Journal of Geography and Social Sciences, 2023, 5 (2), 91-106
http://www.jgss.uob.edu.pk

Original Article OPEN ACCESS

Logistics and Rescue Operations, Role of Aviation in Disaster management in Pakistan

Ali Arshad*, Muhammad Ashraf[2] and Ghulam Murtaza[3]

[1] Department of Disaster Management and Development Studies, University of Balochistan, Quetta, Pakistan,
pkhmz412@gmail.com
[2] Associate Professor, Department of Disaster Management and Development Studies, University of Balochistan, Quetta, Pakistan;
mashraf75@gmail.com
[3] Associate Professor, Department of Disaster Management and Development Studies, University of Balochistan, Quetta, Pakistan;
gmurtaza_80@yahoo.com

ABSTRACT

Background: The aviation industry plays a crucial role in disaster management by providing rapid response and critical support to affected areas. Disaster situations such as natural disasters, pandemics and humanitarian crises often require urgent and efficient transportation of supplies, equipment and personnel to and from affected areas.

Objective: This study examines the current disaster management framework and assesses the extent to which aviation is integrated into it in Pakistan.

Methods: The type of research for this study was a qualitative approach. This approach allowed a comprehensive understanding of logistics and rescue operation viz-a-viz role of aviation in disaster management in Pakistan and it will help to triangulate data from multiple sources to ensure reliability and validity. Hence the type of research used was explanatory.

Results: The findings of this study showed that lack of resources, limited infrastructure, regulatory obstacles and weather condition were the major limitations. Specifically, enhancing collaboration and coordination among different aviation and disaster management agencies, investing in infrastructure enhancement, establishment of centralized information sharing platform, providing specialized training for aviation professionals involved in disaster response by disaster response stakeholders. Furthermore, the study has also highlighted and emphasized the importance of adopting latest technology and innovation in aviation sector to enhance the capabilities of aviation in disaster management. This includes the use of unmanned aerial vehicle (UAVs) for aerial surveillance/ reconnaissance and delivery of relief supplies to disaster stricken areas.

Conclusions: The Role of aviation in disaster management in Pakistan is of paramount importance, keeping in view its mobility and accessibility especially in areas where road links are destroyed due to disaster strike, timely rescue of injured through air ambulance and ensuring dropping of logistic support. There is a dire need of the time for use of UAVs (unmanned aerial vehicles) for a cost effecting and more versatile aviation support in disaster management.

ARTICLE HISTORY

Received: 20 May 2023
Accepted: 24 Sep 2023
Published: 23 Nov 2023

KEYWORDS

Rescue;
Logistics;
Aviation Fleet management;
UAVs (Unmanned Aerial Vehicles);
Pakistan

1. INTRODUCTION

*CONTACT Ali Arshad pkhmz412@gmail.com

The use of aviation in disaster management has proven its metal over the years with the passage of time and advancement in technology has taken it a step forward. Aircrafts like fixed wing aircrafts, helicopters, unmanned aerial vehicles (commonly known as UAVs) are widely used around the world to support disaster relief efforts (Qadir et al., 2021). These assets are worldwide used in coordination with ground disaster response teams to ensure effective disaster relief operations. Nexus to these critical roles like providing critical transportation and logistical support, aviation is also used for situational updates, damage assessment and ensuring communications in far flung areas. Aerial photographs acquired with the help of aviation helps to highlight the affected areas and it also provides important information about the extent of damage. Hence providing key information to response teams in prioritizing their efforts (Luo et al., 2019). UAVs are vastly deployed to gather real-time data and imageries that can provide support for response operations and also helps in decision-making. Though the aviation plays an important role in disaster management, there are few inherent limitations and challenges associated with its employment, which includes the heavy cost of aircrafts, there support equipment and requirement of specialized trained crew and maintenance. In addition to this once the aviation in employed in inaccessible and remote areas there can be logistical challenges as well (Cozzolino et al., 2017). If we consider the role of aviation in disaster management at a larger canvas, it is an important area of research keeping in view its potential to save lives and enhancing the effectiveness of disaster relief operation.

Natural disasters have a significant impact on a country's communities, infrastructure and economy. Logistics plays an important role in disaster management, as effective coordination and allocation of resources is essential to save lives. Aviation plays a key role in disaster response, providing rapid response, transport logistics, emergency evacuation, medical recovery, and leveraging aviation surveillance capabilities. (Gracia and Tavares, 2019). However, there are still some gaps in the literature that need to be filled in order to gain a deeper understanding of how logistics and aviation can be effectively used in disaster management. The problem is the lack of comprehensive research that examines the role of aviation logistics in disaster management from a holistic perspective, considering the entire supply chain process. Current research is fragmented and lacks cohesion with limited work focused on the operational challenges, regulatory and policy aspects, system interoperability and the overall effectiveness of aviation logistics in disaster management (Garcia & Tavares,2019). Therefore, this proposed study aims to investigate the role of the supply chain logistics in disaster management through aviation, emphasizing the use of aviation as a method of transportation and resourcing in disaster situation. The study examined the current literature related to logistics and aviation in disaster management, analyze the effectiveness of current disaster supply chains and proposed recommendations for future development and research. This study intends to contribute to the current understanding by providing a comprehensive and cohesive examination of the impact and effectiveness of aviation logistics in disaster management. This study has also covered challenges and limitations faced by aviation authorities and organizations in Pakistan resultantly helping to enhance disaster management measures and how it can be optimized in delivering disaster relief and assistance during natural calamities? Resultantly the purpose of this study is to focus and provide a real time insights and recommendations for improving the effectiveness and efficiency of aviation in disaster management and response in Pakistan.

Disaster management is a critical aspect of any country’s infrastructure and Pakistan is no exception. With its diverse geographical landscape and susceptibility to natural disasters, the need for efficient logistics and rescue operations is paramount. In recent years, aviation has emerged as a crucial tool in disaster management, revolutionizing the way Pakistan handles emergency situations.

The use of aviation in disaster management has evolved over the years with advances in technology and changes in disaster response strategies. Aircraft such as helicopters, fixed-wing aircraft, rotary-wing aircraft, and unmanned aerial vehicles (UAVs) are currently deployed around the world to support disaster relief efforts (Erdelj & Natalizio, 2016). These resources are often underutilized in coordination with ground response teams to ensure comprehensive and effective disaster relief. In addition to providing critical

transportation and logistical support, air resources are also deployed for damage assessment, situational awareness, and communications. Aerial photographs of affected areas provide important information about the extent of damage and help response teams prioritize their efforts(Kazaferi, 2022). UAVs are increasingly used to collect real-time data and imagery that can serve as the basis for response operations and support decision-making (Liikamaa, 2017). Despite the important role aviation plays in disaster management, there are also challenges associated with its use. These include the cost of aircraft equipment, the need for specialized training and maintenance. Additionally, there can be logistical challenges associated with deploying air assets, especially in remote or inaccessible areas. (Song & Choi, 2018). This article explores the significant role of aviation in logistics and rescue operations, challenges and future potential in disaster management in Pakistan.

Logistics plays a vital role in disaster response operations, as effective allocation of resources and coordination is essential to save lives, hence mitigating the impact of disasters. Aviation also plays a critical role in disaster management. Unfortunately, there are very limited studies carried out on the role of aviation in disaster management, mainly focusing on the role of aviation in terms of logistics supply chains as main stakeholder of support. There are few studies that have catered for integrated solutions for effective use of aviation in disaster management (Bhutta et al., 2022).

This study focused on filling these research gaps through a detailed analysis of the role of logistics and aviation in disaster management. Moreover, with the advancement in technology and global connectivity increase has also increased the responsibility of the aviation industry in providing effective and efficient services to meet the requirements of the global community (Jamshed et al., 2019). Secondly, this study has also provided an insight detailed view of the potential benefits of aviation in disaster management in Pakistan. Nexus, this study has also focused on addressing the important operational challenges those have restricted Pakistan from fully utilizing the benefits of aviation in disaster management. Hence systematically analyzing and identifying gaps where aviation's effectiveness in Pakistan can be improved for disaster management.

2. METHODS

2.1 Research Design

The study has used a combination of both quantitative and qualitative research approaches. A sequential research design is used that first collects quantitative data and then qualitative data for enabling comprehensive understanding of the topic.

2.2 Setting of the study

Pakistan is the fifth most populous country of South Asia with a population of over 241.5 million. Pakistan is divided into three major geographic areas. Pakistan faces some of the highest disaster risk levels in the world, ranked 18 out of 191 counties. Pakistan has a comprehensive disaster management framework in place to address various types of disasters. The National Disaster Management Authority (NDMA) established in 2007 is the apex body responsible for disaster management at the national level. It formulates policies, plans, guidelines and coordinates disaster response and recovery efforts **(Figure.1).** Provincial disaster management authorities (PDMAs) was established in 2010 and are responsible for implementation of disaster management activities within their respective regions. Every province of Pakistan has its own PDMA which works directly under NDMA. Furthermore, district and local authorities play a vital role in disaster preparedness, response and recovery.

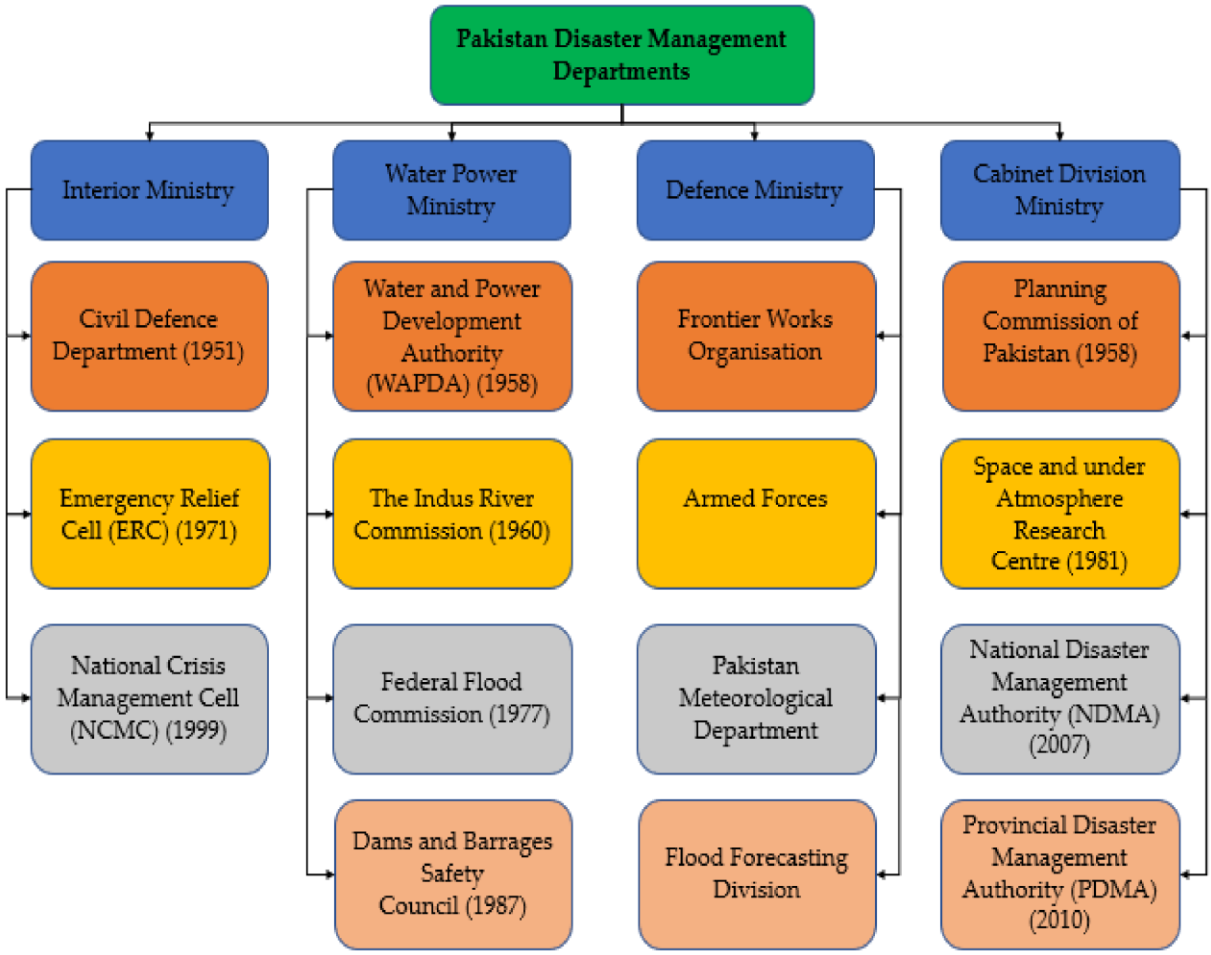

Figure 1 Pakistan's Disaster Management Framework

2.3 Sampling Procedure

This study has used a qualitative research design to research the pivotal role of aviation in disaster management in Pakistan. The research consists interviews with stakeholders from aviation industry and disaster management authorities both governmental and nongovernmental, aviation professionals. The sample for this study included a total of 30 participants, including 12 government officials, 10 aviation professionals, 5 disaster management professionals and 3 people belonging to disaster affected areas. Participants were selected by a targeted sampling technique and the unit of analysis used was individuals.

2.4 Data sources

The primary data were collected through the field survey whereas the secondary data were collected from the different research articles.

Primary (Quantitative data)

Quantitative data were collected through structured questionnaires. The questionnaire will be distributed to key stakeholders involved in aviation and logistics related disaster management activities, including governmental and non-governmental departments, humanitarian organizations NGO's and the military aviation. The questionnaire included questions focusing on assessing aviation's impact on disaster relief operation and aviation resource efficiency, coordination mechanisms, response times and problem faced.

Secondary (Qualitative data)

Semi-structured interviews were conducted with disaster management authorities and aviation

professionals. The purpose of the interviews is to gain an insight about limitations of air resources, coordination mechanisms, advantages and operational challenges in rescue operations. Interviews were recorded for ease of data analysis. Data was also collected from reports of NDMA and available literature.

2.5 Data analysis methods

Qualitative data obtained from interviews was analyzed using thematic analysis to identify themes related to the research question and identify the patterns. Quantitative data from survey questionnaires has been analyzed. The results are compiled to provide a comprehensive and in detail understanding of the role of aviation in logistics and disaster management in Pakistan.

3. REULTS

3.1 Socio-demographic Profile of the Respondents

The socio-economic characteristics of sampled respondents that include gender, age composition, education level, occupation, experience, area of expertise knowledge and awareness level, understanding level of respondents about concept of disaster management and opinions of respondents regarding role of aviation in logistics and rescue operations in Pakistan.

3.1.1 Age composition and professional experience of the respondents

Minimum and maximum age of the respondents ranges from 26 years to 51 years respectively which shows that mostly respondents were in the stage of practical and professional life, having an ample experience in their respective field of expertise. It is important to point out that mostly professionals were having experience of more than 7 years and figures also validate this fact. In some instances, almost 70 % of the respondents were engaged in various activities of disaster management. As far disaster management experience is concerned, it ranges from 3 years to 22 years in the study area. Both young and old were engaged in disaster management activities.

Table 1 Descriptive measures of age and experience of the respondents

Descriptive Statistics	Age	Experience
Mean	37.13	12.23
Minimum	26	3
Maximum	51	22

Source: Survey data (2023)

3.1.2 Knowledge and awareness of the respondents

Majority of the respondents were having a good knowledge and awareness regarding the concept and role of aviation in disaster management. Over the period of time the general masses had developed the fact that role of aviation is of prime importance in disaster management activities in Pakistan. A large number of respondents had good knowledge and responded in a very positive manner regarding role of aviation in logistics and rescue operation in Pakistan during the previous natural disaster encountered by the country (see Table 2). It's worth mentioning that majority of the sampled respondents were having a direct link with disaster management activities currently held in Pakistan.

Table 2. Knowledge and awareness regarding role of aviation in DM

Awareness level	Frequency	Percent
Less Aware	1	3.3
Moderately Aware	17	56.7
Highly Aware	12	40.0
Total	30	100.0

Source: Survey data (2023)

3.1.3 Effectiveness of aviation in providing timely assistance in Disaster Management

To ascertain the effectiveness of aviation in providing timely assistance and response in disaster management. It was categorized in four different categories which were slightly effective, moderately effective, very effective and extremely effective. Majority of the respondents opted that effectiveness of aviation is very effective and 6 percent of the respondents said that effectiveness of aviation in providing timely response and assistance is extremely crucial and important (see Table 3)

Table 3. Effectiveness of aviation in providing timely assistance in Disaster Management

Effectiveness level	Frequency	Percent
Slightly effective	2	6.7
Moderately effective	7	23.3
Very Effective	15	50.0
Extremely Effective	6	20.0
Total	30	100.0

Source: Survey data (2023)

3.1.4 Educational attainment of the respondents

The educational attainment of the sampled respondents is classified into four categories ranges from high school to postgraduate (M.Phil. or doctorate degree). Figures indicates that 30 percent of the respondents were having a bachelor's educational level, 56 percent were Master level and 13.3 percent of the respondents were having postgraduate level (see Table 4).

Table 4. Educational attainment of the sampled respondents

Educational Level	Frequency	Percent
Bachelors	9	30.0
Masters	17	56.7
M.Phil.	4	13.3
Total	30	100.0

Source: Survey data (2023)

3.1.5 Advantages of utilizing aviation in disaster management

Basing on the opinions given by the respondents regarding disaster management in Pakistan. Table 5 indicates that the opinions were divided into four categories i.e., Speed of response, accessibility to remote areas, Ability to transport large quantities of supplies, Enhanced coordination and communication. The bulk of the respondents had an opinion that aviation is of fore most importance in disaster management, However the 45% of the respondents said that speed and response is the most important advantage of aviation in disaster management and 55 % of the respondent opined that accessibility to remote areas and to transport large logistics supplies is the most important advantage of aviation in disaster management.

Table 5. Advantages of using aviation in disaster management

Advantages of Aviation	Frequency	Percent
Speed of Response	10	33.3
Accessibility to remote areas	9	30.0
Ability to transport large supplies	7	23.3
Enhanced coordination and communication	4	13.3
Total	30	100.0

Source: Survey data (2023)

3.1.6 Extend to which aviation plays crucial role in disaster management

To analyze that as per the opinion of respondents to which extend the aviation plays a crucial role in

logistics and rescue operation during disaster management in Pakistan, the questionnaire was developed and these above mentions question was framed with five options to be selected by the respondents that were: that aviation plays an extremely important role, very much important role, moderately important role, slightly important role or it does not play an important role at all. Almost 50 percent of the sampled respondents opted that aviation plays an extremely important role in disaster management and 30 percent have opted that aviation plays a very important role option (see Table 6).

Table 6. Extend in which aviation plays a crucial Role in Logistics

Extend Levels	Frequency	Percent
Slightly	2	6.7
Moderately	4	13.3
Very much	9	30.0
Extremely	15	50.0
Total	30	100.0

Source: Survey data (2023)

3.1.7 Challenges and limitations associated with the use of aviation

The asses the challenges and limitations associated with the use of aviation in disaster management in Pakistan. The views of the respondent were recorded with sub categorization into four different categories which are lack of resources, limited infrastructure, regulatory obstacles and weather condition. A large number of respondents of lack of resources and weather condition. For details of percentages (see Table 7).

Table 7. Challenges and Limitations associated with the use of Aviation

Challenges and Limitations	Frequency	Percent
Lack of resources	11	36.7
Limited infrastructure	7	23.3
Regulatory obstacles	1	3.3
Weather Condition	11	36.7
Total	30	100.0

Source: Survey data (2023)

3.2 Role and Capabilities of Aviation in Disaster Management

3.2.1 Logistics in Disaster Management

Logistics play a critical role in disaster management as they involve the timely and efficient movement of personnel, equipment and supplies to affected areas. In a country as vast and diverse as Pakistan with rugged terrains and remote areas, traditional ground-based transportation can be challenging during disasters. This is where aviation comes into play, providing a lifeline for logistics operations. This includes planning, coordinating and managing resources for civil protection activities. Proper planning, coordination and use of logistics services facilitate efficient delivery of goods and services to disaster victims. Logistics also plays an important role in providing emergency medical assistance, including transporting, storing, and distributing needed medical supplies (Nixon & Smith, 2010). However, logistics operations remain flawed in Pakistan, with coordination and cooperation within and between crisis response departments at record low levels (Azim and Wolfat, 2019).

3.2.2 Role of Aviation in Logistics

Aviation including helicopters and cargo planes, offer unique advantages in disaster logistics. Helicopters can swiftly transport search and rescue teams, medical personnel and emergency supplies to hard to reach locations particularly in mountainous regions. They can also evacuate injured individuals and deliver critical

supplies, such as food, water and medicines to isolated communities. Cargo planes have the capacity to transport larger quantities of relief materials over long distances, reaching areas that are inaccessible by road (Kovács & Spens, 2007). The use of aircraft is essential for providing essential goods and services during the initial response phase. Air resource systems support long distance search and rescue during disasters when other resources are unavailable (Barbarosoğlu et al., 2002). In addition, it is the first choice for transporting bulk goods when road logistics is polluting or impossible. The use of aviation enables search and rescue operations, the provision of medical assistance to wider areas, and emergency transport of victims to hospitals. A major limitation for air travel is the cost-effectiveness of the solution. As these services are generally required as an emergency solution, a cost analysis is not yet readily available for using aviation to provide adequate and efficient disaster management (Murphy et al., 2018). Looking at recent history beginning with the 2005 earthquake in Muzaffarabad, Pakistan, various studies found that helicopters and fixed-wing aircraft were the most commonly used aircraft for disaster management in Pakistan. doing. These assets were used for aerial photography, transporting relief supplies, transporting medical facilities, including medicines, and most importantly, evacuating affected populations. Study by Abbas et al. (2019) found that different types of aviation resources are most commonly used for disaster response in Pakistan and these are the most sensible options for disaster recovery. As with the 2010 Pakistan flood disaster, the aviation sector has played a key role in search and rescue operations and transportation of relief supplies (Abbas et al. 2019).

Figure 2 Aviation Assets providing Logistic support to disaster affected people

3.2.3 Search and Rescue Operations

Aviation plays a vital role in search and rescue operations during disaster management. Helicopters equipped with specialized rescue equipment like hoist and slings. They can rapidly locate and extract individuals trapped in remote areas or areas affected by floods. They can also conduct aerial surveys to assess the extent and severity of damage, identify survivors and properly guide ground rescue teams to the most affected areas (Mayorga et al., 2020). The speed and agility of aviation significantly enhances the chances of finding and rescuing survivors in disastrous situations(Berkoune et al., 2012). Deploying air assets in search and rescue operations during disaster management in Pakistan presents a unique opportunity to increase the efficiency and effectiveness of rescue operations. Aircraft can be used not only for aerial surveillance and reconnaissance, but also for transporting personnel, doctors and medical supplies to disaster areas. Airplanes can also be used to bring relief supplies such as food and water to emergency shelters in disaster-stricken areas where roads have been damaged (Demiane et al., 2020). This section reviews the key aspects and importance of air-led search and rescue operations in disaster response, focusing on the impact of air-led search and rescue operations on lifesaving and vulnerability reduction.

Figure 3 Aviation during search and rescuing the injured from disastrous situation

3.2.4 Enhanced Speed and Accessibility

Aviation provides a significant advantage in disaster management by drastically reducing response time and enhancing accessibility to remote areas. In Pakistan, where natural disasters like earthquakes, floods and landslides are common, aviation plays a pivotal role in reaching affected regions swiftly. Helicopters and fixed wing aircraft can transport relief materials, rescue teams and medical supplies to disaster-stricken areas, bypassing damaged infrastructure and congested road networks. The increased speed and accessibility can save countless lives during critical rescue operations (Kim et al., 2019).

3.2.5 Aerial Surveillance and Damage Assessment

Aviation also enables effective aerial surveillance and damage assessment, providing real time information to disaster management authorities. Equipped with state of the art technology like remote sensing and imaging system, aircraft can capture high resolution images and transmit them to ground command centers. (Demiane et al., 2020).The detailed aerial view helps authorities assess the extent of damage, identify vulnerable areas and plan rescue and relief efforts accordingly. Such comprehensive situational awareness is vital in optimizing resource allocation and coordinating response efforts efficiently (Rana et al., 2021).

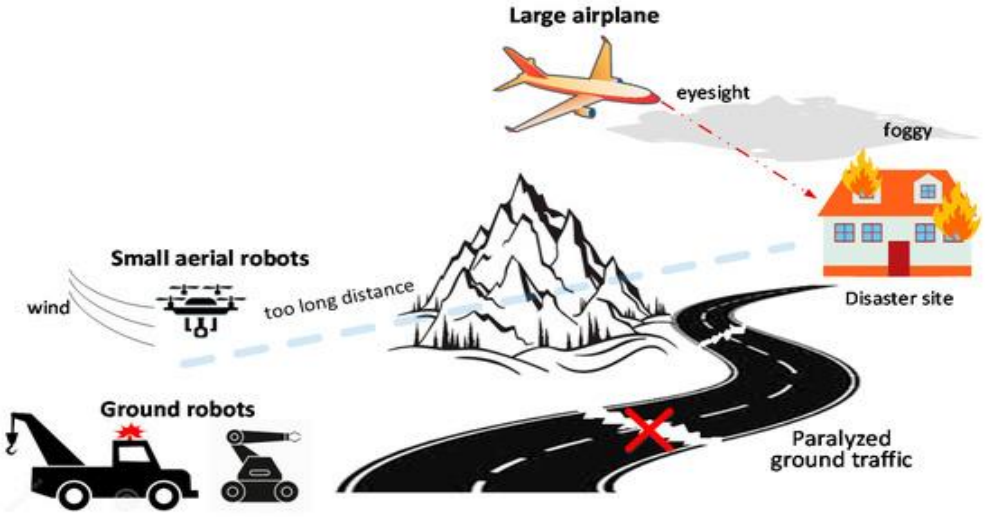

Figure 4 Aviation's mobility and early warning capability

3.2.6 Medical Evacuation and Emergency Services

In disaster situations, medical evacuation and emergency services become indispensable. Aviation's ability to swiftly transport critically injured or sick individuals from remote areas to well-equipped medical facilities can significantly increase their chances of survival. Helicopters in particular can land in challenging terrains and provide on-site medical assistance, ensuring treatment of victims (Bhutta et al., 2022). Moreover, aviation can also facilitate the delivery of medical supplies including vaccines, blood and essential medicines to areas where ground transportation is hindered due to severely damaged or congested roads.

Figure 5 Aviation Medical evacuation services (EDHI air ambulance)

3.2.7 Logistic and Supply Chain Management

Effective logistics and supply chain management are essential for disaster management. Aviation plays a pivotal role in ensuring the seamless flow of relief materials including food, water, shelter and other essential supplies to affected areas. Transporting these goods by air eliminates the challenges imposed by damaged roads, flooded areas or rugged terrains, guarantying timely and efficient distribution. This capability is crucial, especially during the initial stages of disaster when quick response and relief are critical (Ozdamar, 2011).

3.2.8 Coordination and Communication

Aviation assets also play a vital role in disaster management coordination and communication. They serve as platforms for aerial surveillance, allowing authorities to assess the extent of damage and identify potential hazards. Additionally, aviation enables effective communication between disaster management centers, ground teams and affected communities by providing aerial relay points for communication networks (Qadir et al., 2021). Effective coordination and overall control are essential for successful search and rescue disaster response operations (Murphy and Dyer, 2010). Aircraft play a central role in the coordination and integration of air rescue operations. They serve as communication, command and control hubs, connecting search teams on the ground to improve overall coordination (Kunkel et al., 2017).

3.3 Challenges and Future Potential

While aviation has proven to be a game changer in disaster management, several challenges remain.

Limited infrastructure, inadequate funding and the coordination of multiple agencies are just a few hurdles that need to be addressed. Moreover, incorporating advanced technologies like drones and unmanned aerial vehicles (UAVs) can further enhance the efficiency of aviation in disaster management (Rabta et al., 2018). Looking ahead the future potential of aviation in disaster management in Pakistan is immense. Continued investment in infrastructure development, training programs for aviation personnel and collaboration between government agencies, nongovernmental organizations and international partners are crucial(Maza et al., 2011). By harnessing the power of aviation, Pakistan can strengthen its disaster management capabilities, safeguard lives and minimize the impact of future catastrophes.

Figure 6 Coordination and communication in Aviation Safety Management System

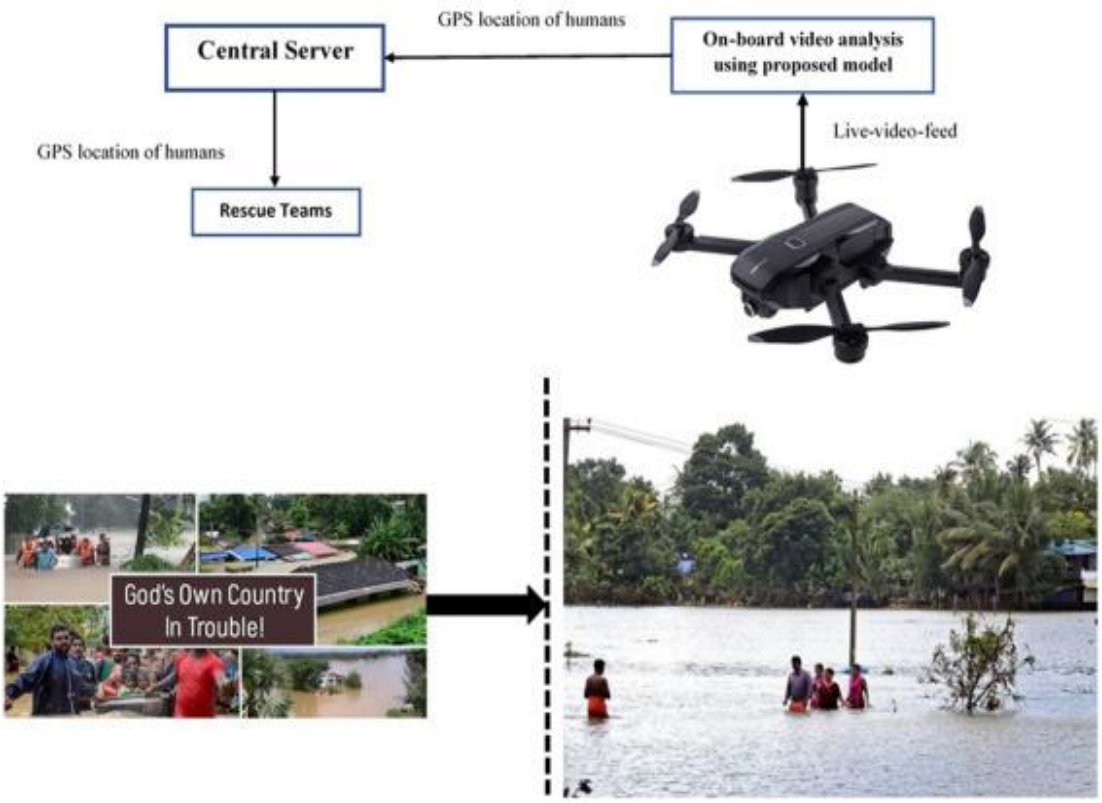

Figure 7 Future Challenges to Aviation and induction of UAVs in Aviation Assets

3.4 Strengths of Aviation in Disaster Management

3.4.1 Review of Literature on the strengths of Aviation in Disaster Management

By reviewing the relevant literature regarding aviation highlighted the strengths of aviation in disaster management, including its ability to provide rapid response, aerial surveillance, search and rescue capabilities, logistical support and mapping of disaster affected areas (Berkoune et al., 2012; Gad-el-Hak, 2008; Kovács & Spens, 2007)

3.4.2 Analysis of data from key stakeholders and experts

Data was collected from interviews with key stakeholders and aviation professionals, which further explained the strengths of aviation in Pakistan's disaster management frame work. The analysis of this chapter surfaced that how aviation's rapid response capabilities enables swift mobilization and deployment of resources, while its search and rescue capabilities help in locating and rescuing survivors in difficult and challenging areas. Additionally, aviation's aerial surveillance and mapping capabilities contribute to effective damage assessment and resources allocation. The logistical support provided by aviation ensures timely and efficient transportation of relief supplies, medical aid and personnel to in accessible areas. Mostly respondents suggested that there is a need of increased budget by government in the aviation industry to endure the maintenance of available aviation assets and further there is a dire need of buying new helicopters dedicated to disaster management departments. Almost all stakeholders and specialist concerned accepted the fact that aviation is the need of the time and its role especially in disaster management is very important.

3.5 Weaknesses of Aviation in Disaster Management

3.5.1 Weaknesses of Aviation in Disaster Response

A review of literature identified the weaknesses and limitations of aviation in disaster management, including limited capacity, weather dependency, cost and sustainability concerns, coordination and communication challenges (Ozdamar, 2011; Rabta et al., 2018). The fore most is the cost factor which is really heavy on under developing country Pakistan. There is a need to enhance the budget as the spares and special equipment used by aviation helicopters is very expensive, which needs to be purchased from other counties from that specific helicopter has been designed and made, resultantly becoming a very cost heavy for the government. Pakistan being a diverse country ranging from mountains to deserts and plains of Punjab, the country is prone to natural disasters in particular in the mountainous terrain of northern area and in south Baluchistan. Nexus to this, the versatile weather conditions is also a limiting factor for aviation related operations.

Pakistan is having a very limited number of helicopters which can be used for recovery of personal from remote area during a disaster strike. In civil sector only Agha Khan Institute and provincial governments maintain a maximum number of two helicopters each respectively. Hence during disaster, keeping in view the previous disasters and NDMA reports, due to shortage of aviation assets the civil government always uses the military helicopters for the search and rescue, causality evacuation, medical evacuation and logistics support to the affected area. The Navy also maintains a limited number of fleet of helicopters which is mostly employed for the sea operations and for recovery of sea crew in case of any accident. Resultantly, when the military aviation assets are employed for civil rescue operation the actual task of military assets gets compromised. Hence this is also a very weak area and one of the limitations faced by the government regarding utilizing of aviation assets during a disaster.

3.5.2 Analysis of Data from key Stakeholders and Experts

Data collected from interviews and surveys with key stakeholders and experts shed light on the weaknesses of aviation in Pakistan's disaster management framework. The analysis revealed that limited capacity, such as the availability of aircraft and trained personnel, poses challenges in responding adequately to large

scale disasters. Weather dependency impacts aviation operations and adverse weather conditions can impede rescue and relief efforts. The high cost of aviation operations and maintenance also presents sustainability challenges. Coordination and communication between aviation units, ground forces and other stakeholders can be hindered by logistical and technical constraints.

3.6 Effectiveness of Aviation in Providing Rescue and Logistical Support

3.6.1 Effectiveness of Aviation in Disaster Response

The effectiveness of aviation in providing rescue and logistical support during natural calamities was evaluated based on the identified strengths and weaknesses. The analysis compared the impact of aviation in intervention in different natural calamities in Pakistan and assessed their effectiveness in mitigating the impact of disasters. In the previous disasters encountered by Pakistan, this is a proven fact the main key role during the entire rescue operation was conducted through aviation whether it be earth quake of Kashmir 2005, floods in swat 2009, KPK floods of 2012 and lately the floods of Baluchistan in 2022. The aviation played a vital role which was acknowledged by all the stake holders in civil government as well the efforts were highly acknowledged by the citizens of Pakistan. The role of media was also very important which highlighted the importance of aviation in disaster management and ensured that every individual of the country is familiar with the role of aviation through social media and other available digital platforms. After the rescue operation by aviation, the secondary task undertook by them was the replenishment of the disaster affected people by air dropping the logistical supplies which included the beddings, eatables and medical supplies.

3.6.2 Analysis of Data from Affected Communities Government Agencies

Data collected from affected communities, government agencies and other relevant sources were analyzed to assess the effectiveness of aviation interventions. The analysis focused on evaluating the overall impact of aviation's strengths and weaknesses on disaster management outcomes. The overall impact of the rescue operation led with aviation was very positive. The efforts of aviation were acknowledged at all appropriate levels of private and government sectors. The data collected from disaster affected communities highlighted that the access to the areas where disaster has strike was not possible with the use of aviation specially the earthquake of 8.5 magnitude of Kashmir in 2005. The people were stuck in such valleys that there was no road link and rescue of the people from such location was not at all possible without the efforts of the aviation helicopters. Hence it increases the confidence of the citizens of Pakistan that in case of any untoward incident they will be rescued at least and will be taken to some safe place.

4. DISCUSSION

Based on the strengths, weaknesses and effectiveness assessments, recommendations were developed to enhance the role of aviation in disaster management in Pakistan. These recommendations include strengthening aviation infrastructure, investing in training and capacity building, improvement collaboration and coordination and encouraging research and development in aviation technology. The prevailing infrastructure in Pakistan for disaster management is not sufficient for a country like Pakistan which is prone to natural disasters and has a history of disasters as well. The improvements in the infrastructure needs a dedicated involvement by the government and all stakeholders as the aviation industry is an expensive equipment and the maintenance of the equipment is also very cost heavy. Hence the government should devise a mechanism for the uplift of the disaster management in general and aviation particular with the available resources. There is need for the investment in aviation sector for the procurement of modern helicopters along with the special equipment used for the rescue operation like hoist and slings; secondly, the training of the flying crew for the specialized tasks is also very important and needs a focus. The coordination and collaboration between the disaster management department and aviation authorities is of prime importance. The world is shifting on the use of UAVs for the purpose of assessment of disaster affected areas and in modern trends the latest drones are also capable of dropping

the first aid and bare minimum ration supplies to remote areas. The initial replenishment is being done by the drones, followed by the cargo helicopters for the larger scale. Hence the need of induction of UAVs in the aviation assets is also very important and needs research and development for the induction by the stake holders.

With regard to the findings on the strengths and weaknesses of Aviation in Disaster Management in Pakistan, a detailed analysis of the strengths and weaknesses of aviation's role in Pakistan's disaster management framework. The strength, including rapid response, search and rescue capabilities, aerial surveillance and mapping, logistical support, contribute significantly to effective disaster response. However, few of the weaknesses such as weather dependency, limited capacity, heavy financial cost, coordination and communication challenges need to be addressed to optimize aviation's effectiveness in disaster management.

A valuable information for improving the role of aviation in disaster management in Pakistan. By addressing the identified weaknesses and improving the strengths can enhance the overall effectiveness of aviation interventions in disaster management, resultantly leading to better disaster response outcome.

Further and future research on role of aviation in disaster management can focus on exploring innovative and technological solutions to overcome weaknesses, evaluating and exploring the long-term sustainability of aviation interventions and studying the impact of latest emerging technologies on disaster response.

Limitations

Obtaining and accessing data related to aviation involvement in disaster management in Pakistan can be challenging. Limited or incomplete information from data sources can affect the depth and accuracy of analysis. The reliability of data obtained from various sources such as government reports, academic literature and interviews may vary. Overall, this methodology aims to provide a comprehensive understanding of the role of aviation in disaster management in Pakistan, identify strengths and weaknesses of existing aviation practices and provide recommendations for improvement, thereby contributing to the disaster management sector.

5. CONCLUSION

In Pakistan, where disaster management poses immense challenges due to its geography and vulnerability to various hazards, aviation plays a pivotal role in logistics, search and rescue operations and overall disaster response. The speed, reach and versatility of aviation assets significantly enhance the effectiveness of disaster management efforts. However, it is crucial to strengthen the coordination and integration of aviation resources with other disaster management components to ensure a seamless and efficient response. Investing in aviation infrastructure, training and capacity building will further enhance Pakistan's disaster management capabilities and contribute to saving lives and reducing the impact of disaster on vulnerable communities. The induction of UAVs in Pakistan Aviation assets is of paramount importance as in the future the most prudent and cost-effective option adopted worldwide will be using UAVs.

Recommendation

Basing on the findings of this study, few important recommendations can be made to enhance the effective role of aviation in disaster management in Pakistan.

i. Investing in Training and Capacity Building

Regular and continuous capacity building programs and specialized training should be conducted for aviation professionals involved in disaster management. These programs should focus on enhancing their knowledge about advanced technologies, disaster response strategies and coordination with other agencies.

ii. Developing Standard Operating Procedures (SOPs)

Standard operating procedures should be developed and adopted by all relevant disaster management departments and stakeholders to ensure effective approach in conducting relief and rescue operations. These SOPs should include guidelines for the development of communication protocols and coordination mechanisms between aviation and disaster management authorities.

iii. Strengthening Inter Agency Collaboration

The government must establish an effective and dedicated platform compromising representatives from various departments involved in disaster management, including aviation, to ensure coordination, information sharing and centralized joint planning.

iv. Promoting Research and Development

The government along with disaster management departments and aviation authorities should invest in research and development activities to explore modern technologies that can enhance the effectiveness and efficiency of aviation in disaster management. This should include the development and induction of UAVs, satellite technology and advanced communication systems.

v. Public awareness and Education

An endeavor should be made to enhance the public awareness regarding the role of aviation in disaster management. This can be achieved by utilizing social media, educational programs and public campaigns that highlights the importance of timely response and the role of aviation during disasters and natural calamities.

By effectively and efficiently implementing these recommendations, Pakistan can enhance the role of aviation in disaster management, resultantly improving the overall preparedness and response capabilities of the country. The findings of this research provide a valuable platform for future studies on the subject and initiatives focused at strengthening disaster management practices in the country.

DECLARATIONS

Acknowledgement: The principal author extends his gratitude to the unanimous reviewer of the manuscript for their invaluable comments and suggestions which significantly improved the quality of the study.

Author contributions: Ali Arshad deliberated the complete study and wrote the article. While Mohammad Ashraf supervised the entire process of study design, write up and analysis. Ghulam Murtaza main contribution was to assist in analysis of the acquired data.

Funding: This research received no external funding.

Conflicts of interest: The authors declare no conflict of interest

Ethical Approval: The confidentiality of the respondents was ensured.

Arshad, A., Ashraf, M. and Murtaza, G. (2023). Logistics and Rescue Operations, Role of Aviation in Disaster management in Pakistan Statistical Analysis. *Journal of Geography and Social Sciences, 5*(2), 91-105.

REFERENCES

Erdelj, M., & Natalizio, E. (2016). *UAV-assisted disaster management: Applications and open issues.* Paper presented at the 2016 international conference on computing, networking and communications (ICNC).

Kazaferi, A. (2022). *UAVs for humanitarian aid: simulation study for Dhading and Nuwakot (Nepal 2015).* (Bechelor's Thesis), University of Twente,

Azeem, S., Ulfat, M. (2019). The role of Logistics in Humanitarian Disaster Relief Operations in Pakistan. *Global Business Review,* 20(4), 985-1005.

Garcia R.,& Tavares , L.V(2019). Aviation in disaster management: A review of the literature. Journal of Air Transport Management, 78, 136-146

Hult, G.T.M & Lennung, S.A.(1980). *Towards a definition of logistics.* International journal of *Physical distribution* &Logistics Management, 10(1), 23 -32.

Kandarpa, N & Mahanty, B. (2018). Supply Chain Management for disasters: *Approaches and challenges handbook of Disaster Risk Reduction & Management* (pp.783-811). Springer.

Liikamaa, K. (2017). Capacity development in aviation *disaster management*. Journal of Air TransportStudies,8(1), 1-21.

Lychage ,J., &Landin, A. (2018). Common operating pictures for effective disaster management: *An international Journal*, 27(2),209-221.

Murphy, R., Boyer, J., Garg, S., Jonkman, S., Walker, L., Olorundami, L & Mengqi, Z. (2018). *Aviation Infrastructure and operations facility for humanitarian* Aid and Disaster Relief. Procedia engineering, 212, 107-115.

Murphy,R., Boyer, J., Garg, S ., Jonkman, S.,Walker,L.,Olorundami,L., & Megqi,Z.(2018). Aviation *Infrastructure and Operations Facility for Humanitarian Aid and Disaster Relief.* Procedia Engineering, 212, 107-115.

Nixon, P., & Smith, G. (2010). Disaster Relief Logistics: The South Asia Earthquake and *Tsunami Experience* in Managing the Global Supply Chain (pp.79-99). Springer, Northampton.

Pugliese, A., Lourenco, J., Palma, L., & Coasta, A. (2019). *The impact assessment of failures in an urban air mobility master plan*. An application to Lisbon. Transportation Research Part E: Logistics and Transportation Review, 121,44-30.

Pugliese, A., Lourenco, J., Palma, L., & Costa, A. (2019). The impact assessment of *failures in an urban air mobility master plan*. An application to Lisbon. Transportation Research Part E: *Logistics and Transportation Review,* 121, 44-30.

Quarantelli, E.L (1987). Disaster crisis management: A summary of research findings. Journal of Management studies ,24(4),385 -396.

Song, H., &Choi, Y. (2018). *Patterns, drivers and* challenges of global logistics integration. Transportation Journal ,57(4) ,305 – 322

Wu, Q., Cai, X., & Du, J. (2018). An *optimization model for dynamic task assignment* of *helicopter fleet in emergency* logistics of earthquake disaster relief. Transportation Research Part E: *Logistics and Transportation Review*, 111, 166-186.

Griffiths, J.G. (2016). *Aviation and Disaster Management*: Challenges and Progressive Approaches.

Johnson, R. (2017). UAV Application in Disaster Management: *A Review of Recent Developments.*

Miller, S.C. (2019). *Helicopter in Disaster Operations*: A Comprehensive Overview.

UNOCHA (United Nation Office for the coordination of humanitarian Affairs). (2017). *Air transportation support of disaster response*: Promoting the use of airstrips and airfields in humanitarian emergencies.