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Cost-effective Analysis of Drone for Disaster Victim Identification (DVI): Islamic Insurance Perspectives

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Abstract
Islamic insurance(takaful) companies use cutting-edge technology to serve their customers better. Drone adoption in the sector has been intermittent, with certain regions of the globe making more use of this technology than others. The process of identifying corpses (often in large numbers) after a catastrophe is known as disaster victim identification. This study provides preliminary results based on cost-effectiveness analysis, net present value and internal rate of return to assess the cost impact of potential drone adoption. The two most essential opportunity costs to consider are time and money.

Keywords: drone; Islamic insurance; *takaful*; disaster

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1.0 Introduction

The process of identifying corpses (often in large numbers) after a catastrophe is known as disaster victim identification (DVI). Drone-assisted DVI is one initiative that is potentially suitable for disaster management. Drones are now frequently employed by insurance companies in developed economies such as the United States of America, Japan, the United Kingdom, and China. In contrast, such progress is not as evident for *takaful* operators, who primarily operate in emerging markets, even though the use of drones is just as relevant and important to these businesses as their developed economy insurer counterparts. Previous studies in this field have identified a notable scarcity of research for the *takaful* business, especially given the influence of the Industrial Revolution (IR) 4.0 and current progress towards IR 5.0. This research aims to examine the cost-effectiveness of using drone technology for disaster victim identification (DVI) compared to a commonly used conventional procedure. Likewise, the findings provide a preliminary assessment based on cost-effectiveness analysis (CEA), net present value (NPV) and internal rate of return (IRR) of the potential cost impact of drone adoption in DVI relative to conventional procedures.

The paper is organised as follows: a description of the *takaful* sector is provided next, followed by a discussion of DVI, which is then appraised from the perspective of *takaful* operators against the backdrop of a drone-assisted DVI programme. Cost-effectiveness analysis

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(CEA) follows in the methodology section, with an eye on *takaful* operators adopting drone-assisted DVI. The conclusion comes last but not least.

2.0 Literature Review

This section discusses the contemporary and essential studies relevant to this paper's research.

2.1 Takaful

Takaful is a mutual protection insurance structure in which all members pledge to reimburse (help) one another in the case of a tragedy as specified in the *takaful* certificate or policy. If we use the Sudanese *takaful* operator, the Islamic Insurance Company of Sudan (founded in 1979) as a reference for modern *takaful* companies, then *takaful* operators have existed for more than four decades globally. The *takaful* industry is divided into two primary business segments: family *takaful* (equivalent to life insurance) and general *takaful*. However, in terms of concentration, *takaful* operators in Gulf Cooperation Council nations earn more from the general *takaful* segment, whilst their counterparts in South-East Asia, such as Malaysia and Indonesia, earn more from the family *takaful* business.

The Islamic Financial Services Board (IFSB) has identified the consistent growth record for this niche industry (IFSB, 2020), with growth of around 8.5 per cent being recorded from 2011 to 2018, and countries such as Iran, Saudi Arabia, Malaysia, the UAE, and Indonesia being the main contributors (91%). *Takaful* assets were estimated to be roughly USD 51 billion globally in 2020, with Saudi Arabia, Iran, and Malaysia accounting for 80 per cent of *takaful* operator assets (ICD-Refinitiv, 2020). However, there is a significant difference in penetration rate for insurance and *takaful* business in the Asia-Pacific region, with life insurance or family *takaful* showing a trend decrease, as compared to general insurance and *takaful* business which showed growth (EY, 2020).

In Malaysia, the penetration rate of *takaful* operators is still modest but increasing in contrast to traditional insurance. Conventional insurance increased by 5.2 per cent for life business while contracting by 1.8 per cent for general business. On the other hand, family and general *takaful* businesses grew at 7.5 per cent and 5.9 per cent, respectively (Zainul, 2018). Regional growth followed a similar pattern. For example, the *takaful* industry in Indonesia for family and general *takaful* business experienced increases in gross contributions (premiums) of 10 per cent and 2 per cent, respectively (Fitch Ratings, 2020). In a nutshell, the *takaful* industry is growing, and technology is one of the primary drivers of this progress. Drones are one of the technologies available, but their use in the insurance industry has been inconsistent, with certain parts of the world using them more than others and *takaful* being part of the latter. This paper appraises the potential adoption of drones from a cost-effectiveness perspective.

2.2 Drone and Disaster victim identification (DVI)

DVI is a procedure of identifying disaster victims, which may include a small or considerable number of victims and is vital to meeting legal and humanitarian criteria via a rigorous scientific and forensic process (Black & Hackman, 2009). Such catastrophes or disasters might occur due to environmental, medical, automotive, industrial, or even terrorist elements (Brough et al., 2015). As a result, even a nation like Malaysia may be distantly impacted by natural catastrophes that could bring enormous numbers of deaths or damage to human life or property. However, man-made disasters may also produce similar impacts in terms of negative results.

Consider the 2018 earthquake that caused a tsunami in Palu, Indonesia, killing hundreds and making the disaster region inaccessible. When a major tragedy such as this strikes a nation, DVI is necessary. Furthermore, following a tragedy, the golden rule of forensics is that the first 48 hours is crucial for identifying victims, this being before the remains deteriorate and become impossible to identify (Dillon, 2021). With that as a foundation, this research investigates the cost-effectiveness for drone-assisted DVI—likewise, the possibility for this endeavor to be supported collaboratively by *takaful* operators.

Drones' distinguished characteristics render them versatile and flexible (Al-Naji et al., 2019). This “little plane” can be maneuvered in various situations for multiple purposes such as fertilization, search and rescue (S&R), intelligence, and other activities. Therefore, in the context of DVI, this device has been used for S&R, particularly to locate the disaster area, or to find lost persons. There is the ability to use this technology to an even greater extent—that being identifying dead bodies—although this application is still lacking (Daud et al., 2021).

2.3 Takaful and DVI

Takaful, as previously stated, is a protection system based on Islamic principles. The involvement of *takaful* operators in the context of DVI is essential, particularly for monetary compensation to policyholders who are victims of tragedy. Muhamat et al. (2022) emphasise the role of *takaful* in catastrophe management (see Diagram 1). *Takaful* operators are essential in the final phase of disaster management, the recovery phase for victims. This is through the compensation issued to affected policyholders allowing them to restore their life, businesses, and properties. Yet, their role can also appear earlier if *takaful* operators were to extend their assistance to the government's relief agencies or first responders in the event of a calamity. Any delay in or absence of identifying the victims will affect their policyholders. Thus. while *takaful* operators are only required to assist their policyholders through compensation, being able to meet this obligation properly suggests they should also participate in the disaster management process, with DVI being an important area.

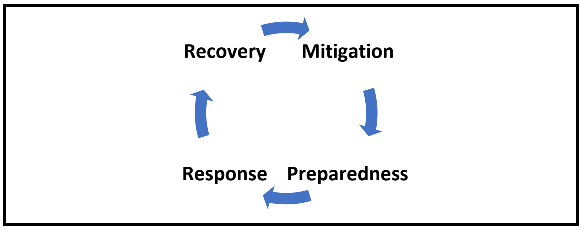

Diagram 1: Disaster Management

It is important to note that such assistance is beyond the typical business activities of *takaful* operators (Muhamat et al., 2022). Based on the feedback from the key informants in their study, Muhamat et al. (2022) identify such assistance would require significant expenditures that *takaful* operators would need to justify to their stakeholders. Additionally, the number of Malaysians who subscribe to *takaful* policies remains low in Malaysia. Consequently, when a catastrophe strikes, most Malaysians will be left without financial assistance except for that provided by government and non-governmental organisations. However, the *takaful* and insurance industries could work together to support government organisations involved in disaster management to provide a joint endeavour that benefits *takaful* policyholders, insured, communities, and the nation. Thus, a collective effort from the industry may be feasible, since the cost will be shared and for the significant benefit of society.

3.0 Method

Cost-effectiveness analysis (CEA) is a common method for determining a project's monetary or perceived benefits relative to its identified cost. Thus defined, cost-effectiveness analysis spans a wide range of methods associated with programme and policy evaluation, including use of present value (PV), net present value (NPV), and benefit-cost ratio (B-C ratio) analyses. When analysing a particular programme or policy to see if the overall societal benefits exceed the cost, or when comparing alternative programmes to see which produces the most benefit to society, CEA is a widely accepted method. The main issue with CEA is that it is sometimes impossible to assign cash figures to all (or many) costs and benefits.

The data utilised in this study is based on a simulation exercise that took place in Melaka for four days from 9 to 12 November 2021. Angkatan Pertahanan Awam Malaysia (Malaysia Civil Defence Department) (APM), Aerodyne (a renowned drone consultant), Analisa Resources (M) Sendirian Berhad, National Institute of Forensic Medicine Malaysia, and institutes and faculties from Universiti Teknologi MARA, including the Institute of Pathology, Laboratory and Forensic Medicine (I-PPerforM), College of Engineering, and Faculty of Business and Management, all participated in the simulation

During the simulation, mannequins representing victims were put randomly on the simulation site (some were concealed) to reflect an actual catastrophe scenario. Drones were utilised in each session to depict the novel DVI process against the APM squad, which mimicked undertaking the regular DVI procedure. Every scenario was timed. Furthermore, the simulation encountered various weather conditions such as drizzle, severe rain, and sunshine. In addition, information on the related expenditures was obtained from the participants during the interview session, which was also held at the site of the simulation exercise.

3.1 Steps in CEA

i. This is the first step in conducting a cost-effective analysis. This process involves identifying comparisons of flying patterns with and without a drone.
ii. Determine who should bear what costs and benefits. The framework is being used to identify the costs and benefits recognised. The costs and benefits are then listed without classification.
iii. Following step 2, the costs and benefits are classified and organised according to whether they are one-time or recurring.
iv. The value of each cost would be monetized after it had been identified and organised.
v. The advantages are then monetized. The time spent during the simulation is monetized, as one second in this study equals to RM 1.00. Table 1 shows the first four steps.
vi. The project's current value is then determined. The formulas for calculating the present value (PV) are as follows:

PV = Present value

= Cash Flow at period 1

r = Rate of return

n = Number of periods

vii. The net present value (NPV) was then computed using the formula, where

NPV = Net Present Value

= net cash flow at time t

i = discount rate

t = time of the cash flow

viii. Table 3 displays the PV and NPV calculations. Table 2 displays the value of the expected profit over the next five years.
ix. The internal rate of return (IRR) and the benefit-cost ratio is calculated to perform sensitivity analysis. The value of IRR and the benefit-cost ratio is shown in table 3.
x. Finally, the best option would be suggested.

4.0 Findings & Discussion

Costs and benefits for each project need to be identified to identify each project's CEA.

Table 1: Cost and time consumption with and without drone during the simulation

Without Drone		With Drone (from 40 meters altitude to survey the area for victims' identification)		
		Circular flying pattern	Zigzag flying pattern	Square flying pattern
Time taken during the simulation (in RM)	RM 93,080 (i)	RM 9,836 (ii)	RM 10,014 (iii)	RM 9,940 (iv)
15-APM (first responder) members (salary)	RM 20,400	RM 20,400	RM 20,400	RM 20,400
1-DNA Expert (salary)	RM 3,000	RM 3,000	RM 3,000	RM 3,000
1-Medical officer	RM 3,000	RM 3,000	RM 3,000	RM 3,000
Buccal Swab	RM 2,000	RM 2,000	RM 2,000	RM 2,000
2-drone pilot (salary)	Not Applicable	RM 7,200	RM 7,200	RM 7,200
Insurance for Drone	Not Applicable	RM 50	RM 50	RM 50
Insurance for Drone Pilot	Not Applicable	RM 200	RM 200	RM 200
Permit to fly Drone	Not Applicable	RM 300	RM 300	RM 300
Drone fleet Management software	Not Applicable	RM 4,055	RM 4,055	RM 4,055
Drone	Not Applicable	RM 56,648	RM 56,648	RM 56,648
Permit to fly drone	Not Applicable	RM 800	RM 800	RM 800
Total	RM 121,480 (a)	RM 104,489 (b)	RM 104,677 (c)	RM 104,593 (d)
Savings	Not Applicable	(a)-(b) 16,991	(a)-(c) 16,803	(a)-(d) 16,887
% Savings		13.98%	13.83%	13.9%
Time reduced (in seconds)		(i)-(ii) 83,244	(i)-(iii) 83,066	(i)-(iv) 83,140
% Time reduced		89.43%	89.24%	89.32%

Source: Authors' calculation

Table 1 demonstrates the cost and value of the projects when a drone is employed to identify disaster victims. The cost of the drone is predicated on the premise that an in-house drone is available for disaster use. The estimated expenses are based on a single calamity every year. The benefit of focus is the reduced amount of time when employing a drone instead of traditional search methods. To demonstrate the monetized worth, 1 second of time recorded during the simulation is valued at RM 1 (1 second=RM 1).

The first significant advantage is saving time when comparing operations without and with drones. During the simulation, three flying patterns were used: circular, zigzag, and square. The most economic and rapid detection of victims is achieved by flying the drone in a circular pattern, saving 89.43 per cent of the time and 13.98 per cent of the money. This is followed by using the drone with square and zigzag flying patterns. Likewise, it emphasizes that the engagement of an expert drone pilot is required since an experienced drone pilot will be able to operate the drone economically and swiftly by choosing a suitable flying pattern in consideration of the disaster area, weather, wind direction, etc.

Table 2: Expected benefits until year five

Year	Circular flying pattern	Zigzag flying pattern	Square flying pattern
0	-56,648	-56,648	-56,648
1	45,239	45,061	45,135
2	31,877	31,699	31,773

3	17,715	17,537	17,611
4	3,553	3,375	3,449
5	-10,609	-10,787	-10,713

Source: Authors' calculation

Table 2 displays the expected benefits associated with each project when a drone is employed over a five-year period. Using the information from Tables 1 and 2, the present value (PV), net present value (NPV), and benefit-cost ratio (B-C ratio) are computed using a 10 per cent discount rate, and the internal rate of return (IRR) also estimated. Nevertheless, if the drones are outsourced from any drone consultant company, it is thought that the cost structure will be different, and possibly cheaper. Further research on this alternative would be required.

Table 3: Present Value, Net Present Value, Internal Rate of Return, and Benefit-Cost Ratio

	Circular flying pattern	**Zigzag flying pattern**	**Square flying pattern**
PV	3.370500387	3.370500387	3.370500387
NPV	RM18,156.30	RM17,542.88	RM17,797.89
IRR	35%	35%	35%
Benefit-cost ratio	1.55	1.53	1.54

Source: Authors' calculation

Each project's PV, NPV, IRR, and benefit-cost ratio are shown in Table 3. According to the results, drones are suitable for use in DVI and would aid the authorities. According to Table 3, there is an internal (investment) rate of return of up to 35 per cent when deploying drones for DVI. When operating the drone, all three conceivable flight patterns would provide monetary returns and significant time reduction compared to the use of conventional DVI procedures.

5.0 Conclusion

The advantages of drones as a tool in DVI are highlighted in this paper based on a CEA assessment approach. While earlier studies have emphasised the distinctive properties of drones that provide diverse advantages to stakeholders, including in DVI, this research pushes the frontier further by emphasising the benefits of drones for DVI, especially in terms of time required and monetary value of their benefits in use. The cost aspect of the CEA can potentially be reduced further if the drone is outsourced from a drone consultancy firm and the initiative is taken collectively as an industry rather than by an individual company. In terms of limitations, the findings of this study are heavily influenced by the only simulation exercise conducted in Melaka, as well as feedback gathered from interviews. Having several rounds of simulations may provide more data for robust analysis.

Therefore, for future research, additional data is needed based on simulations where drones are outsourced by the government relief agency or *takaful* operator instead of having them in-house. The drone consultant will have the expertise and a large fleet of drones that can be deployed for S&R in various situations. In the absence of disaster, the drones will be used for other commercial purposes; hence the drone consultant will have a competitive edge derived through economies of scale and scope.

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Paper Contribution to Related Field of Study

This paper contributes from the standpoint of providing a cost-effective analysis of drones if the takaful operators adopt the *t*echnologies.

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