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HIKING INCIDENTS DATABASE STRUCTURE USING ENTITY-RELATIONSHIP DIAGRAM (ERD)

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Abstract:

The use of Geographic Information System (GIS) database system during Search and Rescue (SAR) operations aims to improve search efficiency and effectiveness while also minimizing operating expenses and response times to identify the mission subject as rapidly as possible. However, in Malaysia, the use of GIS for SAR operation is very restricted. Nowadays, in Malaysia, SAR operation for hiking incidents have occurred frequently whether the incidents happen because of environment factors, human factors, or weather factors. In order to prevent, avoid and reduce the hiking incidents cases, we need to develop a database structure which can be specifically used by hikers, guiders, and SAR team in preparing for SAR operations of any situation. This paper discusses the potential of Entity-Relationship Diagram (ERD) in developing a database structure for hiking incidents. We apply content analysis of literature that will focus on illustrating the three (3) main stages, namely identifying the type of data required, forming entities and attributes, and identifying the relationship between the entities on hiking incidents database. By constructing this database, it is possible to avoid and reduce incidents during hiking and contribute to better preparation for hikers, guider, and SAR team operation.

Keywords:

GIS, Database Structure, ER Diagram, SAR Operation, Hiking Incident

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Introduction

Outdoor recreational activities including hiking are activities that are increasingly favoured by people of all ages (Lee et al., 2020). Recently, reports regarding incidents while climbing and hiking now occur more often due to several factors such as environment factors, human factors, and weather factors. In Malaysia, according to the archive of news articles and newspaper clippings from publications like Kosmo, Berita Harian, and Astro Awani, there were 10 cases of incidents while hiking from the time the Movement Control Order (MCO) went into effect in 2021 until June 2022. The incidences were missing, straying, death, drowning, injured and falling (Rosli et.al, 2022).

Accident response is critical but preventing accidents in the first place is crucial. The key concern, according to the mountain guide from the Malaysian Mountain Guides Association (PMGM) and the Malaysian Mountain Search and Rescue Association, Encik Muzafar Mohamad (2022), is that all information is not gathered into a database that can be specifically used by hikers, guides, and the management team in preparation for SAR. However, the Forestry Department's Portal does not provide information on the hiking area, such as information about character of the hill or mountain, trees, slope, and others as reference for hikers, guiders or even public (Rosli et.al, 2022).

One of the key components of SAR operations is GIS. While searching for an incident victim, a GIS may be used as a powerful planning and analytical tool to ensure that the SAR team arrives at the right locations and in the most successful manner (SARGIS n.d). In order to obtain maps immediately during a SAR operation, SAR teams do not have time to wait for a GIS expertise to arrive. SAR teams must acquire access to ready-to-use GIS technologies before an incident occurred (Vezina and Doherty, 2021). Zawawi (2020) states that GIS which include spatial applications have been widely adopted in the western countries for use in the management of recreational areas, especially in areas subject to SAR operations.

This paper aims to form an ERD by producing a database structure for hiking incidents. We identify three main stages in forming an ERD namely identifying the type of data required, forming entities and attributes, and identifying the relationship between the entities on hiking incidents database. By constructing this database, it is possible to avoid and reduce incidents during hiking and contribute to better preparation for hikers, guiders, and SAR team operation. It is possible to avoid and reduce incidents that occur while hiking and to contribute to improved preparation for hikers, guides, and SAR team operations by developing this database.

Literature Review

Hiking is one of the popular ecotourism activities in Malaysia occurring mostly in nature and is associated with health and wellness benefits (Nordin and Jamal, 2021). People engage in hiking for varied reasons, among which is to be in contact with nature and wilderness, or simply seeking thrill and adventure. Hiking comes in different forms and names in different places. Hiking is also identified as walking, bushwalking, outdoor walking, or even trekking and hill walking (Slabbert and Preez, 2017). In Malaysia, hiking is referred to leisure outdoor recreation activity which comprises physical and mental fitness (Nordin and Jamal, 2021).

However, most of the settings where hiking took place are often associated with risk, which may come in the form of injuries, lost or illnesses, or even worst cases, fatality. She et.al. (2019) outlined two types of perceived risk towards hiking, that is, physical risk and

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psychological risk. The study also indicated that outdoor accidents associated with hiking surpass the benefits derived from the activities. Heggie and Heggie (2012) asserted that the rise in hiking participants, have resulted in an increasing number of hiking injuries and illnesses. As in its name, accidents occur unexpectedly and unintentionally.

Susanto, et.al., (2018) in evaluating risk perception based on gender differences for mountaineering activities, found men are more prone to fatality as compared to women during climbing. It was also reported the factors which underlies climbing accidents comprise of environmental events, equipment, medical events, errors, and time pressure. Faulhaber, et.al. (2017) also highlighted on the gender specific differences in hiking incidents, in which women were more frequent among non-fatal injuries as compared to men. Men contributed to most of the fatality's incidents. She et.al. (2019) reported that female hikers had a higher perceived risk on the physical aspect of hiking, often resort to taking laid-back routes, and worried more on safety aspects of hiking.

Bianchi and Brugger (2015) asserted that researching accidents, involves, identifying the problems, analysing, and rating the related risk factors, and outlining prevention measures. Thus, addressing questions such as: "What happens?" "Why does it happen?" and "How can it be prevented?". Sidi, et.al. (2019) stated that the risk faced by most outdoor recreationist mainly happened in areas with diverse mountain structure and forest compound. Among the factors mentioned associated with hiking incidents are fall, storm/strong wind and falling trees. The rescue operations faced difficulties due to the geographical locations of incidents happening (deep forest area), non-availability of special tracks for rescuers, the number and types of safety tools and rescue equipment to be carried, and the time needed to carry the victims out of the incidents area. It can be concluded that the factors of hiking incidents shown as table below.

Table 1: Factors of Hiking Incidents Based on Literature Review

Author's	Factors of Hiking Incidents
She et.al. (2019)	Physical risk and psychological risk Female hikers had a higher perceived risk on the physical aspect of hiking, often resort to taking laid-back routes, and worried more on safety aspects of hiking.
Heggie and Heggie (2012)	Unexpectedly and unintentionally
Susanto, et.al., (2018)	Environmental events, equipment, medical events, errors and time pressure.
Faulhaber, et.al. (2017)	Gender: which women were more frequent among non-fatal injuries as compared to men. Men contributed to most of the fatality's incidents
Sidi, et.al. (2019)	Mountain structure, forest compound, fall, storm/strong wind and falling trees

Hikers in deciding which areas to undertake their activities should be able to anticipate the risks involved. However, for amateur hikers, deciding the right areas depends on the experience of climbers and expected subjective hazards, such as, exhaustion and lack of knowledge and experience of climbers. A study by Pratiwi and Medyawati (2020) emphasised the need to design and develop decision support applications in determining the best mountain for climbers by using the web-based Weighted Product method. The information comprises of the

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experience of climbers, mountain heights, distance, and travel time for climbing, mountain safety, along with, finding climbing friends.

A study by Toy (2020) mentioned on the reliance of those planning to hike on resources such as guidebooks, to online resources, and mobile applications, in planning their activities. The information consists of trail descriptions, directions to the trailhead, as well as statistics on each hike (vague difficulty rating). However, the difficulty rating may not apply the same to the hikers, when comes to new or experienced hikers. Thus, leading to the development of Angeles Hike Finder (AHF). This application provide information on which factors hikers would consider to be most difficult, and followed by the receiving of customized output which met the search criteria. This application was created with information on trail data, such as, trail distance, elevation gain, maximum elevation, and trail type. In addition, the development of AHF provide the basis for creating a database of hiking trails which can be integrated into GIS, creating web application with database of hiking trails to be explored, as well as, allowing potential hikers to decide on trails based on their attributes and difficulty rating.

Molnar (2021) mentioned the crucial need to provide accurate information on recreational and touristic trail network. However, due to the complex reality and different terminologies used in different parts of the globes, as well as, among visitors and professionals, leads to the need to develop a unified network concept or signage system. This is the basis for the development of TRAILSIGNER, a reliable geospatial conceptual data model suite to assist in managing waymarked trail networks and their signage assets, which can exceed the capabilities of the current system. The development of TRAILSIGNER lessen the possibility confusion, mistrust, and danger for visitors due to information discrepancy. The incidents prevented are summarized in the table below.

Table 2: Incidents Prevention Based on Literature Review

Author's	Incidents Prevention
Bianchi and Brugger (2015)	Identifying the problems, analysing, and rating the related risk factors, and outlining prevention measures.
Pratiwi and Medyawati (2020)	Using the web-based Weighted Product method: The information comprises of the experience of climbers, mountain heights, distance, and travel time for climbing, mountain safety, along with, finding climbing friends.
Toy (2020)	• The reliance of those planning to hike on resources such as guidebooks, to online resources, and mobile applications, in planning their activities. The information consists of trail descriptions, directions to the trailhead, as well as statistics on each hike (vague difficulty rating). • The development of Angeles Hike Finder (AHF): i. This application provide information on which factors hikers would consider to be most difficult, and followed by the receiving of customized output which met the search criteria ii. Was created with information on trail data, such as, trail distance, elevation gain, maximum elevation, and trail type.

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	iii. The basis for creating a database of hiking trails which can be integrated into GIS, creating web application with database of hiking trails to be explored, as well as, allowing potential hikers to decide on trails based on their attributes and difficulty rating.
Molnar (2021)	TRAILSIGNER: • A reliable geospatial conceptual data model suite to assist in managing waymarked trail networks and their signage assets, which can exceed the capabilities of the current system. • The possibility confusion, mistrust, and danger for visitors due to information discrepancy.

Vanpoulle, et.al. (2021) highlighted that due to the rapid development in outdoor activities, especially mountaineering and hiking, have generated considerable numbers of SAR operations. The main aim of any SAR mission it to locate the missing casualties and bring them back to safety as soon as possible. It was mentioned by Jurecka and Niedzielski (2017) that time to execute SAR in the right locations is rather crucial.

Adams et.al. (2007) asserted that after 51 hours, only about 1% victims found, survived. However, it was also suggested to have 2 to 3 days cut off before the SAR operations are put to a halt. In addition, this study also highlighted on other factors to be considered, that is, age, land vs water rescue, health of casualties, fitness level, and readiness for the environmental conditions. However, the study by Adams, et.al. (2007) considered time as their main consideration and applied Classification and Regression Tree (CART) methodology in developing model to assist search managers and Emergency Service (EMS) physicians in deciding when to put a stop to a search. Several factors which may hinder search efforts are the distance, terrain condition, and weather.

The study by Almujalli and Altuwaijri (2023) asserted the imperative need to apply modern geographic techniques for finding missing in the wilderness. GIS was mentioned as playing a vital role in Wilderness Search and Rescue (WiSAR), especially in mapping probability areas, as well as, applying further analysis and modelling to reduce time and effort, and lead the SAR teams to the right direction.

The word Search and Rescue entails two phases of the SAR operations, namely, the first phase Search, and the second phase, Rescue. Ferguson (2008) reported that Search as the first phase involves the locating of the missing item or subject; and Rescue, the second phase, comprises saving the missing item or subject. In doing this, search managers must engage in tactics that are most efficient and do not pose further harm to rescue personnel. The search strategies comprise of the use of behavioural profiling, probability theory, terrain interpretation and resource management. All these elements can be integrated effectively by using GIS as a platform. Ferguson (2008) stated that this process started with providing details to divide the designated search area into probability regions based on the missing subject's behavioural profiling and statistical analysis. Then an operational base map will be developed by combining digital raster graphics, elevation datasets, as well as aerial imagery with diverse

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shapefiles to further segment the search areas. Finally, attribute tables presented a database to track resources, clue logs and area coverage, as well as basic probability estimates.

WiSAR comprise of four basic procedures, which are: Locate, Access, Stabilize and Transport (Doherty, et.al., 2014). In enabling the responder to locate a missing subject, the responder must overlap the subject in both time and space. Searching large areas often contribute the delay in finding the missing subject and reduce their chances of survival. It was also mentioned that demographic and the environment great effect on where the missing subject are located. The demographic of the missing subject includes the type of activities they engaged in before missing, their age and their medical or health condition.

Koester (2018) outlined that to locate a missing subject, the searcher must survey at the right place and way. This can be expressed by three terms, namely the Probability of Success (POS), the Probability of Area (POA), and the Probability of Detection (POD). Several new spatial models were introduced, comprising of track offset, find location, and mobility. A database, named, the International Search & Rescue Incident Database (ISRID) were created. This database consists of over 50,000 incidents from around the globe, 41 different subject categories (based on Bailey's terrestrial eco-region domains) and population density of the Initial Planning Point (IPP), or defined as Point Last Seen (PLS) or the Last Known Point (LKP) (Doherty, et.al., 2014).

Often, the SAR involves the combination of diverse and ad hoc organisation, for example, volunteers, amateurs, and experts in different fields. However, when in emergency, it is essential to establish a common ground of understanding for all these groups. This highlights the need of the SAR managers or decision makers to have precise, understandable, and appropriate information in timely manner before they can proceed with the SAR operations. Hanssen (2018) stated on the usefulness of spatial data and GIS in assisting the SAR operations, for instance, in keeping track of the rescue personnel in the search areas. This is to ensure that the rescue personnel are safe, as well as enabling the monitoring, planning and documentation of operations in the field. In this situation, GIS supports by the visualization of information and presenting it on an updated digital map. Other information includes the location of incidents, affected areas or premises, location of rescue teams, victims/subjects, and shelter.

Lin and Goodrich (2010) stated that in WiSAR situation, a probability distribution map of the possible location of the missing person is created. This map will assist the incident commander (IC) in distributing search resources and coordinating efforts, although, often, the missing subject's profile, experience, and subjective are also in picture. This study proposed a Bayesian model which comprises the following components, namely, topography, vegetation, and elevation.

During SAR, Brown (2014) listed the following as items needed, namely:

i) Search map, to identify the location to go and to provide for the searchers.
ii) Map to assist in analysing topography, as to why the subject is missing and in applying statistical information from Lost Person Behaviour data.
iii) Mark the clues and points in determining patterns.

The study also includes other feature classes information known as Minimal Essential Datasets (MEDS), such as: roads, land use, boundaries, hydrography, elevation, and image base. All these signify the importance of applying GIS in SAR, in the sense that, it assists field mobility,

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data management, planning and analysis, situational awareness, collaboration, and documentation. The table that follows provides a summary of the search and rescue mission or operation.

Table 3: SAR Mission/Operation Based on Literature Review

Author's	SAR Mission/Operation
Adams, et.al. (2007)	• Classification and Regression Tree (CART): developing model to assist search managers • Emergency Service (EMS): deciding when to put a stop to a search
Almujalli and Altuwaijri (2023)	Wilderness Search and Rescue (WiSAR): mapping probability areas, as well as, applying further analysis and modelling to reduce time and effort, and lead the SAR teams to the right direction.
Ferguson (2008)	GIS: The search strategies comprise of the use of behavioural profiling, probability theory, terrain interpretation and resource management. • An operational base map will be developed by combining digital raster graphics, elevation datasets, as well as aerial imagery with diverse shapefiles to further segment the search areas. Finally, attribute tables presented a database to track resources, clue logs and area coverage, as well as basic probability estimates.
Doherty, et.al., 2014	WiSAR comprise of four basic procedures, which are: Locate, Access, Stabilize and Transport.
Koester (2018)	• 3 terms: the Probability of Success (POS), the Probability of Area (POA), and the Probability of Detection (POD). • International Search & Rescue Incident Database (ISRID) were database created: consists of over 50,000 incidents from around the globe, 41 different subject categories (based on Bailey's terrestrial eco-region domains) and population density of the Initial Planning Point (IPP), or defined ass Point Last Seen (PLS) or the Last Known Point (LKP).
Hanssen (2018)	Usefulness of spatial data and GIS in assisting the SAR operations: • The rescue personnel are safe, as well as enabling the monitoring, planning and documentation of operations in the field. • GIS supports by the visualization of information and presenting it on an updated digital map. • Other information includes the location of incidents, affected areas or premises, location of rescue teams, victims/subjects, and shelter.
Lin and Goodrich (2010)	WiSAR: • Probability distribution map of the possible location of the missing person is created.

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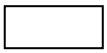
Brown (2014)	• This map will assist the incident commander (IC) in distributing search resources and coordinating efforts, although, often, the missing subject's profile, experience, and subjective are also in picture. • This study proposed a Bayesian model which comprises the following components, namely, topography, vegetation, and elevation. • Search map, to identify the location to go and to provide for the searchers. • Map to assist in analysing topography, as to why the subject is missing and in applying statistical information from Lost Person Behaviour data. • Mark the clues and points in determining patterns. • The study also includes other feature classes information known as Minimal Essential Datasets (MEDS), such as: roads, land use, boundaries, hydrography, elevation, and image base. • All these signify the importance of applying GIS in SAR, in the sense that, it assists field mobility, data management, planning and analysis, situational awareness, collaboration, and documentation.

A GIS which as mentioned by Doke (2012) combined all the data from different sources, visualized that data, and queried and analysed the data in supporting the SAR operations, making it an effective tool for managing SAR. One of the ways to integrate all the information or database for hiking incidents is through the representation of data using ERD. The ERD was introduced by Chen (1976), encompassing notation model, constructed using a natural view representation consisting of entities and the relationships that exist with these identified entities. The ERD model can be used to integrate diverse data, namely the network model, the relationship model and the entity set model. Chen's ERD notation model is a prevalent standard, used widely worldwide in database and software design. It is simple, powerful to replicate real-world problems and easily translated into a database schema (Song, et.al., 1995).

Table 4: Notation for ERD

Components	Symbols	Explanation
Entity		• Represents a set of objects with the same attributes within a data model. • An entity represents a real-world object or concept, such as a person, place, concept, or thing.
Attributes		• A piece of information that describes an entity. • Entities can be further distinguished by type of properties, namely, identifying attributes and descriptive attributes.

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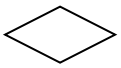
Relationship		An association or relationships between or among several entities, of which, the relationships need to be recalled by the database system.

Source: Adapted from Elmasri and Navathe, 2016

Bagui and Earp (2012) defined data as facts about something or someone, and database, as a collection of related data. The ERD portray data as entities, relationships, and attributes. Then, lines or other symbols may be being used to illustrate the relationship between entities. Entity refers to a thing or object in the real world with an independent existence (Elmasri and Navathe, 2016). An entity represents an object with a physical existence (such as, a person, a place), or a conceptual existence (for example, an organization, a university course). In addition, each of these entities have attributes which describes it, for example, attributes for a person, may include the person's name, age, gender, races, health status and experience. Between the different entities exists relationships. Then, a cardinality notation may describe the relationship between entities. There are (3) three main cardinalities which are one-to-one relationship (1:1), one-to-many relationship (1:M) and many-to-many relationship (M:N).

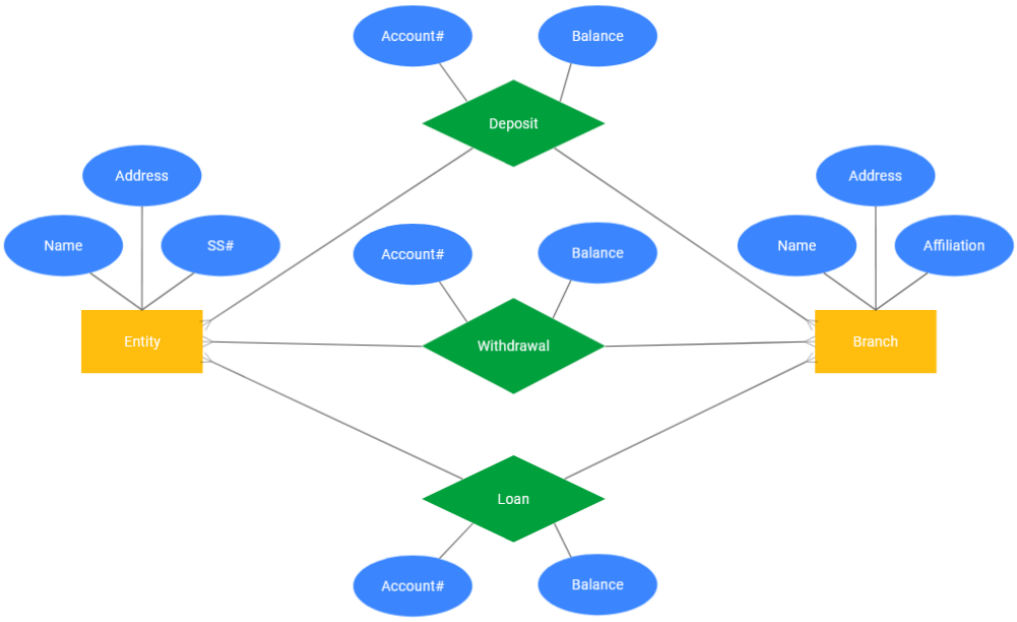


Figure 1: Example of The Chen's ERD Notation

Source: smartdraw (n.d)

Methodology

This paper is using content analysis to examine text in the article and journal as main data in illustrating and formulating database structure of hiking incidents database systems. There are several papers reviewed on hiking incidents, prevention, and SAR missions and operation. It aims to provide a more precise and integrated understanding on hiking incidents. Hiking incidents documented journals is the database that were applied to search for relevant literature. The number of useful papers was reduced to 17 in the final process from 22 at the first searching stage.

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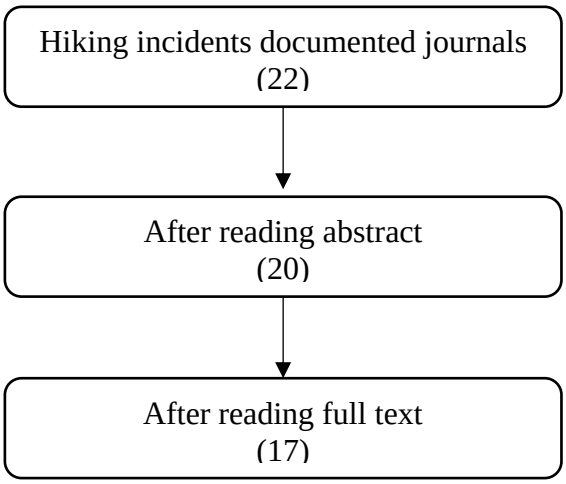

Figure 2: Paper Selection Process

All papers were read thoroughly and highlighted divided into three (3) content including factors of hiking, hiking incidents prevention and SAR missions and operations. Table 5, the brief content, and highlights of every paper can be shown more clearly.

Table 5: Number of Papers by Content Analysis

Content	Frequency of papers
Factors of hiking	5
Incidents prevention	4
SAR missions/operations	8
TOTAL	**17**

The basis for this system is Chen's ERD notations which have been conducted previously and can be used in SAR operations. There are three (3) main stages, namely;

i. identifying the type of data required,
ii. forming entities and attributes,
iii. identifying the relationships between the entities of SAR operation and the factors of incidents occurred.

The Chen's ERD notation is a popular, standard model, still relevant and is considered to present a more detailed way of representing entities and relationships. ERD is an excellent method for the development of a database as it uses diagrams that are provided in the form of graphical data and information, as stated by Sidana (2013). In addition to this, ERD is applied often in a variety of areas since it is an effective method to communicate with individuals operating at all levels. For the purpose of producing a translation that is more accurate and useful, the formulation of a diagram that represents each data point has to be more specific and requires for comprehensive knowledge.

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Result and Discussion

Hiking incidents database structure using ERD

Three (3) stages of formulating database structure are identifying the type of data required, forming entities and attributes, and identifying the relationship between the entities of SAR operation and the factors of incidents occurred.

Identifying the Type of Data Required

In avoiding hiking incidents, it is necessary to categorise and identify incident type. Hiking incidents have occurred frequently whether the incidents happen because of environment factors, human factors, and weather factors. According to Sidi et al. (2019), the information on the environmental factors that may occur during hiking should be obtained on trails data such as, trails distance, elevation gain, maximum elevation, and trails type. In addition, trails data include information such as trails descriptions, directions to the trailhead, as well as statistics on each hike (vague difficulty rating) (Toy, 2020). The human factor is another cause of the incidents, and the factors involved are often such as knowledge, judgment, and emotional state. As stated by Ramos and Reis (2011) a deficiency of previous experiences will have an effect on the quality of decision and lead to situations in which one may "take the incorrect step ahead," as there will be no prior knowledge of situations that are related to the present one. It is important to be aware of both one's physical and medical condition in order to choose the most suitable trip choice, which will enable one to avoid both exhaustion and the possibility of being ill. Depending on the weather, hiking may be a particularly exhausting exercise since humans are exposed to an uncontrollable environment. People who were previously physically fit and healthy are more likely to become ill if they exercise in hot environments (Ramos and Reis, 2011). Additionally, Zürcher et.al., (2020) stated accident situations that because favourable weather includes sunny, cloudy without precipitation, no fog, and no other bad conditions. Rain weather conditions will make hiking activities restricted and dangerous, such as fallen trees and slippery trail surfaces (Jazwiri, 2016). Table 5 shows factors of hiking incidents and type of data required in formulating ERD.

Table 6: Factors of Hiking Incidents and Type of Data Required

Factor	Type of data
Environment	Name of areas
	Travel time
	Signage or landmarks
	Land marked or unmarked trail
	Topography
	Terrain condition
	Vegetation
	Falling trees
	Trail difficulty rating
	Elevation
Human	Name of subjects
	Gender
	Age
	Health level or Level of fitness
	Experience in hiking
	Activities engage in before

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	Friends or companions
	Health or Medical condition
Weather	Temperature
	Sunny
	Cloudy
	Rain

It is generally known that GIS may be helpful for SAR manager and team in search and rescue operations as well as emergency response operations. The ability to effectively connect between planned and documented efforts, the capacity to view areas that are searched or not searched, the ability to see areas that are searched or not searched, and the ability to integrate data from several sources are indeed advantages. Additionally, one could use such tools to visualise the chances of locating the missing person. For instance, one could draw distance circles around the Initial Planning Point (IPP) of the operation, which is typically based on the missing person's Last Known Position (LKP). This would allow one to see how likely it is that the person will be found. (Hanssen, 2018). As stated by Koester (2018), SAR operations is able to be stated by means of three terms: The Probability of Success (POS), The Probability of Area (POA), and The Probability of Detection (POD). Track offset, identify location, and mobility are some of the new spatial models that have been developed. Table 6 shows type of data that required for SAR operations.

Table 7: Type of Data for SAR Operations

SAR	Type of Data
SAR Manager and Team	IPP (Initial Planning Point)
	PLS (Point Last Seen)
	LKP (Last Known Point)
	Mobile connection
	Probability of Success (POS)
	Probability of Area (POA)
	Probability of Detection (POD)
	Location of rescue team
	Logistic (types of tools and rescue equipment)
	Time needed

Forming Entities and Attributes

Based on preliminary searching on the type of data required for hiking incidents database structure, there are four (4) entities and attributes development of each entity are follows as table above. The following table are the entities and attributes of hiking incidents database structure.

Table 8: Entities and Attributes of Hiking Incidents Database Structure

Entities	Attributes
Environment	Name of areas
	Travel time
	Signage or landmarks
	Land marked or unmarked trail
	Topography

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	Terrain condition
	Vegetation
	Falling trees
	Trail difficulty rating
	Elevation
Human	Name of subjects
	Gender
	Age
	Health level or Level of fitness
	Experience in hiking
	Activities engage in before
	Friends or companions
	Health or Medical condition
Weather	Temperature
	Sunny
	Cloudy
	Rain
SAR Manager and Team	IPP (Initial Planning Point)
	PLS (Point Last Seen)
	LKP (Last Known Point)
	Mobile connection
	Probability of Success (POS)
	Probability of Area (POA)
	Probability of Detection (POD)
	Location of rescue team
	Logistic (types of tools and rescue equipment)
	Time needed

Drawing in the form of diagrams as stated in the literature review, ERD which was introduced by Chen has symbols will make it simpler, clearer, and aid with the processing of data in order to translate entities and attributes.

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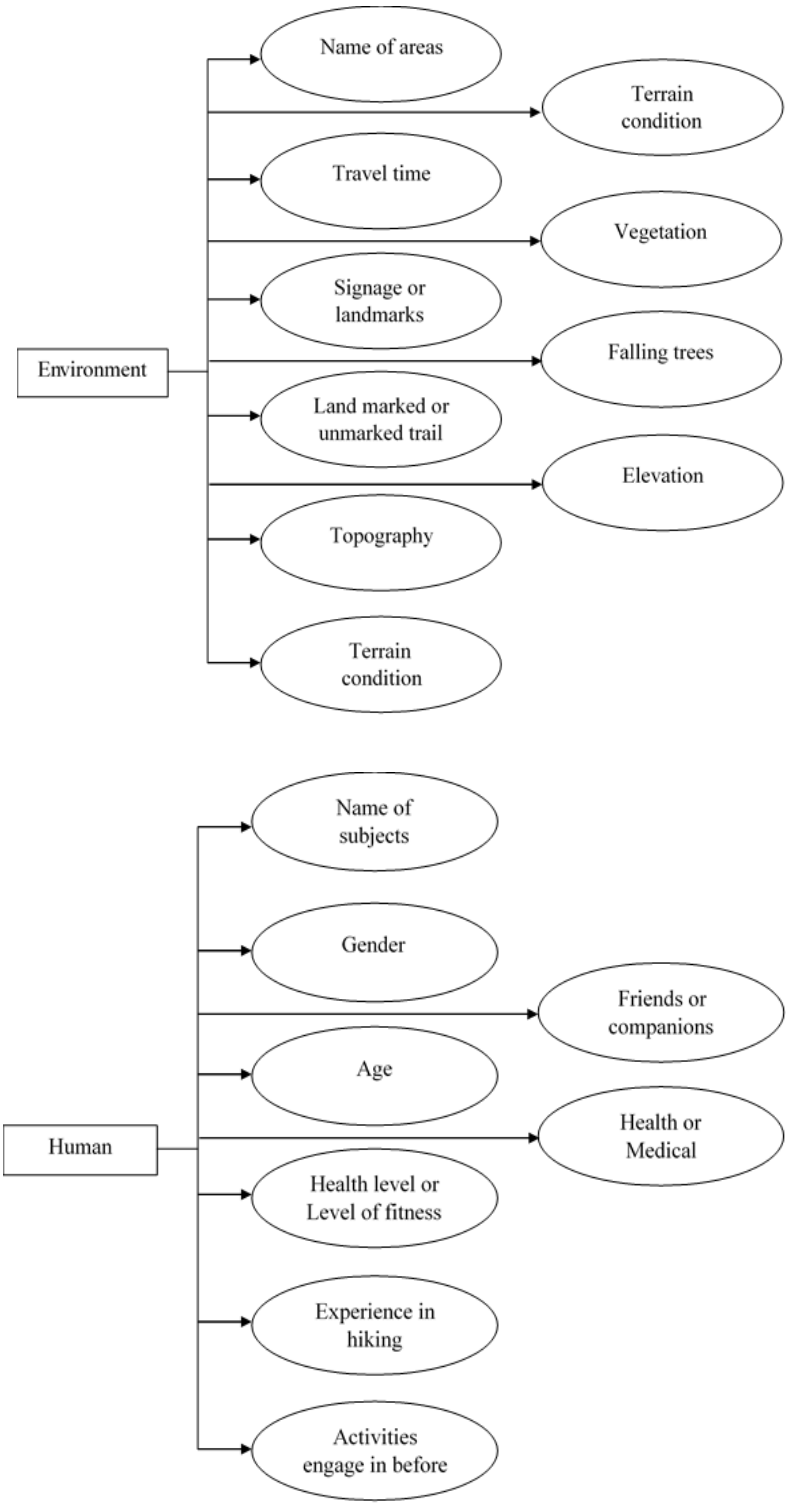

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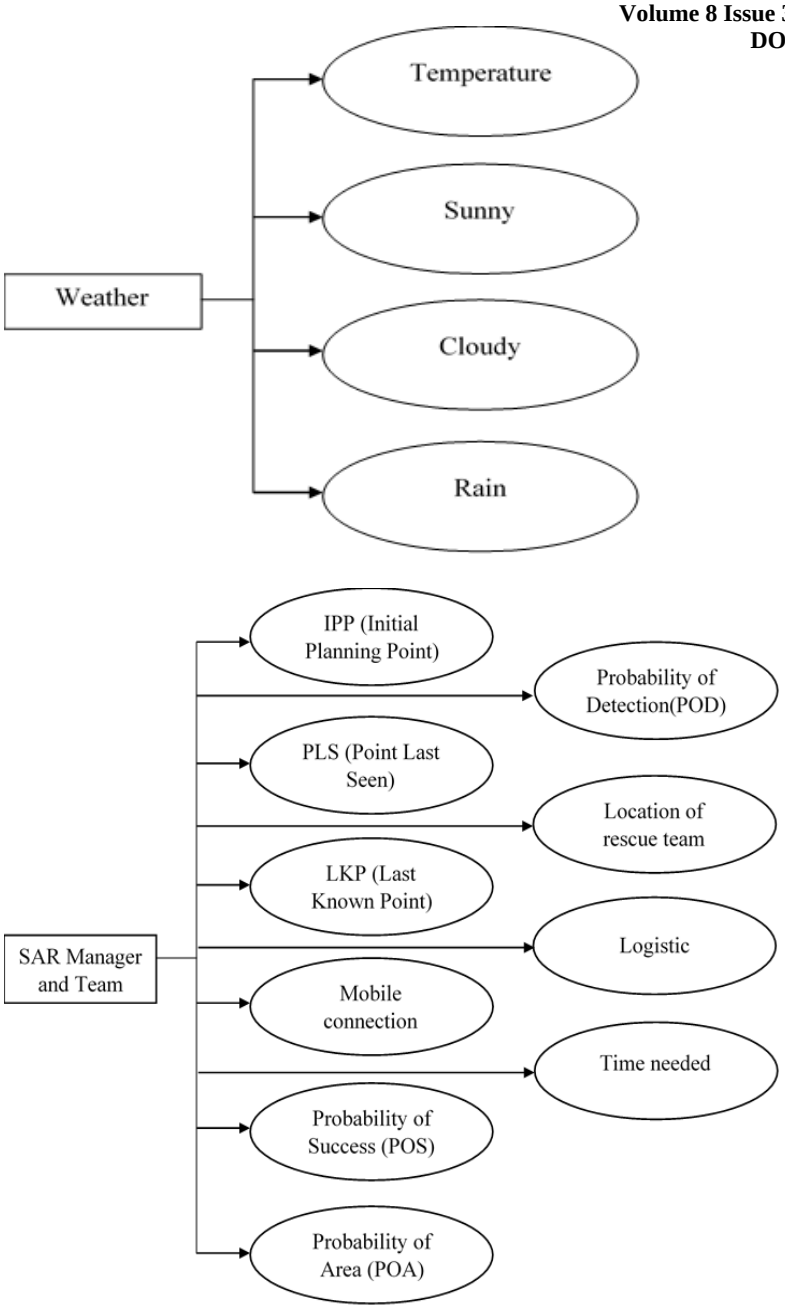

Figure 3: Entities and Attribute Diagram of Hiking Incidents Database Structure

Identifying the Relationship Between the Entities

Next is to identifying the type of relationship that exists between the two (2) entities. When the attribute of one entity relates to the attribute of another entity, then there is a relationship between those two entities. The meaning of a relationship is related to that of a verb that links two nouns (entities). For hiking incidents database structure, the relationship is portrayed as HIKING DATABASE. As mention in the Chen-like Model, the relationship is between the entities, namely FACTORS (ENVIRONMENT, HUMAN and WEATHER) and SAR MANAGER AND TEAMS, which will be called HIKING DATABASE (refer to figure 3). The FACTORS (ENVIRONMENT, HUMAN and WEATHER) give information to SAR MANAGER AND TEAMS and the information (ENVIRONMENT, HUMAN and

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WEATHER FACTORS) will then be used by SAR MANAGER AND TEAMS in SAR Operations. The cardinality to describe the relationship between entities the two (2) entities (FACTORS and SAR MANAGER AND TEAMS) is one-to-many relationship (1:M), it's because the FACTORS of incidents (ENVIRONMENT, HUMAN and WEATHER) may be used to many scopes of work or attributes of SAR MANAGER AND TEAMS, but the attributes of SAR MANAGER AND TEAMS is linked to only one element of FACTORS.

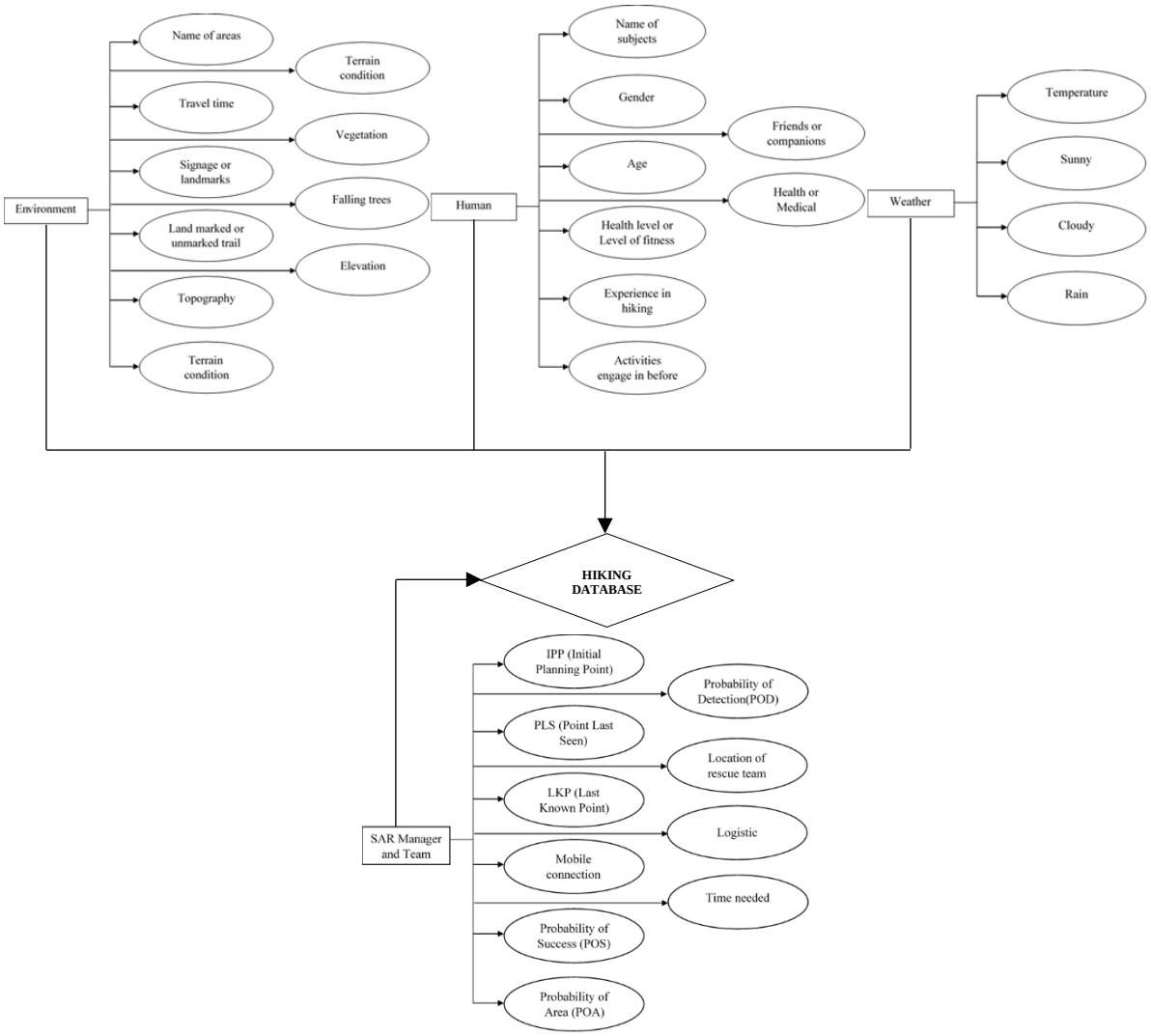

Figure 4: The Relationship Between Entities of Hiking Incidents Database Structure

Conclusion

Database from this research focuses only on the ERD created by Chen, yet several additional notations have been introduced and are further used in other sectors of work. This study's database mainly formulates ERD to prevent and reduce incidents while hiking and to enhance the preparation of hikers, guides, and SAR teams. The management of hiking areas and the operation of SAR teams need more comprehensive data in order to further strengthen the gathering of data to form a database. This will involve the formation of new entities and attributes, as well as the formation of new relationships, which will be formed indirectly. While implementing ERD into operation, the management of hiking areas and the operation of SAR teams need to consider a variety of factors into account. These factors include the appropriate

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GIS application that will be implemented in addition to the financial arrangement of agencies. This is because of the fact that the GIS in Malaysia has many applications that can translate ERD to a database system. Some instances of these programs include MapInfo, ArcGIS, GRASS, and QGIS. These as well as additional applications have been widely used by various fields, whether in the private or public sector. As a consequence, the use of ERD in the development of a database structure for hiking incidents may assist not only the management of hiking areas and the operation of SAR teams, and moreover hikers and guiders in being better prepared for the possibility of an incident while hiking.

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