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Determination of first take-off points for UAVs in case of a disaster

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Abstract

The increase in the frequency of occurrence of natural disasters in the world in recent years leads to an increase in the loss and damage that occurs and negatively affects the lives of millions of people every year. Likewise, the incidence and severity of disasters are increasing in Turkey. There is a need for effective emergency management in order to minimize the loss of lives and properties in large quantities. Emergency management is the management process that starts before the realization of predictable or sudden emergencies and includes the work done to restore the situation and the organization of these works. With the developing technology, unmanned aerial vehicles (UAVs have started to be used frequently in studies such as pre-disaster risk estimation and post-disaster situation determination. The advantages of UAVs such as being fast, safe, flexible and providing easy access to inaccessible areas are some of the reasons why they play an important role in disaster management. In this study, the first take-off points of the UAVs were determined for post-disaster process.

1. Introduction

In disasters and emergencies that cause great damage to the daily life of humans and other living things, quick planning, decision-making, and being able to apply the most correct one at a time are of vital importance. In such cases, when all processes are considered, a complex and dynamic structure is encountered. In order for the management processes to progress rapidly, it is necessary to obtain data at every stage and analyze the incoming data, to alleviate the effects of disasters and to facilitate the response processes (Caglayan et al. 2018).

Figure 1. Disaster management phases (Bosher et al. 2021)

Modern disaster management consists of risk and mitigation, preparedness, response and recovery phases. These stages are called risk management, the steps to be done before the disaster, and the work to be done during and after the disaster are called crisis management (Figure 1)(Uysal et al. 2018).

The most important advantage of using an UAV is that it provides data collection from places that are difficult to reach. Engineering studies using UAVs have been increasing rapidly in recent years (Aykut 2022). Determination of coastline, evaluation of rockfall potential, modeling of river topography, modeling of cities and historical structures, etc. The use of UAVs has increased with the developing technology in many engineering fields such as (Alptekin and Yakar 2022).

Common application areas of UAVs in disaster operations management are; mapping the affected areas after the disaster, analyzing the collected images, coordinating the UAV networks, detecting the disasters through some chemical sensors, integrating the UAVs with other communication tools and providing fast and high quality information transmission (Değirmen et al. 2018). Technological developments provide great convenience in modeling regions exposed to disasters. By using the photographs taken with the UAV, the current situation of an area can be learned in 3D as soon as possible and at the most affordable cost (Alptekin et al. 2019).

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2. Method

Samsun Atakum province was chosen as the study area. In this study, 11 neighborhoods with the highest human and building population were selected (Figure 2), considering that the devastating effect of the disaster affected urban areas and damage assessment studies would be located in areas with dense urban construction.

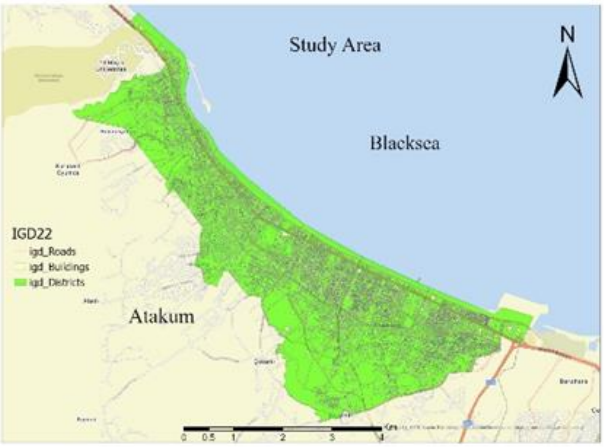

Figure 2. Study Area

In this study to determine red zones for the flight DEM, buildings footprints, roads, waterways, gas stations locations used as a data. DEM is created using SRTM satellite images. Buildings footprints collect from Atakum zoning plan, Open Street Map was used as road data and waterways data (Farr and Kobrick 2000), gas stations locations obtained from addresses.

2.1. Buffer Analysis

Buffer analysis is a GIS querying for desired information within a certain geographic distance. This analysis is done for point, line or polygon features in vector data. Buffer analysis is performed around a point with respect to a certain diameter, to the right or left of a line for a certain distance, or both, and inside or outside a polygon with respect to a certain distance. 2D buffer analysis, which is one of the classical GIS operations, is a spatial analysis based on the examination of the distances of any geographical feature from other features around it (Karaş 2011). In this study, Buffer Analysis was used to determine the distance to restricted objects.

2.2. Directorate General of Civil Aviation - Unmanned Aerial Vehicle Systems Instructions (SHT-UAV)

Directorate General of Civil Aviation (DGCA) has published an SHT-UAV instruction containing all the rules about flight rules. This Instruction has been prepared in order to determine the procedures and principles regarding the import, sale, registration and registration of civil UAV systems to be operated or to be used in Turkish Airspace, ensuring airworthiness, qualifications required of people who will use the systems, air traffic services and UAV operations (DGCA, 2019).

Flight zones subject to special permission and no-fly zones are clearly stated in the 18th and 19th articles of the instruction (Figure 3).

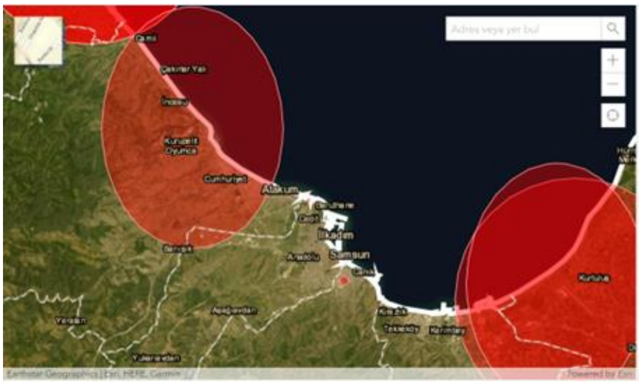

Figure 3. DGCA SHT-UAV Instructions red zones for the flight (DGCA 2019)

The contents of these articles are given below.
- for flights over 400ft
- at a distance of 5NM (9km) to any airport, heliport, etc.
- to fly in “Forbidden, Restricted and Dangerous Areas” in ENR 5.1 section of Turkish AIP
- around critical structures and facilities such as military facilities, prisons and fuel stations and warehouses
- In the fields declared with NOTAM

While the above points are about the situations subject to special permission, the points that attract attention as flight conditions are;
- The UAV must be in the pilot's field of view, not exceeding 500 meters horizontally,
- -Do not exceed 400 feet (120 meters) above the ground,
- Flight must be carried out at a distance of at least 50 meters from people and structures.

2.3. Defining red zones for the study

“In unforeseen emergencies such as search, rescue and disaster, Flight Permit may be granted exceptionally, provided that the necessary coordination is ensured with the General Directorate” is clearly stated in Article 18 (DGCA 2019).

In case of a disaster, immediate flights will be required to detect damaged structures as a first response after the disaster. In this case, the effects of the disaster as the risk of flooding, the possible collapse of structures, and the inability to take off on road networks should also be taken into account when choosing the location as the flight departure area. While performing the disaster analysis, the first take-off area should be determined at a distance of 50 meters from structures, 50 meters from rivers, 20 meters from road structures, and 250 meters from gas stations. Areas with a slope of more than 5% were selected as unsuitable for take-off. Considering the post-disaster tsunami effect, areas up to 10 m above sea level were determined as unsuitable areas (Figure 4-9).

Figure 4. Roads buffer 20m

Figure 5. Buildings buffer 50m

Figure 6. Over 5% slope

Figure 7. 10m from sea level

Figure 8. Waterways buffer 50m

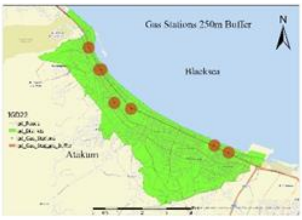

Figure 9. Gas stations buffer 250m

3. Results

All areas that hindered the take-off were combined and areas that were not suitable for the first take-off in case of post-disaster were created.

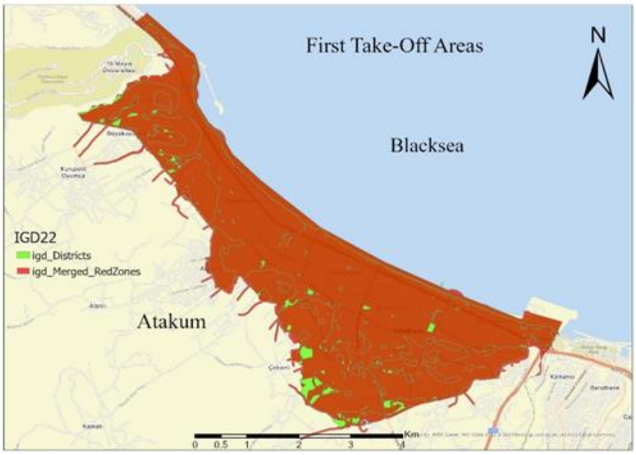

Figure 10. Green zones for the first take-off

When Figure 10. is examined, it is seen that the small green areas in the study area are suitable for take-off in the post-disaster situation when all the areas that prevent take-off are combined. 75 points detect as a take-off points.

When these areas are selected as the take-off point, 2 km buffer areas have been created since it is known that they can fly at an average distance of 2 km, considering the flight capabilities of UAVs (Figure 11).

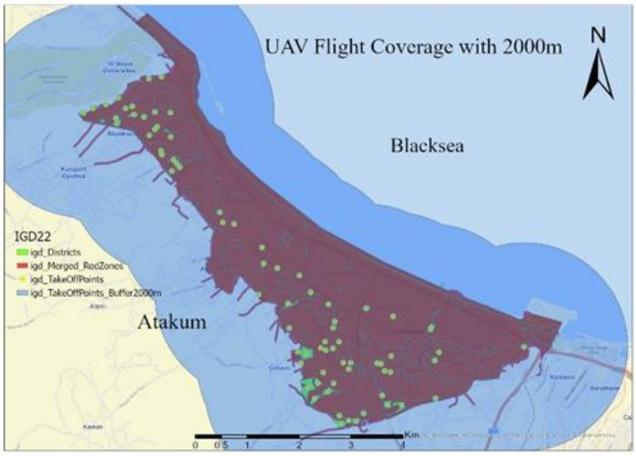

Figure 10 2000m flight coverage

Considering the Modeling Capacity and DGCA flight directives, the 500 m buffer analysis result created when it is thought that a healthy flight can be made at a distance of 500 meters within the pilot's vision is seen in the Figure 12.

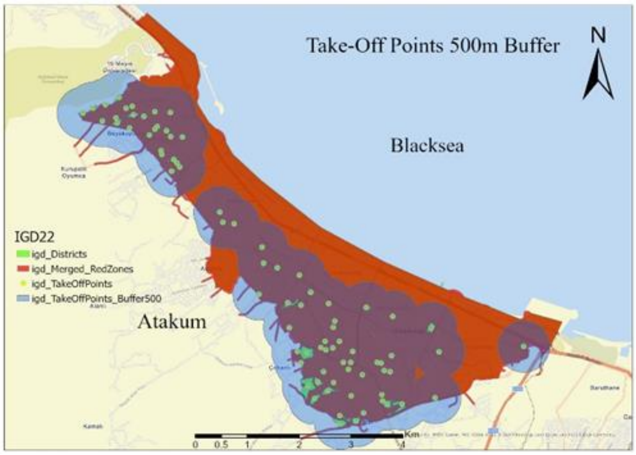

Figure 11. 500m flight coverage

4. Conclusion

It is critical for disaster management to immediately collect ground data, damage assessment and modeling in post-disaster studies. As a result of the analyzes made, the first departure points were determined by considering the disaster effects. The coverage areas that can be reached with the flights to be made using these points have been determined.

75 points suitable for take-off have been identified. It is seen that there is sufficient coverage for the flights that can be carried out at 75 points and the studies to be carried out at a distance of up to 2000 meters. However, it has been determined that there is not enough coverage in the densely populated areas of the coast during the flights to be made at a distance of 500 meters and within the pilot's field of view.

Acknowledgement

"Map data copyrighted OpenStreetMap contributors and available from https://www.openstreetmap.org".

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