-use plastics. This law is an obligation of Greece coming from EU directive EU2019/904 of the European Parliament and of the Council of 5 June 2019 on reducing the impact of certain plastic products on the environment. In Greek law, it is mentioned that the plastic manufacturing industry will be responsible not only to recycle the plastic litter from the public recycling system but also to clean the plastic litter out in the open environment. Therefore, it is believed that there will be a need to find and monitor the plastic litter both in the open environment and coastal zones to collect them later.

In addition, the Hellenic Government and Hellenic Ministry of Environment and Energy have created a government organisation called the Hellenic Recycling Agency (HRA/EOAN) that is responsible for checking that the plastic manufacturing industry is actually implementing the recycling and cleaning processes and reporting in the European Council yearly. Hence, there will be a future need for this organisation and other governmental ones to monitor the cleaning processes. Our solution is the current fastest way to monitor and map the plastic litter in the open environment.

Finally, as for the UAV mapping market, land surveyors and mapping service providers are increasingly using drones to augment their resources of measuring instruments, which in turn creates a large amount of information that requires analysis. The geo-referencing digital images obtained by drones provide precise data with a higher resolution of 5 cm per pixel. Businesses across the world are increasingly using drones across a wide range of industries. In agriculture, farmers are utilising maps generated with drone software to identify areas of damage & crop variation and aid in diagnosing the potential causes for damages, such as pests, equipment malfunctioning, irrigation problems, and prescribe solutions such as variable-rate nitrogen applications. Therefore, it is expected that there will be market growth in the rest of our mapping product services shortly, together with an increase in demand for custom UAV mapping services.

3.2. Competition

Currently, no other companies in Greece have the expertise and scientific background to UAS close remote sensing over the marine environment. Furthermore, the team of the envisaged company is highly specialised in mapping emerging phenomena in the coastal zone, such as marine litter, coastal erosion, and marine habitat monitoring. In Greece, a few SMEs provide aerial services for data acquisition only for topographic services or aerial photography. These are operating solely over the land. The expertise provided by the envisaged team in mapping spatiotemporal phenomena and changes in the coastal zone is not yet a good product from other SMEs.

As for the European market, there are some possible competitors. For example, DroneMatrix from Belgium offers custom UAV services, such as traffic monitoring, security, event surveillance, etc. The company's competitive advantage is that we are more plastic litter oriented. A second possible competitor is VITO, a research centre in Belgium that offers many UAV monitoring services as products. Our competitor advantage is that we have more experience in open field data. A third possible competitor is an NGO from the Netherlands called The Ocean Cleanup. They aim to clean and remove plastic litter from the world's Oceans. We believe that we are in a more mature state of development in monitoring marine litter in the coastal zones. Finally, the fourth and fifth competitors are LitterDrone (Research Project from Spain) and Deep Trace Technologies (university Spin-off from Italy), aiming to develop ways to detect marine litter using UAVs. From studying their reports and publications, the envisaged team firmly believe that it is in a more mature stage of development.

Main advantages:

1. More accurate and faster data collection than practising the old conventional monitoring methods,
2. Ability to cover broad areas with fewer resources and funds,
3. Production of marine litter density maps with the use of sophisticated AI algorithms,
4. Team members have together combined 31 years of experience in remote sensing technologies,
5. Ability to produce any other type of custom maps with the use of UAVs based on specific needs.

3.3. Marketing plan & Sales

The designed marketing plan is to invest in six pathways for advertising. Firstly, direct contact with potential customers is essential. Lists of potential customers that may be interested in buying products and services will be researched and created. Directly communication will be used for advertising material through telephone and email to present products and real-life examples of the provided work. One to one online meetings will be arranged for pitching the provided solution in person.

Secondly, a monthly newsletter will be created for massive customer reach. The potential customers will have the ability to subscribe to this newsletter through a dedicated page on the website. Then, a monthly email will inform them about the products, their news, and the ongoing projects.

Thirdly, directly lobbying is needed to promote and uptake the proposed service. The company will try to reach contacts into ministries and government organisations to indicate the importance of the provided solutions. The case of marine litter mapping will be the priority since it will be required in the future by government organisations to report marine litter pollution in coastal zones.

The fourth marketing plan is conference participation. Currently, there is a plan to attend only virtual conferences and web seminars due to the Covid19 pandemic issue. By attending conferences, the company will have the opportunity to present new products and solutions and their scientific background. By this path, the company will advertise their scientific background. After the pandemic, large conferences will be carefully selected for reaching a large audience and specific customers.

The fifth marketing plan is to organise web seminars/meetings. In these web seminars company will deeply present the provided solutions, and real case studies will be given to potential customers. The attendees of these meetings will be reached through social media, advertisements and from mouth to mouth.

Last but not least, the sixth marketing plan is to join the Elevate Greece Platform (https://elevategreece.gov.gr). Elevate Greece is an initiative launched by the Greek Government, intended to identify promising startups and support their growth, nurturing a robust innovation ecosystem along the way. The initiative provides a digital gate through which Greek startups can apply, requesting to be officially accredited by a competent State Ministry (Ministry of Development & Investments – General Secretariat for Research & Technology [GSRT]). Joining this platform will help the startup become known to potential clients and investors using the platform for new business opportunities.

Due to the nature of provided services, each product will have a different price plan. For the main product, the marine litter density maps, there will be a base fee for each kilometre of coastline to be monitored. This fee will be 1 € per meter of coastline the UAV collects data. This price tag also contains the processing work, AI litter detection, density map creation and reporting. The minimum fee for this product will be 1000 €. Hence, for the company and be profitable, for beaches with a coastline than 1 km, the cost will be 1000 €. In case the operations take place away from Lesvos Island, the final product price will also include the travelling and lodging expenses of the company's operational team. For larger projects (>10km), discounts may be applied based on the nature of the projects. In addition, the price plan will be expanded more in the coming future based on the company's needs and costs.

The final product will be given in a report form and through a web analytics tool. The plan is to use an analytical web tool with all the provided information, and customers will be informed of the detections and the litter concentration maps.

3.4. Company overview and technical operations

The envisaged company (LitterDrones) shall be a Private Capital Company (IKE or PCC) legal format. IKE is a Greek flexible and straightforward format for starting a new business (introduced by Law 4072/2012). IKE is a private capital company, i.e. it is a company not subject to public listing that has capital and the liability of its members for the company debts, except for those with the guarantee contribution, is limited. The three significant advantages of the IKE format are:

i. No minimum amount of initial capital is required,
ii. An IKE can be set up with a minimum possible capital of 1 euro. The insurance fees are optional for the partners of IKE, while only the manager of IKE is compulsorily insured.
iii. The company's articles of association can also be drafted in a private document without the need for the assistance of a notary.

The LitterDrones shall have a spin-off status. It will have the form of a capital company established to commercialise and exploit the results of scientific research. The company will be directly connected with the University of the Aegean. There will be further discussions between LitterDrones and the University's Research Unit to define the exact format of their cooperation.

At least three entrepreneurs shall undertake LitterDrones to seek, develop, and validate a scalable economic model. The LitterDrones shall have a startup status. Their vision has to drive global plastic litter mapping and cleaning and make it profitable. The main reason for the team should be their belief that they can transform their business idea into a successful venture. The team has to believe that their business idea is innovative and will create a new business sector within the current UAV mapping services market.

The LitterDrones shall be formed from at least three shareholders with specific positions and stake percentages. Partners need to coalify very early the stakeholders and their shares. The company needs to be based on trust and the evident organisation from its birth.

The experience of such a company shall be proven in the time. For example, LitterDrones can be seen as a natural result of seven years of intensive work on UAS technology and visualisation of the geoinformation conducted at the University of the Aegean. The company will gain from the produced knowledge acquired from the university environment and transform it into a valuable modern product for society. The Marine Remote Sensing Group (MRSG) (http://mrsg.aegean.gr) of the Department of Marine Sciences of Aegean University was created in 2014 aiming of developing methods and processes for the use of Unmanned Aircraft Systems (UAS) in the collection, mapping and visualisation of spatial information in the sciences of Geoinformatics, Remote Sensing and Cartography. The team conducts research on the exploration, analysis and imaging of satellite and UAS data. It combines image processing algorithms and on-site measurements to develop new methods, technologies and products for the visual representation of geospatial information. The team has participated in several international, national or development - design projects such as H2020-MSCA-RISE-2015 SEO-DWARF, MARISCA, ERABeach, MARINE-EO, DRAGON, EDK ARSx2, MARRE, ARGO, AQUASAFE. The experience of such a team is essential for the services, and ideally, the derived

knowledge of the research group has to be transformed in the company. The company will use the developed ability to solve major environmental problems that require special remote sensing techniques.

Due to the company's nature initially, there is only a need for a regular office (e.g. 60-100 sqm) to set up offices. In the financial tables, the operational and rending costs of an office are included. The envisaged company is planned to act as a University spin-off, and the use of the University premises of any other incubator offices will be further explored. The geographical office should be based in Mytilene, Greece, close to the University of Aegean premises.

The designed solutions and products are based on one unified platform, which takes advantage of four states of the art technologies, i.e. UAVs, Artificial Intelligence (AI) and Spatial Data Infrastructure (SDI), and analytics. It starts from UAV data collection in the desired region, followed by image processing and analysis using AI algorithms. It ends with creating marine litter density maps that show where the litter is in the desired area and provide the info in a web-based Spatial Data Infrastructure (SDI). The analytical toolbox will help in understanding time series analysis and litter change.

The system is fully autonomous and can create different types of density maps based on customers' needs. Algorithms are trained to perform better and faster, and the provided limitation is a cup of water bottle of 2 cm diameter. The current algorithm's detection rate is 85% for litter larger than 2 cm.

Hence, the four main technology assets are:

- Experience in collecting UAV data in coastal zones through a dedicated image acquisition protocol.
- Trained Artificial Intelligence algorithm for litter detection,
- Web-based Spatial Data Infrastructure (SDI) for marine litter monitoring,
- Analytical toolbox for litter monitoring.

The equipment that the company is going to need shortly is:

- A DJI Phantom 4 Pro v2 UAV for collecting data
- Two desktop PCs for processing collected data.
- One laptop for using it as a UAV base station.
- One iPad mini for using it as a monitor for the UAV controller

Additionally, image analysis software is needed (Agisoft) for orthophoto map creation.

3.5. Financial Plan

In this section, an analysis of the financial plan is given. Revenue, future expenses, and projection are provided. Examples are based on the following years, 2022-2023.

The company's revenue is set in detailed projections based on previous projects experience. The estimations for the next three years are:

- 1st year: 25km of shoreline data – 25.000 €
- 2nd year: 50km of shoreline data – 50.000 €
- 3rd year: 100km of shoreline data – 100.000 €

The company will have a robust presence in the incubation programs. Any potential grants have not been added to the revenue stream. Also, there is no extra revenue from our other products; hence several other funding streams are expected for the best-case scenario. The projection for the worst-case scenario is for around 30% profit in about three years. The personnel costs and significant expenses are analysed in the use of funds section.

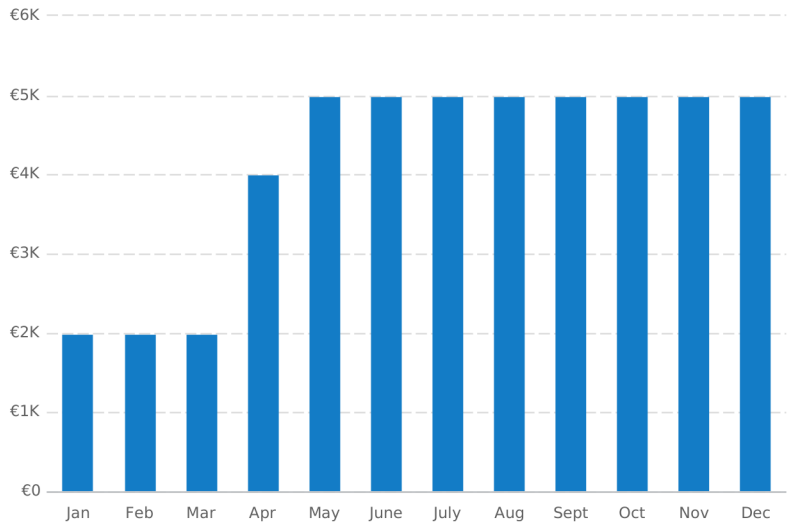

Figure 14. Revenue by month (for starting year)

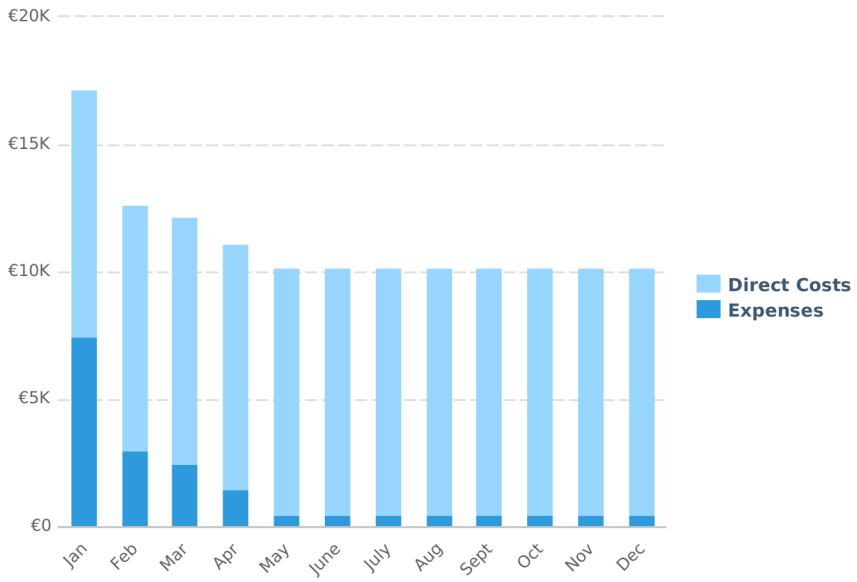

Figure 15. Expenses by Month (for starting year)

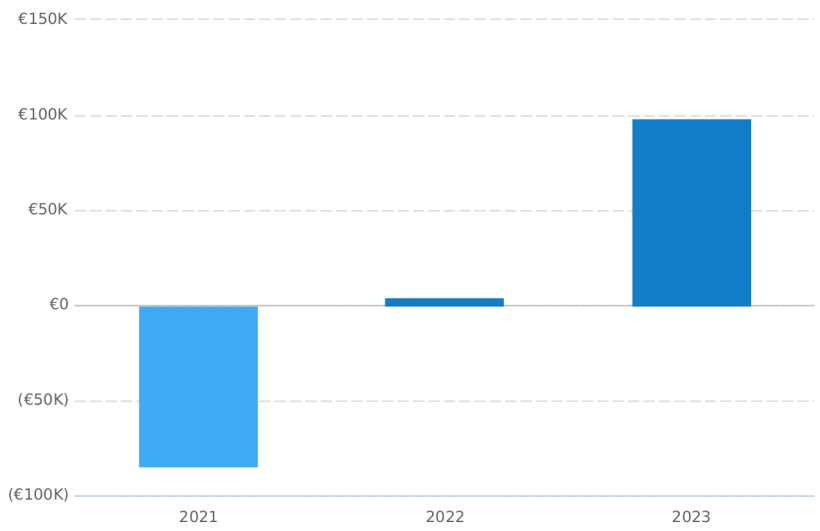

Figure 16. Example for Net Profit (or Loss) by Year for 2021-2023

Future expenses have also been calculated, keeping a straightforward basic company structure. The costs are estimated for three basic costs direct costs (rending office, accountant, operational costs), salaries, and initial expenses.

The calculated direct costs will be:

- 500 € per month for renting an office
- 200 € per month for having an accountant
- 500 € per month for operational expenses (e.g. travelling, electricity, internet etc.)

The salaries costs will be:

- 15.250 € per year for the next three years. This amount will cover the salary of each team member.

The initial expenses will be:

- 20.000 € in 2022 for office refurbishment and preparation
- 3.000 € in 2022 for buying our first drone (DJI Phantom 4 Pro V2)
- 10.000 € in 2022 will cover initial startup costs. This amount is for hiring a lawyer, starting the business, paying a graphic designer for improving our logos and graphical templates, buying our working laptops and creating our website.

The primary source of funding will come from selling products to potential customers. However, the initial funds needed to start the business should be derived from available startup funding schemes. Several centres for entrepreneurship and innovation should be reached for this reason, e.g. Athens Center for Entrepreneurship & Innovation (ACEin) accelerator of Athens University of Economics and Business. The ACEin can provide a coaching mentor helping to reach potential investors and funding schemes through weekly meetings.

Also, the company has to participate in the serval EU initiatives for SMEs funding, e.g. Knowledge and Innovation Communities (KIC) organised under the European Institute of Innovation & Technology (EIT). One example is the EIT Climate KIC funding startup competition of the EIT Climate KIC Greece.

The following three tables present the basics for the projection of the economic behaviour of the company for the following three years. They give an overview of the expectations and the future cash flow.

Table 1. Projected Profit and Loss

	2022	2023	2024
Revenue	**€50.000**	**€150.000**	**€250.000**
Direct Costs	**€115.800**	**€145.800**	**€145.800**
Gross Margin	(€65.800)	€4.200	€104.200
Gross Margin %	**(132 %)**	**3 %**	**42 %**
Operating Expenses			
Office Furniture	€3.000		
DJI Phantom 4 RTK full kit	€7.500		
Startup initial costs (lawyers, banks etc.)	€2.000		
2 Desktop PCs	€4.000		
Laptop	€1.500		
Printer	€500		
Total Operating Expenses	**€18.500**		
Operating Income	**(€84.300)**	**€4.200**	**€104.200**
Interest Incurred			
Depreciation and Amortisation			
Gain or Loss from Sale of Assets			
Income Taxes	€0	€0	€5.784
Total Expenses	**€134.300**	**€145.800**	**€151.584**
Net Profit	**(€84.300)**	**€4.200**	**€98.416**
Net Profit / Sales	**(169 %)**	**3 %**	**39 %**

Table 2. Projected Balance Sheet

	2022	2023	2024
Cash	(€84.300)	(€80.100)	€24.100
Accounts Receivable	€0	€0	€0
Inventory			
Other Current Assets			
Total Current Assets	**(€84.300)**	**(€80.100)**	**€24.100**
Long-Term Assets			
Accumulated Depreciation			
Total Long-Term Assets			
Total Assets	**(€84.300)**	**(€80.100)**	**€24.100**
Accounts Payable	€0	€0	€0
Income Taxes Payable	€0	€0	€5.784
Sales Taxes Payable			
Short-Term Debt			
Prepaid Revenue			
Total Current Liabilities	**€0**	**€0**	**€5.784**
Long-Term Debt			
Long-Term Liabilities			
Total Liabilities	**€0**	**€0**	**€5.784**
Paid-In Capital			
Retained Earnings		(€84.300)	(€80.100)
Earnings	(€84.300)	€4.200	€98.416
Total Owner's Equity	**(€84.300)**	**(€80.100)**	**€18.316**
Total Liabilities & Equity	**(€84.300)**	**(€80.100)**	**€24.100**

Table 3. Projected Cash Flow Statement

	2022	2023	2024
Net Cash Flow from Operations			
Net Profit	(€84.300)	€4.200	€98.416
Depreciation & Amortisation			
Change in Accounts Receivable	€0	€0	€0
Change in Inventory			
Change in Accounts Payable	€0	€0	€0
Change in Income Tax Payable	€0	€0	€5.784
Change in Sales Tax Payable			
Change in Prepaid Revenue			
Net Cash Flow from Operations	**(€84.300)**	**€4.200**	**€104.200**
Investing & Financing			
Assets Purchased or Sold			
Net Cash from Investing			
Investments Received			
Dividends & Distributions			
Change in Short-Term Debt			
Change in Long-Term Debt			
Net Cash from Financing			
Cash at the beginning of Period	€0	(€84.300)	(€80.100)
Net Change in Cash	(€84.300)	€4.200	€104.200
Cash at the end of Period	**(€84.300)**	**(€80.100)**	**€24.100**

4. MVP and Value pyramid

Creating value from a product or service is essential for its success. The elements of values for each service are unique; however, a universal block of values can be used to define those expected to help companies increase their performance. Also, the values can be used to break into new markets like the service of litter detection. Target is to increase customer loyalty and the customer willingness to use the service. The value pyramid (Figure 14) represents the Abraham Maslow's hierarchy of needs and arrange the element into four needs: i) functional, ii) emotional, iii) life-changing, and iv) social impact. The Maslow's hierarchy of needs represents a pyramid of the needs in real life. It starts with the very basic needs of a person belonging to an organized society and ends at the top of the pyramid with the self-fulfilment needs. At the top of the pyramid, the sources of value have to do with altruism, humanity, or philanthropy. The idea of the pyramid uses a heuristic concept to guide on the human needs. The value pyramid organizes the values that are important to customer in 30 elements, however, there is no definite limits either to the number or the actual values.

4.1. Elements of value pyramid

The basis in the Maslow's hierarchy of needs contains the physiological needs which are the very basic needs necessary for survival i.e. food, water, warm and rest. Once these needs are satisfied, then new elements are taken into consideration for a better life. Also, the physiological needs include the safety needs like security in life and safety in everyday life.

Once, the physiological and the safety needs are satisfied, customers are driven to the next level of hierarchy needs, the psychological needs. These needs contain the esteem needs and the belongingness or love needs. The esteem needs contain the prestige and feeling of accomplishment. Customers look for regard, reverence, approval of the society, honour, respect and appreciation through the esteem needs. Additionally, the belongingness and the love needs are very important for the customers. Those needs determine the intimate relationships and the friendships. In this category, values are connected with the product on its reliability, trusty, faithful, and intimation. It contains the human need to belong to a group of people with specific characteristics like brands close to technology or represent status or achievements. The belongingness many times is better understood in after-sales services with personalized assistances, series of products, prices etc.

The third level of need in the top of the pyramid is the self-fulfillment needs i.e., those that aim to the self-actualization. Those needs target achieving one's full potential in creative activities. At the top of the pyramid are the values of being a better person, fighting for humanitarian needs and better environments. It is most of the times life achievement and is hard to accomplish.

The products today need continuously to look at the "combinations of values" they satisfy and target to their maximization of them. A great example of the satisfying the needs is the smartphones. They deliver multiple elements of value in an extraordinary way, like no other product did in history. They are responsible for communication, connecting people, information, enjoy, creativity, safety and much more. This is why the smartphone industry is

one of the largest product markets in the world. The values they offer can be easily understood when there is no connectivity or when we lose them.

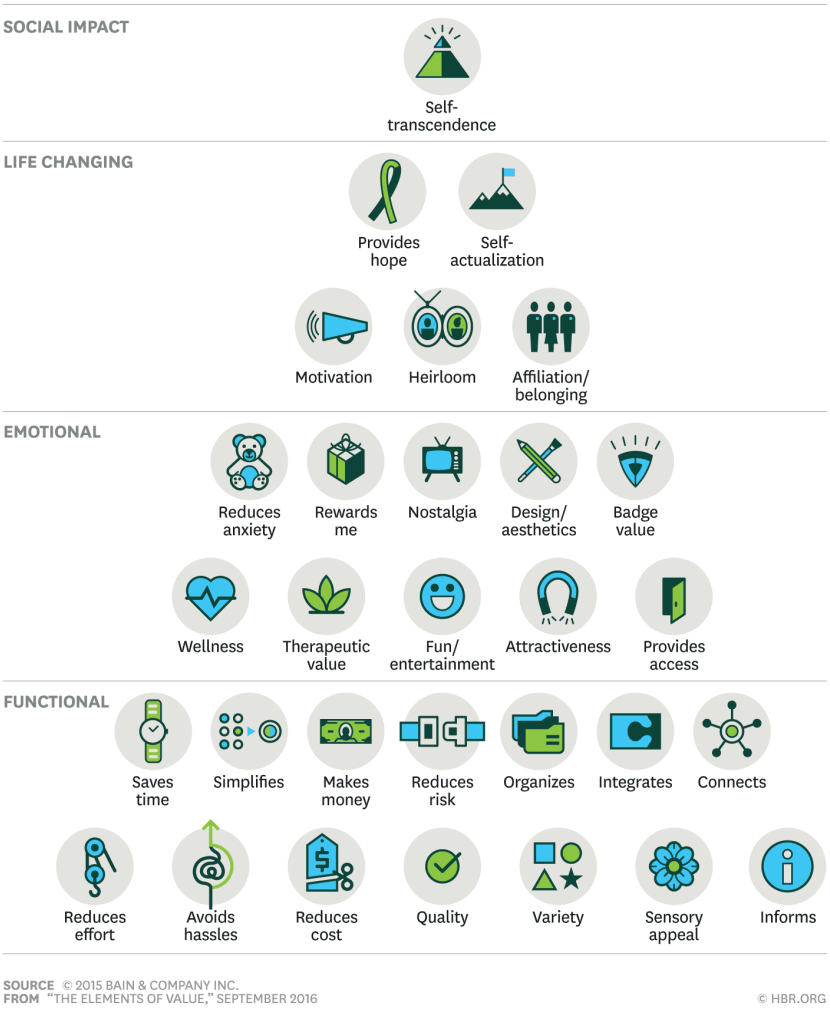

Figure 17. The elements of the Value Pyramid (adapted from Bain & Company 2015)

In general, the more elements provided from a product or service the great customer's loyalty will be and therefore the higher the company's expected revenue growth. The elements of value have to prove their usefulness in solving real business problems. For example, if a new product or service can "reduce cost" will be very fast be adopted from customers. The same if this product "reduces effort" to achieve the same result. In case this product "simplifies" the procedures, "saves time" and relates to "wellness" will probably be a gave changer in the market. A product like this can be the smart watches or the electrical cars.

Specific customer values have importance for each industry and they should be taking into consideration on product development. For example, the mort important elements in smartphone industry are values of "quality", the "deduces effort", "variety", "organization" and "connectivity". For a discount retail other values are important like, "quality", "variety", "reduces costs", "saves time" and "reward". The concept of values remains in psychology, but the structured way it is presented in the elements of value pyramid makes the planning, the decision and execution less amorphous, more confident and with positive potential in the psychology of the customers.

4.2. Customer segmentation and elements of values

The customer segmentation is very important to satisfy the needs and therefore the elements of the value pyramid. Each company needs to specify in detail the targeted customers, define their needs, identify the weak and strong point of their product, define the ways of introducing in the market and their pricing strategy. The new-product development can be stimulated from the elements of value pyramid, and new products or services to be added on the existing ecosystem. Prices change the consumer value understanding and any discussion on the price rising should consider the addition of new values elements.

Customer segmentation is straight forward for most companies. They have a formal method of segmentation into demographic, behavioral, psychographic, geographic or using other local indicators. The goal of the segmentation should be decision on the relation of the elements of values on the new product, in a way that each segment maximize the value or each customer to the business. Elements of values are directly connected with the customers and each segment should require study on the values it covers.

The demographic segmentation answers the question “who is the target group”?. Usually, the information that is taking into consideration is:

- Age
- Gender,
- Level of education,
- Religion,
- Profession,
- Ethnicity.

Traditional demographic segmentation is used for example to target potential customer based on their age, or income. The marketing budget should be directed on the right people, having the same needs, but also, the company should aim to cover the same needs of the customers i.e., support the satisfaction of their values in the levels of needs.

The psychographic segmentation targets to answer the question “why is this the target group?”. The psychographic segmentation focusses to the customers’ interests, personalities, characters, and behaviors. Traditionally the customers are divided according to their:

- Lifestyles,
- Beliefs,
- Personality,
- Character,
- Life goals,
- Hobbies,
- Values of life.

This segmentation is harder to achieve compared to demographic segmentation and many times require ling studies and specific data management tools. A detailed research or data mining infrastructure is vital for deriving information on the psychographic segment. This is

because most customers do not feel open to share personal information, to describe their believes, or to allow entering in personal space. However, once such information is derived is crucial for understanding the need of the segment values. Nowadays, the psychographic segmentation is crucial for understanding the needs of the targeted group and therefore the values which must be covered.

The geographic segmentation answers the question “where is the targeted group?”. This information is directly connected with the element of values, since each geographical area has its own characteristics, ethics, traditions. This segmentation is most of the times easy to be defined and has mainly to do with the scale of the segment. For example, can be:

- Continent,
- Country,
- Region,
- City,
- Block,
- Tax office,
- Postal code.

With geographic segmentation we can group people around a specific area and focus on the needs and the values of these customers. Traditionally, this targeting is ideal for marketers on live events, local restaurants, shops, supermarkets, all those looking to reach local customers. However, the customers location is crucial when environmental problems arise in an area, and the provided services deal with prevention and restoration. Pollution most of the times has a very specific geographical domain and companies offering products dealing with environmental solutions should always taking into consideration the geographical area of their contribution. In large areas, e.g. countries, customers shall be grouped with the needs of the local patterns. Seasonal segmentation is also very important parameter in the geographical area of interest. The specific time is crucial for delivering the right product, which covers specific values. A very good example is the CMLO, where the beaches should be cleaned for the touristic season, and therefore the service should be applied before summer for plastic collection and during the summertime for monitoring.

Finally, the behavioral segmentation answers the question “how the product will be purchased?” from the customers. This customer segmentation is one of the most important and useful for sales and should be directly connected with values of elements. Most of the times it is straight connected with e-commerce businesses, and it requires specific data for being effective. In the modern web-based sales, this information is derived directly from the website itself. The segments of this category can be:

- Spending time,
- Habits on purchasing
- Habits on browsing
- Products ratings
- Loyalty to the brand.

This information can be used to utilize targeted campaigns, on the number of behavioral patterns, however, the element of each value behind the behavioral decision is crucial for increasing the market growth. For example, the “shopping cart value” is one of the many that a customer is interested in buying a product, or in the case of CMLO the “litter monitoring history” i.e., the spatiotemporal monitoring of an area is a very important element for the customer loyalty.

4.3. Elements of values for the CMLO MVP

The values of the pyramid can be analysed for the Costal Marine Litter Observatory (CMLO) MVP presented here. Starting from the functional elements, the CMLO MVP can fulfil several elements like:

- Information: The developed system provides a systematical uniform way to inform customers on the litter existence in a specific area or the result after a beach cleanup procedure.
- Quality: The provided information is directly connected with the observations and, therefore, for the first time, depicts the litter existence in a specific area. This information is essential to understand the beach environmental status then consequently ensure its quality.
- Reduce risks: Local authorities can use the litter concentration map for cleaning operations to map their cleaning results and provide evidence on their efficiency. This information reduces the risk of their unreliability and increases the sense of a clean and healthy coastal area.
- Saves time: The system is ideal for guiding local authorities, NGOs, and environmental agencies to locate the most polluted areas and drive cleaning forces in the right direction. Additionally, cleaning devices, human recourses, and expected litter volume can be calculated by measuring the litters and their area coverage.

In the emotional category, the CMLO MVP can provide significant values to the customers on:

- Providing access: the system is open to the public, and the quality of a coastal area is directly available. Local authorities can use it to illustrate the environmental status of their regions. Access to environmental information is directly relevant to well-being, and many customers care about the openness of the data.
- Attractiveness: The CMLO system increases its attractiveness through a connection to locally loved places. It provides information to specific areas and gives a tool for improving the authorities awareness for the protection and systematically monitoring. It can also increase its attractiveness by connecting people in the same local area, acting against a common problem and reducing their health risks.
- Reduce anxiety: The clean environment is essential for health issues. Exploring the mental health benefits of natural environments and spending time in nature reduces stress and anxiety. Plastic-free coastal areas are necessary to ensure health and increase the feeling of completion.
- Badge value: The areas with less litter concentration can be easily located and stand out from the rest. Also, specific regions, e.g. ports, can prove their environmental situation and award "blue" status.

The life-changing values are also directly connected with the CMLO MVP product:

- Motivation: A system that depicts the environmental health of an area is essential to motivate people on acting proactively. The MVP can present plastic pollution, a purely anthropogenic problem, and encourage the locals to mitigate actions with behavioural assumptions.
- Provides hope: There is no doubt today that plastic pollution is a global public health problem. It threatens everyone in daily life. The evidence of a clean coastal area provides hope for the environmental health of the coastal regions. It gives the necessity of a healthy planet able to provide benefits to society.
- Affiliation belonging: Many people seek a sense of belonging in an environmentally friendly group or organisation. This is because ecological protection drives them to be accepted by others and perform well for their expectations. This type of environmental motivation can be scaled up by using the MVP. Also, the use of MVP can connect local teams against plastic pollution and provide an overall benefit to regional areas.

Finally, the MVP can create social impact and increase the self-transcendence on environmental protection. Many customers want to act against environmental problems, and the CMLO can allow them to understand their effects the plastic pollution. Their environmental behaviour can be altered if they see the impact of plastic pollution on areas they use daily. Additionally, governments and intergovernmental organisations can use the CMLO to monitor the effectiveness of the legislation, to help them better decide on the measures needed and observe the result of their actions in the long term.

5. Conclusions

Plastic pollution is a global emergency environmental problem. United Nations has recognised its significance and through the Sustainable Development Goal 14 requires actions on protecting life under the water. The developed CMLO system is ideal for the UN SDG Indicator 14.1.1b, i.e. monitoring marine plastic litter on the beaches. This indicator will help governments and authorities to protect their natural sea environment. The reporting on the plastic pollution on the beaches provided information on the health of the seas and their ecosystems. Although the traditional measuring methods can give an overview of plastic pollution, modern technologies can provide detailed information on a large scale on the extent of the problem.

In a world facing severe environmental problems, disrupted technology is expected to change the information flows and, therefore, provide timely solutions on a large scale. The CMLO MPV development can be seen as a natural step of many years of research and development. Initially, large areas covered by litter were observed and mapped with aerial images captured with the help of drones. Later, larger size covered, taking into advantage of the development of drone technology to acquire better quality images in that stage, automatisation of image analysis is needed to produce a service capable of monitoring plastic pollution in large areas. Artificial Intelligence (AI) deep learning algorithms were used to detect and identify plastic pollution types automatically. A large amount of data required additional state-of-the-art technology, i.e. cloud computing for analysis and visualisation. Finally, a web-based analytical toolbox was necessary to provide user-friendly functionalities. The combination of such technologies gave birth to a powerful operating system for monitoring plastic pollution in coastal areas. The primary conclusion extracted from the MVP development is the effectiveness of disrupted technology on monitoring any environmental problem and its ability to provide valuable information in a fast and accurate way.

The development of the advanced marine litter detection algorithm and the initial target to build plastic pollution alerting service gave the idea of a small company to serve this niche market. Since the creation of a company requires a detailed business plan, an effort was given in that direction. The target market and competition were analysed for understanding the potentiality of such business. It was soon realised that although there is a need for plastic litter detection and monitoring, no market exists to support the development of such a service. Therefore, it can be concluded that the creation of SMEs to serve plastic pollution monitoring was mainly transformed to the need of building a whole new market.

The next stage of SME financial planning was critical for understanding the potentiality of development. The business model was based on the kilometre of the coastline monitored for plastic pollution. From this observation, it can be concluded that SME creation is realistic only if some early customers are willing to pay for such a service. The projection for the worst-case scenario was for around 30% profit in about three years, starting from 25 k€. Although the plan is feasible, the early adopters are crucial for the first steps and, therefore, company development.

Finally, the CMLO MVP was analysed for value creation. Several values were identified and analysed from the four Maslow's hierarchy of needs. Value creation is essential for the development and growth of a company. However, it has to be stated that value creation has a significant advantage when applied to an ecosystem of services. In a single service like CMLO, and without proven customers, is in doubt on their effectiveness. Nevertheless, the values identified are expected to have a substantial impact on the first customers.

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