

# UNMANNED AERIAL VEHICLE BENEFITS AND DRAWBACKS IN CRITICAL SITUATIONS

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**Abstract.** Disasters and crisis are types of critical situation which is unexpected events that cause uncertain and dangerous impacts. Natural, man-made, industrial, accidents, or even terrorist crises should be treated quickly to protect as many people as possible, reduce injuries, rescue the wounded, aid the injured survivors, or transport the victims. On the other hand, it is necessary to reduce the overall impacts of the critical situation by reducing the destructive infrastructures and damaged roads, also by offering information about the affected region and survivors, and even by providing road networks and communication links. Nowadays researchers develop the techniques used to overcome most of our life problems. One of the main used techniques is UAVs unmanned aerial vehicles that are mainly used in the operations of surveillance and rescuing victims in a critical situation, also used in transportation, communication, and public safety. UAVs can assist and treat many aspects and fields in all critical situation management stages. There are many physical and capabilities benefits represented by the use of UAVs, but also, there are still some challenges facing the use of wireless UAVs in managing such situations. This paper shows the disaster stages with UAV effects on them and the main advantages and challenges accompanying the use of UAVs helping researchers to exploit and enhanced those advantages or work on developing weaknesses and discovering different methods or combining existing technologies.

**Keywords:** *unmanned aerial vehicle, critical situation, disaster management, WSN, IoT*

## Introduction

Whatever the type of the critical situation especially disasters which include a lot of types (Al-Naji et al., 2019) even the man-made and accidental ones should be treated as fast as possible to reduce their effect and save the life of peoples in the region. Many recorded statistics and researches confirm the large number of victims these disasters leave behind in many regions of the world (Rohman et al., 2019; ReliefWeb Official Portal, 2015), *Figure 1* shows the dead people's rate from multiple natural disasters. About 80 percent of survivors buried under the rubble can be rescued within two days and this percent is reduced according to the situation of the victims (age and health condition) and the region including its area, the large area makes the rescue mission more difficult (AlAli and Alabady, 2022a). Disasters also cause great economic losses in various fields, in addition to destructive infrastructures and roads, some of which can be reduced if they are dealt with quickly and with advanced methods, *Figure 2* shows some economical losses from disasters in the world (McCarthy, 2015). With the wide development of technology, we can realize the role of using UAVs in most application fields, especially in managing critical situations due to its multiple characteristics that will be mentioned in this paper. Nowadays researchers try to solve the problems of communication networks related to UAVs where they can reach a wide area and overcome the difficulties of accessing the damaged infrastructures, *Figure 3* shows the

increase in the number of UAV research and articles over years (Gomez and Purdie, 2016).

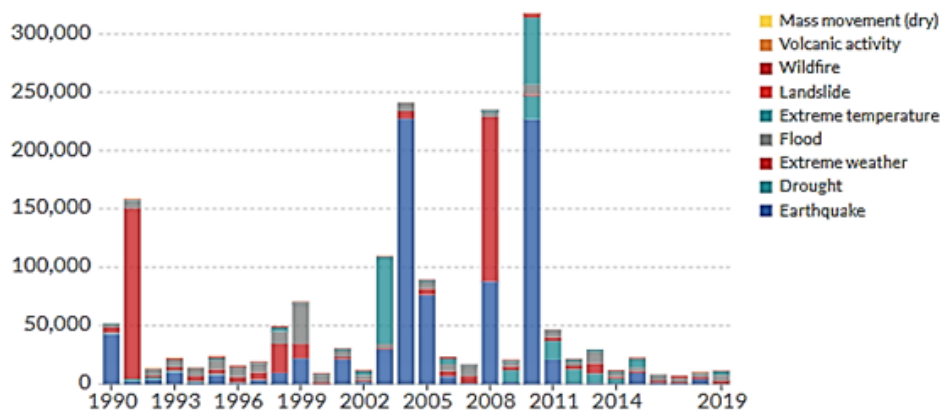


Figure 1. The death rate from natural disaster.

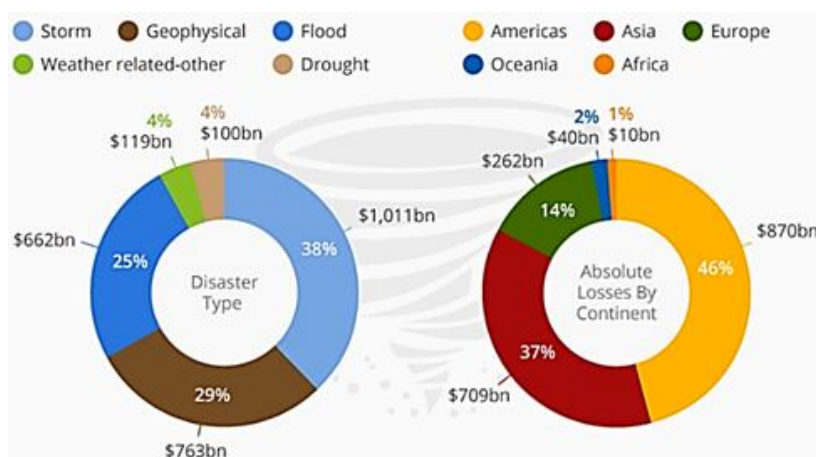


Figure 2. Economic losses by region and disaster types.

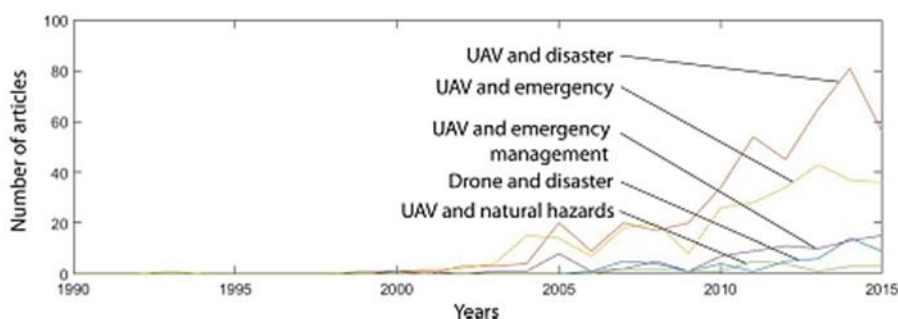


Figure 3. Number of articles that used UAVs in a different situation.

There are multiple types of technologies used with wireless UAVs network with various functionalities such as networking, monitoring, communication, and sensing (AlAli and Alabady, 2022b) that directly help in critical situations and disaster management by reducing its effect and rescuing more survivors. Many of these technologies and functionalities included in the research will be displayed and discussed in this paper.

### UAV in disaster management and stages

The two main stages of disaster are the pre-disaster which includes operations in a known environment and the post-disaster stage which represent the response and also the reconstruction that occurs in an unknown environment as shown in *Figure 4* (Reyes-Rubiano et al., 2021), the primary assessment represented by the immediate response can be used to offer the information needed to plane the response operation for both long and medium-term. The preparedness or planning stage includes the documentation, studies, and analysis needed to prepare for a crisis, whereas assessment or mitigation includes all the operations that can be reduced or eliminate the effects and risks of the disasters. Finally, response, recovery, or reconstruction includes other substages such as a plane, organization, and control, these stages are represented by the operations of search and rescue survivors and victims, establishing communication networks, and converting the region to its initial condition (AlAli and Alabady, 2022a). The humanitarian aid organizations suffer from limited information obtained in disaster management and for this reason, many survivors and victims may not assist when others may gain the help more than one time. UAVs can cover some geographically affected areas after disasters in a reasonable period. *Figure 5* shows the importance and value of the impact of UAVs over various stages of disasters (Erdelj et al., 2017).

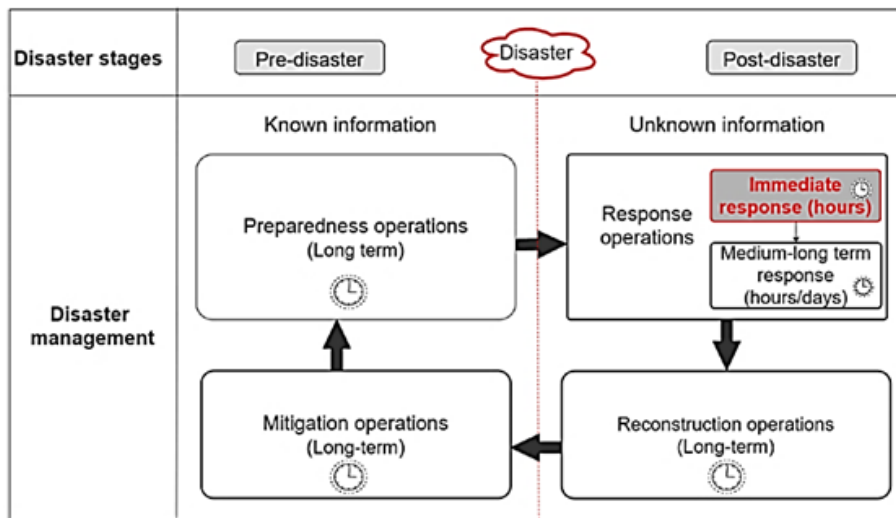
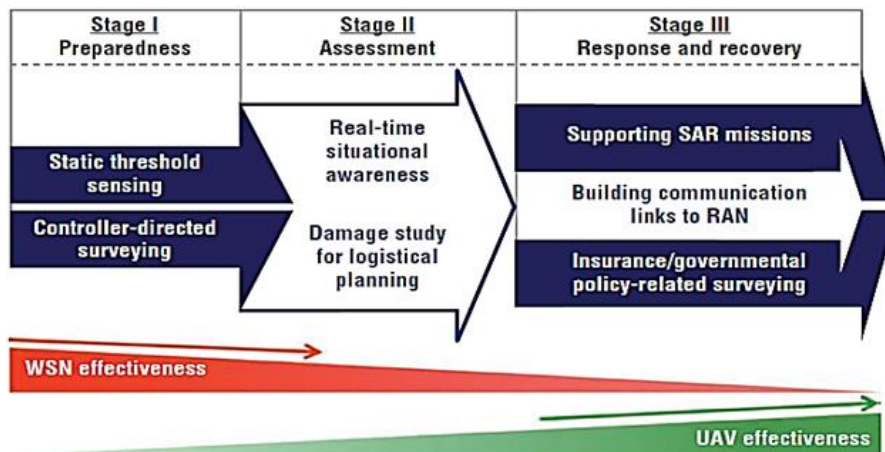
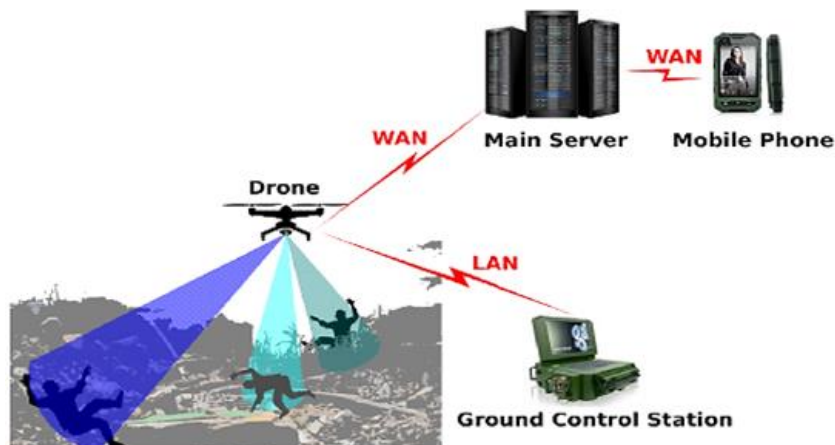


Figure 4. Disaster stages and management.



**Figure 5.** The effect of unmanned aerial vehicles UAV over disaster stages.

It should also be mentioned the great impact of the unmanned aircraft system on every stage of the disaster. Before, during, and after the event, UAS is used in an Ad-hoc manner to manage the risk of disaster in different ways and technologies. UAVs are often accompanied by multiple types of sensors that can detect different types of data and information such as temperature, visual information, and so on; this data is used to serve the management of disaster stages (AlAli and Alabady, 2022b). *Figure 6* shows a system with multiple sensors and the main server with a UAV to detect survivors in disaster regions (Rohman et al., 2019). The recovery stage in post-disaster often includes multiple operations performed by UAV, it is efficient to implement multiple tasks in one UAV mission, and multitask joint planning has a positive effect to achieve UAV heterogeneous tasks to increase work speed and conserve resources (Rottondi et al., 2021).

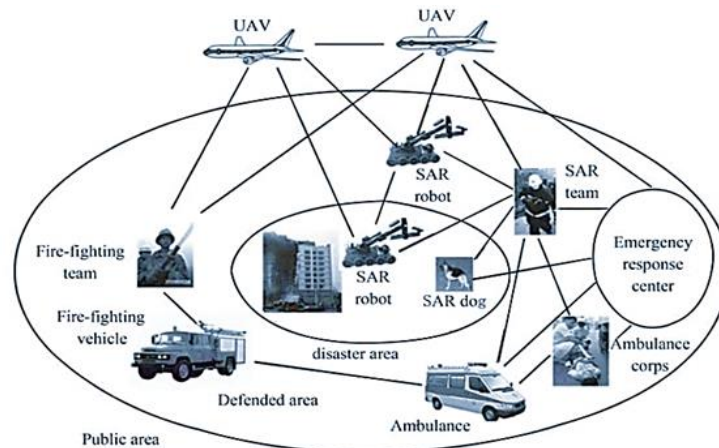


**Figure 6.** A multisensory surveillance UAV system in a disaster area.

### ***The main advantages of using UAV***

The main merit of the UAV, which makes it highly effective in managing critical situations and disasters, is its ability to search and rescue and manage relief operations with high efficiency, by its ability to move quickly over large and uninhabited regions to obtain a general overview for taking useful and good plans and decisions (Rudol and Doherty, 2008). With continuous work and development and with the help of other technologies and tools, the UAV has the advantages of (Mehallegue et al., 2021; Albanese et al., 2020; Hildmann and Kovacs, 2019; Ullah et al., 2019): (1) easy to implement and use due to the high development in the manufactures field; (2) fast to perform the duties and missions; (3) can works for a long time in the desired way; (4) keep the rescuer safe by remotely managing UAVs; (5) independent as it does not need a network with specific specifications; (6) efficient in managing missions more than the grounded stations; (7) low cost in implementing activities; (8) wide range coverage ability in different critical situations such as natural, industrial, manmade or terrorist disasters and incidents; (9) ability to cover unreachable and dangerous areas; (10) best monitoring and observation tools with high-resolution imaging; (11) safe and controlled without any direct human contacted; (12) real-time capability to transfer information and data; (13) robustness and versatility due to the development in UAV markets; (14) most UAVs can make their own decisions; as well as (15) UAVs with router can be

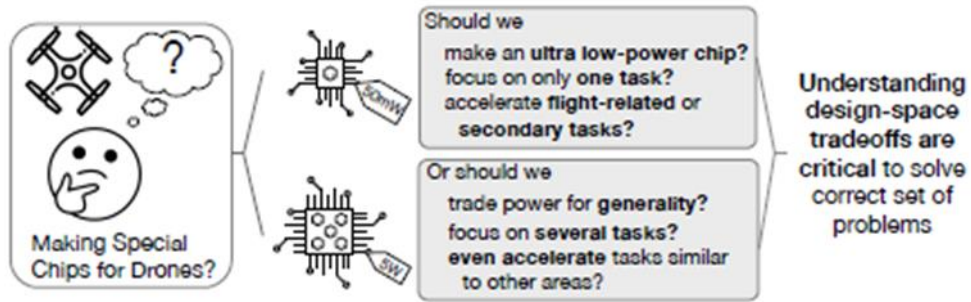
used as communication bridge between users in ground and wireless network. A scene of the critical situation management process using UAVs is shown in *Figure 7* (Liu et al., 2007).



*Figure 7.* An example of the role of UAVs in managing crises and carrying out SAR operations.

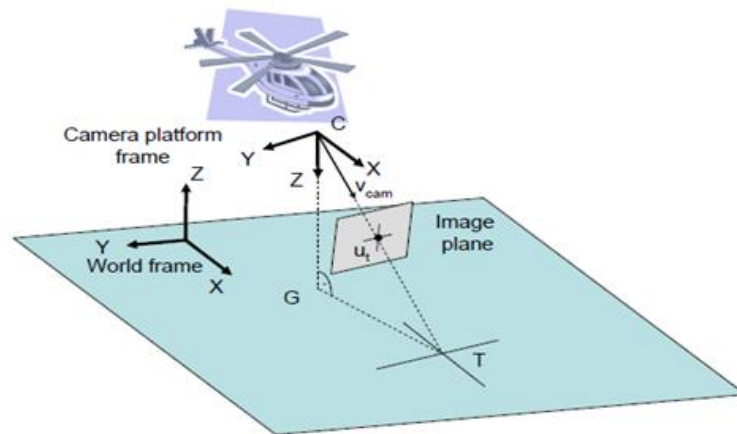
### ***The main challenges of using UAV***

Despite the continuous development and much research in the field of UAV use, there are still many issues and challenges that need to be overcome and resolved. One of these challenges is the privacy and legislation of UAVs used in many countries, also the design of UAV chips as shown in *Figure 8* (Hadidi et al., 2021). Other challenges are: (1) energy consumption and battery lifetime; (2) Wireless coverage efficiency, links, reliability, and others (Simon et al., 2015); (3) transmission power to cover people in the disaster region (Shakhatreh et al., 2017); (4) behavior in unstable atmospheric conditions or bad weather; (5) privacy and rights should be taken during the operation of UAVs over disaster regions, data privacy governed by restrictive regulations may also hinder data sharing between UAVs that are independently owned (Brik et al., 2020); (6) performance of up and downlink coverage; (7) UAV position for efficient spectral (Fotouhi et al., 2017); (8) Select the minimum number of UAVs able to perform a mission; (9) Swarm UAVs manage and control efficient navigation; (10) MUTA problem is represented by the task allocation of multiple UAVs and how to reach efficient allocation for search and rescue tasks (Alhaqbani et al., 2021); (11) The security problems in UAV aerial networks should be managed as spoofing and eavesdropping in some situations (He et al., 2017); (12) It the difficulty to measure the control points of the disaster zone by UAVRS due to the geographical complicated (Li et al., 2016); (13) Collision avoidance of the internet of the UAVs and the mobility support, also in the use of multiple UAVs (Ullah et al., 2019), interface management between UAVs when more than one provides the service in a large disaster region and even between devices obtain the service from different UAVs; (14) Communication between UAVs or even multiple UAVS and the base or control station represented another important challenge to be managed especially if there is a data processing to ensure the right decisions and UAV safety (PONGRÁCZ and PALIK, 2012); as well as (15) component's autonomy of UAV system should be available for a successful system, some of the autonomy characteristics are safety, reducing human dependency, and minimizing the physical size and traffic flow.



**Figure 8.** Quantifying the tradeoffs for impactful contribution in UAV design.

Figure 9 shows the coordinates calculation challenge of the UAV camera to compute the corresponding region of the images that were used to locate survivors (Rudol and Doherty, 2008). The challenges mentioned above are considered an outlet for many ideas and issues that researchers can work on, including some important issues such as how to implement an intelligent method and algorithm to manage UAVs especially multi-UAVs in a wide disaster region for best tasks scheduling and manage trajectory. Table 1 includes the effect of UAVs in disaster stages and the various technologies accompanied by the use of UAVs.



**Figure 9.** An illustration of calculating target coordinates from the UAV image.

**Table 1. Some UAV application in disaster management.**

No.	Disaster stage				Fields of managing disaster						Purpose	Tools and methods	Achievement	Ref.
	a	b	c	d	e	f	g	h	i	j				
1			/		/						Detect alive human motion or breathing	UAV camera & computer vision	Presented an efficient and robust system for detecting human motion or life signs	(Al-Naji et al., 2019)
2		/						/			Find reachable road network	Online algorithms for disrupted road network	Proposed an efficient online algorithm & strategies to minimize UAV route length	(Shao et al., 2020)
3			/			/					Find survivors or victims	Classification thermal and color images	Presented a high-rate detection algorithm to find humans over a large region	(Rudol and Doherty, 2008)
4			/				/				Public safety	Mathematical square area method	Maximize coverage flying base station and reduced the delay time of covering	(Mehallegue et al., 2021)
5			/			/					Detect the mobile phone location	Machine learning techniques and UAV	Introduced an efficient and rapid mobile network system (SARDO)	(Albanese et al., 2020)
6				/				/			Manage the power of wireless base station	Cognitive radio in 5G	Investigated higher data rate with acceptable power consumption	(Naqvi et al., 2018)
7		/								/	Ground and aerial connectivity	A platform of UAV and IoT	Designed NDN architecture for managing fires and aware peoples by network data	(Ejaz et al., 2019)
8	/				/						Analyze surface deformation	The technology of photogrammetry	Proposed an efficient method to analyze and estimate the deformation of landside	(Wang et al., 2021)
9	/					/					Enhanced the search and rescue operation	Study multi-death tolls by regression method	Developed the indicators and analyze them to increase the efficiency	(Chiu et al., 2020)
10				/			/				Recover communication link	Process algorithm of handling multi-UAV	Overcome broken links and maximize the communication time	(Chang et al., 2021)
11				/			/				Manage network failure	Statistical RF propagation model	Prevent the loss of path in the environments of low altitude	(Al-Hourani et al., 2014)
12	/				/						Mapping disaster area	Testing simulator	Demonstrated fine-tuning maps of disasters for better performance in rescue	(Aljehani and Inoue, 2019)
13		/					/				Tracking & providing maps and information	M2M system & UAV visual information	Presented a reliable multi-UAV system able to provide routes and maps	(Aljehani and Inoue, 2016)

14	/	/	Estimate the inundation of floods	Methods of (SFM) and deep learning (CNN)	Proposed method to estimate the depth of floods and compared the results	(Gebrehiwot and Hashemi-Beni, 2021)
15	/	/	monitoring for emergency response	UAV and IoT platform including sensors	Presented a method & platform to provide secure UAVs communication & sensors	(Seo et al., 2017)
16	/	/	Enhanced ad-hoc wireless network	UAV and wireless ad-hoc network with SDN	Proposed a cost-efficient programable and scalable ad-hoc network for management	(Dhiman et al., 2020)
17	/	/	Offer messages communication	UAV with wireless communication	Designed a wireless system based on flying UAV for send and receive messages	(Mase and Okada, 2015)
18	/	/	Crowd evacuation for rescuing survivors	UAV with control models	Proposed efficient strategies and architecture for safely and avoid poisoning	(Xiong et al., 2016)
19	/	/	Enhance the service of wireless coverage	UAV and probability	Presented system to enhance the coverage area and the capacity of wireless network	(Saif et al., 2021)

*Notes: a=Pre-disaster (preparedness); b=Impact assessment; c=Post disaster (response); d=Post disaster (recovery); e=Monitoring; f=Search & rescue; g=Assessment & public safety; h=Communication; i=Wireless recovery; j=IoT*

## Conclusion

The most important issue that researchers continuously work on is preserving the safety and lives of people from any harm, and, also preserving their property and their environment in general. This research sheds light on two important and more effective issues, which are the preservation of people's lives from the dangers resulting from disasters and critical situations, and the role of UAVs in this way. UAVs can be used to manage disasters by reducing time, complexity, and cost, maintaining the rescue and medical teams, as well as controlling the scale of the disaster at the lowest time and complexity, and also affecting other goals and objectives that have a great impact on the success of disaster management. This research shows the main benefits and features that made UAVs an important and effective element of technology in various aspects and applications, especially in disaster management. also, the role of UAVs in several aspects that positively affect them, such as surveillance and monitoring, search and rescue operations, and supporting an effective wireless communication network which is important in many sides and other applications.

The paper represents a useful base for researchers in the field of disaster management or researchers working on supporting and developing UAVs through the issues and ideas presented in the paper, which showed several basic conclusions, including the absence of a specific model and structure for UAVs as its effect depends on the required manufacturing and application, Also, to achieve the purpose efficiently and in the required manner, some hardware elements, algorithms, and techniques should be merged because no single technology is sufficient. The paper has confirmed the great and effective role in all stages of the disaster pre-disaster, assessment, and post-disaster. The paper also shows that despite the many benefits of UAVs, some challenges and problems must be taken seriously to minimize them to make their system operate at high efficiency.

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## Conflict of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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