

## A Systematic Review of The Recent Geospatial Approach in Addressing Spatially-Related Radicalism And Extremism Issues

---

### Juhaida Jamal

Geospatial Imaging and Information Research Group, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia

### Mohd Faisal Abdul Khanan, Ami Hassan Md Din

Geospatial Imaging and Information Research Group, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia

### Hafiz Aminu Umar

Department of Environmental Sciences, Faculty of Science, Federal University Dutse, P.M.B 7156, Dutse, Nigeria

### Mohd Mizan Mohammad Aslam

Department of International Relations, Security and Law, Faculty of Defense Studies and Management, Universiti Pertahanan Nasional Malaysia, 57000 Sungai Besi, Kuala Lumpur, Malaysia

---

### ABSTRACT

This systematic review article focuses on the geospatial issues of radicalism and extremism. The scholar has intensified the application of geospatial in radicalism and extremism study to understand better the causes, patterns, and trends of the radicalism and extremism incidents. The advanced geospatial approach provides more spatio-temporal information on radicalism and extremism incidents'. It improves the conventional study method that only focuses on fundamentals and theory. Unfortunately, some geospatial issues from previous radicalism and extremism studies have been found. Hence, the present study reviewed past studies on geospatial applications in radicalism and extremism. Meanwhile, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method were used to review the current research. This systematic review utilises two major journal databases, Scopus and Web of Science. Searching works found in a total of 24 articles can be analysed systematically. The selected article was separated into four corresponding geospatial analysis types: distribution pattern analysis, cluster analysis, statistical and prediction analysis, and 3D technology. Finally, several recommendations were offered after this study for future scholars' consideration.

### Article History

Received : 04 January 2023

Received in revised form : 16 June 2023

Accepted : 04 August 2023

Published Online : 31 August 2023

### Keywords:

Systematic Review, Geospatial Issues, Radicalism, Extremism

### Corresponding Author Contact:

mdfaisal@utm.my

DOI: 10.11113/ijbes.v10.n3.1112

© 2023 Penerbit UTM Press. All rights reserved

---

### 1. Introduction

The term radicalism and extremism has not yet been well defined but has developed and improved. Some research has defined

radicalism and extremism. However, radicalisation most often centres around two different foci. Firstly on violent radicalisation, where the emphasis is put on the active pursuit or acceptance of violence to attain the stated goal. Secondly, on a broader sense of

radicalisation, where the emphasis is placed on the active pursuit or acceptance of far-reaching changes in society, which may or may not constitute a danger to democracy and may or may not involve the threat of or use of violence to attain the stated goals (Veldhuis & Staun, 2009). Extremism is the commitment to extreme forms of resolving social conflicts, so it allows and justifies the need to use violent means, including terrorism and different manifestations (Baisagatova *et al.*, 2016). Besides that, extremists usually do not qualify for another point of view, and they hold their opinion as being quite exclusive when they do not allow for the possibility of differences. The occurrence of terrorism events until 2019 had shown a decreasing trend. The number of deaths has decreased by 52 per cent since 2014, from 33,555 to 15,952. However, it is still a severe and significant issue in many countries. In 2019, 63 countries recorded at least one death from a violent act, while seventeen countries recorded more than 100 deaths from terrorist incidents, this trend has shown that the violent act is still widely spread globally (Peace & World, 2020). Terrorism has transformed the environment and created a severe challenge for many countries in recent years. Scholars are attracted on how GIS can contribute to radicalism and extremism.

Although many studies focus on the GIS approach in radicalism and extremism, there was still a small amount of systematic review of the previous studies. Hence the present article conducted a systematic literature review to address spatial-related issues in radicalism and extremism studies involving the GIS approach.

Doing a systematic review of past studies is crucial. As mentioned by (Neal Robert Haddaway & Macura, 2018), traditional

literature may lack transparency, making it impossible to verify how rigorously they were conducted, whether they missed necessary evidence, or may reflect vested interests. Besides, this also might reduce the reliability and usability of a synthesis. Instead, systematic reviews that use rigour to synthesise data from many research may be required. The systematic review is a research synthesis that relies on evidence-based methods to maximise rigour and minimise susceptibility to bias. (Neal R. Haddaway *et al.*, 2020). Systematic reviews involve steps to mitigate biases and limitations. Most importantly, perhaps, they aim to be as transparent as possible by documenting all activities during the reviewing process (Neal Robert Haddaway & Macura, 2018).

### 1.1 Background of Radicalism and Extremism

Radicalism and extremism are frequently misused concepts. The war that took place has confused in distinguishing between these two terms. The violent action during the incidents gave the community the impression that radicalism and extremism were groups in the same circle. This impression happens when people only assess radicalism and extremist actions from the point of view of violence. Undeniably, most radicalism and extremism events will end up with the destruction and damage to property and possibly even life. There are ten critical distinctions between radicalism and extremism, focusing on the action taken by the perpetrator, the concept practised, and the ideology (Bötticher, 2017). Table 1 lists the ten differences between radicalism and extremism.

**Table 1:** Difference between radicalism and extremism

Aspect	Radicalism	Extremism
<b>Types of violence</b>	<ul style="list-style-type: none"> <li>• Tend to use political violence pragmatically and on a selective basis</li> </ul>	<ul style="list-style-type: none"> <li>• Consider violence against their enemies as a legitimate form of political action and tend to embrace extreme forms of mass violence as part of their political ideology</li> </ul>
<b>Consent to democratic action</b>	<ul style="list-style-type: none"> <li>• Radicalism is emancipatory (freedom on social or political freedom and rights) and not anti-democratic. Democracies can live with radicals but not with uncompromising, aggressive extremist militants.</li> </ul>	<ul style="list-style-type: none"> <li>• Extremism is anti-democratic action that aims to eliminate representative government and the rule of law. Extremist movements cannot be integrated into societies due to their intolerance toward ideologies other than their own.</li> </ul>
<b>Human rights</b>	<ul style="list-style-type: none"> <li>• Not opposed to equal human rights; historically, progressive radicals have sought to extend human rights to the underprivileged.</li> </ul>	<ul style="list-style-type: none"> <li>• Extremists openly confront the notion of universal human rights and those institutions that serve to uphold them for all.</li> </ul>
<b>Acceptance of an open-minded society</b>	<ul style="list-style-type: none"> <li>• Radicalism action may differ from the continuation of the status quo, but they do not seek to close open societies and do not destroy diversity in society.</li> </ul>	<ul style="list-style-type: none"> <li>• Extremists want to close/ reject the open marketplace of the idea. Extremism is extreme in both its goals and the choice of means to reach them.</li> </ul>
<b>Acceptance of the</b>	<ul style="list-style-type: none"> <li>• Radicalism stands in rebellious opposition against the establishment.</li> </ul>	<ul style="list-style-type: none"> <li>• Against those who do not embrace its principle in transforming society.</li> </ul>

<b>establishment</b>		
<b>Reaction when in the weak phase</b>	<ul style="list-style-type: none"> <li>When numerically weak, radicals can withdraw from mainstream society into intransigent isolationism, co-existing with plural societies and not continuously seeking a direct conflict with society.</li> </ul>	<ul style="list-style-type: none"> <li>Extremists engage in provocative and aggressive interventions against the established order when numerically weak.</li> </ul>
<b>Morality</b>	<ul style="list-style-type: none"> <li>It is oriented more towards a universal morality.</li> </ul>	<ul style="list-style-type: none"> <li>It is characterised by a particular morality valid only for its members.</li> </ul>
<b>Concept and ideology</b>	<ul style="list-style-type: none"> <li>Radicalism has been more egalitarian and less elitist.</li> </ul>	<ul style="list-style-type: none"> <li>Extremists are supremacists opposed to the sovereignty of the ordinary people. The concept of extremism is closely linked to authoritarian dictatorships and totalitarianism.</li> </ul>

The differences in Table 1 have brought to the varying factors causes of radicalism and extremism incidence, which can be social, political, economic, individual, modernisation, etc.

Many factors can contribute to the occurrence of radicalism and extremism. The factor of radicalism needs attention as it is vital for the future deradicalisation process. Previous cases of radicalism and terrorism have shown that multiple factors can act as catalysts, triggering the outbreak of such incidence. Much research has been done to study the roots of radicalisation and violent acts. It has been found that an enormous scope of factors can be related to radicalisation. For example, demographic and socioeconomic factors such as poverty, inequality, and economic issues contributed to the violent act (Ehrlich & Liu, 2002). Another studied had found a connection between poverty, education, and terrorism, where reducing poverty or increasing education will reduce the number of violent acts (Krueger & Malečková, 2003). Most studies focused on the economic scope in

explaining the causes of radicalisation. Poverty can contribute to radicalisation in the context of the economic factor. However, it needs to be realised that not all impoverished individuals are involved in radicalisation. Poverty is not a direct factor but depends on individual and social aspects (Veldhuis & Staun, 2009).

Figure 1 shows the model developed to explain how different factors and levels related to each other and how those factors contributed to radicalisation (Veldhuis & Staun, 2009). There are distinguishing factors layers at the micro and macro levels. The model clearly shows that many factors are related to radicalisation, where individual factors as the central point, as individuals are strongly influenced by their environment. The environment can be classified in terms of the political environment, social environment involving religion, and ethnicity.

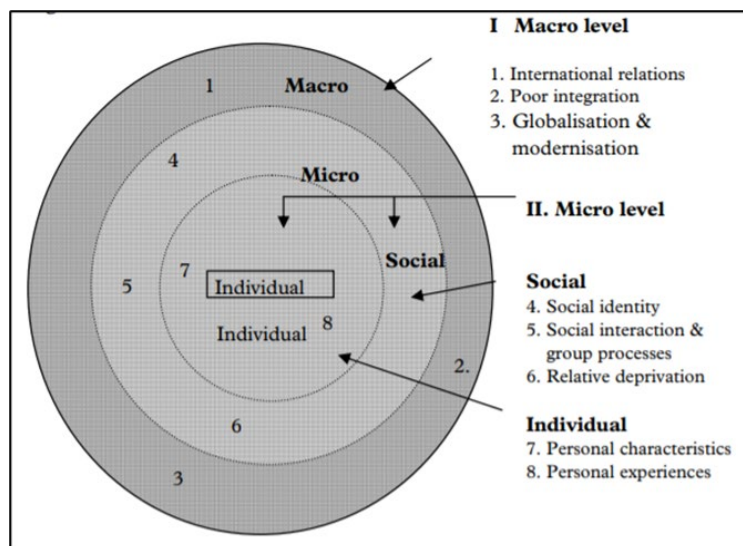


Figure 1: Casual factor of radicalisation

Based on Figure 1, radicalism and violent extremism were separated into macro and micro factors. Macro-level variables influence social structures and include, among other things, demographic changes, political, economic, and cultural shifts, educational attainment, and labour-force involvement. The model's two inner layers represent the micro-level emphasising the individual's importance as an embedded unit. The micro-level is further subdivided into social and individual factors. Social factors, represented by the second or middle layer, define the individual's relationship to relevant others. The model's third and final layer represents causative factors at the personal level. Individual factors, like social factors, are subcategorisation of micro-level variables. Individual variables include psychological traits, personal experiences, and personal ideas and values. The biological differences between men and women, and the consequent behaviour implications of those natural disparities, provide a simple illustration of how individual traits impact human behaviour. Similar to this model, (Allan *et al.*, 2015) also came up with a multi-layer radicalism and extremism factor. Conversely, the authors have devised the idea to group the macro level as the push factor while social and individual factors as the pull factor.

However, the factors for radicalism and extremism can be better understood from a geographic perspective. Where and when the incident happens, and what triggers them to occur, is the big question that needs to be understood to prevent radicalism and extremism. The historical event helped people to understand more about the factor and the causes of such incidence.

Even though the research on radicalism and extremism was still low, the research increased yearly after the 11/9 incident. 11/9 was the starting point that attracted more researchers to study radicalism and extremism to understand the behaviour of radicals and extremists. The systematic study of terrorism began decades ago, assuming that understanding and combating this type of political violence was urgently needed (Bahgat & Medina, 2013). The September 11<sup>th</sup>, 2001 terrorist attacks dramatically extended this community of terrorism academics and encouraged attempts for new and novel research methodologies from a wide range of disciplines, ushering in what some have dubbed as the second wave of terrorism study (A. U. Khan, 2005).

The latest method of research used for radicalism seems more focused on the use of GIS technology. However, non-geospatial research is still crucial and contributes to geospatial research. It can be seen that geospatial technology has enhanced non-geospatial research. Geospatial help create the relationship between the time, location and situation and give a more understanding to analyse the radicalism incident. However, non-geospatial research is still needed to strengthen further the analysis of studies conducted using geospatial and verification purposes. All studies will usually be related to theory and basic field knowledge.

Radicalism and extremism happen anytime and everywhere around the world at different locations. Every location brings

different perspectives. Among the perspective are social, political, economic, and individual. This shows that the occurrence of radicalism and extremism incidents is varied in terms of location, time, and causes. Apart from that, radicalism and extremism have been increasingly subjected to scientific study. It involved the social science area and involved many kinds of other studies area including Geographic Information Systems (GIS). GIS can provide more information on incidence patterns and improve the conventional radicalism and extremism study method. The geospatial approach provided geographical connections that would otherwise go neglected or ignored in traditional terrorism and counter-terrorism research (Henkin *et al.*, 2020).

## 2. Methodology

### 2.1 PRISMA

This systematic review was conducted using the reporting guidelines in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). PRISMA is a published standard for conducting a systematic literature review. PRISMA's general concepts and topics are relevant to any systematic review (Moher *et al.*, 2009).

### 2.2 Data Source And Search Term

The data for this systematic review were retrieved mainly from the electronic bibliographic database of Web of Science and Scopus. Besides, the JSTOR database is also used to retrieve the fundamentals of the radicalism and extremism theory. JSTOR encompasses books, other primary sources, and current issues of humanities and social sciences journals. Due to the low number of research, a google scholar database is also included to increase the number of the journal. Even so, minimal studies still focus on both subjects, radicalism and extremism. The time interval was started from early 2000 until 2021. Several steps were taken to identify significant literature for this review.

### 2.3 Systematic Review Process

#### 2.3.1 Identification

The systematic review process involved three main stages in selecting the relevant articles. The first stage is the identification using the keywords and other related and similar terms. This systematic review searched for the associated keywords and terms with 'radicalism' and 'extremism'. Then, follow with the 'geospatial' words. After that, both queries were combined with the 'AND' operator to identify literature likely to contain studies on both topics. Table 2 shows the search string on the Scopus and WOS database. Current research retrieved 20 articles from both databases, while manual searching contributed to the 17 articles. In total, 37 articles were retrieved in the first stage of the systematic review process.

**Table 2:** Search string

Database	Search String
WoS	((“radicalism” OR “radical” OR “extremism” OR “extremist” OR “terrorism” OR “terrorist” OR “violence” OR ) AND (“geographic information system” OR “geographic” OR “GIS” OR “geospatial” OR “spatio-temporal” OR “spatial analysis”))
Scopus	Article Title-Abstract-Keywords ((“radicalism” OR “radical” OR “extremism” OR “extremist” OR “terrorism” OR “terrorist” OR “violence” OR ) AND (“geographic information system” OR “geographic” OR “GIS” OR “geospatial” OR “spatio-temporal” OR “spatial analysis”))

### 2.3.2 Screening

The screening was done mainly to remove the duplicated articles. Three articles were eliminated during the first stage. In the second stage, 37 articles were screened based on the eligibility criteria. The article that was considered eligible for this review were assessed on a) published in English, b) reviewed journal articles, c) radicalism and extremism as the main topic, and d) presented the application of geospatial analyses. Moreover, it is crucial to note that 11 years (2010- 2021) were chosen for the timeline. The 2010- 2021 period is selected because geospatial only became popular among radicalism and extremism after 9/11.

#### 2.3.3 Eligibility Criteria

A total of 34 articles then moved to the third stage, known as eligibility. At this stage, the article's title, abstract, and main contents were examined thoroughly to ensure that they fulfilled the inclusion criteria to achieve the objective of the current research. Consequently, ten articles were excluded because they are not based on the subject area and do not use geospatial as the main method. Finally, a total of 24 are ready to be analysed. Figure 2 shows the flow diagram of the study.

#### 2.3.4 Selection of Studies

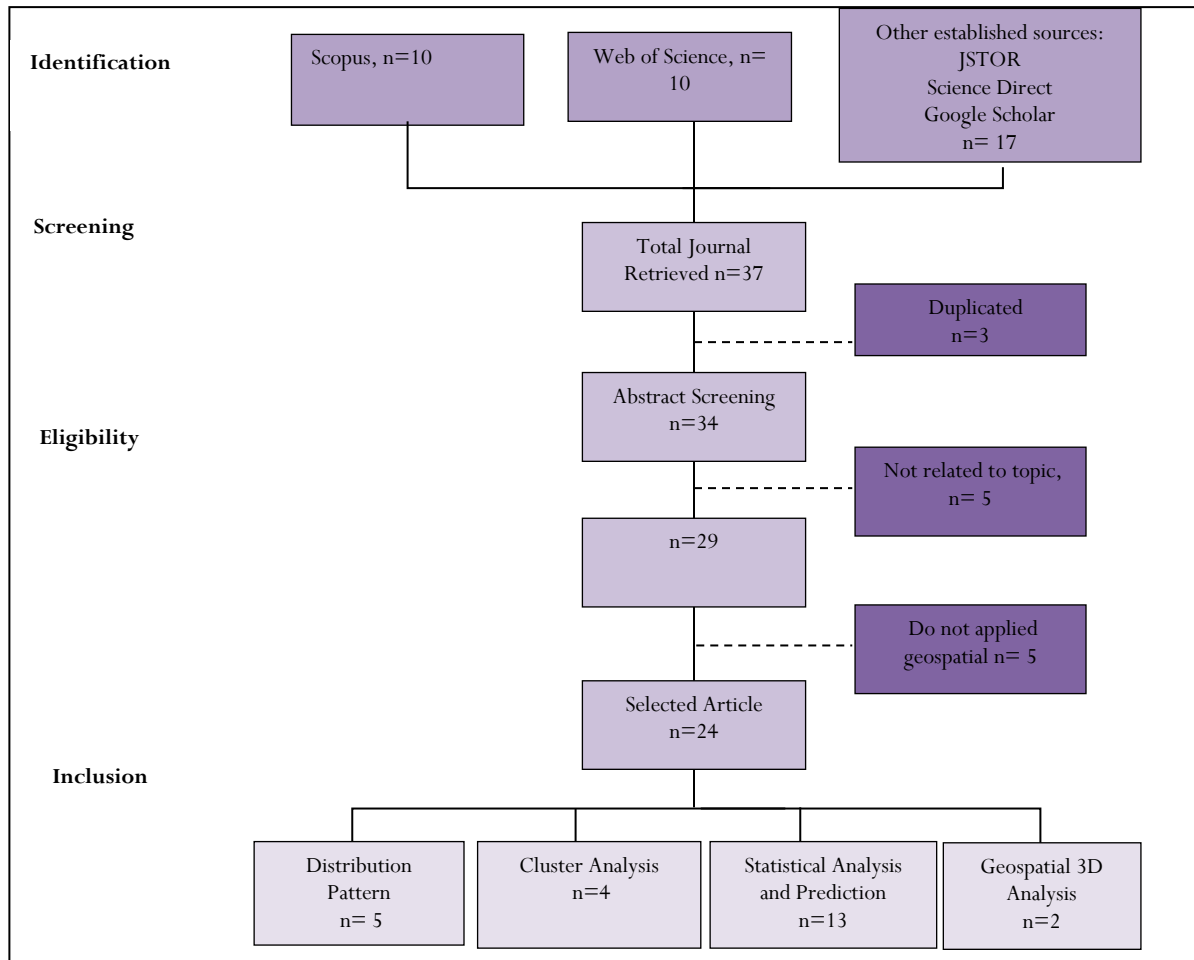
All citations retrieved through database searching were imported into Mendeley reference manager software for curating the collective bibliography. Then, the variable of a) publication details, b) the objective of the study, c) the data sources, d) the scope of radicalism studies, e) the application of geospatial analysis, and f) research output and finding from the selected journals article were extracted.

### 2.3.5 Summary And Characteristics Of Review Articles

These studies retrieved 37 research. After applying the selection process, summarised in Figure 2, 24 studies were included for review. The research paper was categorised into four general groups based on the geospatial analysis applied in the study. The selected article was published in a peer-reviewed journal such as *Terrorism and Political Violence*, *Perspectives on Terrorism*, and *Behavioral Science of Terrorism and Political Aggression*.

In total, 10 out of 24 studies choose Middle East countries (Iraq, Iran, and Afghanistan), Kenya (2), Nigeria (2), Indonesia (2), America (1), and Malaysia (1) as their study area. Several studies involve global-scale analysis. Another study involves Asian countries such as Malaysia, the Philippines, Indonesia, and Thailand. The high number of studies concerning the Middle East can be due to the country's situation, which is undergoing a series of long-term wars.

Esri ArcGIS was the most common platform used in the review research. Besides, some of the studies used open-source platforms like QGIS for the data analysis process. 80% of the studies used the Global Terrorism Database (GTD) as the leading platform for the data source. The GTD is the most extensive terrorist database. The database contains roughly 120 pieces of information, including the targeted location's name and coordinates, assault date and time, attack method (e.g., bombing), offender identity, and other relevant details. Until July 9<sup>th</sup> 2020, the database had more than 200,000 terrorism incidents recorded from 1970 to 2019. The database is updated once a year. Apart from all review articles, two studies used remote sensing data such as aerial photogrammetry and USGS satellite image as the support data to interpret their finding and 3D analysis.



**Figure 2:** Geospatial applications in radicalism and extremism research literature search and evaluation for inclusion

### 3. Result and Analysis

Geospatial can provide more information on the geographical patterns of radicalisation and improve the conventional method in radicalism study. The geospatial approach provided geographical connections that would otherwise go neglected or ignored in traditional terrorism and counter-terrorism research (Henkin *et al.*, 2020). This review focused on the different geospatial approaches in radicalism studies. The selected article in this review was separated into four thematic groups based on the geospatial analysis types; attack trend pattern (n=12), Incident distribution (n=8), Predicting future incidents (n=7), and the use of 3D geospatial analysis (n=2).

#### 3.1 Distribution Pattern of Radicalism and Extremism

Identifying geographic patterns is essential for understanding how geographic phenomena behave. In radicalism and extremism studies, pattern analysis started to be used after 2000. However, it was widely used after the incident of 9/11 as researchers began to understand more about the behaviour of the radicals and extremists. The increasing data source is also one of the reasons

trend pattern analysis developed among radicalism studies (Webb & Cutter, 2009). A substantial number of studies were found to apply spatial-temporal and statistical analysis in analysing distinct aspects of radicalism and extremism. Most of these works were focused on analysing the spatial distribution pattern of radicalism and extremism cases using the previous incident data.

##### 3.1.1 Spatial Distribution Pattern

A study by Chukwudi (Okeniyi *et al.*, 2018) examined terrorism in Africa using Nigeria and Kenya as case studies. From 2010 to 2016, terror incidents were investigated using Armed Conflict Location and Event Data data. Density and hot spot analysis were applied to study the attack pattern in Negeri and Kenya. Using the additional information from the data collected, the researcher examines the mode and target of attack types used by the radicals and extremists. Results showed similarities in the trend of attacks in both countries, peaking in 2012 and declining in 2016. The shooting was the highest mode of attack in Nigeria and grenades in Kenya, with civilians mainly targeted, resulting in deaths and injuries, which climaxed in 2014.

Another study (Chen & Mu, 2021) performed a trend analysis to analyse the number of terrorist attacks in the Belt and Road

regions. This study seems different as the scale does not focus on the region or sub-region, but the area was grid into hexagonal unit cells. Figure 3 shows the gridding result of the study area using the honeycomb model. Honeycomb was claimed to be the best topological structure covering a two-dimensional plane and help

reduce distortion caused by the earth's curvature when a large study area is involved. Most people were alert that terrorists, radicalism, and extremism usually occurred in the Middle East. This study discovered that many terrorist attacks occurred, with Iraq having the most attacks.

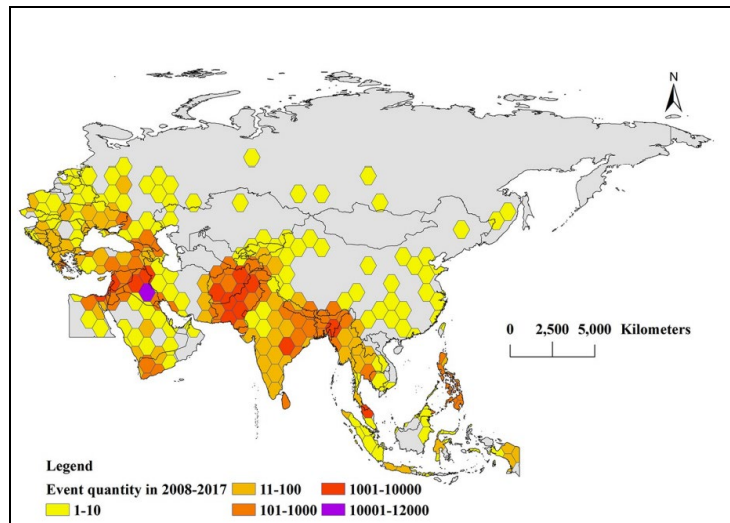


Figure 3 The result of attack distribution using the honeycomb grid

### 3.1.2 Temporal Distribution Pattern

Violent acts by extremists, radicals, and terrorists do not occur spontaneously, but it is the planning work prepared before the targeted attack. Figure 4 shows the general principle of terrorist

attacks and examples of planning activities involved in the planning. From this figure, it can be summarised that the violent act required a specific period to move from one phase to another phase.

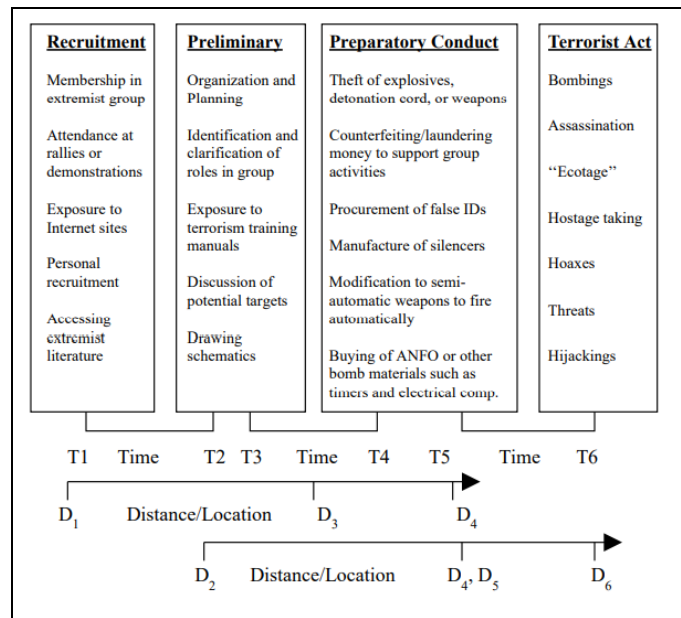


Figure 4 General principles and examples of each type of behaviour

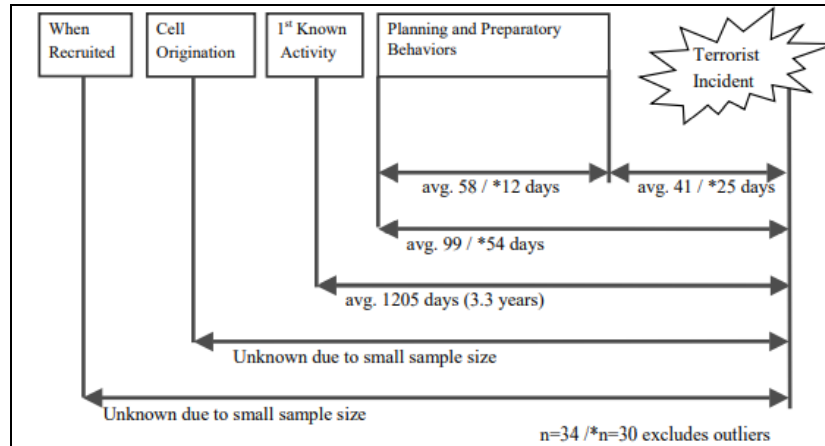
Two studies focus on the temporal pattern to study the time the radical shifts from the recruited phase to the incident day. Using 29 and 30 sample data,(Cothren et al., 2008) and (Smith et al.,

2008) measured the time the radical allocated to move from a planning phase to incident day. From the analyses, (Cothren et al., 2008) found that almost 14 days are required from the planning



phases to the attack incident day. However, (Smith *et al.*, 2008) conclude that only 24 hours are needed to start the incident after the last planning preparation. Figure 5 shows the result produced by (Cothren *et al.*, 2008). However, from the result, the patterns shown in the figure reflect "averages" rather than behavioural

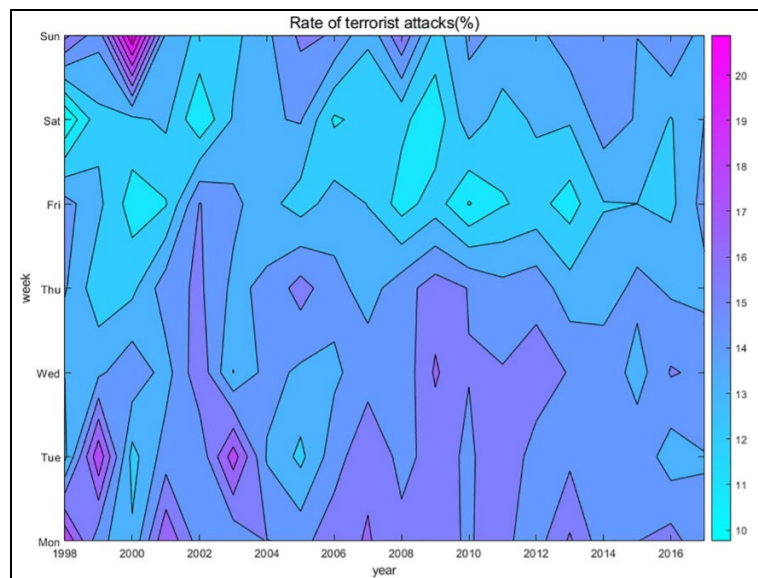
trends. This can be due to the number of outliers affecting these statistics. Hence, temporal distribution analyses are needed to help the researcher predict the future incident by observing the previous trend. However, a large data sample may be required to understand the movement (Li *et al.*, 2018).



**Figure 5:** Behavior temporal trend of violence activity planning

Besides mapping the incidents based on the location, another research was done by (Chen & Mu, 2021) and (Li *et al.*, 2018) to analyse the distribution of the terrorist attack temporally. (Li *et al.*, 2018) has used wavelet analysis to determine the distribution law of terrorist attacks in BRI regions for ten years. The wavelet function may uncover hidden change phases in diverse time series and represent a trend at different time scales. Figure 6 shows an example of the result of the study. Dark colours show a higher number of events, and light colours show fewer numbers of events. This study also mentions that most attacks occur on Fridays and during the weekend.

(Chen & Mu, 2021) examined the distribution pattern in two ways: the periodic characteristics of the group and the link between behaviour and the network. However, as operation-oriented terrorist groups have some specific characteristics, only a thorough understanding of the characteristics can effectively predict their behaviour. Both studies also overcome the issue of the previous research, which either considered spatio-temporal characteristics in a limited way or analysed such characteristics without connecting them.



**Figure 6** Contour map shows the week-year relationship between the incidence of events. Dark colours show a higher number of events, and light colours show less number of events.



### 3.2 Cluster Analysis

Cluster analysis was performed to identify statistically significant hot spots, cold spots, spatial outliers, and similar features or zones. Clustered mapping allows visualisation of the cluster locations and extent.

A study done by (Rokhman *et al.*, 2020) applied spatial multi-criteria analysis to study the distribution of radicalism based on the targeted attack; church, residential, police station, business, and government building. The AHP method was used to calculate the vulnerability index and sensitivity analysis to validate the result. Another study by (Zhang *et al.*, 2018) used a machine learning approach (Python Programming) to study the distribution of radical incidents with multi-factor within 11 countries. A result produced with 88% accuracy showed that the Indochina Peninsula and the Philippines are high-risk areas, and medium-risk areas are mainly distributed in the coastal regions. This study looks to improve the previous research as they included other factors of radicalism instead of time, location, type of attack, and type of target, which is commonly used by the earlier study.

Different studies have applied several methods to map the pattern of radicalism incidents. For example, the IDW method (I. Khan *et al.*, 2020), Moran's I analysis (Siebeneck *et al.*, 2009) and Person R correlations (Okeniyi *et al.*, 2018) were used to analyse the distribution of the number of incidents, the number of deaths, types of attack, type of weapon used, and types of target attack within a specific time and location. At the end of the studies, risk assessment was done by compositing all the distribution maps to analyse the high level of risk location. By using the result, future radical incidents were predicted. However, it is good to include the causes of radicalism in the analysis because any risk location for radical incidents has its own related causes of radicalism.

### 3.3 Statistical Analysis and Prediction

Most of the studies were focused on examining the spatial distribution and relationship between the location of radicalism incidents, number of deaths, types of targets, and types of attacks. Prediction of future incidents of radicalism was one of the studies that were difficult to be found. However, these studies found seven articles related to the prediction of future incidents. The previous researcher had applied many methods to predict the future violent act, including using the spatial regression statistical and machine learning approach.

#### 3.3.1 Geographically Weighted Regression (GWR)

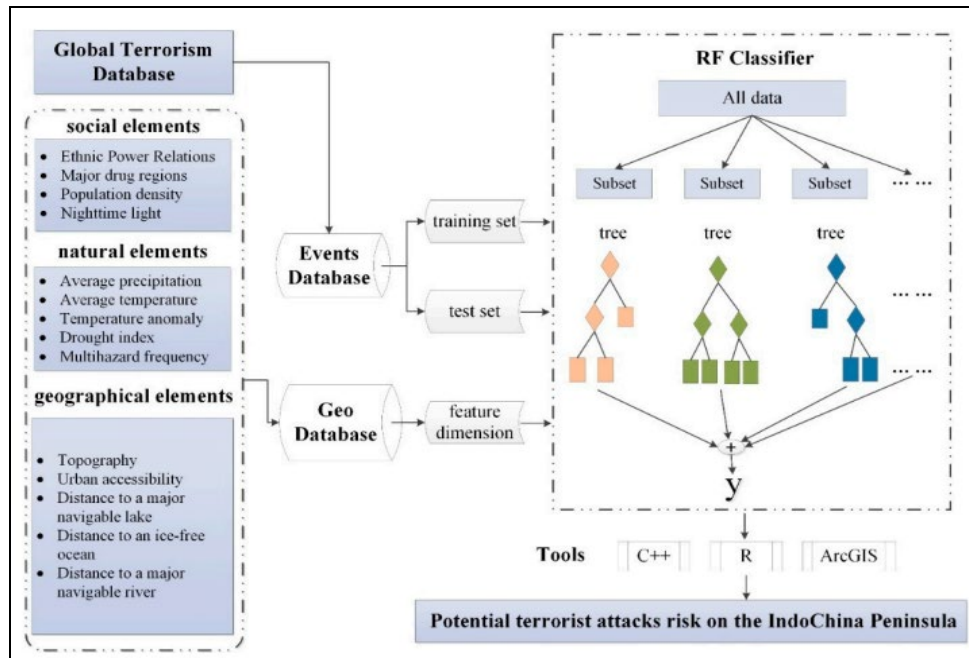
Geographically Weighted Regression (GWR) is a local form of linear regression used to model spatially varying relationships. A

GWR approach models the relationships that vary over space by introducing distance-based weights to provide parameter estimates for each variable and geographical location. A study by (Nadir *et al.*, 2010) analysed the effects of terrorism on economic growth across provinces of Turkey from 1987 to 2001 using a geographically weighted regression approach. The empirical result suggests that the GWR model outperforms the classic global model in model fitting, implying that the old global model is misspecified. Furthermore, the GWR model estimates indicate significant differences in parameter estimations, particularly in the case of terrorism.

(Gao *et al.*, 2013) used spatial scan and space-time statistics to predict the radicalism incident at an early stage. (Jha, 2009) and (Brown *et al.*, 2004) use the concept of crime to model the prediction of radical events. (Jha, 2009) used Dynamic Bayesian Network to predict the likelihood of future attacks, which acts as an initial step in predicting terrorist behaviour at critical transport infrastructure facilities. A study by (Caplan *et al.*, 2011) applied risk terrain modelling to predict the crime event and criminal behaviour, including shootings, aggravated assaults, assaults on police officers, and terrorism at the province level. Another study by (Basu *et al.*, 2017) used GIS and machine learning random forest methods to predict radicalism. Various parameters, such as the date and incident information, incident location, attack and weapon information, and target information, were used to develop the model.

#### 3.3.2 Forest-based Classification and Regression

A study by (Hao *et al.*, 2019) predicted the risk of terrorist attacks on the Indochina Peninsula by using (1) social, (2) natural, and (3) geographical elements as the parameter to run the prediction. After applying Kernel Density to analyse the evolution of terrorist attacks from a time and space perspective, the author prepared spatial geographic data and corresponding raster data of the terrorist attack and constructed the RF algorithm to predict terrorist attacks at the spatial scale of the Indochina Peninsula. The author seems to improve the previous studies primarily on the national scale, focusing only on the time and location parameters. Figure 7 demonstrates how to simulate a terrorist attack using the RF model. An RF classifier with various element kinds was applied to estimate future terrorist threats. This study found Thailand is the most hazardous location for terrorist attacks, according to the possible terrorist attack risk zones, notably in southern Thailand, Bangkok, and its surrounding cities. The centre of Cambodia and sections of Myanmar's north and south were categorised as high-risk zones.



**Figure 7** The system architecture that is used for predicting a terrorist attack

A study by (Kanika et al., 2019) concentrated on examining the GTD dataset and making predictions on several aspects that could have harmed terrorism. This study focused on analysing the dataset of GTD and predicting different factors that might have given a blow to terrorism. Various data mining and machine learning algorithms such as SVM, Random Forest, and logistic regression were used. Research by (Kalaiarasi et al., 2019) has developed multiple classifiers for the terrorist group and predicted terrorist activities using the k-NN algorithm and Random Forest techniques. They used the GTD dataset for the detection of terrorism.

A study by (Maniraj et al., 2019) developed a system that examines the growth or decay of terrorist groups by the time, location, type of attack, target motives, weapon type, and availability. They analysed the GTD dataset and used a machine-learning algorithm to predict the probability of attacks in different regions. In 2019, (Freilich et al., 2015) studied the dynamics of unclaimed terrorism events in Pakistan using machine learning algorithms. They predicted terrorist attributes such as an attack, target, weapon type, spatial attack, and lethality. The study attempted to match the unattributed terrorist attack to known terrorist groups.

Another research in 2019 (Ahmad et al., 2019) developed a method for detecting and classifying social media-based extremist affiliations based on sentiment analysis. The focus was to classify tweets into extremist and non-extremist classes. The system uses deep learning-based sentiment analysis to classify the tweets. Other similar studies in 2020 can be found in (Gui et al., 2020) and (Yu et al., 2020).

Apart from the various method used, some improvements have seemed to expand the use of geospatial to predict the future

radical event. But still, some improvement needs to be done in choosing the parameter for the model. The study only focuses on the incident's time, location, and frequency as the prediction indicator. This is because each site has a different factor in the occurrence of the radical incident.

### 3.4 3D Analysis

Geospatial analysis not only concentrated on 2D analysis but also involved 3D modelling. The 3D approach is popular in other fields such as urban planning, construction, medical, and historical building study. However, little research has applied this approach in radicalism and extremism studies. GIS's potential to simulate local spatial interactions to protect individuals from terrorism situations in a 3D model. Research (Kwan & Lee, 2005) has focused on using the 3D approach to prevent and respond to future terrorism incidents. They have conducted a study to examine the possibility of utilising real-time 3D GIS to implement GIS-based intelligent emergency response systems (GIERS) to assist in rapid emergency response to terrorist attacks on multi-level facilities.

Another research (VanHorn & Mosurinjohn, 2010) examines the prevention of terrorism using 3D model analysis to protect populations in urban environments. They found that creating urban viewsheds using DSMs and visualisation can estimate the area where a target would be vulnerable to sniper attack. Apart from this study, there is no other study that has concentrated on GIS's potential to simulate local spatial interactions to protect individuals from terrorist situations in a 3D model.

#### 4. Discussion

The number of studies that applied the geospatial approach in radicalism and extremism studies is still low. However, previous studies have shown that geospatial is directly or indirectly involved in increasing the understanding of radicalism, especially in spatial and temporal scope. Geospatial had improved the temporal pattern analysis. Temporal analysis is used to analyse the pattern of terrorist distribution at a specific location within a particular duration, such as daily, weekly, yearly, and monthly (Millett, 2009). Literally, from all the previous research, some improvements can be made to increase the use of geospatial applications in studying radicalism and extremism.

Firstly, the limitation or the geospatial issues in the previous study can be found in the parameter used for the analysis. Most studies are concentrated on time and location, type of attack, type of target, and type of weapon for the research until some important parameter was neglected. As mentioned before, it is better to include the aspect of the causes of radicalism in the analysis. When the cause of radicalism is included, much other valuable and essential information can be analysed and extracted. For example, if the causes of radicalism at a location are due to religion, the probability of worship being the target is high. In contrast, if radicalism is due to poverty, it is possible for the religious building to be the targeted attack. So, when it comes to analysis, more focus can be directly done by analysing the parameter related to the causes of radicalism.

Large scale study seems to be less valuable compared to a small-scale study. Small scale can be easy to integrate and provide helpful information that various parties, such as the state authority, can use. This information can be used to counterattack the radicals and extremists. However, many data or samples are needed to produce a high accuracy result.

The data collection was the most challenging part of using the geospatial approach in radicalism and extremism studies (Freilich *et al.*, 2015). The methodology used to gather the data is still the issue in applying the geospatial approach to radicalism. As mentioned by (Okeniyi *et al.*, 2018), the researchers were highly dependent on just two methodologies for data collection (1) the analysis of documents (or secondary data analysis) and (2) form interviewing. In 2010, (Freilich *et al.*, 2015) stated concerns over the reliability of research that depends heavily on such open sources. Nowadays, many available databases, such as GTD, seem to be used as the source of data gathering. The question is now how the sincerity of this data source can be trusted without doubt and how to ensure that this data source supplies accurate and unquestionable data.

Undeniable direct inventory (parameter) data such as the incident location, timing of incidents, types of attack, number of death, types of weapons and other related data is essential to map the distributions, trends, patterns and predicting radicalism incidents. However, indirect parameters are also crucial to run the analysis and produce a more accurate result. Historical radicalism incident has proved that many causes lead to radicalism, such as crime, ethnicity, poverty, economic,

religious, and political (Veldhuis & Staun, 2009). So, it is essential to consider the causes factor to produce more accurate prediction results for better analysis. For example, in the geospatial prediction model, apart from time and location, the parameter of the incidents (causes incidents to happen) is also essential to be used as a critical consideration in the model. Including other related parameters was needed to ensure the model could predict the incident based on the exact situation.

Finding studies on radicalism or extremism associated with such predictions is pretty tough. If any, the percentage is deficient when compared to the use of other geospatial applications. However, researchers have started developing the geospatial model to predict the radicalism incident. Nevertheless, some improvements can be applied to their study. The previous study built the model by considering that radicalism incident in every location was due to the same factor (I. Khan *et al.*, 2020),(Siebeneck *et al.*, 2009),(Gao *et al.*, 2013),(Jha, 2009), (Donald Brown, Jason Dalton, 2004). Considering each location have the same factor may produce bias because a different factor might influence radicalism in a different location. So, it is better if a model was built according to their parameter (causes of radicalism) to generate the prediction result based on the actual situation and factor.

#### 5. Conclusion

This systematic review evaluated the issues of geospatial in radicalism and extremism context. It explored the scope of geospatial analysis in the current research efforts and future research and practice. In the age of the digital revolution, there is a rising demand for the exchange of technical advances across scientific fields. The geospatial approach and associated technology in radicalism and extremism illustrate such integrations and offer academic insights into how complex societal and global concerns may be comprehended using current tools. However, this also requires reconsidering evidence curation's current strengths and limitations across different contexts. Institutions must enhance their geospatial research and development capacity to counter radicalism and extremism, enabling research groups to collaborate more effectively.

This review article has sparked the idea of enhancing the benefits of geospatial applications in overcoming existing issues and limitations. Current geospatial issues have shown that most research does not emphasise the factors of radicalism and extremism in their investigation. Randomly they assume the events that occur in each place are due to the same factors. Finding the research that came up with the analysis related to radicalism is infrequent. The previous research used the wavelet method to analyse why violent acts are higher on weekends than weekdays. Ideally, it is good to come up with research that relates the distribution of radicalism with the factor of its occurrence. By adding the factor of radicalism as one attribute, geospatial can identify the roots of radicalism and extremism act at any location. Some existing research uses statistical analysis such as Geographically Weighted Regression (GWR) to predict future radicalism acts. The current prediction study seems to

produce a biased result. Most researchers do not include the factor of radicalism as one of the parameters for the prediction. It is crucial to predict any event based on the surrounding circumstances. Building the geospatial predictive model by including the occurrence factor as the parameter or indicator is suggested to overcome this limit.

The efforts in addressing the geospatial issue can maximise the use of GIS technology in tackling the radicalism and extremism act. However, these implications can benefit various parties, such as the agencies that maintain national harmony. The key to maintaining harmony is combating and preventing things that threaten national security. With the support of several data, geospatial manages to identify or predict the situation that can lead to a threatening act and provides information for areas where security control needs to be emphasised. Geospatial acts as the medium to provide information to ensure that early preventive measures can be done and indirectly can inhibit the acts of radicalism and extremism. Besides, geospatial can measure the harmony index of any area. This helps the authority plan the actions that must be taken to maintain national security. For example, the additional police station or security post at the hot spot area (low level of harmony index) was essential as a preparatory measure in the face of threats. Using various GIS tools, geospatial help to identify the host spot area. Next, strong and enough geospatial data can provide information on the roots that triggered the occurrence of violent activity at any location. This may help the authority to manage the radicalism and extremism issue by strengthening the effectiveness of deradicalisation programs. This is because the existing module was flexible, and the rehabilitation process for the detainee is general and does not focus on the causes of one's involvement in radicalisation. Based on the location where the radicalism act occurs, geospatial manages to identify the causes of the radicalism act.

## Acknowledgements

This work was supported by the UTM Others-MG grant (Grant No. R.J130000.7352.4B831))

## References

Ahmad, S., Asghar, M. Z., Alotaibi, F. M., & Awan, I. (2019). Detection and classification of social media-based extremist affiliations using sentiment analysis techniques. *Human-Centric Computing and Information Sciences*, 9(1): 24. <https://doi.org/10.1186/s13673-019-0185-6>

Allan, H., Glazzard, A., Jespersen, S., Reddy-Tumu, S., & Winterbotham, E. (2015). Drivers of violent extremism: Hypotheses and literature review. *Serial Report, October*, 35. [https://assets.publishing.service.gov.uk/media/57a0899d40f0b64974000192/Drivers\\_of\\_Radicalisation\\_Literature\\_Review.pdf](https://assets.publishing.service.gov.uk/media/57a0899d40f0b64974000192/Drivers_of_Radicalisation_Literature_Review.pdf)

Bahgat, K., & Medina, R. (2013). An Overview of Geographical Perspectives and Approaches in Terrorism Research. *Perspectives on Terrorism*, 7(1): 38–72.

Baisagatova, D. B., Kemelbekov, S. T., Smagulova, D. A., &

Kozhambardiyeva, A. S. (2016). Correlation of concepts “extremism” and “terrorism” in countering the financing of terrorism and extremism. *International Journal of Environmental and Science Education*, 11(13): 5903–5915.

Basu, A., Saha, S., Aladi, H., Kurian, A., & Basu, A. (2017). *Future Terrorist Attack Prediction using Machine Learning Techniques*. PESIT South Campus: Bengaluru, India, 2017. <https://doi.org/10.13140/RG.2.2.17157.96488>

Bötticher, A. (2017). Towards academic consensus definitions of radicalism and extremism. *Perspectives on Terrorism*, 11(4): 73–77.

Brown, D., Dalton, J., & Hoyle, H. (2004). Spatial forecast methods for terrorist events in urban environments. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 3073: 426–435. [https://doi.org/10.1007/978-3-540-25952-7\\_33](https://doi.org/10.1007/978-3-540-25952-7_33)

Caplan, J. M., Kennedy, L. W., & Miller, J. (2011). Risk Terrain Modeling: Brokering Criminological Theory and GIS Methods for Crime Forecasting. *Justice Quarterly*, 28(2): 360–381. <https://doi.org/10.1080/07418825.2010.486037>

Chen, L., & Mu, F. (2021). Spatiotemporal characteristics and driving forces of terrorist attacks in Belt and Road regions. *PLoS ONE*, 16(3 March): 1–24. <https://doi.org/10.1371/journal.pone.0248063>

Cothren, J., Smith, B. L., Roberts, P., & Dampousse, K. R. (2008). Geospatial and Temporal Patterns of Preparatory Conduct among American Terrorists. *International Journal of Comparative and Applied Criminal Justice*, 32(1): 23–41. <https://doi.org/10.1080/01924036.2008.9678776>

Donald Brown, Jason Dalton, H. H. (2004). Spatial Forecast Methods for Terrorist Events in Urban Environments. *Symposium on Intelligence and Security Informatics*, 426–435. <https://doi.org/10.1007/978-3-662-19161-3>

Ehrlich, P. R., & Liu, J. (2002). Some roots of terrorism. *Population and Environment*, 24(2): 183–192. <https://doi.org/10.1023/A:1020700221602>

Freilich, J. D., Chermak, S. M., & Gruenewald, J. (2015). The future of terrorism research: a review essay. *International Journal of Comparative and Applied Criminal Justice*, 39(4): 353–369. <https://doi.org/10.1080/01924036.2014.922321>

Gao, P., Guo, D., Liao, K., Webb, J. J., & Cutter, S. L. (2013). Early detection of terrorism outbreaks using prospective space-time scan statistics. *Professional Geographer*, 65(4): 676–691. <https://doi.org/10.1080/00330124.2012.724348>

Gui, R., Chen, T., & Nie, H. (2020). Erratum: In-depth analysis of railway and company evolution of Yangtze River Delta with deep learning (Complexity (2020) 2020 (5192861) DOI: 10.1155/2020/5192861). *Complexity*, 2020. <https://doi.org/10.1155/2020/7562682>

Haddaway, Neal R., Bethel, A., Dicks, L. V., Koricheva, J., Macura, B., Petrokofsky, G., Pullin, A. S., Savilaako, S., & Stewart, G. B. (2020). Eight problems with literature reviews and how to fix them. *Nature Ecology and Evolution*, 4(12): 1582–1589. <https://doi.org/10.1038/s41559-020-01295-x>

Haddaway, Neal Robert, & Macura, B. (2018). The role of reporting standards in producing robust literature reviews. *Nature Climate Change*,

8(6): 444–447. <https://doi.org/10.1038/s41558-018-0180-3>

Hao, M., Jiang, D., Ding, F., Fu, J., & Chen, S. (2019). Simulating spatio-temporal patterns of terrorism incidents on the Indochina peninsula with GIS and the random forest method. *ISPRS International Journal of Geo-Information*, 8(3): 133. <https://doi.org/10.3390/ijgi8030133>

Henkin, S., Boyd, M. A., & Martin, A. (2020). Southeast Asia after the Caliphate: Identifying Spatial Trends in Terrorism and Radicalization in Malaysia. *Statistics, Politics and Policy*, 11(2): 139–165. <https://doi.org/10.1515/spp-2020-0001>

Jha, M. K. (2009). Dynamic Bayesian Network for Predicting the Likelihood of a Terrorist Attack at Critical Transportation Infrastructure Facilities. *Journal of Infrastructure Systems*, 15(1): 31–39. [https://doi.org/10.1061/\(asce\)1076-0342\(2009\)15:1\(31\)](https://doi.org/10.1061/(asce)1076-0342(2009)15:1(31))

Kalaiarasi, S., Mehta, A., & Bordia, D. (2019). Using Global Terrorism Database (GTD) and Machine Learning Algorithms to Predict Terrorism and Threat. *International Journal of Engineering and Advanced Technology*, 9(1): 5995–6000. <https://doi.org/10.35940/ijeat.a1768.109119>

Kanika, S., Anurag, C., & Parmeet, K. (2019). A Machine Learning Approach for Enhancing Defence Against Global Terrorism. *2019 Twelfth International Conference on Contemporary Computing (IC3)*, 1–5. <https://doi.org/10.1109/IC3.2019.8844947>

Khan, A. U. (2005). The terrorist threat and the policy response in Pakistan. *SIPRI Policy Paper No. 11*, 2007(11): 56. <http://www.sipri.org/contents/publications/Polycypaper11.pdf/>

Khan, I., Hamza, S., Burke, F., & ul-Hud, S. N. (2020). Application of GIS for evaluation of ethnic fault lines of Karachi. *Malaysian Journal of Society and Space*, 16(4): 15–29. <https://doi.org/10.17576/geo-2020-1604-02>

Krueger, A. B., & Malečková, J. (2003). Education, poverty and terrorism: Is there a causal connection? *Journal of Economic Perspectives*, 17(4): 119–144. <https://doi.org/10.1257/089533003772034925>

Kwan, M. P., & Lee, J. (2005). Emergency response after 9/11: The potential of real-time 3D GIS for quick emergency response in micro-spatial environments. *Computers, Environment and Urban Systems*, 29(2): 93–113. <https://doi.org/10.1016/j.compenvurbsys.2003.08.002>

Li, Z., Sun, D., Li, B., Li, Z., & Li, A. (2018). Terrorist Group Behavior Prediction by Wavelet Transform-Based Pattern Recognition. *Discrete Dynamics in Nature and Society*, 2018. <https://doi.org/10.1155/2018/5676712>

Maniraj, S. P., Chaudhary, D., Deep, V. H., & Singh, V. P. (2019). Data Aggregation and Terror Group Prediction using Machine Learning Algorithms. *International Journal of Recent Technology and Engineering*, 8(4): 1467–1469. <https://doi.org/10.35940/ijrte.d7590.118419>

Millett, S. M. (2009). Trend Analysis as Pattern Recognition. *World Futures Review*, 1(4): 5–16. <https://doi.org/10.1177/194675670900100403>

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *BMJ (Online)*, 339(7716): 332–336. <https://doi.org/10.1136/bmj.b2535>

Okeniyi, C. G., Ayara, O. O., & Akoth, N. N. (2018). Terrorism in Africa: Mapping the Nigeria and Kenya situation. *International Journal of Development and Sustainability*, 7(3): 993–1014. [www.isdsnet.com/ijds](http://www.isdsnet.com/ijds)

Peace, M., & World, I. N. A. C. (2020). *Institute for Economics & Peace. Global Peace Index 2020: Measuring Peace in a Complex World*. <http://visionofhumanity.org/reports>

Rokhman, M., Chalim, A., Sholahuddin, A., Suharnoko, D., & Usman, F. (2020). *Geo-spatial of Terrorism and Radicalism in Indonesia -A Preventive Efforts-*. 25(7): 1–9. <https://doi.org/10.9790/0837-2507010109>

Siebeneck, L. K., Medina, R. M., Yamada, I., & Hepner, G. F. (2009). Spatial and temporal analyses of terrorist incidents in Iraq, 2004–2009. *Studies in Conflict and Terrorism*, 32(7): 591–610. <https://doi.org/10.1080/10576100902961789>

Smith, B. L., Cothren, J., & Damphousse, K. R. (2008). *Geospatial Analysis of Terrorist Activities: The Identification of Spatial and Temporal Patterns of Preparatory Behavior of International and Environmental Terrorists*. May 2014, 86.

VanHorn, J. E., & Mosurinjohn, N. A. (2010). Urban 3D GIS Modeling of Terrorism Sniper Hazards. *Social Science Computer Review*, 28(4): 482–496. <https://doi.org/10.1177/0894439309360836>

Veldhuis, T., & Staun, J. (2009). Islamist radicalisation: a root cause model. In *Clingendael Security Paper* 12(October). <http://www.clingendael.nl/cscp/publications/papers/?id=7740&&ty pe=summary>

Webb, J. J., & Cutter, S. L. (2009). The geography of U.S. terrorist incidents, 1970–2004. *Terrorism and Political Violence*, 21(3): 428–449. <https://doi.org/10.1080/09546550902950308>

Yu, X., Zhe, Z., Lei, W., Wei, P., Hechang, C., Zhezhou, Y., & Bin, L. (2020). Deep Ensemble Learning for Human Action Recognition in Still Images. *Complexity*, 2020. <https://doi.org/10.1155/2020/9428612>

Zhang, X., Jin, M., Fu, J., Hao, M., Yu, C., & Xie, X. (2018). On the risk assessment of terrorist attacks coupled with multi-source factors. *International Journal of Geo-Information Article*, 7(9): 354. <https://doi.org/10.3390/ijgi7090354>